सत्यमेव जयते

Annual Report

2020-21

विज्ञान और
इंजीनियरी
अनुसंधान बोर्ड

Science and
Engineering
Research Board

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Science and
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वार्षिक रिपोर्ट 2020-21 **Annual Report**

From the Secretary's Desk

I feel truly privileged to present the 10th Annual Report of the Science and Engineering Research Board (SERB), Department of Science and Technology, illustrating a comprehensive review of our activities and R&D support mechanisms in the year 2020-2021. This year was particularly challenging for research investigators and SERB given the prevailing conditions of Covid-19 pandemic and its effect on the closure of research laboratories. I feel proud to share that despite these circumstances, SERB was able to provide non-stop support to our investigators, students and other research personnel, and launch a number of new initiatives to strengthen the R&D capabilities and to address gender disparities in science and engineering.

Special research calls were released for COVID-19 and related respiratory viral infections for urgent strategic investments to accelerate antiviral research with a strong interdisciplinary component in the research areas of new or repurposed antivirals, viricidal coatings, affordable diagnostics for respiratory viral infections. In addition, a special call was made to develop mathematical models to study the rate of spread of COVID-19, statistical forecasting and inferences from pandemic data, algorithms for infectious disease modeling and quantitative approaches for epidemiological models.

SERB-FIRE (Fund for Industrial Research Engagement) was created as a new vertical to enhance industry engagement in public-funded research. Memorandum of Understanding have been signed with Intel India, GE India Private Limited, and Applied Materials, to catalyze research and development through public-private-partnership mode. Many strategic and upcoming themes such as next-generation gas turbines, additive manufacturing, engine services technology, computational biology, new semiconductor materials, digital and health care technologies, are expected to be supported through open calls.

As a major initiative to mitigate gender disparity in R&D funding, SERB-POWER (Promoting Opportunities for Women in Exploratory Research) was launched for female S&T researchers serving in Indian academic institutions and R&D laboratories. SERB-POWER Program is specially designed to provide structured effort towards enhanced diversity in research to ensure equal access and weighted opportunities for Indian women scientists engaged in research and development activities. The first call of this scheme was immensely liked by the community and a large number of research applications were received acknowledging the impactful nature of this scheme.

This Annual Report further highlights our dedicated efforts to support niche areas of research to ensure Indian leadership on the world stage. The processes involved are due to sincere efforts of SERB Program Advisory Committees, subject experts, and numerous other colleagues who volunteered to maintain the highest levels of quality, transparency and integrity in funding mechanisms.

It is envisaged that newer programs and strengthening of our ongoing flagship schemes will further add value to the drive of innovation, inclusion and collaborative spirit, and the ideas of today will be executed well to position India at the top of the S&T pyramid at the global scale. SERB will remain focused and committed to support exponential science in India and bring the right return on investment to closely aligned with national missions and to usher ease-of-living for all Indians with desired innovation and breakthrough.

Jain Hind!

Sandeep Verma
Secretary, SERB

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THE ORGANIZATION

The Science and Engineering Research Board (SERB), a Statutory Body of the Department of Science and Technology was established in the year 2011 for planning, promoting and funding internationally competitive research in emerging areas of Science and Engineering. SERB, since its inception has been instrumental in building a sustainable research ecosystem in the country through its diverse programme portfolio that includes research grant funding, fostering young researchers, recognizing and rewarding research excellence, promoting scientific networks and partnerships, along with enhancing gender and social inclusiveness. Through its programmes, policies, procedures, and practices, SERB strides ahead in its mission to advance scientific research in the country.

Fig. 1.1: SERB Office at Vasant Kunj, New Delhi

1.1 VISION, MISSION AND GOALS

To better focus its energies and resources on realization of its mandate, SERB defined its vision, mission and goals as per the following.

Vision

To position science and technology as the fulcrum for social and economic change by supporting competitive, relevant and quality scientific research and development.

Mission

As the premier national research funding agency, raise the quality and footprint of Indian Science and Engineering to the highest global levels in an accelerated mode, through calibrated, competitive support of research and development.

Goals

I. Stimulating the search for new knowledge and encouraging invention, discovery, innovation and development by supporting bottom-up research competitively and at all levels of our research eco-system.

II. Support conceptually new directions, even when risky, but having the potential for non-incremental and transformative success. Strengthen deep-expertise in specific domains and link them through inter-disciplinary and multi-institutional 'top-down' programmes that address challenging national problems.

III. Develop funding programmes which connect with needs of our society and identify key scientific questions, both basic-science and application that have concrete societal values.

IV. Launch and strengthen programmes to bring in researchers from under represented regions, weaker and marginalized segments of the society.

V. Realizing the importance of gender parity, ensure that all programmes pro-actively have mechanism to encourage enhanced and equitable representation of women scientists.

VI. Initiate and strengthen schemes that link teachers in colleges and resource-poor universities with opportunities in active research, thereby aiding in expanding the footprint of quality science.

VII. Through global bilateral and multilateral partnerships support collaborative top-quality research in cutting-edge areas to ensure the rapid growth of quality science in India.

VIII. Scout, mentor, incentivize and reward exceptional performers, teams and institutions.

IX. Show unstinted commitment towards science by constantly improving our methods and swiftness for research support, while ensuring the highest adherence to financial processes.

X. Recognizing that all research support has at its base the development of quality, well-trained researchers; initiate and strengthen programmes of identifying research potential, mentoring, training and hands-on workshops, on a broad-based national scale.

XI. Make SERB the vehicle of choice for all R&D funding agencies for their core programmes by developing inclusive processes and proactively synergizing with them for the requisite integration and consolidation of the research effort in Science and Engineering in the country.

Fig. 1.2: The vison, mission and goals of SERB.

1.2 ORGANIZATION CHART

The organization structure of SERB is given in Figure 1.3.

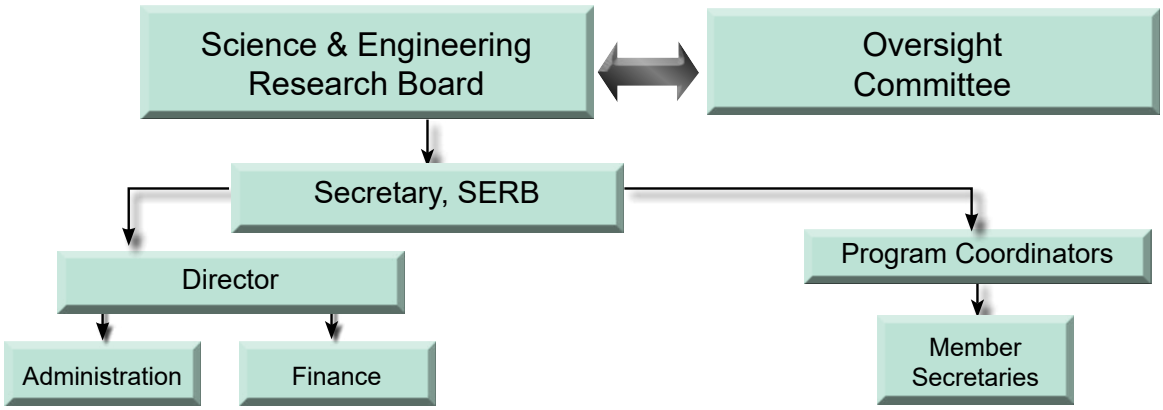


Fig. 1.3: Broad working organization chart of SERB

1.3 PROGRAMME CHART

The various scientific programmes and schemes handled by SERB are given in Figure 1.4.

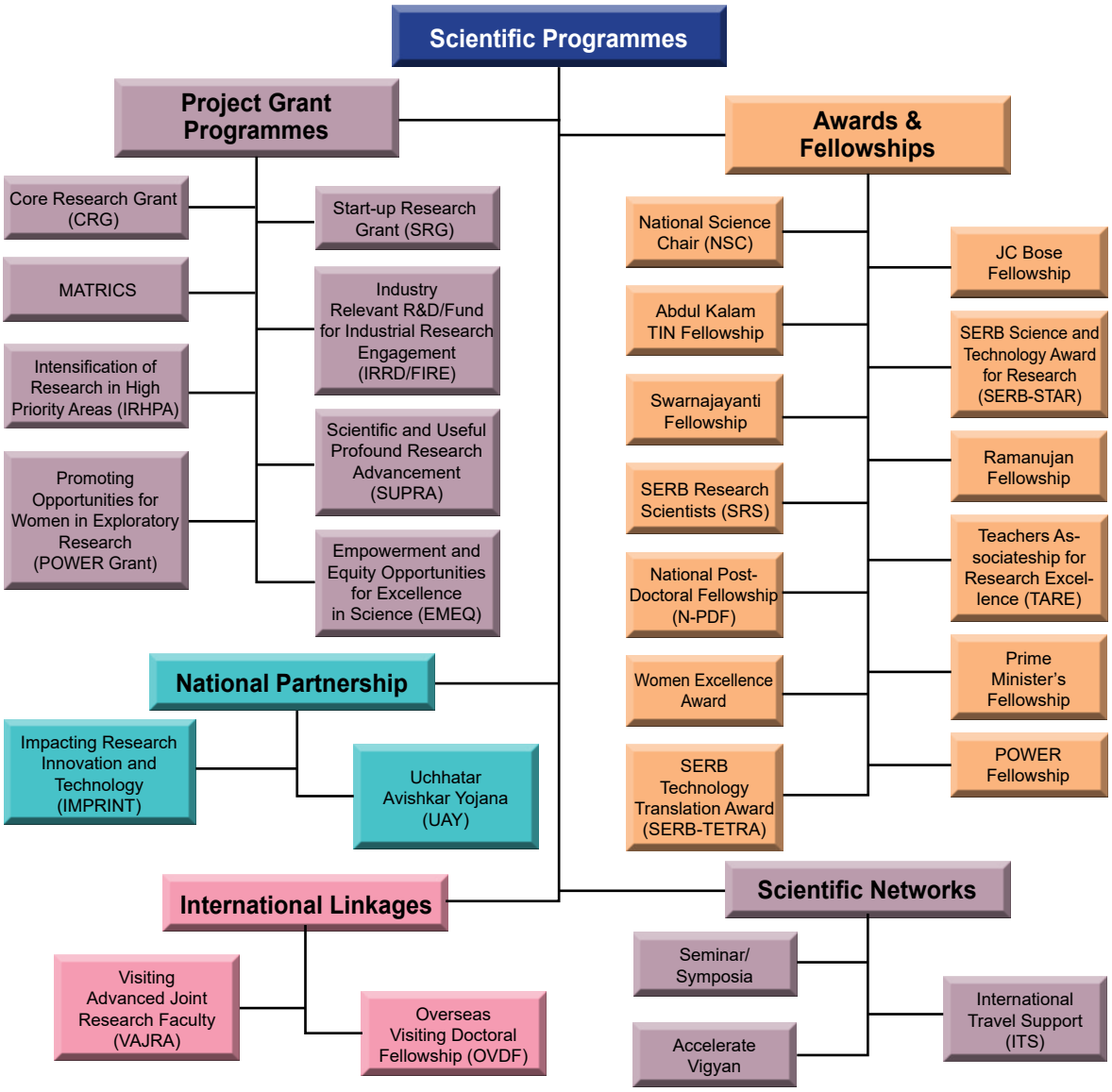


Fig. 1.4: Flowchart depicting programmes handled by SERB

1.4 BOARD AND OVERSIGHT COMMITTEE

a) The Board

The Board, chaired by Secretary, Department of Science and Technology (DST), is comprised of 16 members including a few eminent Indian Scientists and six Secretaries to the Government of India. Following are the Members of the Board as depicted in the Flowchart (Fig. 1.5).

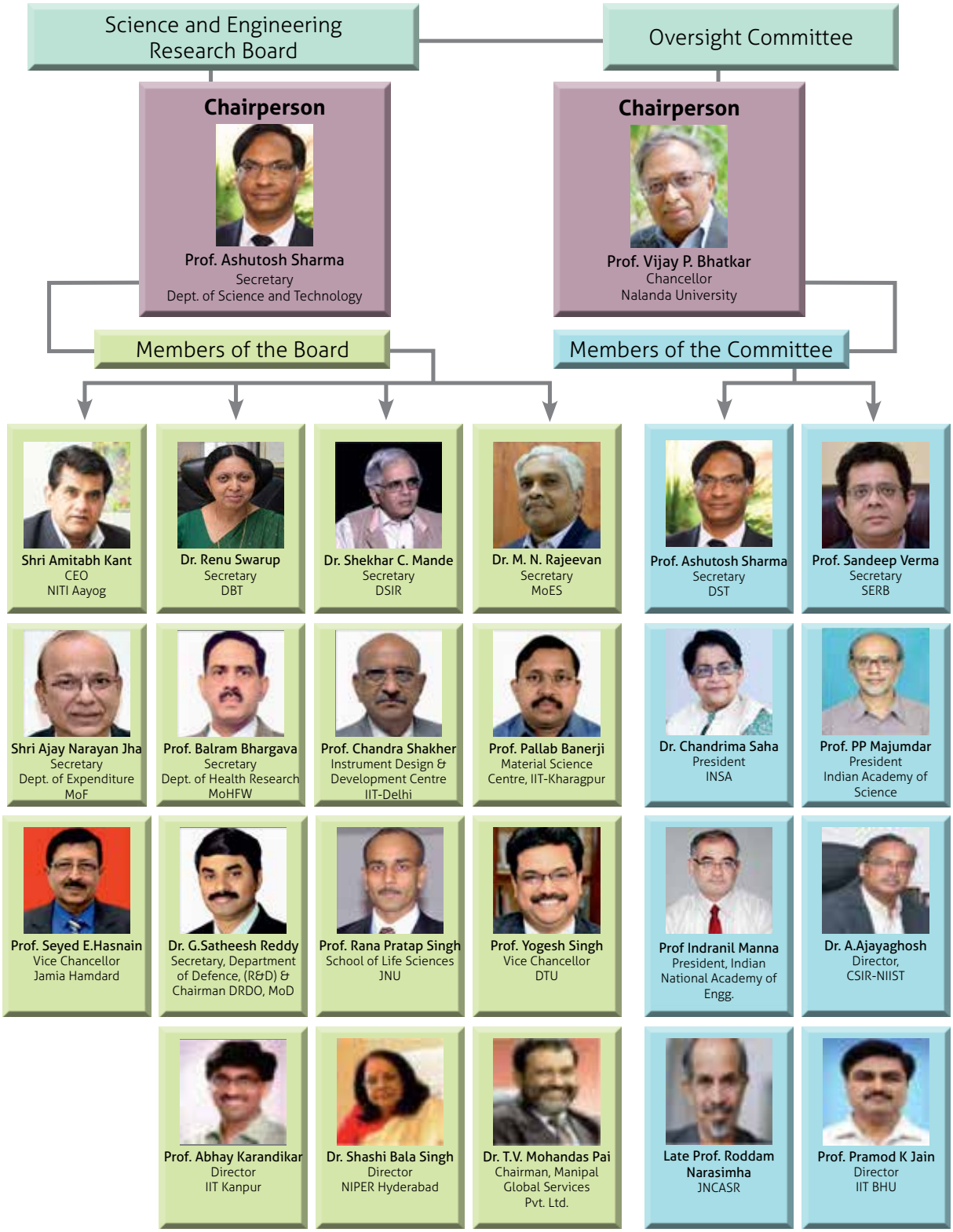


Fig. 1.5: Members of the Board and Oversight Committee

b) The Oversight Committee

The SERB Act provides for constitution of an Oversight Committee to advise and assist the Board. A scientist of eminence and international repute chairs the Oversight Committee with Secretary to the Government of India in DST as Vice Chairperson and a few distinguished experts, Secretary SERB and Presidents of Indian National Science Academy, Indian Academy of Sciences and Indian National Academy of Engineering as members. The members of the Oversight Committee are depicted in Figure 1.5.

1.5 THE PEER REVIEW COMMITTEES

The Board has a robust peer review mechanism for taking funding decisions. The proposals received under various schemes and programmes follow a peer review process, which involves two levels of appraisals. At first stage, the proposals are sent to at least four domain experts for their comments. At second stage, the proposals are generally evaluated for funding by specific committees. A number of committees have been constituted to evaluate R&D proposals and other applications for seeking support under various schemes and programmes. Major committees are listed below:

1.5.1 Empowered Committee

An empowered committee is constituted under the Chairmanship of Secretary, SERB. If the recommended cost of the proposal is greater than Rs. 80 lakh, it is referred to an Empowered Committee. This committee is empowered to approve projects upto Rs. 5 crore, whereas for proposals costing more than Rs. 5 crore the same committee will serve as an appraisal body to the Board.

1.5.2 Programme Advisory Committee (PAC)

Programme Advisory Committee (PAC) is the first level peer review committee in the system. Sixteen PACs in various disciplines, each with a composition of 7 - 10 core members and a cohort of experts who can be co-opted in the committees whenever required take decisions on R&D proposals submitted under Core Research Grant.

1.5.3 Expert Committees / Task Force

Five Expert Committees help the Board in taking decision on Start-up Research Grant (SRG) and National Postdoctoral Fellowship (NPDF) proposals. A Task Force constituted under the Board takes decision on proposals received under EMEQ Scheme. These Committees take funding decisions on proposals received under the said schemes.

1.6 GROWTH PROFILE

The Board has bought forth several innovative programmes and schemes to identify potential scientists and support them for undertaking R&D in frontier areas of Science and Engineering. The Board interventions were primarily focused to expand the research base in the country without compromising the quality of research.

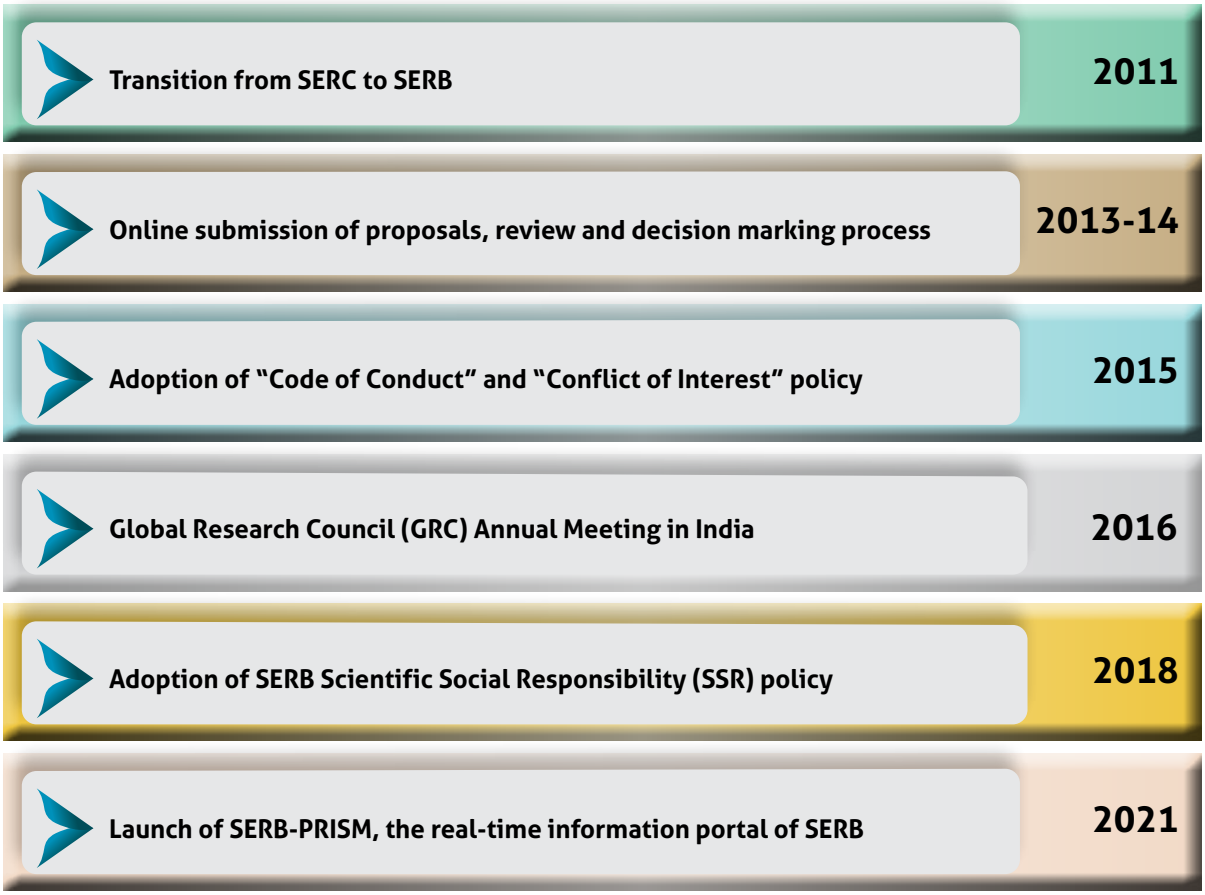


Fig. 1.6: Key milestones of SERB since inception

1.6.1 Milestones

The Board has come a long way in its journey from the erstwhile SERC to its current profile as depicted. Some of the major milestones over the years are shown in Figure 1.6.

1.6.2 Adaptability

The Board, since inception had introduced several schemes and programmes to cater various segments of the scientific community. Its adaptability to suit the changing S&T needs of the country is depicted in Figure 1.7

1.6.3 Budget

The budgetary allocation for SERB since inception is shown in Figure 1.8.

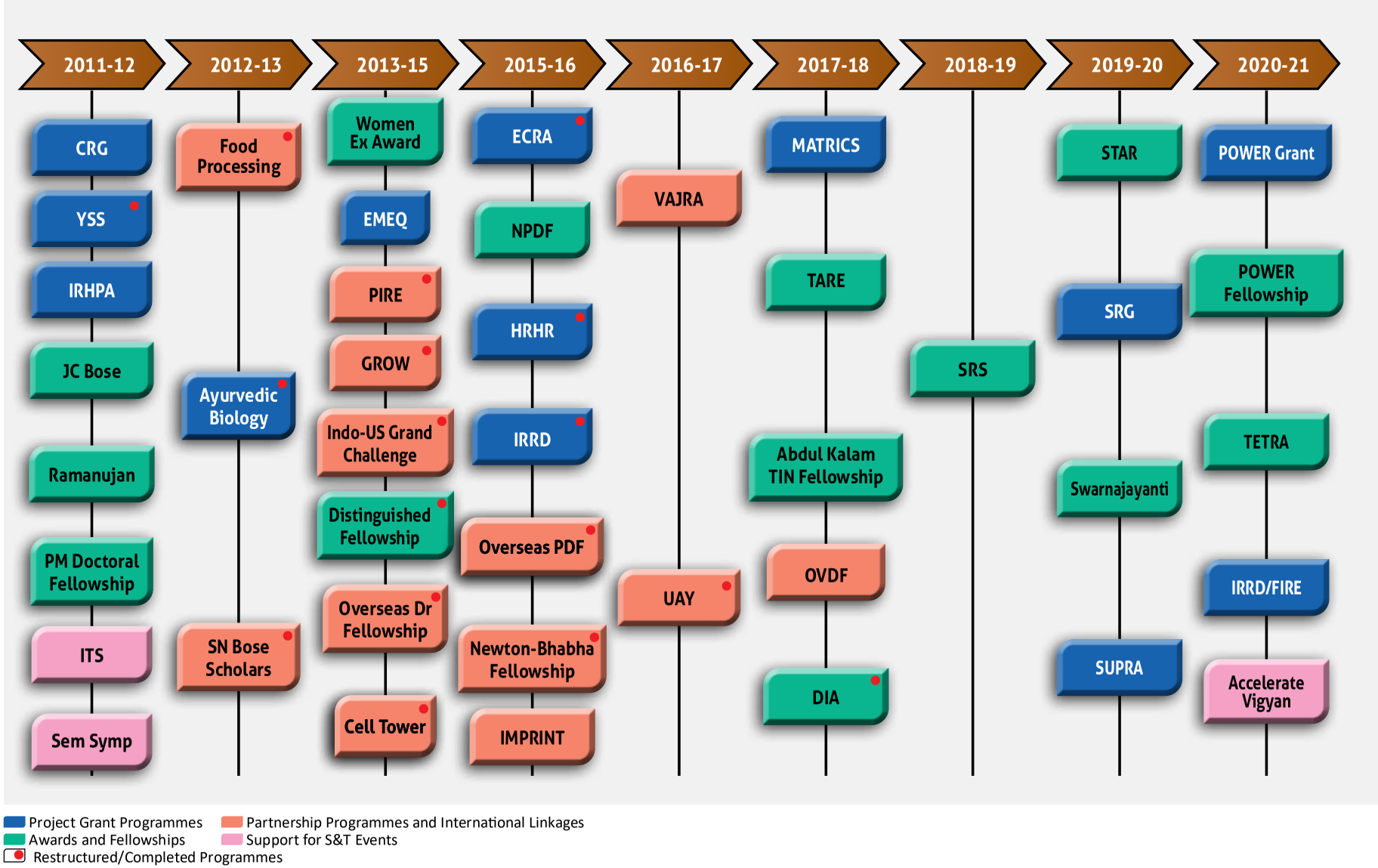


Fig. 1.7: The growth profile of SERB programmes since inception

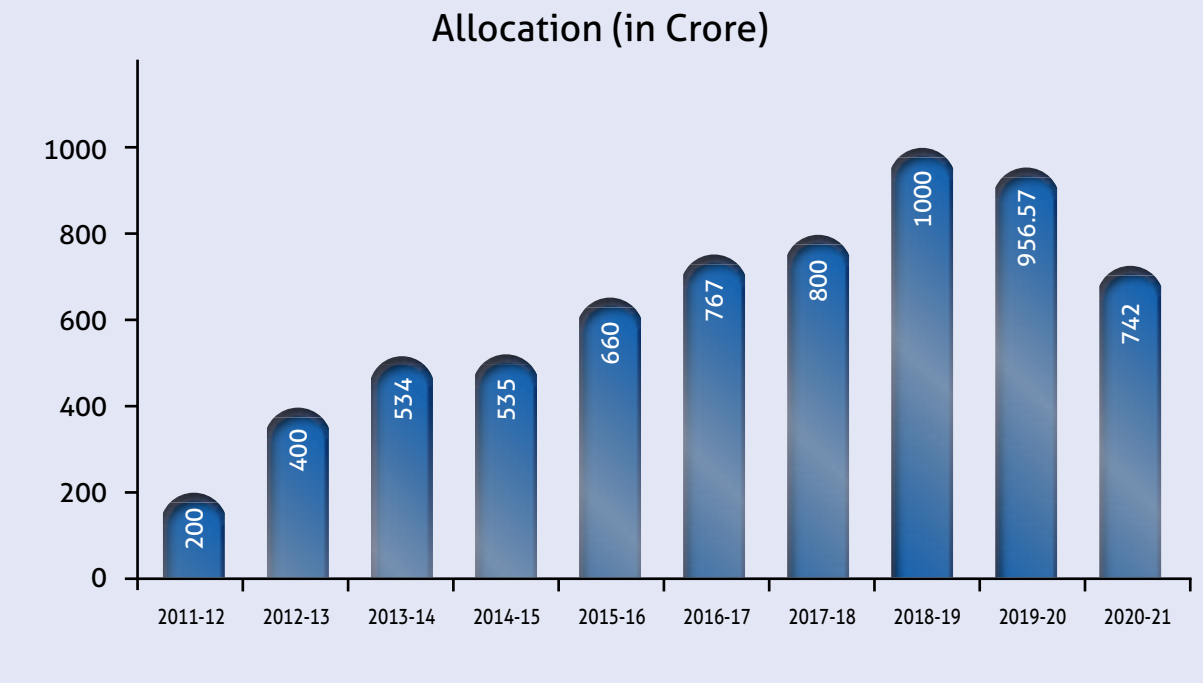


Fig. 1.8 : Budget allocation

2

OVERVIEW

SERB serves as a premier funding agency in terms of planning, promoting, and supporting competitive basic research in the field of Science and Engineering. SERB programmes and schemes are designed to cater to a wide spectrum of researchers, to pursue and excel in their research endeavours. SERB strives to foster a rich research culture by enabling synergy between academic institutions, research and development laboratories and industry for promoting basic and translational research in all emerging areas. The Board ensures transparency, accountability and responsiveness by way of various policies, procedures and practices that have been adopted from time to time.

In the wake of COVID-19 pandemic, SERB had taken several national R&D initiatives by formulating and announcing COVID-19 special calls in priority areas that required immediate R&D support. The major thrust areas identified were affordable diagnostics, anti-viral nanomaterials, vaccines development, drug repurposing and mathematical modelling to understand and find the best intervention modalities to combat COVID-19.

In addition to the urgent support rendered for research related to the pandemic, SERB continued its normal research funding through its various programmes and schemes. In spite of the unprecedented challenges, SERB functioned as usual adhering to its commitments and upholding the aspirations of the research community. The proposals received under various programmes and schemes were evaluated and funding decisions made within the funding cycle. The evaluation meetings as well as monitoring meetings to review the progress of ongoing projects were held in virtual mode. Some new programmes were also launched in the year for strengthening the national R&D activities.

Taking into consideration the disruptions caused by the pandemic, several measures were taken to address the difficulties faced by Research Fellows and Principal Investigators (PIs) of ongoing projects. The tenure of the ongoing National Post-doctoral fellowship was extended with fellowship support. The ongoing projects were accorded extension for successful completion of the committed work.

While a detailed account of activities and initiatives of SERB in the year 2020-21 are presented in the following chapters, the highlights are briefly indicated in this Overview.

2.1 ONGOING PROGRAMMES / SCHEMES

SERB continued its research support through its ongoing programmes and schemes, the salient aspects of which are described below.

Core Research Grant (CRG) is the flagship programme of SERB. It provides individual-centric research support to researchers from academic institutions, research laboratories and other R&D organizations for undertaking research in frontier areas of science and engineering. The support is provided for three years with no upper limit for funding. One call for proposals was solicited and 6472 applications were received. A total of 814 projects were sanctioned under the 15 research verticals.

Start-up Research Grant (SRG) programme aims to assist researchers to initiate research career in a new institution. It is meant to enable researchers to establish themselves and move on to the mainstream core research grant. The support comprises of a flexibly structured research grant of Rs. 30 lakh plus overheads for a period of two years. One call for proposals was solicited and 2614 grant applications were received. A total of 443 projects were supported under SRG in the year 2020-21. The ongoing projects under the erstwhile Early Career Research Award (ECRA) and Young Scientist Scheme (YSS) were continued to be supported.

MATRICS scheme provides fixed grant support to active researchers with good credentials in Mathematical Sciences, Theoretical Sciences and Quantitative Social Sciences. The main feature of the scheme is submission of a simple 1-2 page proposal and a flexible grant to cater to the specific needs of Mathematical and Theoretical Sciences research. In the one call for proposals that was sought, 687 proposals were received. 101 grants were sanctioned in the reporting period.

SERB Scientific and Useful Profound Research Advancement (SERB-SUPRA) is a scheme beyond normal core grants and purposefully designed for high quality proposals consisting of new hypothesis or challenge existing ones, and provide 'out-of-box' solutions. The proposed research is expected to contain significant risk elements but promise of high reward if the difficulties could be circumvented. The success of such proposals are expected to have far reaching implications providing new and significant theoretical or experimental advances, formulation of new hypothesis, or breakthrough science, which will lead to new technologies. The funding is provided normally for a period of three years. In the reporting period, a total of 532 proposals were received and 36 proposals were supported under the SERB-SUPRA scheme.

Empowerment and Equity Opportunities for Excellence in Science (EMEQ) scheme is aimed to provide research support to researchers belonging to the Scheduled Caste and Scheduled Tribe in undertaking research in frontier areas of Science and Engineering. Support consists of a project grant upto Rs. 50 lakh plus overheads for a three year duration. One call for proposal was solicited in which 634 proposals were received. 118 new projects were sanctioned in the reporting period.

National Science Chair (NSC) intends to recognise distinguished Indian superannuated scientists for their outstanding contributions in the areas of Science, Technology, Engineering and Mathematics (STEM) and Medicine to promote excellence and growth in R&D. The NSC is provided in two modes, Mode 1: Scientific Excellence, the objective of which is to extend continuance of support for excellence in R&D activities and Mode 2: Science Leadership which is more to do with recognition for thought leadership made by the awardee in his professional career. Four scientists were awarded NSC under Mode 1 and one under Mode 2.

JC Bose Fellowship is awarded to eminent senior scientist as a recognition for their outstanding performance in national R&D activities. The fellowship is scientist-specific and very selective. 46 fellowships were awarded under JC Bose Fellowship scheme in the reporting period.

Abdul Kalam Technology Innovation (AKTIN) Fellowship is awarded to outstanding engineers to recognize, encourage and support translational research of excellence in the fields of engineering, innovation and technology development. 6 AKTIN fellowships were awarded in the year 2020-21.

SERB Science and Technology Award for Research (SERB-STAR) is a prestigious award instituted by SERB to recognize and reward outstanding performance of PIs of SERB Projects. The award consists of a fellowship of Rs. 15,000 per month, research grant of Rs. 10 lakh per annum and Rs. 1 lakh per annum as overhead

charges for a period of three years. The second call for nominations was made in the year 2020-21. 128 nominations were received out of which 14 received the SERB-STAR award.

Swarnajayanti Fellowship had been instituted by DST to commemorate India's fiftieth year of independence. Under this scheme a selected number of young scientists with excellent track record are provided special assistance and support to enable them to pursue research in frontier areas of Science and Technology. The fellowship is scientist specific, very selective and has close academic monitoring. Scientists selected for the award are allowed to pursue unfettered research with a freedom and flexibility in terms of expenditure as approved in the research plan. The award consists of a fellowship of Rs. 25,000 per month in addition to the salary drawn from the parent institute for a period of 5 years. SERB will be providing additional funding to meet the required expenditure pertaining to the research objectives enumerated in the proposal submitted by the awardee. 20 Swarnajayanti awardees were granted projects by SERB in the year 2020-21.

Ramanujan Fellowship offers support to brilliant scientists returning from all over the world to pursue their research career in India. These fellowships are for young researchers below the age of 40 years with a proven outstanding track record. The Ramanujan Fellows can work in any of the scientific institutions and universities across the country. The amount of fellowship offered under the scheme is Rs. 1,35,000 per month with a research grant of Rs. 7 lakh per annum and overhead charges of Rs.60,000 per annum for a period of five years. In the reporting period 23 Ramanujan Fellowships were awarded.

SERB Research Scientists (SRS) scheme was initiated in 2018-19 to provide a platform for sustainment of research careers of INSPIRE Faculty and Ramanujan Fellows for an additional period of two years. The amount of fellowship is Rs.1,35,000 per month and in addition a research grant of Rs. 7 lakh per annum and overhead charges are provided. 44 applications were received and 15 were supported.

Teachers Associateship for Research Excellence (TARE) scheme intends to facilitate mobility of faculty members working in state universities, colleges and private academic institutions to carry out research in an established public funded institutions such as IITs, IISc, IISERs, NITs, national institutions and central universities, preferably closer to the institution where the faculty member is working. The support consists of research fellowship of Rs. 60,000 per annum subject to completion of minimum 90 days research work per year in the host institution and a research grant of Rs. 5 lakh per annum and overheads. One call for applications was solicited and 450 applications were received. 84 associateships were sanctioned in the reporting period.

SERB National Postdoctoral Fellowship (NPDF) programme is designed to support and foster highly potential young researchers in leading research labs with accomplished mentors. The support consists of fellowship of Rs. 55,000 per month plus HRA, research grant of Rs. 2 lakh per annum and overhead of Rs. 1 lakh per annum for a period of two years. One call for proposal was solicited under NPDF programme which received 2799 applications. In the year 2020-21, 197 promising young researchers were awarded SERB NPDF fellowships.

SERB Women Excellence Award is a prestigious award instituted to recognize and reward outstanding research achievements of young women scientists in frontier areas of Science and Engineering. The award strives to serve as a source of inspiration to women scientists who have the potential to become world class leaders in their field of research. Women scientists below 40 years of age who have received recognition from one or more of the National Science and Engineering Academies are considered for this award. The awardees are supported with a research grant of Rs. 5 lakh per annum for a period of three years and overhead charges of Rs. 1 lakh per annum for a period of three years. 8 women scientists were bestowed the SERB Women Excellence Award in the year 2020-21. The award were presented on National Science Day 2021.

IMPRINT (Impacting Research Innovation and Technology), is a program piloted by the Ministry of Education (MoE) (previously, Ministry of Human Resource and Development). The programme aims to address and provide solutions to the most relevant engineering challenges faced by our nation by translating knowledge into viable technology (product and processes) in selected technology domains. IMPRINT-II, a new and revised edition of IMPRINT programme, was subsequently launched, to streamline and simplify the processes and sharpen the focus on translational research and also to attract wider participation of stakeholders including industry. IMPRINT–II is sourced on a corpus set up jointly by MoE and DST and it also intends to derive contribution from various participating ministries. SERB has been entrusted for the implementation of IMPRINT programme. The ongoing projects of IMPRINT-II received continued support in the reporting period.

Visiting Advanced Joint Research (VAJRA) Faculty Scheme aims to tap the expertise of overseas faculty/scientist including non-resident Indians (NRIs) and OCIs to undertake high quality collaborative research in public funded academic and research institutions in India. 21 scientists were offered VAJRA Faculty award.

Accelerate Vigyan is an inter-ministerial initiative scheme conceptualized and steered by SERB. The aim of the scheme is to expand the research base, with three broad goals – consolidation and aggregation of all national scientific training programs, initiating High end Orientation Workshops and creating opportunities for Research Internships. During the reporting period, 894 applications were received for High End Workshop (Karyashala) and Training and Skill Internship (Vritika). Total 72 and 64 applications were recommended for support for High End Workshop and Training and Skill Internship, respectively.

2.2 NEW INITIATIVES

SERB-POWER (Promoting Opportunities for Women in Exploratory Research), is a new programme initiated to mitigate gender disparity in science and engineering research funding in various S&T programmes in Indian academic institutions and R&D laboratories. SERB-POWER is specially designed to provide structured support towards enhancing diversity in research and to ensure equal access and weighted opportunities for Indian women scientists engaged in R&D activities. The funding framework consists of two categories: SERB – POWER Fellowship and SERB – POWER Research Grants.

The SERB – POWER scheme was launched by Dr. Harsh Vardhan, Hon'ble Minster for Science & Technology, Earth Sciences and Health & Family Welfare on October 29, 2020.

The first call for proposals under SERB–POWER scheme was announced subsequently. 2880 proposals were received under SERB–POWER Grants out of which 99 proposals were approved for funding and 21 projects were sanctioned in the reporting period. 100 nominations were considered for SERB POWER Fellowship out of which 25 were supported.

IRHPA - Cryo Electron Microscopy: A call for proposals under IRHPA scheme was made in the area of Cryo-Electron Microscopy of Macromolecular Structures and complexes. To have a finite number of state-of-the-art cryo-Electron Microscopy facilities with a vision to upscale the Cryo Electron Microscopy-based structural biology research, SERB recommended four machines for North, East, West and South regions with similar facilities and equal budget.

Core Research Grant (Quantitative Social Sciences): A new research vertical Quantitative Social Sciences (QSS) was introduced within the Core Research Grant programme of SERB, considering the importance of integration of socio-economic dimension into R&D space of SERB. Research in QSS is expected to allow a deep dive into exploration of quantitative methodologies as applied to human behavioural studies, economic landscapes, and complex cognition events, to place India in the top position in related research areas. QSS, under Core Research Grant (CRG) will offer structured R&D support to innovative quantitative research skills, computational techniques and work strategies, as applied to three broad areas of behaviour, economics, and cognition (excluding biological component). The first call for proposals was made in February 2021.

Core Research Grant (Exponential Technologies): A new program advisory committee on "Exponential Technologies" was created within Core Research Grant for supporting projects that aims for exponential growth of future technologies as applicable to societal challenges and national missions, with a chance of creating truly remarkable and sustainable solutions, preferably through collaborative research cluster approach. In the first call for proposals, 85 applications were received under CRG (Exponential Technologies) and 5 projects were sanctioned.

SERB Technology Translation Award (SERB-TETRA): The scheme was initiated to challenge scientists executing SERB grants to establish an effective, functional and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to TRL level 5 and beyond. TETRA Support will help entities having successful ideas to kickstart new venture processes. With a seed capital, flexible working spaces and interaction between mentor and start-up entrepreneurs, the SERB-TETRA will expand the scope by providing numerous networking opportunities, followed by presenting the finished prototype to an audience of large investors, established MSMEs and private companies, and public sector enterprises. The first call for proposals was announced in 2020-21. 90 proposals were received and 10 of them were supported.

SERB-Fund for Industrial Research Engagement (SERB-FIRE) aims to utilize the expertise available in academic institutions and national laboratories to solve industry specific problems for the larger benefit of society. The scheme supports ideas that address a well-defined problem of industrial relevance in a project mode. The project proposal

shall be jointly designed and implemented by the academic partner and industry. In this direction, SERB had signed a Letter of Intent (LoI) in the year 2019-20 to engage a Program titled: Fund for Industrial Research Engagement (FIRE) with partners from Applied Materials India Private Limited, Intel Technology India Private Limited, Mentor Graphics (Sales & Services) Private Limited, NXP India Private Limited, Texas Instruments (India) Private Limited.

In continuation to the above, SERB signed LoI with GE India Private Limited on June 30, 2020. The plan of activities including the quantum of investment from industry side was redrawn in the event of COVID–19 pandemic. A Public Private Partnership Agreement with Intel India & GE India was signed on 23 March, 2021 through virtual platform.

Adoption of Emoluments and Guidelines for Scientific/Technical manpower in SERB sponsored programmes: SERB adopted DST norms including emoluments for Scientific/ Technical manpower other than JRF/SRF/RA in SERB sponsored R&D programmes as given in DST office memorandum No. SR/S9/Z-05/2019 dated 10.07.2020, with effective from 10 July 2020.

SERB – Project Information System and Management (SERB – PRISM) is a real-time information portal that provides information related to research support extended by SERB over the years. This portal (prism.serbonline.in) was launched by Prof. Ashutosh Sharma, Chairman, SERB, & Secretary, DST, on 4 March 2021.

SERB-PRISM provides a platform to provide project details, research outcomes, facilities created and their achievement, making a strong scientist-scientist and science-society connect.

This portal is designed to provide information regarding projects sanctioned by SERB from 2011 onwards including funding details, status, research summary and project output information such as publications and patents. Search facilities enable to retrieve information about projects by Name of PI, Institution, State, Keywords, as well as year-wise listing and search of Equipment that has been sanctioned by SERB in these projects. SERB-PRISM will be a significant step forward in SERB's commitment towards transparency, accountability and dissemination of research outcomes originating from SERB funding, while allowing researchers to look at research trends, learn about cutting-edge science, locate critical equipment in their vicinity and help seek collaborations across disciplines.

2.3 COVID-19 RELATED R&D INITIATIVES

In response to the unprecedented COVID-19 situation, SERB launched a series of special calls under various research schemes in its endeavour to address the pandemic situation and to find plausible remedial solution for COVID-19 related issues.

Core Research Grant COVID-19 Special call for rapid, short-term projects of one year duration were announced by SERB. To urgently ramp up national R&D efforts against the COVID-19 pandemic in various thrust areas such as anti-viral nanomaterials, affordable diagnostics, drug repurposing and computational identification and validation of COVID-19 targets, proposals were invited, preferably with multi-disciplinary efforts. Under this special CRG COVID-19 special call, 1121 proposals were received and 43 proposals were supported.

Intensification of Research in High Priority Areas COVID-19 (IRHPA COVID-19) Special Call was announced to intensify the R&D efforts to understand the SARS-CoV2 disease and related respiratory viral infections. Under this special call 310 proposals were received and 13 proposals were supported for three years.

MATRICS COVID-19 Special Call was initiated considering the importance to develop mathematical models to study the rate of spread of SARS-CoV2 among the population and also the criticality of data driven inference for forecasting of coronavirus. Under this special call 624 proposals were received and 38 proposals were supported for one year.

COVID-19 India National Supermodel: SERB co-ordinated the efforts of COVID-19 India National Supermodel committee constituted by DST to bring out mathematical correlations and a comprehensive model concerning the spread of COVID-19 pandemic and spatio-temporal progression of the viral disease throughout the country.

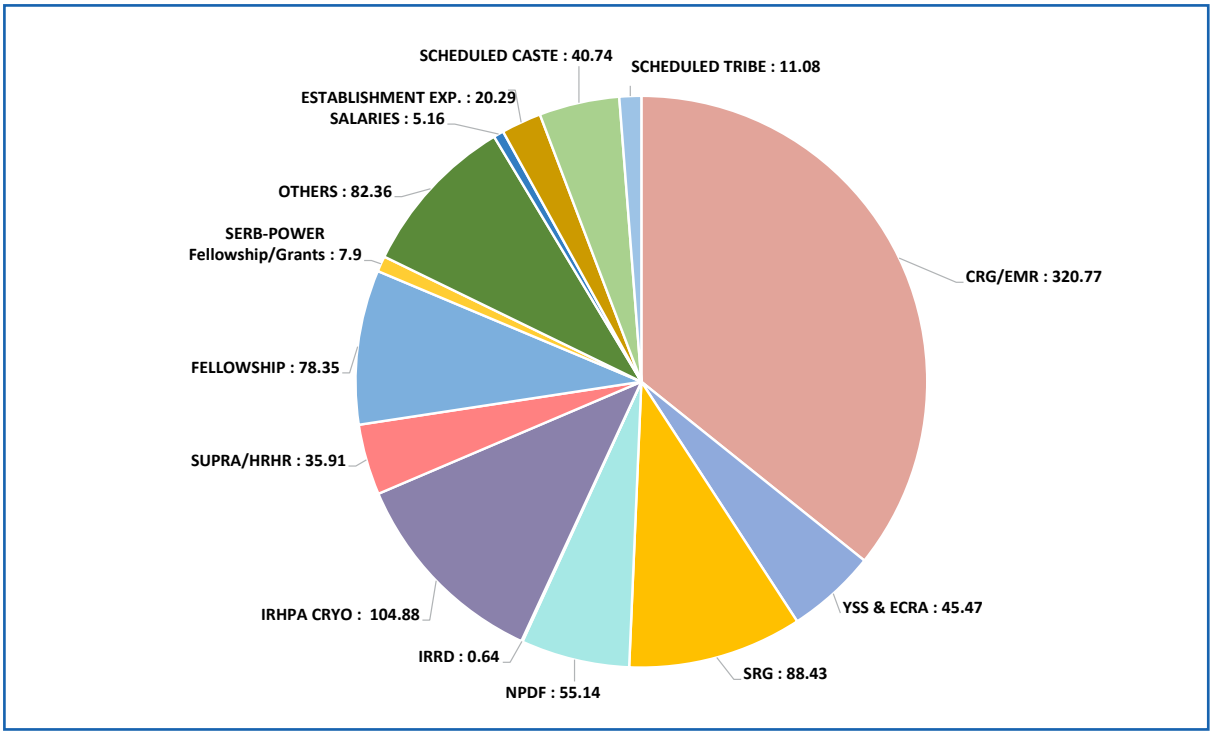
COVID-19 Emerging Research (SERB-COVER) Webinars: SERB launched monthly webinar series called SERB-COVER on selected thematic areas to deliberate on SERB-supported COVID-19 projects for wider dissemination among the scientific community.

Extension of Ongoing National Post-Doctoral Fellowship tenure: Considering the impact of COVID-19, tenure of National Postdoctoral Fellowship (N-PDF) was extended for a period up to six months with fellowship assistance. The extension was provided in order to aid the National Post-Doctoral Fellows to successfully complete the proposed research work that was affected due to lockdown.

Extension of Ongoing SERB Projects: In view of the extraordinary situation due to COVID-19, projects supported under CRG, ECRA and EMEQ Schemes which completed within 1st April 2020 and 30th September 2020 were given six months no-cost extension to complete the unmet objectives due to nationwide lockdown.

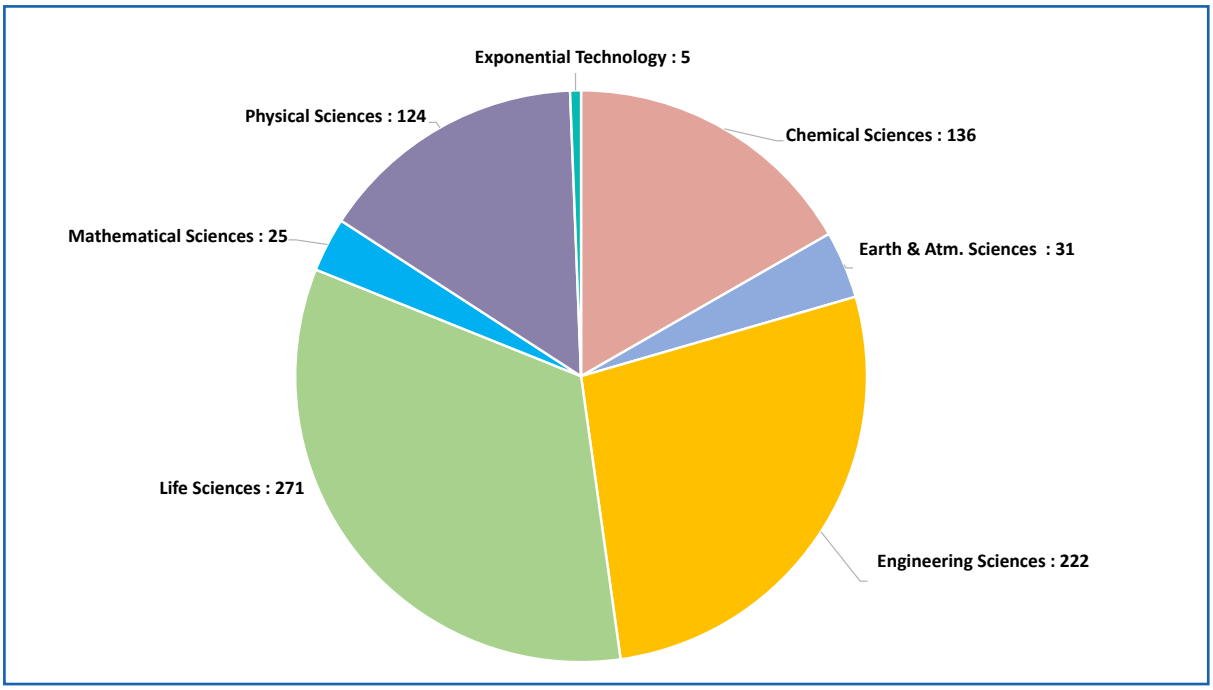
2.4 TOTAL EXPENDITURE FOR THE YEAR 2020-21

Total expenditure for the year 2020-21 was Rs. 897.12 crore. The breakup of expenditure under different schemes and administrative heads is given in the chart below.

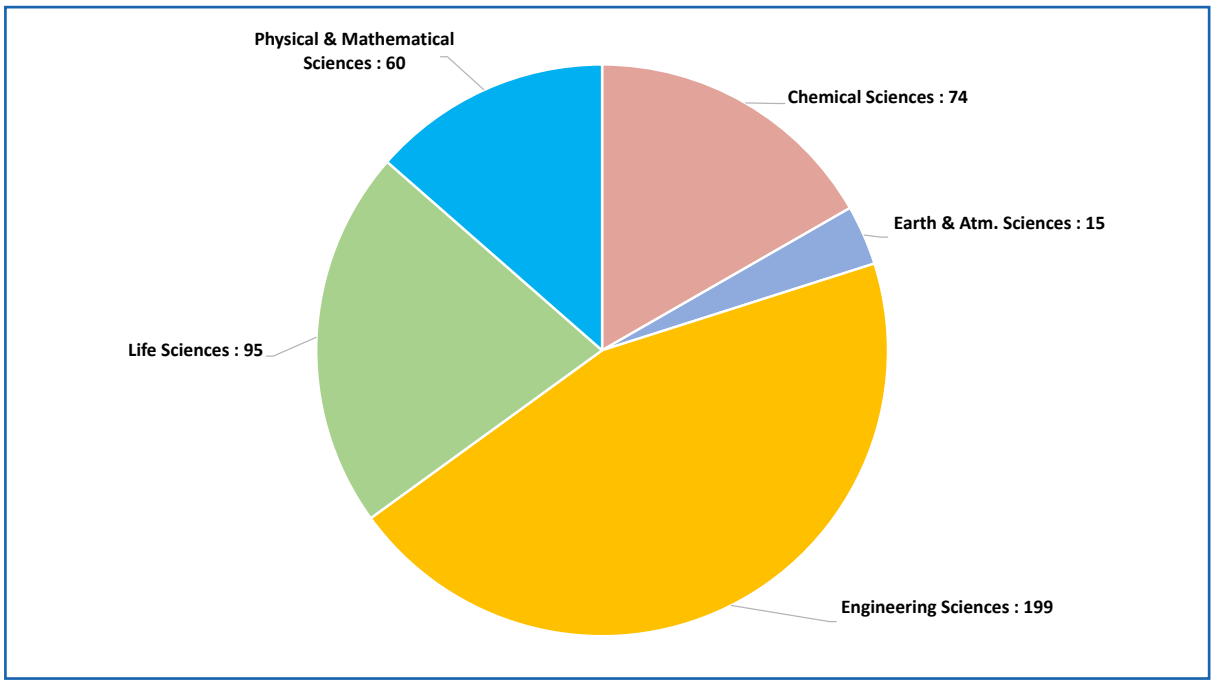


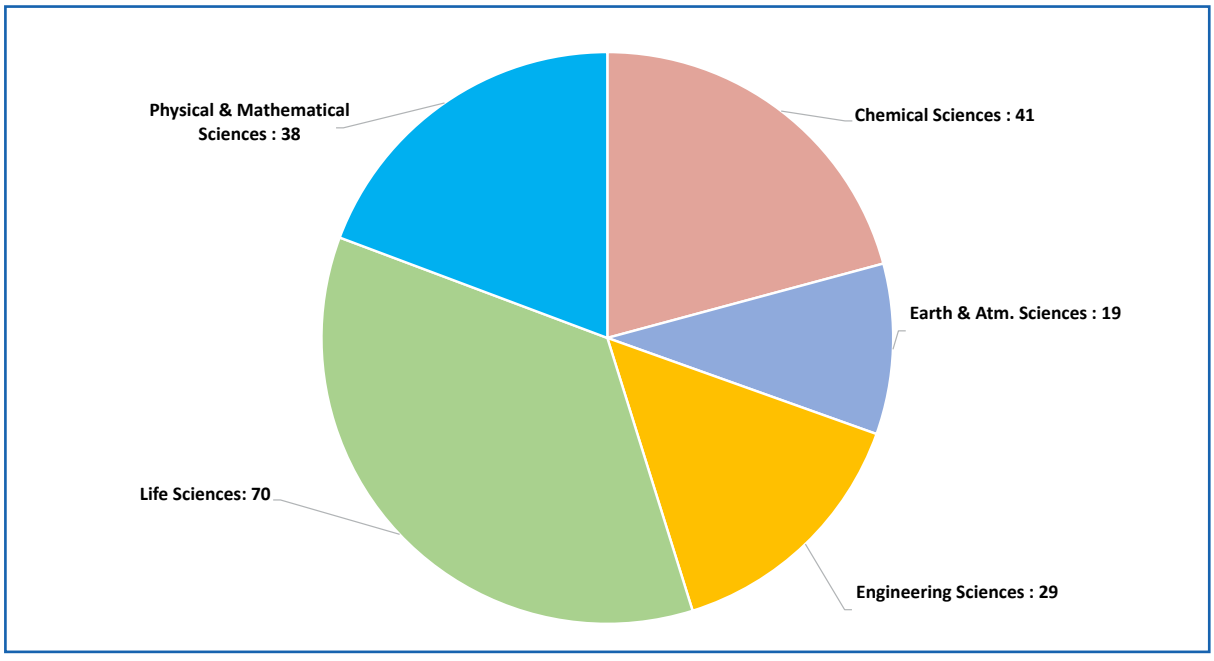
2.5 NEW PROPOSALS SANCTIONED DURING THE YEAR 2020-21

The number of new proposals sanctioned in the year 2020-21 under CRG scheme distributed sub-discipline wise is given below:



The number of new proposals sanctioned in the year 2020-21 under SRG and N-PDF scheme distributed sub-discipline wise are given below:





3

PROJECT GRANT PROGRAMMES

The project-based funding programmes of SERB have been instrumental in building substantial research culture in academic institutions and creating environment for scientific pursuit in the country. These programmes offer time-bound projects to researchers in regular positions in their areas of interest. Programmes such as Core Research Grant (earlier known as Extramural Research (EMR) programme), Young Scientist Scheme and Intensification of Research in High Priority Areas (IRHPA) carried forward from SERC, serve as steady source of support for the scientific community over several decades. In the past few years, SERB has initiated several other new programmes with specific aim and characterteristics with an insight to address specific requirements. Further, some of the programmes have been reformatted or replaced depending on the changing needs and evolving research scenario.

Core Research Grant (CRG), earlier known as Extramural Research (EMR) programme is the most distinguished programme of SERB, catering to the research community without any restrictions in age of the Investigator or limitation in budget. Start-up Research Grant (SRG) is for assisting young researchers of the country to jump-start their scientific career in a new place. As the requirements of Mathematical and Theoretical research are distinct in comparision to experimental research, a specially designed programme named MATRICS was established to provide fixed grant support to active researchers in Mathematical, Theoretical and Quantitative Social Sciences areas.

The IRHPA programme follows the 'top-down' approach where contemporary scientific areas have been identified with immediate needs and researchers are invited to submit proposals addressing those issues. Scientific and Useful Profound Research Advancement (SUPRA) is a programme specially orchestrated in order to seek and support proposals of high quality with new hypothesis or challenge to existing ones and to offer 'out-of-box" solutions.

SERB strives for promoting research excellence together with equity and inclusiveness. Special schemes have been launched to facilitate enhanced participation of weaker sections of the society. The scheme, Empowerment and Equity Opportunities for Excellence in Science (EMEQ) provides project support to researchers belonging to the SC and ST communities. POWER (Promoting Opportunities For Women in Exploratory Research) Grant has been recently launched to mitigate the problem of gender disparity in science.

In this chapter, the activities of programmes offering project-mode funding are described along with research highlights of some of the projects supported under these programmes.

CRG - PROGRAMME ADVISORY COMMITTEES

CHEMICAL SCIENCES

- Inorganic & Physical Chemistry
- Organic Chemistry

- Earth & Atmospheric Sciences

ENGINEERING SCIENCES

- Chemical & Environmental Engineering
- Civil, Infrastructure & Transportation Engineering
- Electrical, Electronics & Computer Engineering
- Materials, Mining & Minerals Engineering
- Mechanical, Manufacturing, Aerospace Engineering & Robotics

- Exponential Technologies

LIFE SCIENCES

- Biomedical & Health Sciences
- Interdisciplinary Biological Sciences
- Organismal & Evolutionary Biology

- Mathematical Sciences

PHYSICAL SCIENCES

- Physical Sciences - I (CMP & MS)
- Physical Sciences - II (PHENNA-LOAMP)

- Quantitative Social Sciences

3.1 SUPPORTING CORE RESEARCH

3.1.1 Core Research Grant (CRG)

Core Research Grant is the flagship programme of SERB and is in prominence for more than four decades since the inception of Science and Engineering Research Council (SERC). CRG programme provides individual-centric competitive-mode projects to researchers belonging to academic institutions, research laboratories and other R&D organisations to carry out basic research in all frontier areas of Science and Engineering. The programme had been the fulcrum in building research capability across the country and sustaining the research interests of scientists. CRG programme functions across 15 discipline/theme wise verticals with individual Programme Advisory Committees and programme officers.

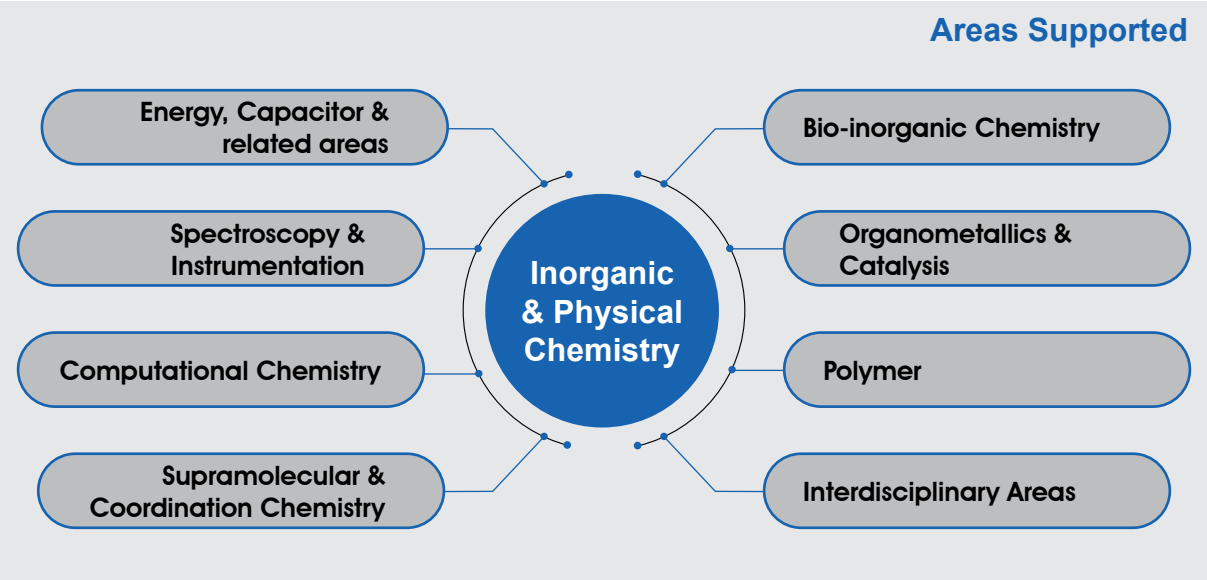
FEATURES

- **Highly competitive bottom-up project support**
- **For researchers holding a regular academic/research position in a recognized academic institution or national laboratory or any other recognized R&D institution in India**
- **The normal duration of the project is three years with no upper limit of budget**

Website links
http://serb.gov.in/emr.php
https://serbonline.in/SERB/emr

3.1.1.1 Inorganic and Physical Chemistry

In the reporting period, 84 new projects were sanctioned. The areas supported under CRG - Inorganic and Physical Chemistry are shown in the following figure.



Research Highlights

Designing of Mn-based electrocatalysts for CO_2 vs proton reduction: The main goal of the project was to perform systematic computational studies of CO_2 reduction reaction using earth abundant metal-based catalysts having structurally tuneable ligands sphere. In particular, to investigate the mechanistic pathways and finding out the efficient and selective catalysts for the formation of valuable products like CO, HCOOH and CH_3OH (Fig. 3.1).

Two-electron reduction of the N-heterocyclic carbene-pyridine containing Mn(I) complexes has been computationally investigated under inert and CO_2 gas environments. Mn(I) complex [MnBr(NHC-pyridine)$(CO)_3$] displays a strong selectivity for CO_2 reduction over proton reduction (Fig. 3.2a). The CO_2 hydrogenation reaction has been carried out on the Mn-based complexes by changing the ratio of the σ- and π-acceptor characters of the ligands (CO, PH_3, PF_3, and PMe_3). This has been also demonstrated that σ-donor ligands (PMe_3/PH_3) of Mn-based complexes favor the hydride transfer, whereas the π-acceptor ligands (CO/PF_3) favor the heterolytic H_2 cleavage.

84
Projects Sanctioned

36.77 cr
Expenditure
(New & Ongoing Projects)

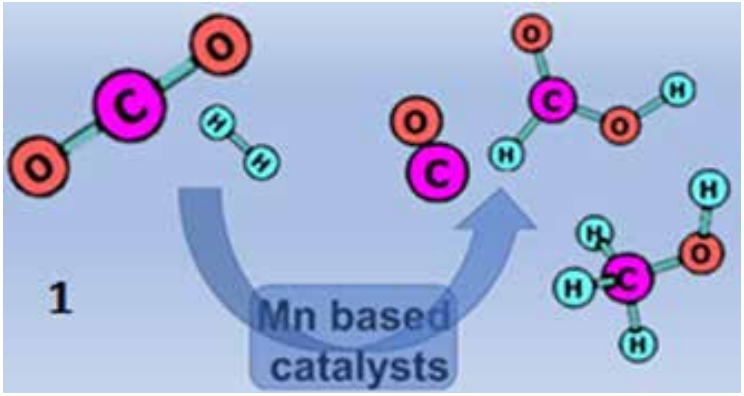


Fig. 3.1: Possible CO_2 reduced products: CO, HCOOH and CH_3OH

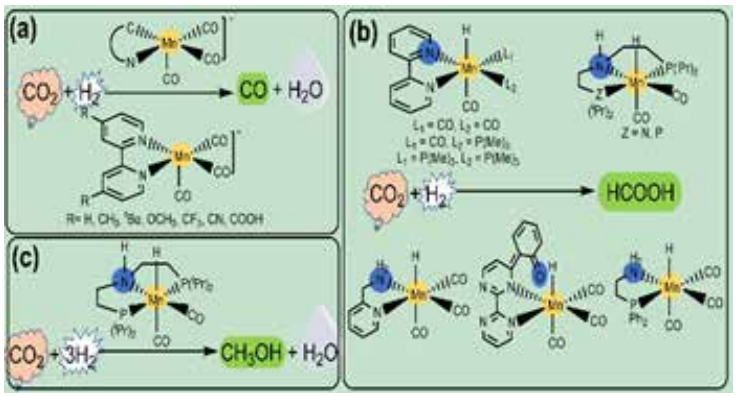


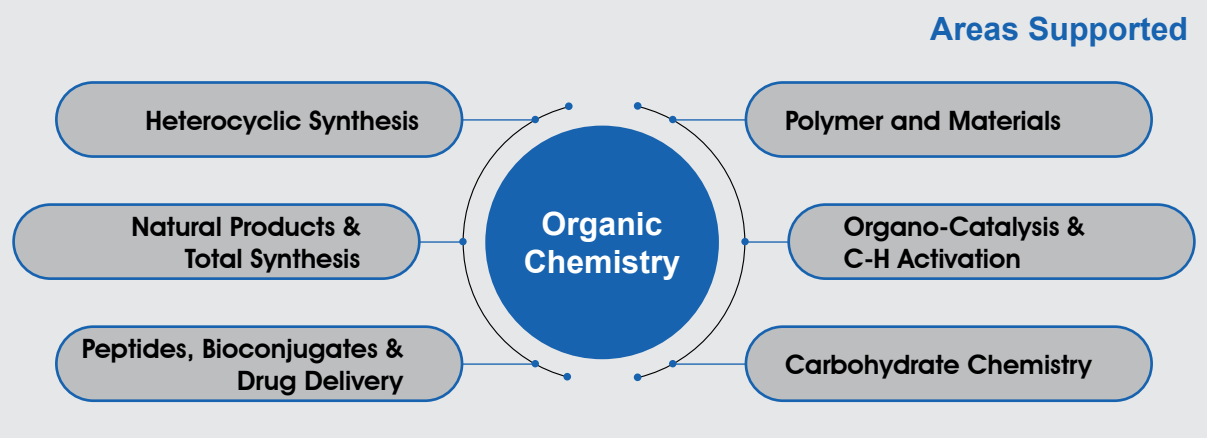
Fig. 3.2 : (a) Electrochemical CO_2 reduction to CO using bipyridine and N-heterocyclic carbene based Mn complexes (b) CO_2 hydrogenation to HCOOH using Mn based pincer complexes (c) PNP based complexes for CO_2 hydrogenation to CH_3OH.

Therefore, a combination of both ligands is very important for such reaction (Fig. 3.2b). The underlying reaction mechanism of CO_2 hydrogenation to methanol by PNP-based Mn(I), Fe(II) and Ru(II) metal complexes in the presence of a morpholine co-catalyst has also been explored (Fig. 3.2c). In recent times, the C_2–C_5 based products has gathered special interest as these can be used for transportation fuels to enhance the octane levels which improve the efficiency of the engines and reduce emissions. Compared to the formation of low carbon-based products synthesis, C_{2+} based products formation is more challenging because of the inertness of CO_2 and very high energy barrier of C–C coupling. Therefore, the importance of finding an efficient and selective catalyst for the formation of C_2 and higher carbon-based products is highly essential and progressive research has been initiated in this direction.

The work was done at Indian Institute of Technology, Indore.

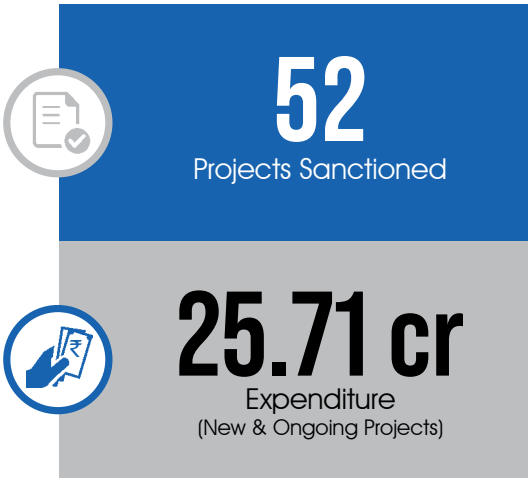
3.1.1.2 Organic Chemistry

In the reporting period, 52 new projects were sanctioned. The areas supported under CRG - Organic Chemistry are shown in the following figure.



Research Highlights

Stereoselective total synthesis of marine macrocyclic lactone biselyngbyaside and its variants and their biological activities: Many natural products possess outstanding cell growth antiproliferative properties, making them valuable molecular probes for the investigation of biochemical pathways and promising lead compounds for the development of new antitumor chemotherapeutic agents. Biselyngbyaside class of marine macrolides in this regard might be useful to decipher cancer biology due to their potential bioactivities. Thus, chemical synthesis of these potent molecules and their analogues is quite important.



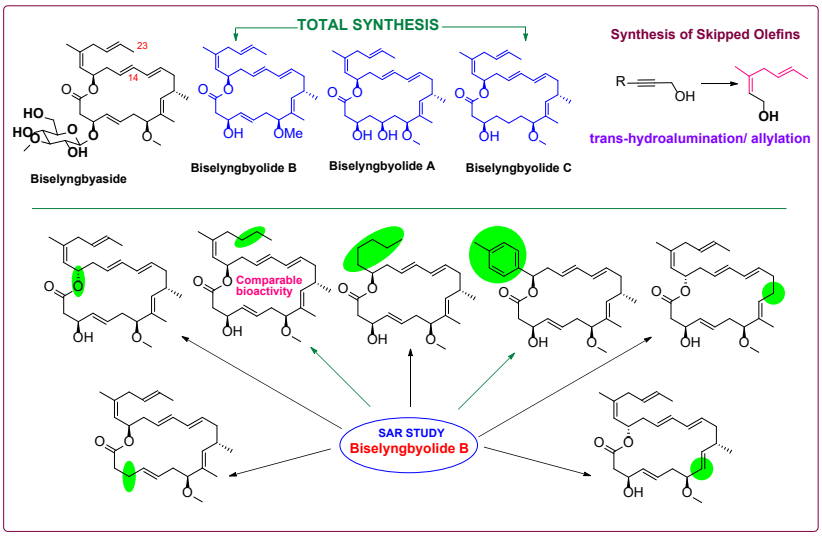


Fig. 3.3: Total synthesis of biselyngbyaside group of marine natural products and some of their analogues

An efficient route for the synthesis of (2Z,5E)-3-methylhepta-2,5-dien-1-ol moiety and its extension to the construction of (C_{14}-C_{23}) olefins moiety of biselyngbyaside class of molecules in shortest way (3 steps only) has been developed. In this way, first successful implementation of intramolecular Heck coupling for the synthesis of macrolide bearing very sensitive skipped olefins has been shown. Efficient routes for the asymmetric total synthesis of cytotoxic macrolide biselyngbyolides A, B and C has also been developed. Synthesis of different analogues of biselyngbyolide B has been achieved for its structure activity relationship (SAR) study against different human and murine cancer cell lines. This study discovered a simplified analogue without skipped olefin having anticancer activities almost similar to the parent molecule (Fig. 3.3). Anticancer activities of biselyngbyolides A and C were evaluated against different human cancer cell lines which revealed that apoptosis follows an intrinsic pathway. Some strategies, materials used or planned for this project have been successfully implemented for the synthesis of others polyketide based bioactive natural products like petalotioprolides E-H, carolacton, baulamycin A, cytospolides E and Q, separacenes A and B, cananginone C and debilisone A, sterevertene A and G, macrotermycin C, nafuredin B, penicitide A, sunshinamide which could have great value in basis as well as in medicinal chemistry.

The work was done at Indian Association for the Cultivation of Science, Kolkata.

Acyclic and cyclic lipopeptides to combat bacterial resistance and eradicate biofilms: The increasing occurrence of antimicrobial resistance, coupled with the dwindling approvals for newer classes of antibiotics, calls for development of novel antibacterial agents, to tackle multidrug-resistant pathogens. The objective of project is the development of peptide-based antimicrobial agents, which can eradicate different multidrug-resistant bacteria, with negligible resistance development. As a part of this project, three different classes of lipopeptides were prepared with a view of performing a detailed structure-activity-relationship (SAR) study. The first class of compounds (acyclic lipopeptides) were prepared by conjugating amino acids to an acyclic triamine-based backbone, which was further lipidated at the secondary amine. The optimized lead compound, D-LANA-14, derived from structure-activity-relationship (SAR) studies was active against various clinical isolates of Gram-positive and Gram-negative bacteria at a low concentration (MIC ranged between 3.1-6.3 µg/mL) and displayed low toxicity towards mammalian cells (Fig. 3.4A). Additionally, it was able to kill metabolically inactive bacterial cells and eradicate preformed biofilms of MRSA with no propensity of resistance development (Fig. 3.4B). It also revealed potent efficacy in an ex-vivo model of human skin-infection (with reduction of 85% MRSA burden at 50 µg/mL), which indicates great potential of the compound as an antibacterial agent to treat skin-infections (Fig. 3.4C). More importantly, excellent activity of D-LANA-14 was observed in a mouse model of skin-infection with reduction of ~4 log MRSA burden at 40 mg/kg dose without any sign of skin-toxicity even at 200 mg/kg (Fig. 3.4D).

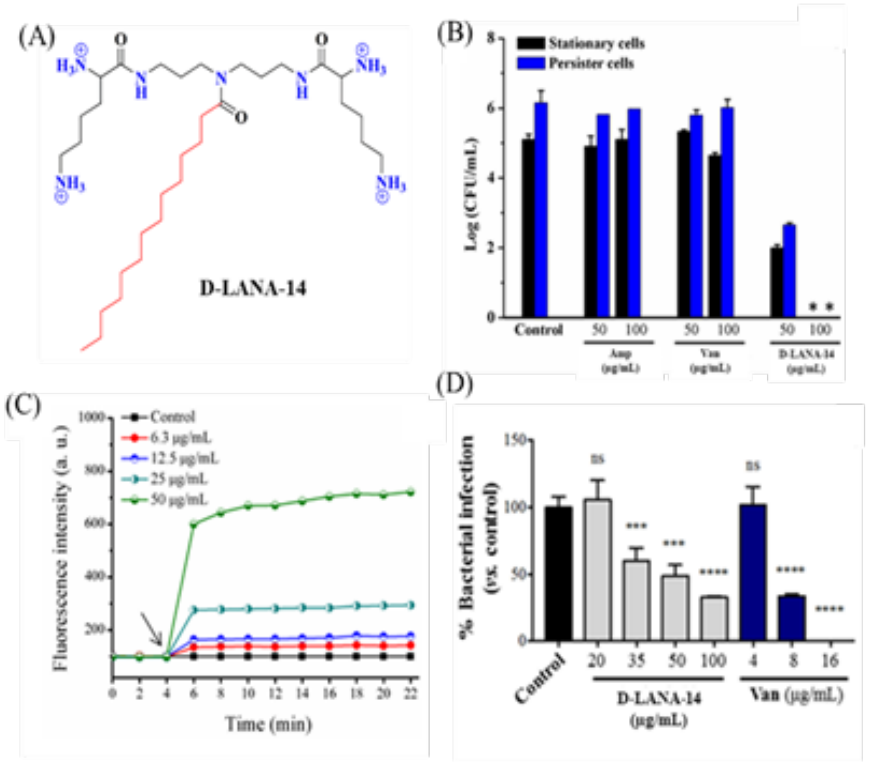


Fig. 3.4: A) Structure of D-LANA-14 B) Antibacterial efficacy against stationary and persister cells of S.aureus C) Membrane depolarization of planktonic S. aureus cells. Arrow indicates compound addition. D) Antibacterial activity of D-LANA-14 in ex-vivo model of human skin infection of MRSA.

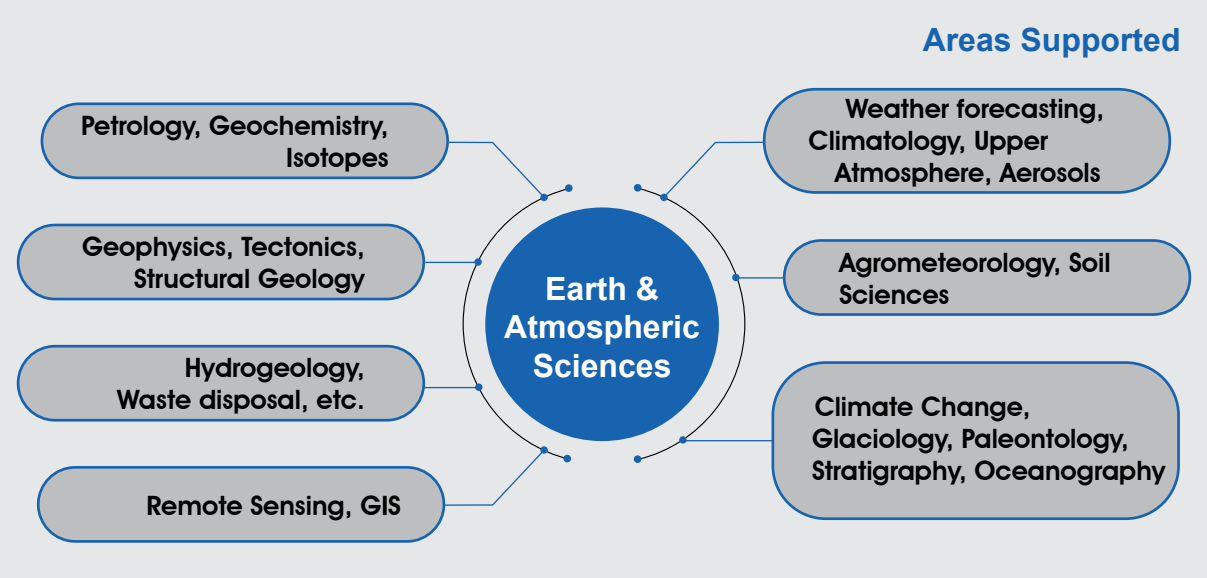
In the second part, PMAM-based dendrimeric analogues, with increasing number of charges (3 or 5 or 7 or 11 charges) were synthesized and screened for their antibacterial activity and toxicity. It was observed that the antibacterial activity increases and the toxicity decreases upon increasing the number of charges in the compounds, which resulted in a huge enhancement in the selectivity towards bacterial killing over mammalian cells. This class of compounds was highly active against both, gram-positive as well as gram-negative bacteria and displayed membrane depolarization as their preliminary mechanism of action. The third set of compounds (cyclic lipopetides) was prepared to assess the role of cyclization in antibacterial activity. However, these designs did not display good antibacterial activity as compared to the acyclic analogues.

In conclusion, the project yielded a highly active acyclic lipopeptide (D-LANA-14), which displayed excellent in vitro and in vivo activity in a murine model. The lipopeptide also displayed negligible resistance development after multiple passages. Its potent antibiofilm activity and activity against metabolically inactive stationary and persister cells, further asserted its potential in tackling complicated infections. This design was patented by JNCASR [Antimicrobial Conjugates, Method for Production and Uses Thereof – JP2017514887 A, WO2015136311 A1 EP3116597 A1, CA2941933 A1, US20170144969 A1].

The work was done at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru.

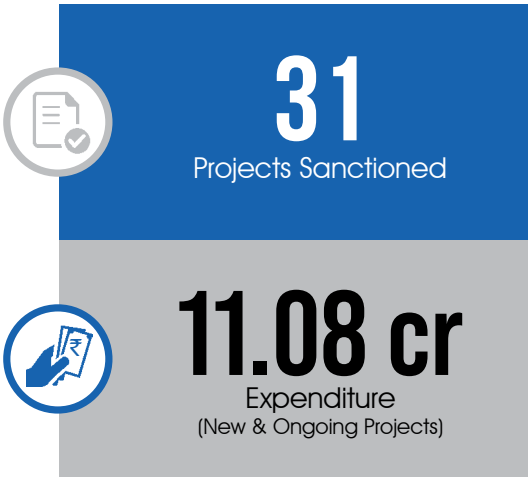
3.1.1.3 Earth and Atmospheric Sciences

In the reporting period, 31 new projects were sanctioned. The areas supported under CRG – Earth and Atmospheric Sciences are shown in the following figure.



Research Highlights

Implications Paleogene fossil soils of the NW himalayan foreland basin: Implications for the oldest tropical weathering and monsoonal conditions over the Indian subcontinent: The main aim of the project was to explore the fossil soils from the oldest continental sediments of the HFB to comprehend the Paleogene weathering process and inception of paleomonsoon over the Indian sub-continent. Main findings of the completed project show: Latitudinal shift and climate change and the evolution of red and yellow palaeosols of Himalayas, evidence for the early Oligocene seasonality and its strengthening in Miocene (Fig. 3.5). This provides details of the fluvial sedimentary sequences from HFB to interpret weathering and pedogenesis during early Oligocene to Mid-Miocene time. Palaeopedological investigation of a 3.1 km thick succession from the Kangra sub-basin of the HFB shows the lower 2 km part of the succession is characterized the red (10R hue) and the upper 1.1 km part of the succession by the yellow (2.5Y hue) palaeosols with varying intensity of weathering and pedogenesis. The association of sedimentary rocks and pedogenic expression in palaeosols indicates four (Type-A to Type-D) of pedofacies in the entire Oligocene-Miocene succession. The pedofacies are defined by a decrease in the intensity of palaeopedogenic development from strongly developed palaeopedofeatures in Type-A, moderately developed palaeopedofeatures in Type-B, weakly developed palaeopedofeatures in Type-C, and to the only incipient stage of palaeopedogenesis in Type-D pedofacies. The palaeolatitudinal shift during the convergence of the Indian Plate played a major role in weathering and palaeopedogenesis with the inception of seasonality during the early Oligocene, which is demonstrated by the formation of the red palaeosols with pedogenic $CaCO_3$ and vertic features in tropical conditions. The transition to yellow palaeosols at about 20 Ma is marked by increased humidity, rapid aggradation, pronounced uplift and enhanced erosion of the hinterland. These yellow palaeosols are characterized by the abundance of weakly developed Bw and Bss horizons, pure clay pedofeatures and the absence of any pedogenic $CaCO_3$ during short pedogenic intervals in subtropical conditions.



The work was done at University of Delhi, New Delhi.

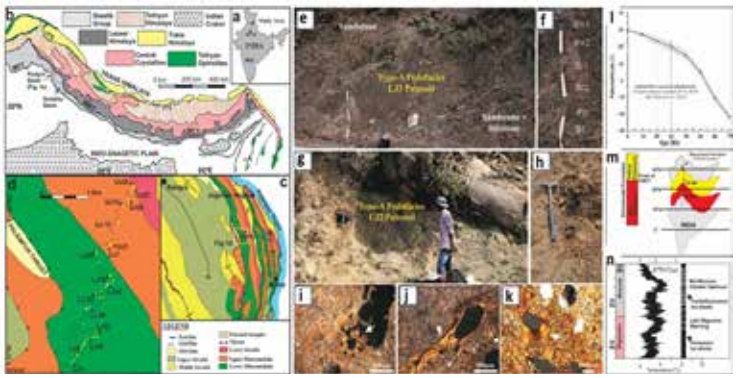
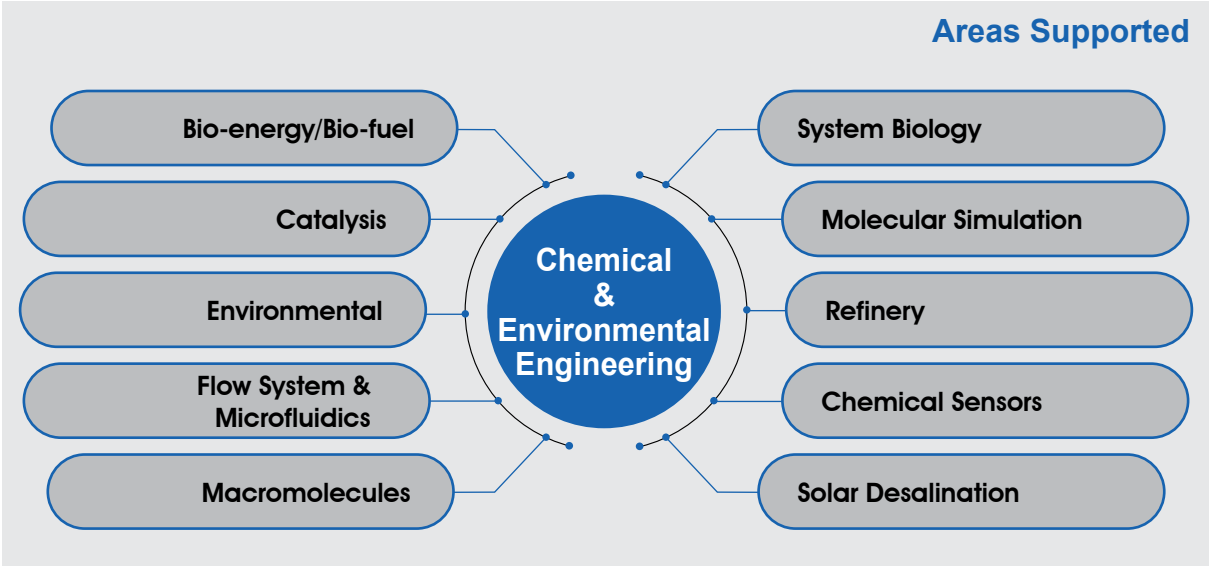


Fig. 3.5: (a) Location of the study area, (b) Kangra and Subathu sub-basins in the HFB, (c) General geology of the Kangra basin, (d) Red paleosols (1_11-U39, yellow paleosols (U.11-U128), (e) well-developed red paleosol and Type-A pedofacies and (f) different paleosol horizons, (g) well-developed yellow paleosol and (h) its horizons, (i) illuvial features, (j) pure clay coatings, (k) microlaminated pure clay coatings, (l), (m), and (n) explains the role of paleolatitudinal control on the formation of the red and yellow paleosols in the HFB during 31 Ma to 13 Ma (after Upreti and Srivastava, Sedimentology 2019).

3.1.1.4 Chemical and Environmental Engineering

In the reporting period, 36 new projects were sanctioned. The areas supported under CRG – Chemical and Environmental Engineering are shown in the following figure.



Research Highlights

Molecular separation membranes via controlled moulding of polymer nanofilms at the liquid-liquid interface: Membranes with high liquid permeance and high salt retention are needed to reduce the energy consumption in the membrane-based separation processes. Conventional purification processes like evaporation and distillation are energy-intensive, whereas the membrane-based separation process are cost-effective. However, there are intricacies in the membrane preparation process, and they suffer from trade-offs between water permeance and solute selectivity.

36
Projects Sanctioned

14.10 cr
Expenditure
(New & Ongoing Projects)

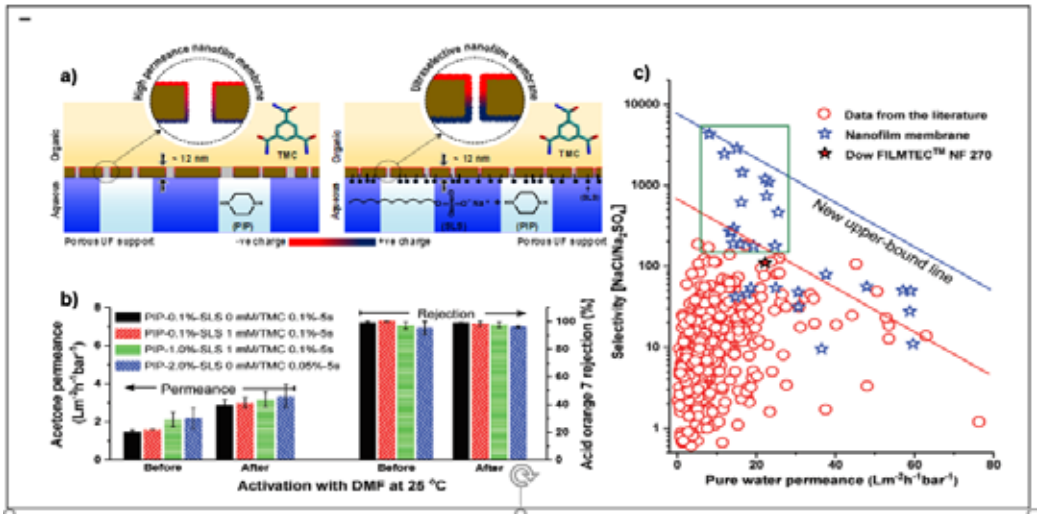


Fig. 3.6: a) Schematic representation of the formation of polyamide nanofilm composite membrane on top of the ultrafiltration support. b) Molecular separation performance of the membrane in the organic solvent and the effect of solvent activation. c) New upper-bound line of the nanofilm composite membranes. Data and images are reproduced from Adv. Funct. Mater. 2021, 31, 2007054 (https://doi.org/10.1002/adfm.202007054).

Therefore, membranes with high solute-solute selectivity are essential for high-precision separation with increased water recovery in desalination systems.

Scientists from CSIR-Central Salt and Marine Chemicals Research Institute (CSIR-CSMCRI), Bhavnagar, Gujarat have developed ultraselective and yet highly water permeable molecular separation membranes that can precisely separate ions and molecules from both aqueous and organic feeds. They have established a new fabrication strategy for creating polyamide nanofilms via interfacial polymerization at the interface between aqueous piperazine (PIP) solution and a hexane solution containing trimesoyl chloride (TMC). They used an anionic surfactant (sodium lauryl sulfate, SLS) in the aqueous solution to control the kinetics of the interfacial polymerization by maintaining the stoichiometric equilibrium at the interface.

In polyamide composite membrane formation (Fig. 3.6a), the nanofilm layer was only 7 to 12 nm thick – a thousand times thinner than the width of a human hair – with high liquid permeance that permits selective separation of ions and molecules. With this nanofilm, they have achieved the highest rejection of Na_2SO_4 (99.99%) and very high selectivity (>4000) between NaCl and Na_2SO_4 (Fig. 3.6b). The selectivity value is 30 to 275 times higher than the value reported in the literature and commercially available nanofiltration membranes (Fig. 3.6.c). Two PCT applications protect their invention (priority application no. 201911054162, date: 27/12/2019 and priority application no. 201911054150 date: 27/12/2019). Their paper, published in the journal Advanced Functional Materials, 2021, 31, 2007054 (https://doi.org/10.1002/adfm.202007054), describes the property of ultraselective nanofilm membranes and their potential uses.

In another study, polyimine nanofilms in a large area with thicknesses down to ≈14 nm synthesized via self-assembly of pre-synthesized imine oligomers were developed as depicted in schematic representation (Fig. 3.7a). Nanofilms were fabricated at the water–xylene interface followed by reversible condensation of polymerization according to the Pieranski theory. Polyimine nanofilm composite membranes were made via transferring the freestanding nanofilm onto polyacrylonitrile ultrafiltration supports. TEM and AFM images are shown in figures (3.7b) and (3.7c). Composite membranes were applied for the separation of salt from dye/salt mixture. Very high water permeance of 49.5 $Lm^{-2}h^{-1}bar^{-1}$ with a complete rejection of brilliant blue-R (BBR; molecular weight = 825 $gmol^{-1}$) and no more than 10% rejection of monovalent and divalent salts was achieved (Fig. 3.7d). Their paper, published in the journal Advanced Materials, 2020, 32, 1905621 (https://doi.org/10.1002/adma.201905621), describes the property of ultraselective nanofilm membranes and their potential uses in molecular separation.

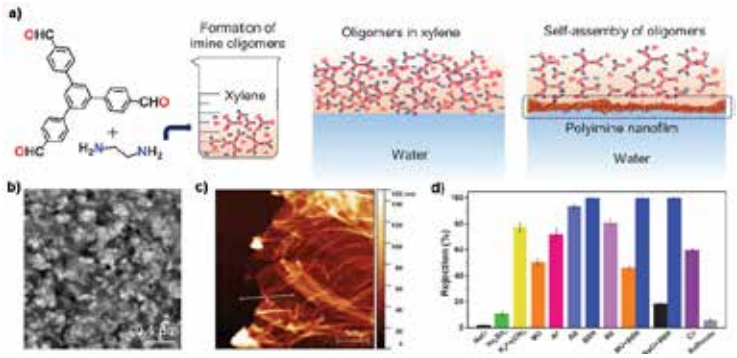
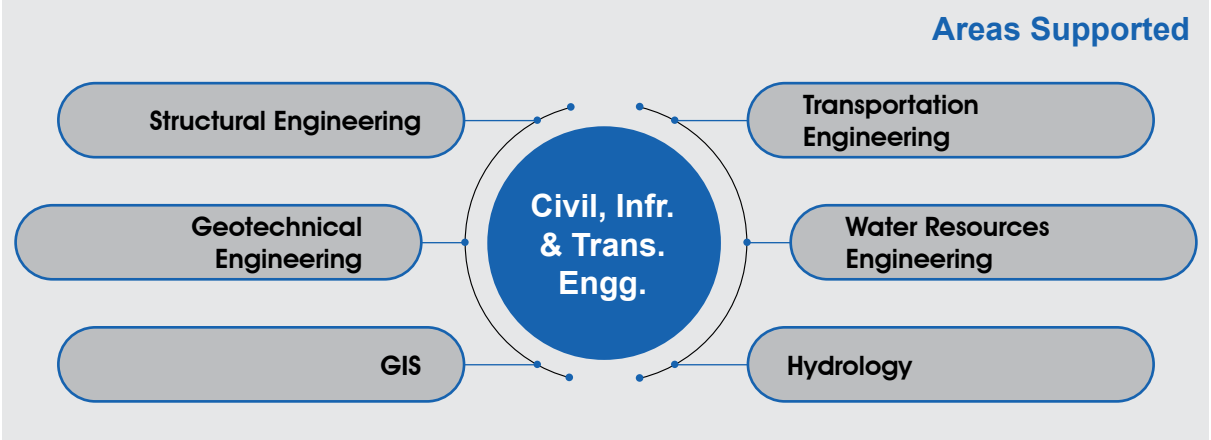


Fig. 3.7: (a) Schematic presentation of the formation of large-area polyimine nanofilm at the liquid-liquid interface. b) TEM image and c) AFM image of a 16-nm thick freestanding polyimine nanofilm. d) Molecular separation performance of the polyimine nanofilm transferred onto polyacrylonitrile support. Data and images are reproduced from Adv. Mater. 2020, 32, 1905621 (https://doi.org/10.1002/adma.201905621).

The work was done at CSIR-Central Salt and Marine Chemicals Research Institute, Gujarat.

3.1.1.5 Civil, Infrastructure and Transportation Engineering

In the reporting period, 13 new projects were sanctioned. The areas supported under CRG - Civil, Infrastructure and Transportation Engineering are shown in the following figure.



Research Highlights

Study on the impact of bio-aerosols, particulate based organics and metals on the health of exposed population residing at a major site within the Indo-Gangetic Plain : The widespread and uncontrolled emissions in air are mainly due to anthropogenic factors. These pollutants majorly consist of finer size particulate matter (PM) bound metals, polycyclic aromatic hydrocarbons (PAHs), organic carbon (OC), elemental carbon (EC), NO_3^-, SO_4^{2-}, bioaerosols along with harmful gases. In this study, chemical composition of atmospheric aerosols in the submicron fraction (PM1) were addressed along with the seasonal study of bioaerosols. Microbial identification among collected bioaerosol via morphological study and staining techniques has been

carried out to assess the presence of airborne pathogens. Further, the cancer risk assessment due to carcinogenic metals and PAHs present in submicron aerosol has been carried out for the whole one year by sampling carried out within IITK campus as well as an outdoor site within the Kanpur city. The bioaerosol study revealed that the average total viable concentration was about 750 Colony Forming Units (CFU)/m^3 in the indoor microenvironment. However, in the outdoor environment it varied between 500 to 700 CFU/m^3 within the IITK campus. The bacterial genera were mostly dominated by bacillus, staphylococcus, micrococcus, streptococcus, and enterococcus. Hymophycetes, which is a fungal class containing aspergillus, ladosporium, fusarium, penicillium, etc. was observed to be most abundant. Winter months reported high GPB concentration, with highest 520 CFU/m^3 in February, whereas highest GNB concentration of 403 CFU/m^3 was obtained in July. For fungi, the largest concentration was obtained in the winters (around 390 CFU/m^3) at indoor site and 445 CFU/m^3 was reported in the month of May for outdoor. Total indoor bioaerosol load at City Centre was comparatively low (400 CFU/m^3) during winter period but increased up to 1000 CFU/m^3 in summer months.

The major elements found in PM_1 were aluminium, calcium, iron, potassium, magnesium and sodium and among trace elements which are carcinogenic in nature only chromium and lead were found in significant levels within PM_1. For the total metals, the incremental lifetime cancer risk (ILCR) value was > 10^{-4} much above the safe limit of < 10^{-6} (Fig. 3.8). To summarise, the chemical analysis of PM_1 particles revealed anthropogenic sources like vehicular emissions and biomass burning as the dominant ones causing the enhanced toxicity. The combined cancer risk assessment due to PAHs and toxic metals was very high in this region and calls for immediate remedial measures to reduce air pollution.

The work was done at Indian Institute of Technology, Kanpur.

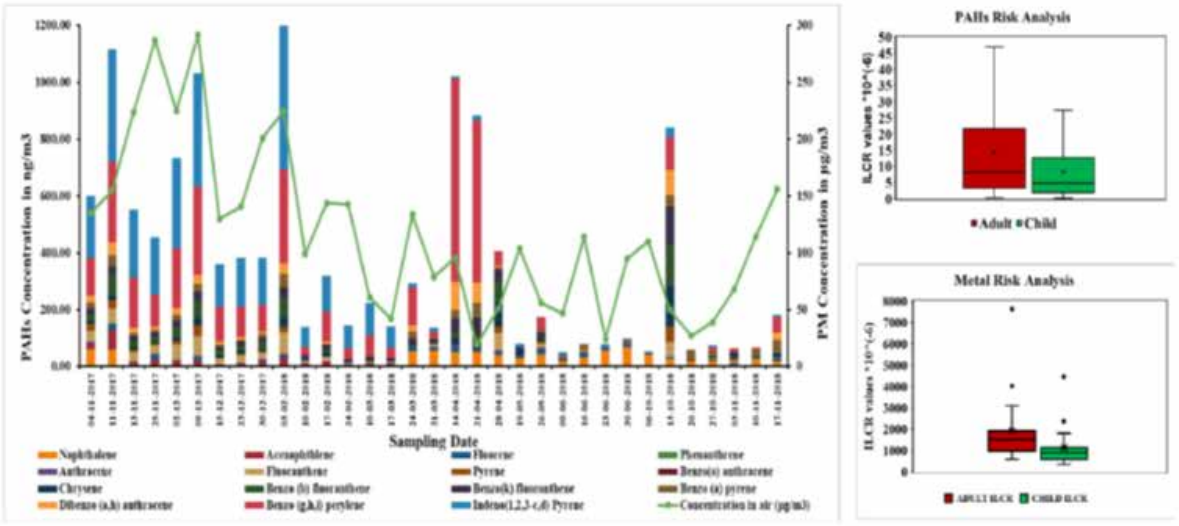


Fig. 3.8: Daily PAHs concentration and ILCR box plots for total PAHs and total metals.

Urban flood dynamics through experimental and numerical investigations: Exponential population growth, subsequent migration and urban expansion, inadequate drainage system, and frequent downpours many a time lead to urban floods. Despite active research, many unanswered queries exist due to the complex-chaotic nature of urban floods. Surface-sewer flow interactions, minute topographical features, complex orientations of buildings and difficulty in obtaining real-time flood data make mathematical modeling and validation more difficult. Hence, in SERB supported study, need to develop a better understanding of flood dynamics, surface-sewer flow interactions, the effects of buildings and streets and the lack of reliable data to validate existing numerical urban flood simulation models were addressed.

The objective of The work was to analyze the flow and inundation pattern induced by a combination of river overtopping and drainage surcharge over an urban area in the floodplain using both experimental and mathematical modeling techniques.

Fig. 3.9: River network-urban floodplain setup

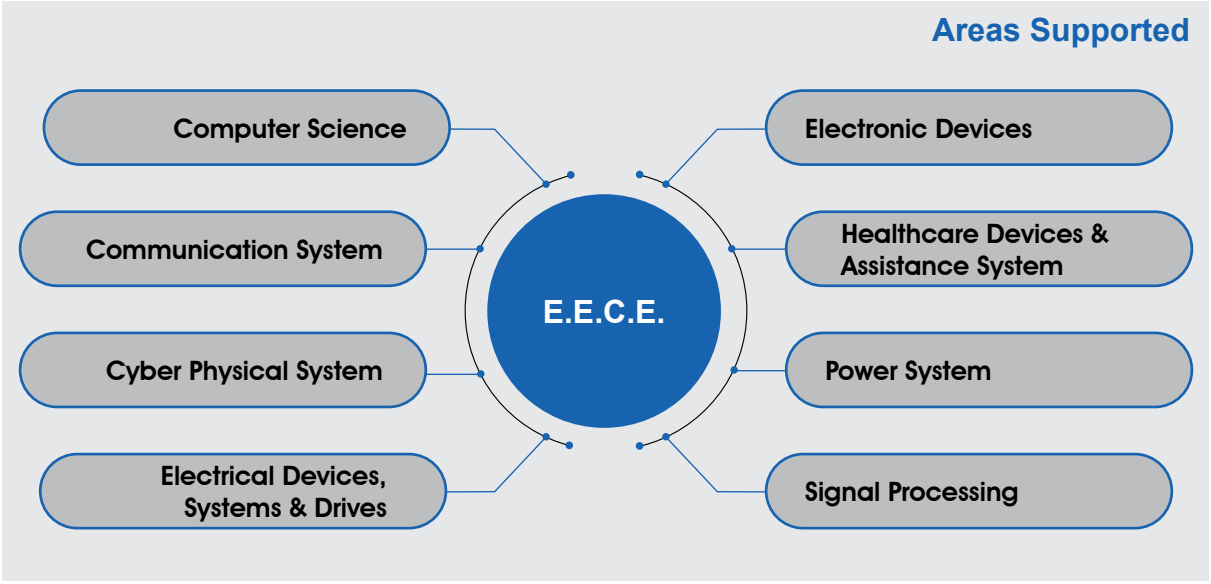
Experiments were conducted on a laboratory river network with flood plains (Fig. 3.9) to obtain detailed data for flood inundation, depth of flow and velocity vectors to validate the mathematical models. The flood inundation extents were measured using photogrammetry technique. The surface velocity was extracted using PIV and velocity in channel cross-sections was measured using ADV. The dynamic flow depths were measured with ultrasonic sensors. In the future, experiments will be conducted to understand the interaction between pluvial flooding and overflowing sewers. Also, pressure sensor measurements will be made to understand forces on structures located on the floodplain.

Mathematical models are usually employed to model and forecast urban floods in real-time. However, many of these models suffer from numerical instability and numerical efficiency problems. Also, they need to be validated using carefully measured data. An in-house numerical model IITMflo-2D has been developed to address the numerical issues. It has been validated using the experimental data. A computationally efficient flood routing model was also developed for large river networks.

The work was done at Indian Institute of Technology, Madras.

3.1.1.6 Electrical, Electronics and Computer Engineering

In the reporting period, 66 new projects were sanctioned. The areas supported under CRG – Electrical, Electronic and Computer Engineering are shown in the following figure.

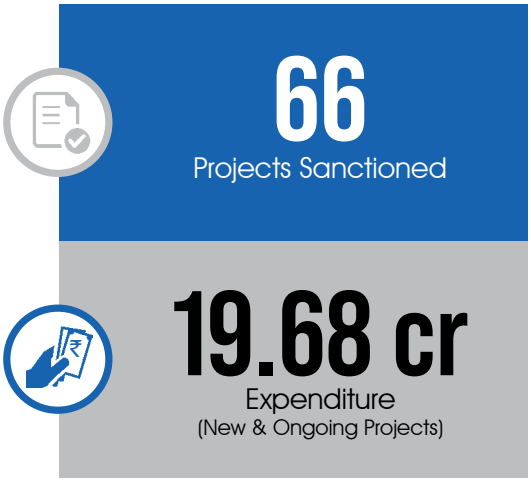


Research Highlights

Software-defined techniques for hardware limitations in the spectrum and power-efficient 4G/5G communication: This project proposes digital solutions for the already available digital processor in the base-station for unwanted

effects of hardware imperfections while considering 4G/5G communication for spectrum and power-efficient operation.

Figure 3.10 shows the carrier aggregation (CA) schemes adopted in LTE-A (3rd generation and beyond) to utilize spectrum resources efficiently. In such multi-band cases, due to hardware limitations such as power amplifier nonlinearity and modulator imperfections, intermodulation and cross-modulation distortions occur. Similarly, throughput-enhancing applications such as Multiple-Input-Multiple–output (MIMO) transmission have hardware limitations, where linear and nonlinear crosstalk between MIMO signals due to antenna coupling adds to even more signal corruption. With so many distortions introducing elements in a practical transmission front-end, actual signal quality becomes very poor. It does not derive comprehensive benefits from techniques such as MIMO communication and multi-band carrier aggregation. Therefore, there was a specific research gap between the proposition of spectral and power efficient techniques and their practical realization.



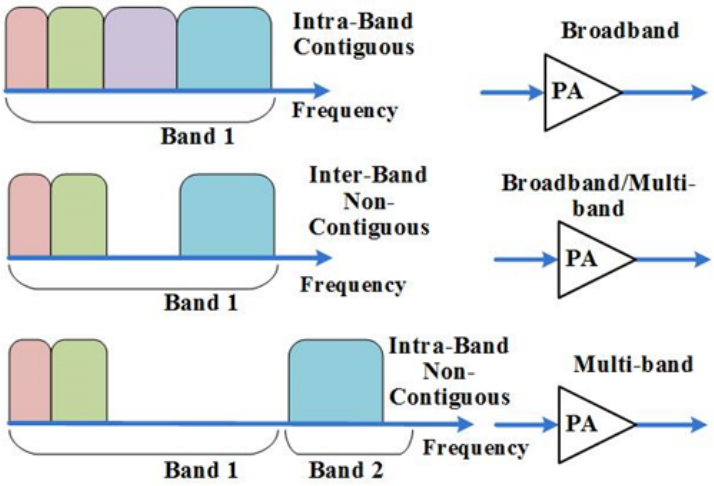


Fig. 3.10: Carrier aggregation for spectrum efficient communication.

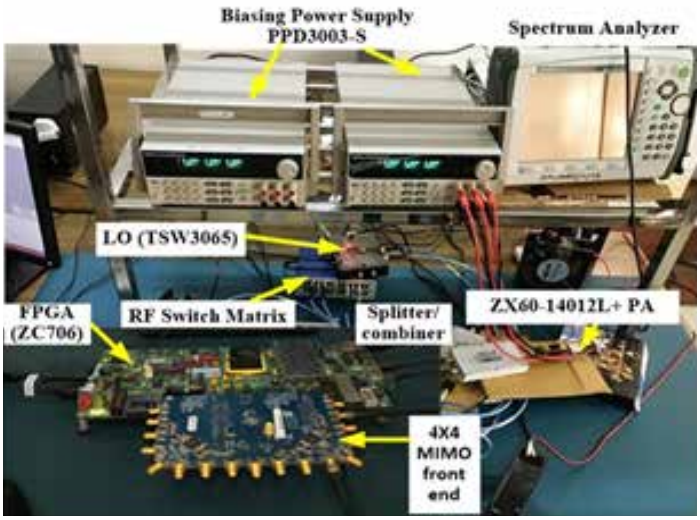


Fig. 3.11: Experimental setup.

This project targets two problems whose system-level description has a certain similarity. However, digital-level algorithms and implementation challenges differ from each other. These two problem statements are as follows:

(1) Distortion mitigation techniques for MIMO signal transmission, where the signals are being transmitted at 'same carrier frequency using the different PAs and antenna/antenna array.

(2) Distortion mitigation techniques for carrier aggregation (multiband signal transmission), where different signals are being transmitted at different carrier frequencies using a single power amplifier and a single antenna.

Figure 3.11 shows the experimental setup created for the implementation of the proposed digital solution. Basic GUI had been developed using python to transmit the digital signal via Zynq 7000 series FPGA ZC-706 to the RF front end consisting of FMCOMMS5/ADRV9371-W/PCBZ from analog devices. The switch matrix hardware, combined with the analog devices supplied API software, allows for digital as well as RF synchronization. A novel time-delay compensation technique is proposed to compensate for variation in RF cables' group delay behavior at different frequencies. The developed low-cost setup has received the 'best student paper award' at RF Conf., (IMaRC), Ahmedabad.

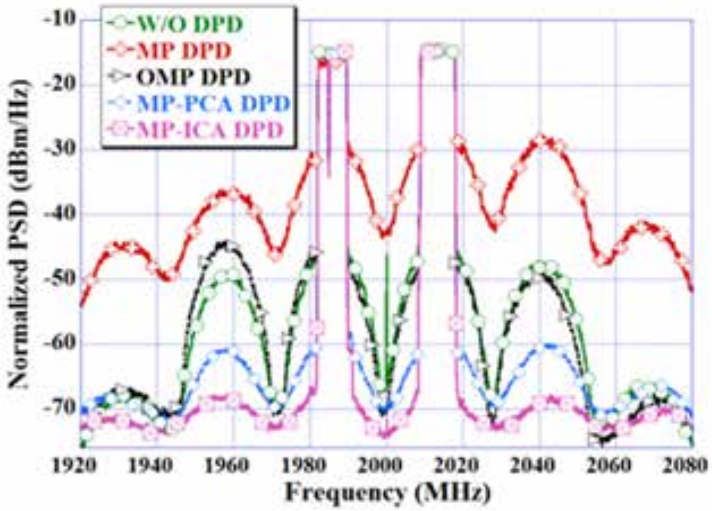


Fig. 3.12: MP-ICA technique for 12-bit fixed-point DSPs (intra-band non-contiguous CA LTE-A)

Table 1: DPD results for different models in 4×4 MIMO Transmitters of LTE 111, 30MHz Signal

	Case I			Case II		
Models	NMSE (dB)	ACPR (dBc)	Total No. of Coef./Flops	NMSE (dB)	ACPR (dBc)	Total No. of Coef./Flops
W/O DPD	-8.22	-39.86	N/A	-6.46	-39.22	N/A
COMPM DPD	-37.48	-48.47	480/3832	-35.92	-47.82	480/3832
PH DPD	-41.24	-56.33	10080/80632	-40.45	-54.86	10080/80632
Proposed DPD	-41.05	-56.04	1500/11992	-40.18	-54.39	1500/11992

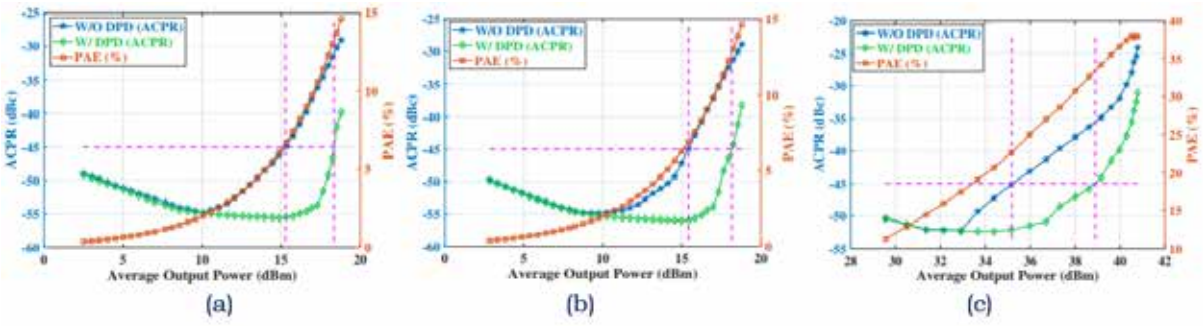


Fig. 3.13: Power efficiency vs. linearity (a) Intra-band contiguous (b) Intra-band non-contiguous (c) Inter-band noncontiguous CA LTE signal.

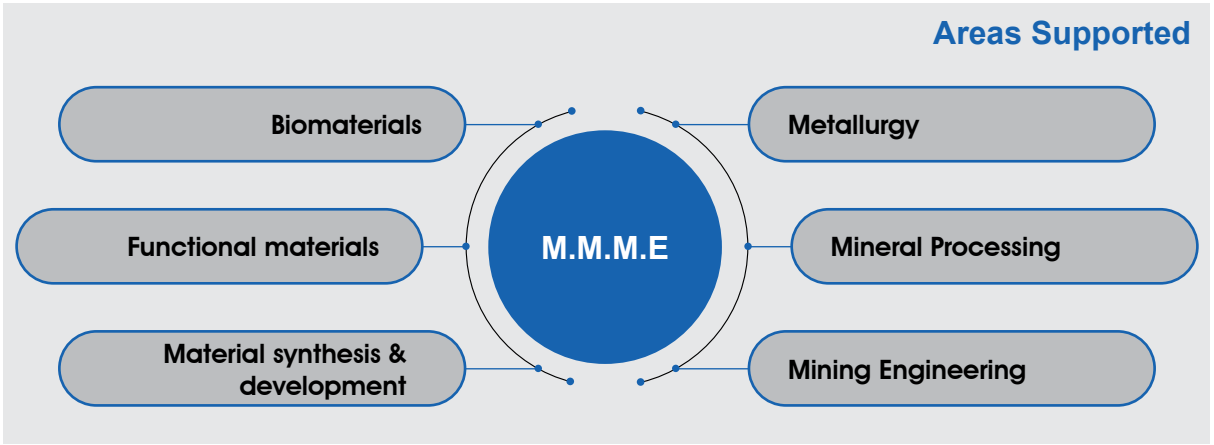
Digital predistortion (DPD) techniques are proposed for (a) Inter-band and intra-band interference in multi-band transmission, (b) Cross-channel interference in the MIMO case. The major challenges in implementing DPD for the CA signals shown in Fig. 3.10 are wider bandwidth support, multi-band operation, power consumption, and a digital processor's digital processing cost. The PI and group proposed numerically stable techniques such as memory polynomial model implementation using independent component analysis (MP-ICA). Figure 3.12 shows that in the FPGAs' fixed-point precision environment MP-ICA outperforms other state-of-the-art implementation by providing maximum out-of-band distortion suppression. Figure 3.13 shows that for qualifying the adjacent channel power ratio criterion of 45 dBc, the power added efficiency (PAE) for a Class-AB amplifier with the proposed DPD technique increases by approx. 10% in intra-band CA and 8% for inter-band CA. PI and her research group have proposed a novel Volterra-based pruning technique for MIMO transmission by observing the positions where the coupling takes place. Table-1 shows that the performance of the proposed model is similar to the state-of-the-art PH model , however with lower implementation complexity in terms of coefficients / no. of flops used.

As a research contribution, one patent is applied, ten papers in SCI journals and nine papers-in conferences are published. The PI delivered workshop lectures in International Microwave Conference-2018 in Philadelphia, June 2018; and International Microwave Conference-2019 in Boston, June 2019; and Radio Wireless Week (RWW) January 2020, in San Antonio, USA. The low-cost SDR setup is commercialized via start-up 'The linearized amplifier technologies and services private limited".

The work was done at Indian Institute of Technology, Roorkee.

3.1.1.7 Materials, Mining and Minerals Engineering

In the reporting period, 54 new projects were sanctioned. The areas supported under CRG – Materials, Mining, and Minerals Engineering are shown in the following figure.

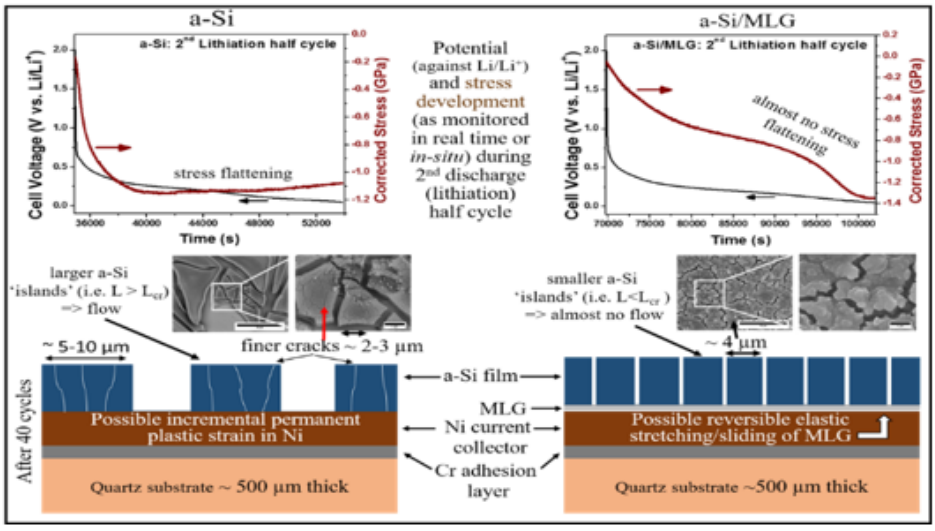


Research Highlights

Towards enabling the usage of high capacity and safe anode materials in the next generation alkali metal-ion batteries: The sustained development-cum-usage of advanced electrochemical energy storage systems are at the forefront of combating issues associated with the ever-increasing environmental pollution and depletion of fossil fuels. Among the various electrochemical energy storage technologies of today, Li-ion batteries possess the highest energy density. Nevertheless, for meeting the demands of heavy duty applications, such as in electric vehicles, the energy density needs to be further enhanced, along with substantial improvements in the stability over multiple discharge/charge cycles (i.e. cycle life), ability to take-up/release energy at a rapid rate (i.e. power density) and safety aspects. One of the avenues towards achieving all the above simultaneously is the replacement of the presently used graphitic carbon-based anodes with higher capacity and safer anode materials, such as Si, Sn; which can reversibly alloy with Li under electrochemical conditions that are typical of the anode half in Li-ion cells (viz., alloying-reaction based anode materials).

54
Projects Sanctioned

17.30 cr
Expenditure
(New & Ongoing Projects)



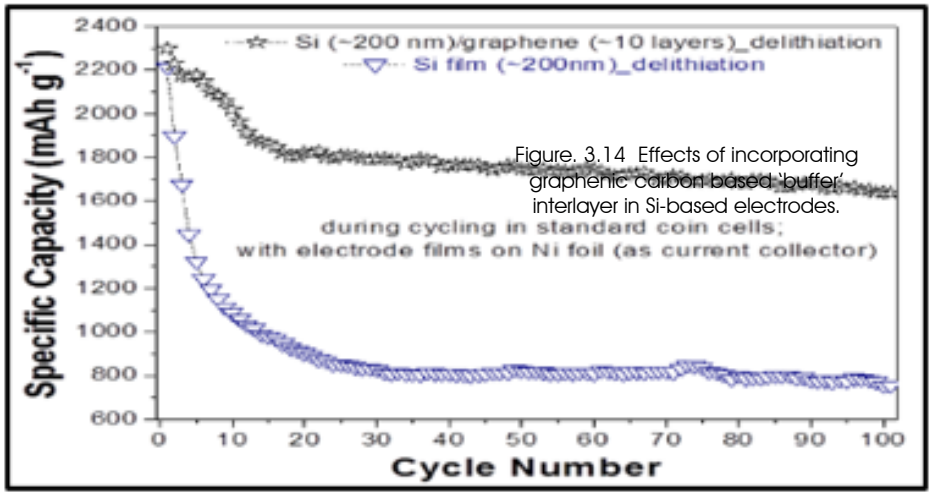


Figure. 3.14 Effects of incorporating graphenic carbon based 'buffer' interlayer in Si-based electrodes.

Fig. 3.14: Effects of incorporating graphenic carbon based 'buffer' interlayer in Si-based electrodes.

Furthermore, looking beyond the Li-ion battery system, the successful usage of such alloying-reaction based anode materials is possibly even more important for the upcoming and deemed-to-be more sustainable Na-ion battery system, where graphitic carbon cannot be used as anode material because it does not intercalate Na-ions (unlike Li-ions).

However, the alloying-reaction based anode materials suffer from cyclic instability (i.e. rapid fade in Li/Na-storage capacity) upon being repeatedly lithiated/de-lithiated (or sodiated/de-sodiated) during charge/discharge cycles of Li-ion and/or Na-ion cells; which is, in fact, the major bottleneck towards their potential usage as anode materials. The cyclic instability stems from mechanical degradation due to colossal stress developments during insertion/removal of the guest Li-ions (or Na-ions) to/from the host lattice. Such stress development arises primarily from constrained dimensional changes (along with concentration gradients), structural changes, phase transformations and undesirable surface reactions. Accordingly, the aspects concerning stress development in such anode materials needed thorough understanding, preferably by way of monitoring the stress development in-situ/operando during electrochemical lithiation/de-lithiation (or sodiation/de-sodiation); followed by engineering the anode composition/structure/design towards addressing the stress-related issues (based on such in-depth understanding).

The present set of investigations highlighted the influences of adhesion characteristics at the interface between the active electrode material and buffer interlayer/additive towards the electrode stress and concomitant deformation-cum-integrity upon lithiation/delithiation (or sodiation/desodiation). It was also established that two materials that definitely qualify as effective buffer interlayers (as per the above criterion) are graphenic carbon (Fig. 3.14) and NiTi (Fig. 3.15); with the pseudoelastic property of the latter being utilized. While graphenic carbon can also reversibly store some Li-ions (thus, partly contribute to overall electrode capacity), NiTi is inactive, but less expensive as a buffer interlayer, despite possessing nearly similar effectiveness as graphenic carbon (as was revealed during the course of the present investigations). Additionally, in contrast to a more popular belief, it was realized that nanoscale dimension of Si particles/islands is not needed to achieve good cyclic stability in the presence of such buffer interlayers; rather, Si-dimension of the order of a few microns is good enough. This finding has immense practical significance since nano-sized active particles reduce the tap density of the electrode (thus, lowering the net Li-storage capacity) and also accrue the negative impacts of irreversible deleterious/side reactions that take place at electrode/electrolyte interfaces; and, hence, not too desirous. Finally, on a more practical perspective, the above understandings/findings could be successfully translated towards achieving excellent cyclic stability of alloying-reaction based anodes, as part of the research; which, in turn, promises to allow the successful usage of such, otherwise high capacity and safe, anode materials towards the development of next generation Li-ion batteries and beyond.

The work was done at Indian Institute of Technology, Bombay.

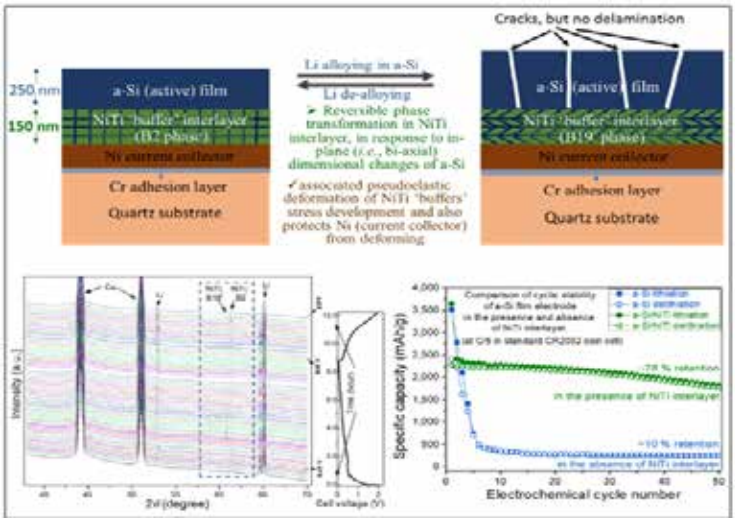


Fig. 3.15: Effects of incorporating NiTi-based buffer interlayer in Si-based electrodes.

Investigation into the coupled phenomena of ferroelectric-ferroelastic domain wall motion and interferroelectric phase transformation in high performance piezoceramics: Piezoelectric materials develop strain on application of external electric field (converse piezoelectric effect) and develop voltage on when stressed (direct piezoelectric effect). These functionalities make them useful as actuators, pressure sensors and transducers. With the discovery of large piezoelectric response in ferroelectric perovskites five decades ago, this class of materials got industrial and academic attention world over. $Pb(Zr_xTi_{1-x})O_3$ (commonly known as PZT) has been the most important piezoceramic material for the past four decades. However, environmental concerns in the last two decades have challenged the research community to find suitable alternatives of Pb-based materials in industrial products. The last decade and half have witnessed a phenomenal surge in the research interest in Pb-free piezoceramics. Among the Pb-free, the NBT-based piezoceramics exhibit enigmatic behaviour and have puzzled the scientific community. A research group at IISc Bangalore has extensively explored the structure-property correlations in NBT-based piezoceramics and could resolve some of the outstanding issues related to the structure-property correlation of this system. They have also developed new experimental strategies and discovered new materials and phenomena of scientific and technological interest.

The group have discovered a piezoceramic composition in the pseudo-ternary alloy system $BiFeO_3$-$PbTiO_3$-$LaFeO_3$ which exhibits extraordinarily large electrostrain of ~ 1.2 % (Fig. 3.16). This is the highest ever electrostrain reported in polycrystalline piezoceramics. The work was published in Nature Materials.

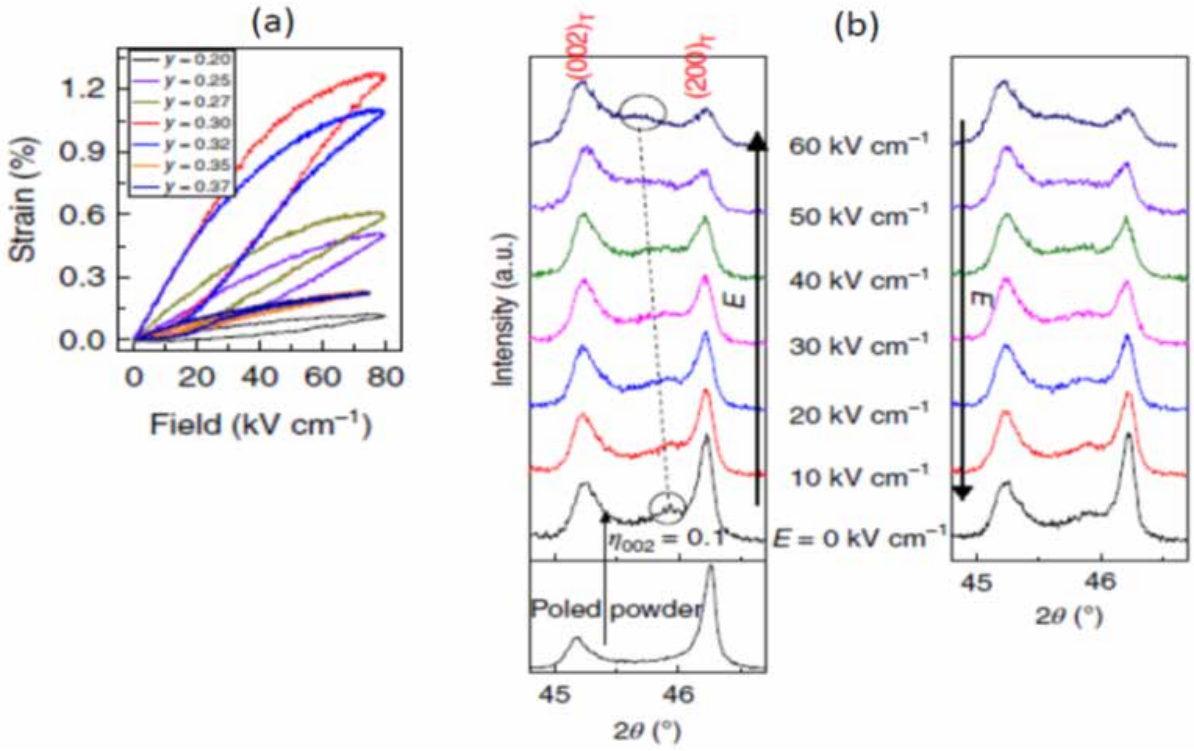
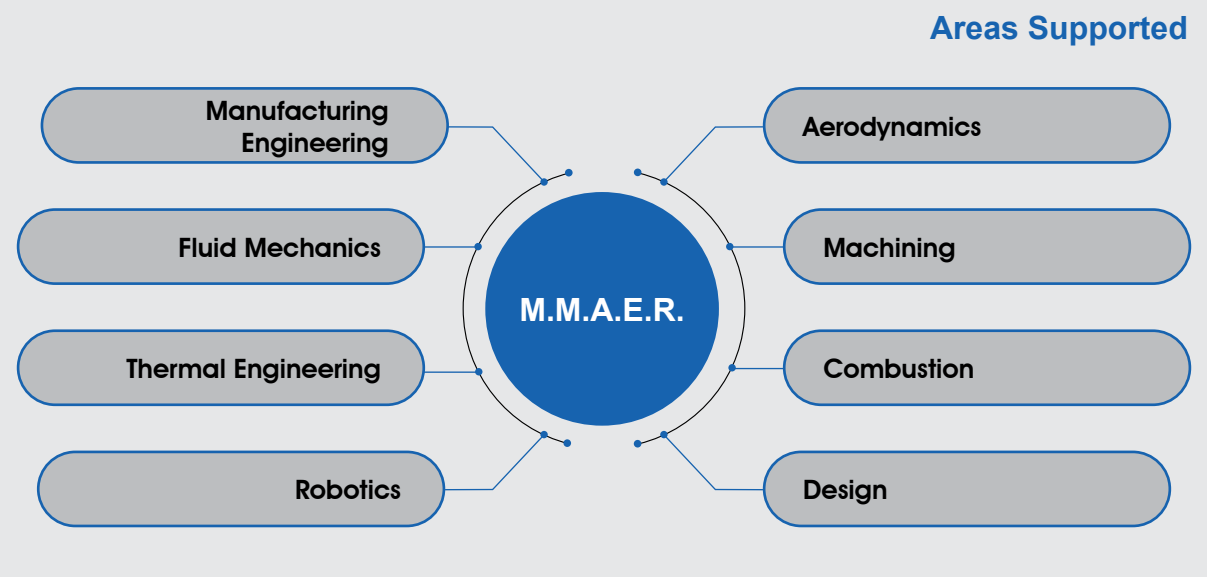


Fig. 3.16: (a) Longitudinal strain as a function of electric field of 0.55 $Bi_{1-y}La_yFeO_{3-0.45}PbTiO_3$. The composition with y = 0.30 shows ultrahigh electrostrain of ~ 1.2 % at 80 kV/cm. (b) X-ray diffraction in-situ with the electric field of y=0.30. The tetragonal peaks are indexed as (002) and (200). The small peak in between corresponds to the disordered phase.

The work was done at Indian Institute of Science, Bangalore.

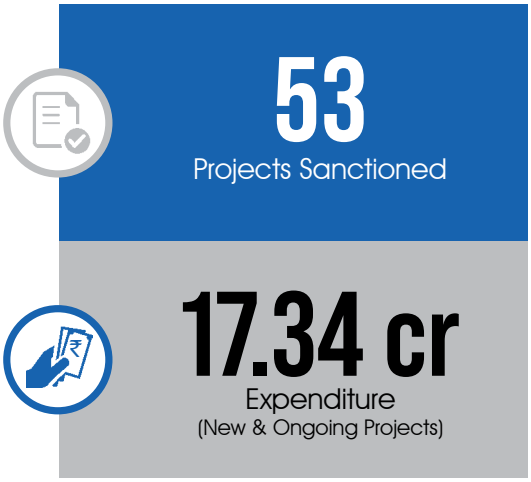
3.1.1.8 Mechanical, Manufacturing, Aerospace Engineering and Robotics

In the reporting period, 53 new projects were sanctioned. The areas supported under CRG – Mechanical, Manufacturing, Aerospace Engineering and Robotics are shown in the following figure.



Research Highlights

Droplet deposition on a solid surface: Towards engineering dewetted surfaces, improving interfacial heat transfer and controlling colloidal deposits: Understanding impact and evaporation dynamics of droplets on a solid surface has potential applications. For instance, several textured surfaces of plants and animals exhibit dewetting properties and this property may be leveraged in applications such as pesticide spray coating, drag reduction, anti-snow adhesion surfaces, self-cleaning surfaces and water harvesting. In context of evaporating droplets laden with colloidal particles on solid surfaces, potential technical applications include inkjet printing, surface coating and designing biosensors. The physics involved during the droplet impact and evaporation is a complex interplay of several multi-scale transport phenomena, namely, severely deforming liquid-gas interface under influence of inertia, surface and gravity forces, dynamic wetting at the contact line, heat conduction and convection in the droplet, heat conduction in the substrate, liquid-vapor diffusion outside the droplet, advection of the colloidal particles in the droplet. The measurement of such coupled transport phenomena is not trivial and is further challenged by the fast time scale as well as small spatial scale (on the order of microscale).



A research group at Department of Mechanical Engineering, IIT Bombay investigated wetting and water repellency characteristics of Colocasia esculenta (taro) leaf and an engineered surface, bioinspired by the morphology of the surface of the leaf. Scanning electron microscopic images of the leaf surface reveal a two-tier honeycomb-like microstructures, as compared to previously-reported two-tier micropillars on a Nelumbo nucifera (lotus) leaf (Fig. 3.17). Using standard photolithography techniques, bioinspired surfaces with hexagonal cavities of different sizes were manufactured. The ratio of inner to the outer radius of the circumscribed circle to the hexagon

(b/a) was varied. It was found that the measured static contact angle on the bioinspired surface varies with b/a and this variation is consistent with a free-energy based model for a droplet in Cassie-Baxter state. The static contact angle on the bioinspired surface is closer to that for the leaf for b/a ~1. However, the contact angle hysteresis is much larger on these surfaces as compared to that on the leaf and the droplet sticks to the surfaces. This behavior was explained using a first-order model based on force balance on the contact line. Finally, the droplet impact dynamics was recorded on the leaf and different bioinspired surfaces. The droplets bounce on the leaf beyond a critical Weber number (We ~ 1.1), exhibiting remarkable water-repellency characteristics. However, the droplet sticks to the bioinspired surfaces in all cases of We. At larger We, droplet breakup on the surface with larger b/a and droplet assumes full or partial Wenzel state. The breakup is found to be a function of We and b/a and the measured angles in full Wenzel state are closer to the predictions of the free-energy based model. The sticky bioinspired surfaces are potentially useful in applications such as water-harvesting.

The work was done at Indian Institute of Technology, Bombay.

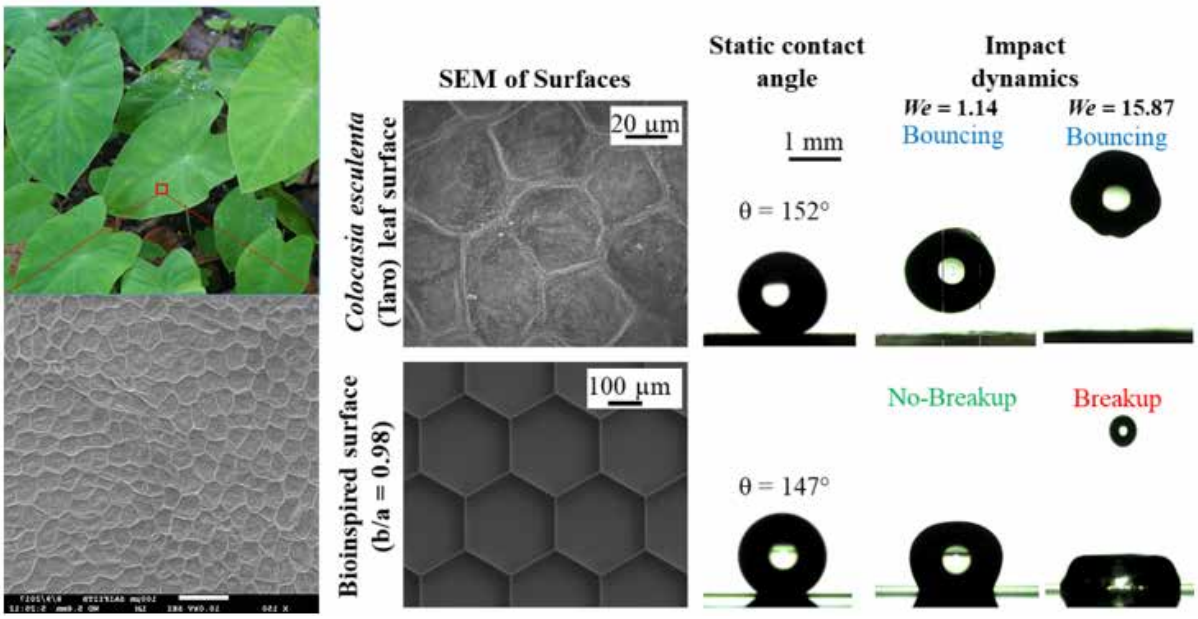


Fig. 3.17: SEM of the leaf (left) and bioinspired surfaces thereof.

Design and development of a novel honing type magnetorheological finishing process: A research team at Department of Mechanical Engineering, Thapar Institute of Engineering and Technology, Patiala developed a technology for fine finishing of internal surface of cylindrical components undergone through the traditional honing/grinding process (Fig. 3.18). The developed technology is capable to attain surface finish upto 40 nm or even less. The nanometer level finishing with good surface characteristics fulfills the demand in today's industries for improving the operative functionalities of the cylindrical components. The finely finished surface of the industrial components improves features such as appearance, resistance to abrasion which guards against wear, corrosion and chemical damages of the surfaces. Thus, the developed process can reduce wear, energy consumption and leads to savings in service, maintenance costs and improve functional applications as compared to traditional finishing techniques. The overall results reveal that the present developed MR honing process can be used for its extensive applications in industries for enhancing the functional capability of various cylindrical components like cylindrical molds, air bearings and injection molding machines, etc.

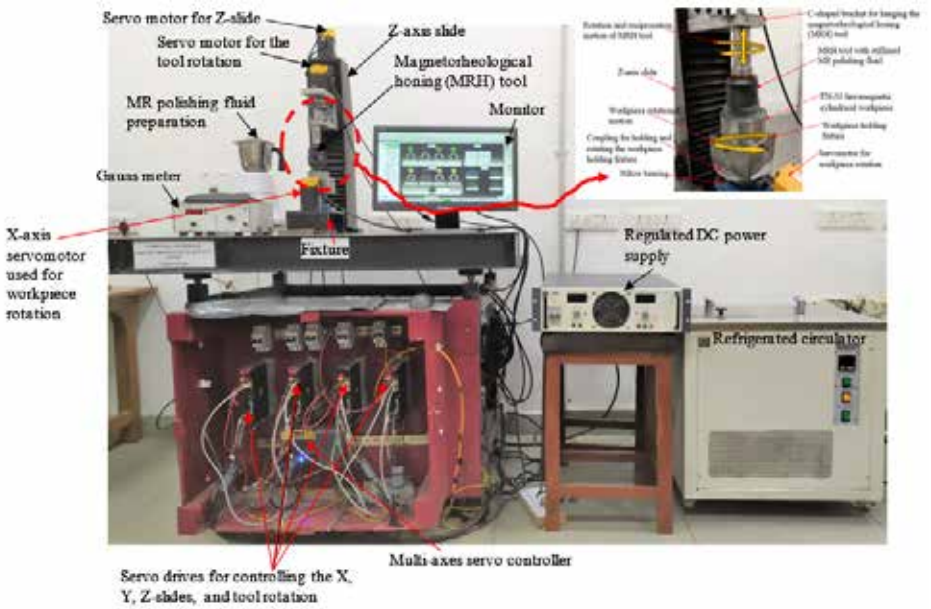
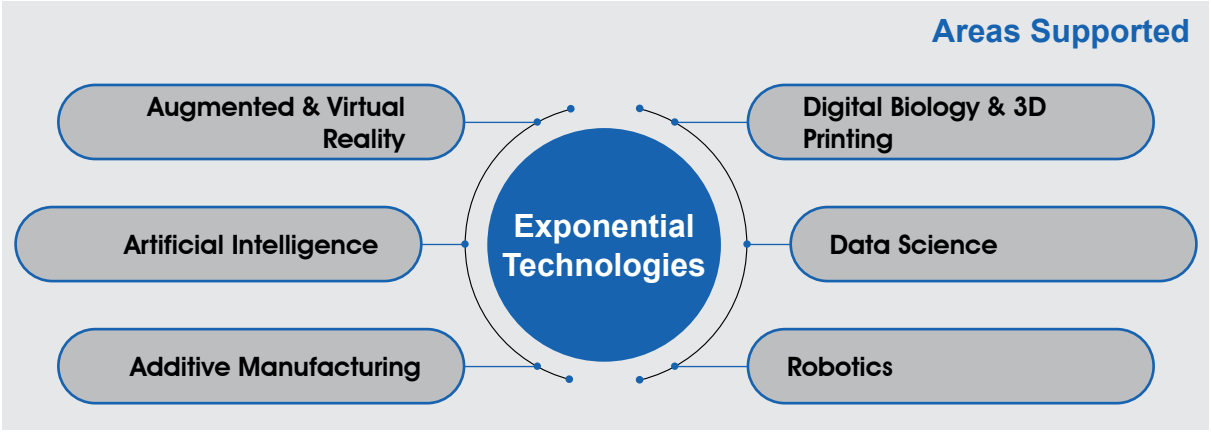


Fig. 3.18: Photograph of the developed computer controlled magnetorheological honing setup.

The work was done at Thapar Institute of Engineering and Technology, Patiala

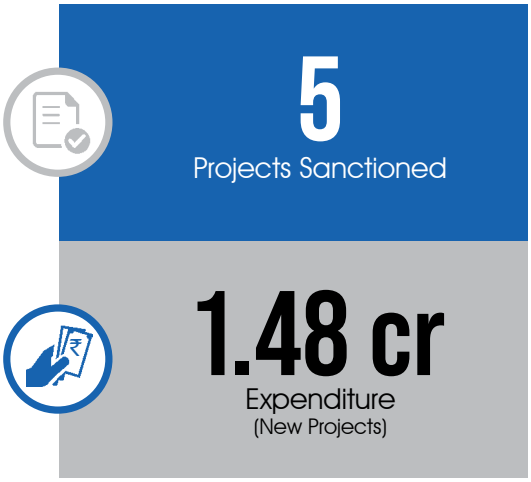
3.1.1.9 Exponential Technologies

In the reporting period, 5 new projects were sanctioned. The areas supported under CRG – Exponential Technologies are shown in the following figure.



Research Highlights of one of the proposals supported is given below:

The polar liquids like water are used in steam power plants, steam turbines, hydro-pumps in electricity generation and in heat pipes/boilers/ condensers as heat absorbing and heat releasing devices. Water is also used in smooth pumps, smooth pipes, and smooth tubes, multiple tubes for pumping from one source to drain. The polar liquids used in these applications generate higher electricity, higher heat transfer enhancement and giant transport in smooth pipes compared to rough pipes. Aim of the

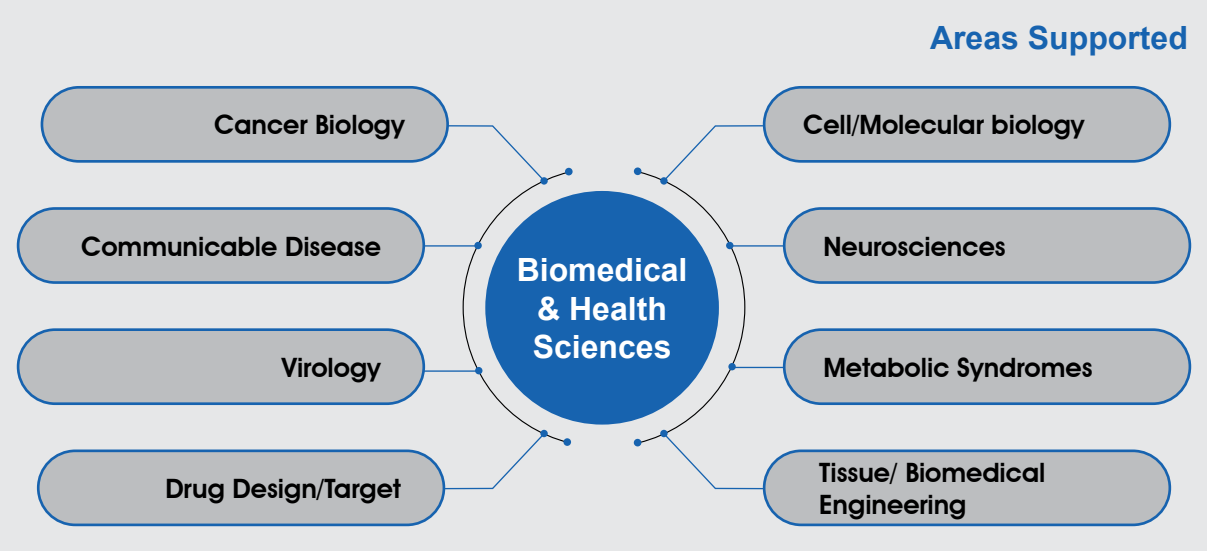


project is to study flow of such polar liquids inside channel sizes of the order of few nanometers to understand the strong inter-facial transport effects at the solid-liquid interfaces which is not observed in bulk-like flows. In the current project, PI and group will be studying using both experiments and molecular dynamic simulations the novel slip-like velocity boundary condition for the first time inside slit-like nanochannel. The nanochannel device fabrication will be set up to study the nanoscale hydrodynamics of polar liquids and the inter-facial transport of polar liquids inside nanochannels. The study may open up avenues for understanding nanoscale flows in nanoscale pumps and biomicrofluidics applications. Also PI will be studying cell-like nanostructures for understanding solid-liquid inter-facial transport dynamics in cells for the first time. These cells are deformable hence the study of nanoscale hydrodynamics in deformable cells may lead to exciting new physics that is not observed in rigid nanochannel like-channels. The cell-like capsule nanoscale hydrodynamics will unfold opportunities for using nanoscale flows for organ-on-chip application, for example transport of molecules across alveoli-like nano/ microstructures on microfluidic chip.

This work will be done at Indian Institute of Technology, Madras.

3.1.1.10 Biomedical and Health Sciences

In the reporting period, 84 new projects were sanctioned. The areas supported under CRG – Biomedical and Health Sciences are shown in the following figure.



Research Highlights

Chemical biology approaches to exploit FIKK kinase(s) from Plasmodium falciparum to develop potent anti-malarials: Malaria is one of the most important public health problems in tropical and subtropical areas with approximately 200 million cases worldwide annually. In absence of an effective vaccine, rapid treatment is vital for effective malaria control. However, parasite resistance to currently available compounds underscores the urgent need for identifying new antimalarial therapies. Among the potential targets for new anti-malarial drugs, protein kinases are of great interest. Taking the scientific clue, investigator proposed to investigate FIKK kinase that is present only in malarial parasite and plays an important role in host pathology, RBC remodeling and intracellular stress.

84
Projects Sanctioned

40.68 cr
Expenditure
(New & Ongoing Projects)

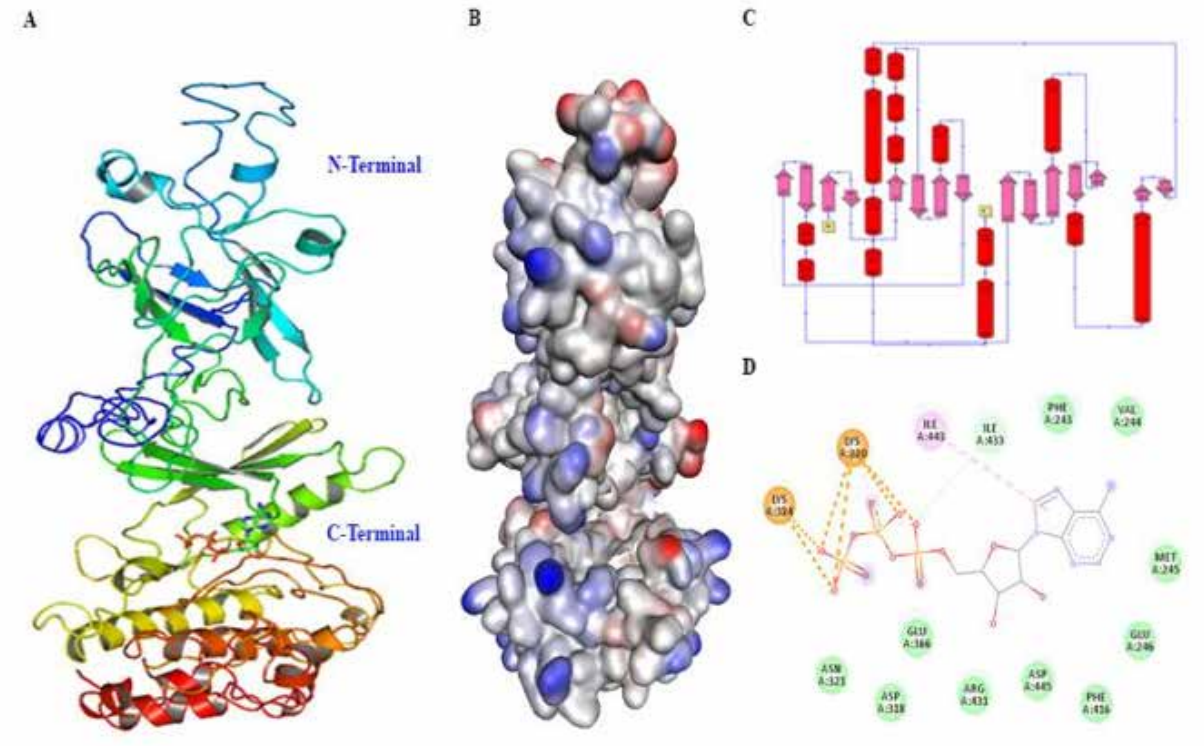


Fig. 3.19: Molecular modeling of FIKK9.1.3

In order to address the specific objectives, investigator modeled FIKK9.1.3-D to study the details and functional role of aminoacids present in the two distinctive domains namely N-terminal and C-terminal (Fig. 3.19). Further to understand the pharmacophore environment in FIKK motif, which is present in between the two domains, investigator performed fingerprinting analysis and identified crucial aminoacids which are important for selection of inhibitors for kinases. Based on the molecular structural information investigator synthesized and characterized heterocyclic compounds with different core chemical moieties and created a library of molecules. Total 623 novel chemical inhibitors were extracted and virtually screened for identifying novel inhibitors of FIKK9.1 to develop antimalarial targets.

Based on the docking studies and toxicity profiling, 7 heterocyclic compounds were selected for antimalarial assays. Two compounds namely TP403 and TP524 showed greater hydrophobic interaction and hydrogen bonding with certain aminoacids which are responsible for anchoring and positioning adenosine ring and phosphate residues in ATP.

To test the potency of the compounds against malarial parasite the compounds TP403 and TP524 were treated to parasite cultures and found to inhibit or halting the erythrocytes developmental stages (from ring to schizont) of parasites (Fig. 3.20). Though both the FIKK9.1 inhibitor are effective in schizonticidal assay whether it also effective against parasiticidal activity is not known. To test this, investigator accessed the growth of treated parasites for 96 hrs after removing inhibitors. Most of the parasites appeared to be dead and in deformed states in treated condition compared to control parasites (Fig. 3.21). To further confirm parasite killing is mediated through chemical knockout of FIKK9.1 kinase inhibition assay was performed. In the absence of FIKK 9.1 inhibitor, FIKK9.1 was extensively phosphorylating BSA by addition of ATP whereas in presence of inhibitors the phosphorylation of BSA is found to be decreased by several fold (Fig. 3.22). This shows that FIKK9.1 was one of the primary targets for TP403 and TP524 for parasite death. From this study it is evident that FIKK9.1 can be exploited as drug target.

The work was done at Indian Institute of Technology, Guwahati.

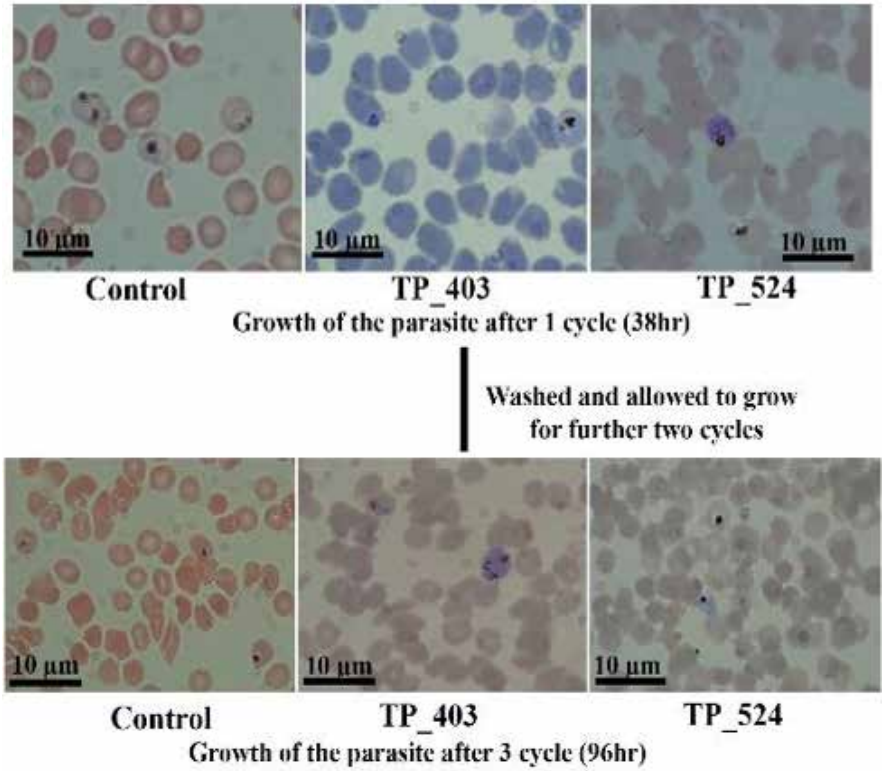


Fig. 3.20: Schizonticidal assay with and without inhibitors

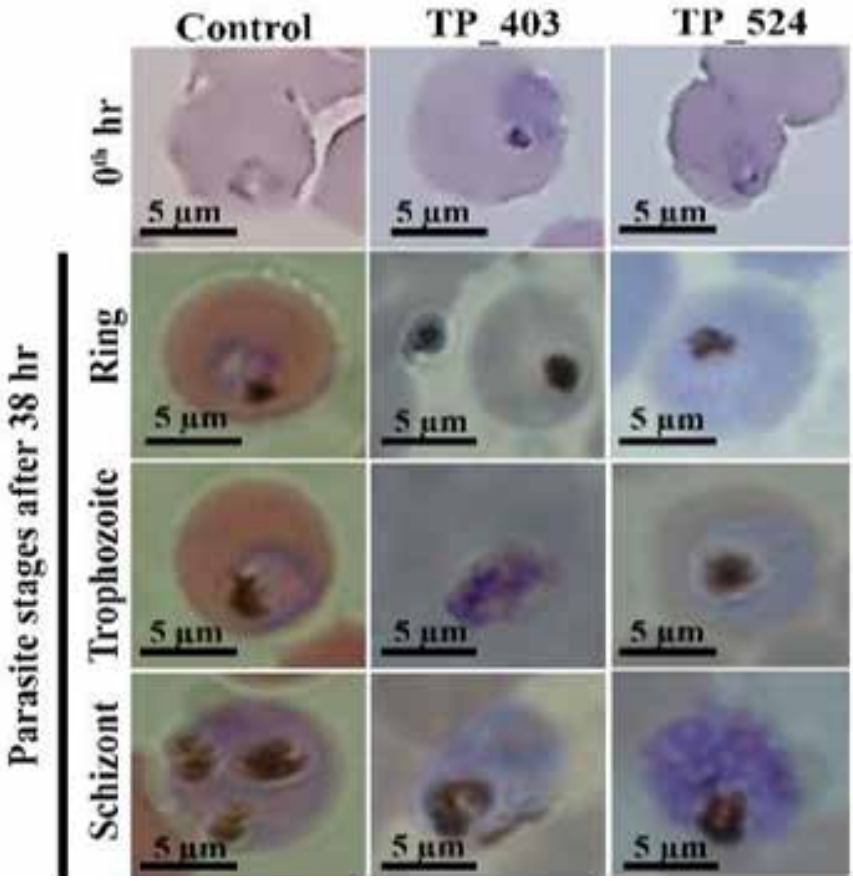


Fig. 3.21: Parasiticidal activity assay

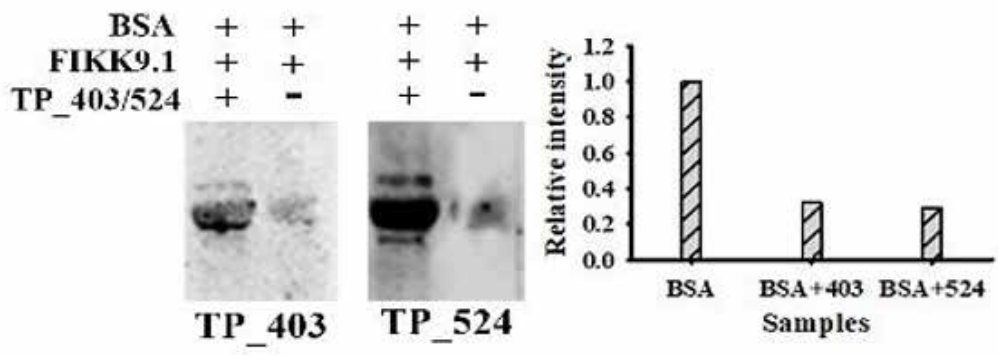


Fig. 3.22: FIKK9.1 Kinase inhibition assay

Investigating metabolic reprogramming in stroke as a consequence of homocysteine induced bidirectional activation of neutrophils and platelets: Elevated serum levels of homocysteine and reduced levels of folate and vitamin B12 are found to be strongly associated with Asian population who are suffering from metabolic syndrome. Hyperhomocystenemia is an earliest strong risk factor for stroke and other vascular diseases. Thrombosis associated signatures depends on robust interaction between innate immune cells (neutrophils, monocytes and dendritic cells) leading to platelet activation called immunothrombosis. Neutrophils are one of the critical components of innate immune system and eliminate pathogens during infections either by phagocytosis or by producing extracellular traps (NET). In this study, investigators examined the influence of homocysteine and its modifications on NET formation when compared to other metabolic inducers such as glucose and LPS (Fig. 3.23). Investigator found a significant variation in formation of NETs in between these inducers. To further investigate the differential regulation of proteins levels they performed mass spectrometry based phosphoproteomics analysis and revealed varied levels of hyper and hypophosphorylated peptides in neutrophils in response to these inducers and interestingly, LPS (Lipopolysaccharides) induction resulted in elevated hypophosphorylated proteins compared to that of homocysteine and glucose. This indicated the existence of distinct signaling pathways between homocysteine, LPS and glucose inducing NETosis (Fig. 3.24). Using string analysis, it was identified that homocysteine induces phosphorylation of proteins involved in positive regulation of NAD+ ADP ribosyltransferase activity, glomerular visceral epithelial cell migration, pathways related to RNA processing, whereas glucose stimulation conditions pathways related to senescence, chemotaxis and regulation of RNA processing. To further confirm the above findings investigator used hyperhomocystenmimic mouse model to study the NETosis and observed increased neutrophil elastase, cell free DNA and citrullinated histone levels. The same has been found in the serum samples isolated from the stroke subjects (Fig. 3.25).

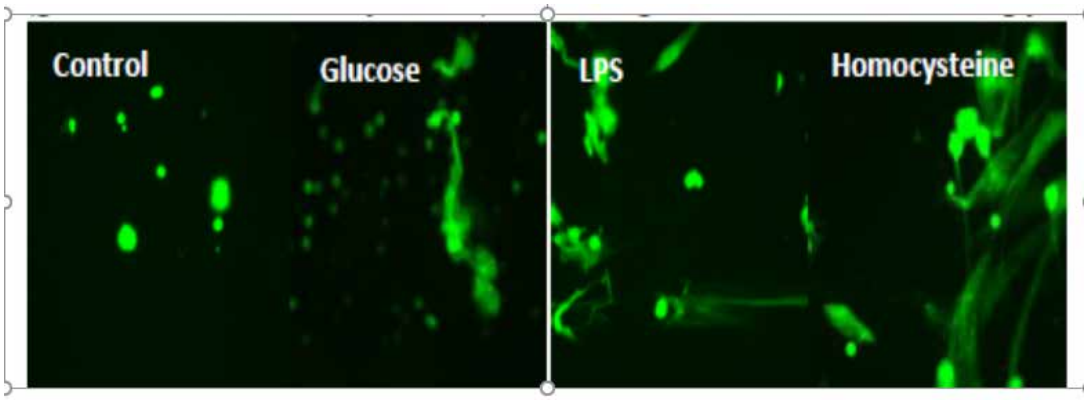


Fig. 3.23: NETosis formation with different agonist

Through this study it was revealed that hyperhomocysteinylation has dramatic effect towards development of stroke which was confirmed through suitable invivo rodent model as well as stroke study subjects. Identification of differential regulation of phosphor-proteins induced during NETosis may act as a potential candidate towards drug discovery and as well as suitable drug targets to prevent stroke. A proposed model (Fig. 3.26) is to depict how the LPS induces NETosis.

The work was done at Manipal University, Manipal.

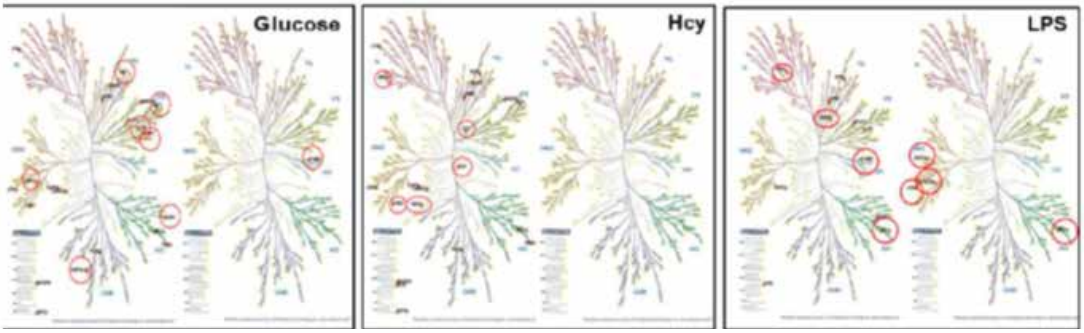


Fig. 3.24: String analysis : differential regulation of proteins under various agonist

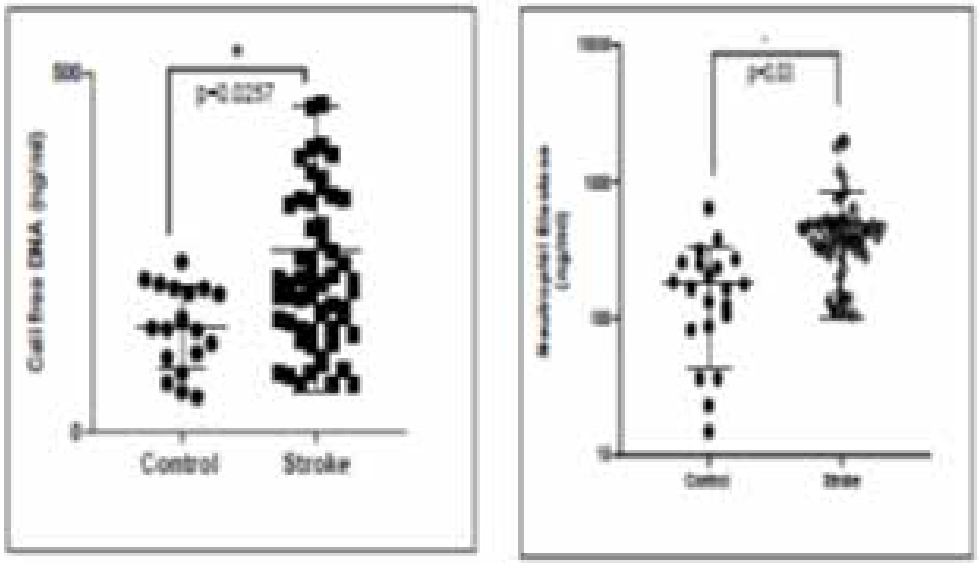


Fig. 3.25: Proposed NETosis model under normal and high- glucose condition

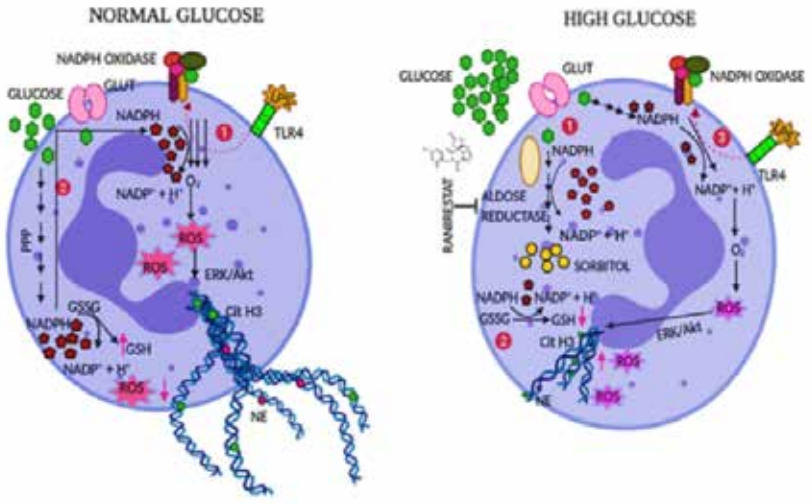
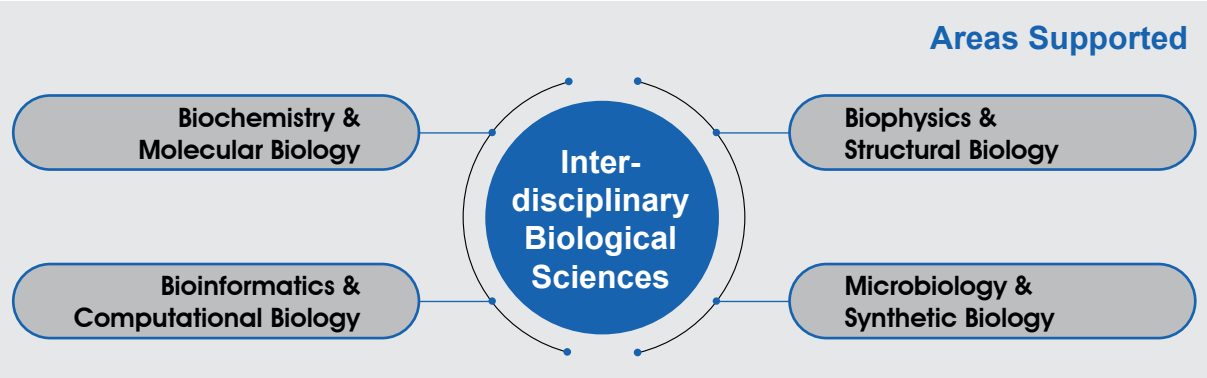


Fig. 3.26: NETosis formation evaluation

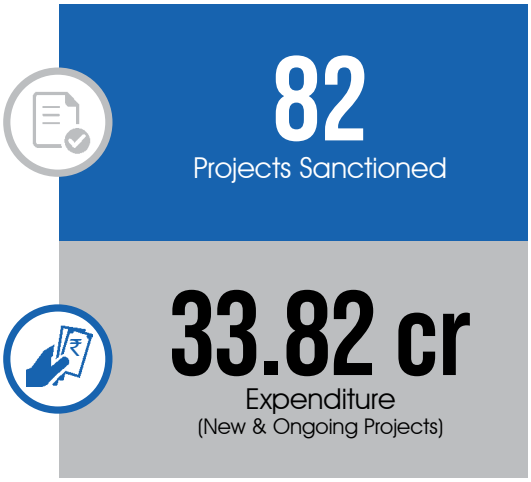
3.1.1.11 Interdisciplinary Biological Sciences

In the reporting period, 82 new projects were sanctioned. The areas supported under CRG – Interdisciplinary Biological Sciences are shown in the following figure.



Research Highlights

Uncovering the novel family proteins in mitochondrial health, DNA and protein homeostasis: Parkinson's disease (PD) is a progressive human brain disorder with many noticeable early symptoms including tremors, which gradually cause stiffness, leading to a slowing of movement. In PD, a decrease in dopamine production causes the brain to function abnormally, leading to impairment in coordination and movement. Although there is no cure for PD, medication such as analogues of dopamine significantly improves the management of disease symptoms.



The main cause for the development of PD is still unknown, however, researchers have identified genetic mutations in several loci (faulty genes) that can cause the susceptibility of an individual to the disease. PD can occur in rare cases in families due to faulty genes (produces abnormal proteins) that can pass on from parents to their successive generations. The genetic alterations in some loci are well mapped in humans, which include *PARK7, LRRK2, PARK2, PINK1, SNCA*, etc. The investigator's previous research findings provided useful insights into how the gene *PARK7*, which encodes for a protein called DJ-1 protects cells (neurons) under oxidative stress conditions. However, how DJ-1 protein controls the cell's functions is poorly understood (Fig. 3.27).

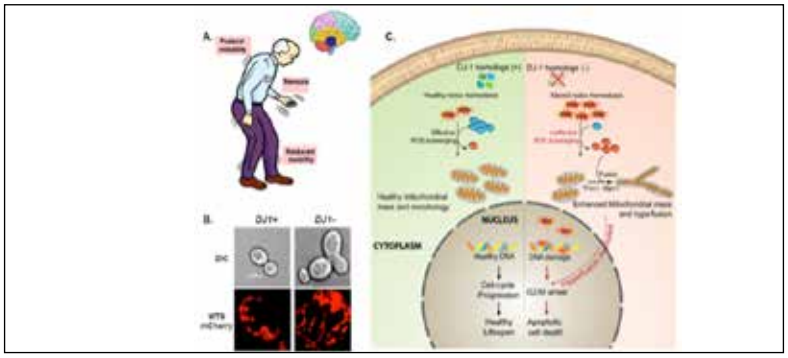


Fig. 3.27: A) Clinical manifestation of Parkinson's disease includes reduced neuron activity, postural instability and mobility. B) Maintenance of cell and mitochondrial integrity by DJI protiein. C) Mechanism of how DJI protein regulates mitochondrial function and therefore aid in cell survival and health.

To address the above scientific question, the research group have utilized baker's yeast as a model organism in which a similar class of proteins exists, and their functions can be explored in depth by simple genetic manipulations. Genetic mutations in human DJ-1 result in abnormal mitochondria, which is a key part of the cell component responsible for the energy generation also known as the powerhouse of the cell. This is one of the important symptoms observed at the cellular level causing a reduction in the energy currency, which is implicated in the disease manifestation leading to eventually neuronal loss. The research findings elucidated mechanisms associated with the mitochondrial changes in response to the DJ-1 removal from the cell. The study observed that removal of DJ-1 led to respiration defects, mitochondria and cell abnormalities due to stress, delayed cell-cycle due to DNA damage and cell death by apoptosis.

The current findings highlight a significant lacuna in our understanding of the underlying mechanisms of how PARK7 (DJ-1) is involved in the maintenance of mitochondrial health. Based on the results, the group hypothesized that loss of function of mammalian DJ-1 may be responsible for an adaptive mitochondrial stress-response, which could eventually trigger cell death. Besides, DJ-1 could serve as an interesting therapeutic enzyme target to restore the mitochondrial equilibrium by modulating its activity linked to several neurodegenerative diseases, including PD, Alzheimer's disease (AD) that is associated with impaired mitochondrial health.

The work was done at Indian Institute of Science, Bangalore.

Mechanism of meiotic crossing over through the Msh4-Msh5 dependent pathway: During meiosis, crossovers facilitate physical linkages between homologous chromosomes that ensure their accurate segregation. Failure to receive at least one crossover per chromosome usually results in aneuploid gametes and associated congenital disabilities in offspring. Meiotic crossovers are initiated from programmed DNA double-strand breaks (DSBs). In the baker's yeast and mammals, DSBs are repaired into crossovers, primarily through a pathway involving the highly conserved mismatch repair related Msh4-Msh5 complex along with other crossover promoting factors. To understand the mechanistic role of Msh4-Msh5 in meiotic crossing over, the group performed genome-wide ChIP-sequencing and cytological analysis of the Msh5 protein in meiotic cells.

The study demonstrates that Msh5 specifically binds to DSB hotspots, chromosome axis and centromere sites on chromosomes. Efficient binding to these chromosomal features requires DSB formation and resection and is further enhanced by the formation of double Holliday junction structures (Fig. 3.28). Msh5 binding to DSB hotspots was sensitive to DSB frequency and also enhanced on smaller chromosomes that have higher DSB and crossover density. In mutants that show reduced DSB frequency (spo11-HA), Msh5 showed increased association along chromosomes to ensure crossover numbers are maintained through a homeostasis mechanism. Chromosome axis integrity was required for Msh5 association with DSB hotspots and the chromosome axis but not at centromeres. These results on the in vivo localization of the Msh5 protein in wild type (Fig. 3.29) and meiotic mutants provide novel insights into how the Msh4-Msh5 complex may work with other crossover and synapsis promoting factors to facilitate crossover formation.

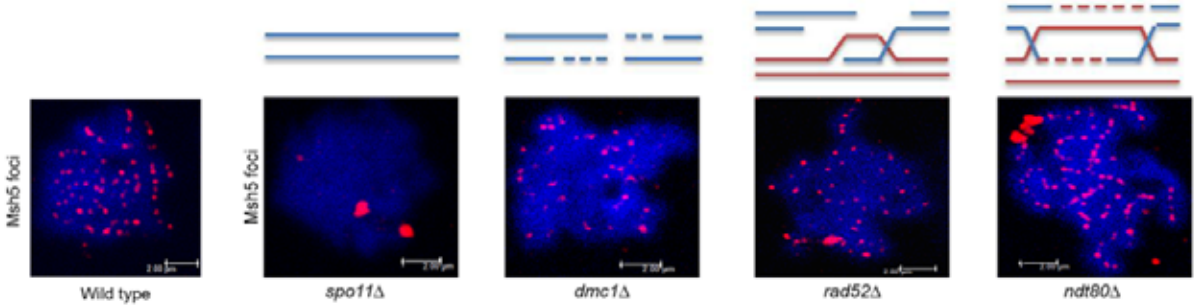


Fig. 3.28: Msh5 binding to chromosomes is facilitated by DSB formation and DSB repair intermediates.

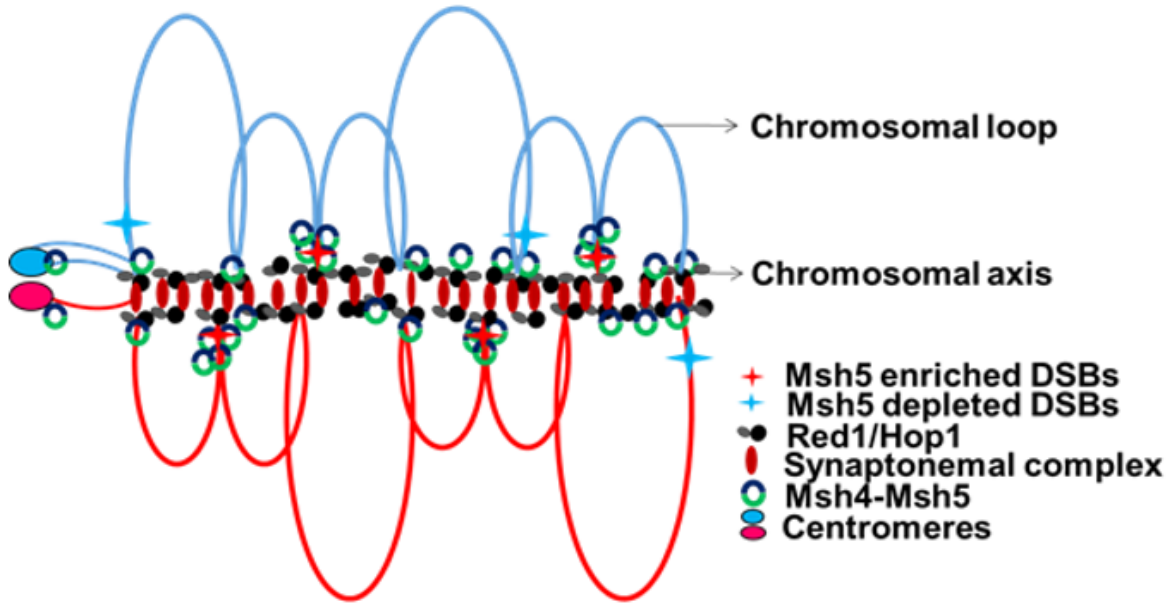


Fig. 3.29: Model showing Msh4-Msh5 localization on meiotic chromosomes

The insights into meiotic crossover mechanisms from this study will help to understand the molecular basis for birth defects such as Down syndrome and other congenital diseases caused by missegregation of meiotic chromosomes.

The work was done at Indian Institute of Science Education and Research, Thiruvananthapuram.

Investigating the role of epigenetic reader TCF19 as a cellular glucose sensor in conjunction with p53: Cancer cells have great metabolic flexibility that allows them to adapt and proliferate in the changing extracellular environment fulfilling the necessary energy demands. It is important to understand the molecular mechanism that helps the cancer cells to undergo metabolic reprogramming through epigenetic perspective. In this context, the core histones undergo posttranslational modification and play a crucial role in metabolic gene expression regulation. These modifications are recognized by a class of proteins called chromatin readers/ effectors which fine-tune the underlying gene expression programs depending upon different molecular cues. The investigator group have recently observed that an important epigenetic reader protein Transcription Factor 19 (TCF19) interacts with H3K4Me3 via its Plant Homeo Domain (PHD) finger and recruits Nucleosome Remodelling Deacetylase Complex (NuRD) to repress Gluconeogenic gene expression. Previous studies have indicated the involvement of TCF19 in the promotion of cellular proliferation in Hepatocellular carcinoma (HCC), colorectal cancer and non-small cell lung carcinoma (NSCLC). In the context of cellular proliferation, the tumour suppressor protein p53 has been intensively studied. Depending upon the extent of cellular stress accumulation, it either turns on the cell cycle arrest mechanisms or triggers the phenomenon of cell death. Other than its role in regulating cell proliferation, recent findings have revealed a new role of p53 in regulating glucose metabolic pathways. Interestingly, p53 gets post-translationally modified and regulates metabolic programs in cancer cells. Thus, it acts as a sentinel for the activation of several stress-responsive factors. This study has the following key outcomes- I. The present study reveals the co-operative function of TCF19 and p53 in regulating key genes of Glycolytic and OXPHOS pathway in short-term and prolonged high glucose-mediated stress situations. And also observed that TCF19/ p53 complex co-regulate these pathways through transcriptionally reprogramming TIGAR and SCO_2 genes to maintain the Glucose homeostasis leading to altered mitochondrial energy metabolism in HCC cells. Together, this group has shown that epigenetic regulator TCF19 and p53

can concomitantly regulate glucose metabolic pathways which cater to the energy demand for HCC proliferation (Fig. 3.30A).

II. The group has also investigated the chromatin recognition function of the Plant Homeodomain (PHD) finger of TCF19 in hepatocellular carcinoma cell proliferation. Here, the data shows that the proliferation genes like CCND1, HDAC1, FGF2 etc are under direct regulation of TCF19 through its H3K4me3 binding ability and W316 residue of PHD finger is critical in this recognition. This study data suggests that TCF19 functions as a pro-oncogenic factor in the progression of hepatocellular carcinoma (Fig. 3.30B).

This study provides a glimpse of a network of epigenetic regulators and metabolic enzymes that act together to maintain cellular energy homeostasis. In-depth analysis of the molecular mechanisms of metabolic rewiring in cancerous cells may have immense potential towards a therapeutic regimen of cancer.

The work was done at Saha Institute of Nuclear Physics, Kolkata.

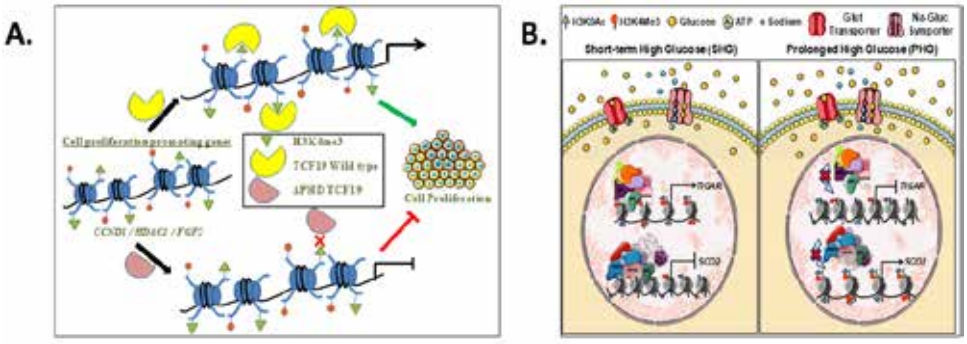
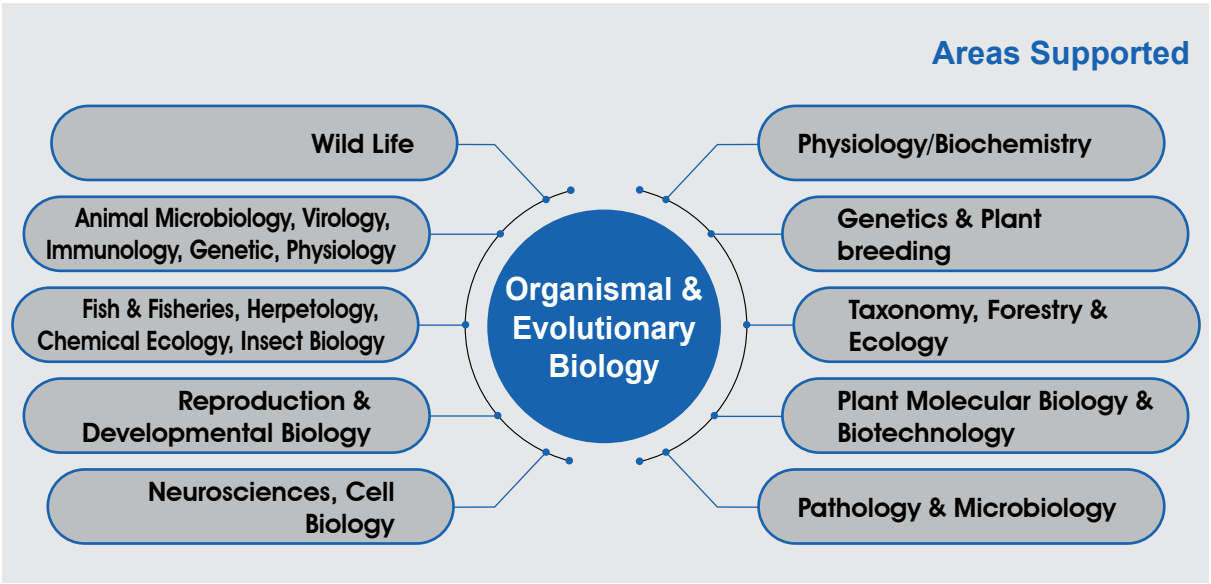


Fig. 3.30: A). PHD finger of TCF19 is important for cell proliferation. B). TCF19 and p53 form different complexes and get recruited to the chromatin in a gene-specific manner to transcriptionally regulate important glucose metabolic genes TIGAR and SCO2 through two different molecular mechanisms.

3.1.1.12 Organismal and Evolutionary Biology

In the reporting period, 105 new projects were sanctioned. The areas supported under CRG – Organismal and Evolutionary Biology are shown in the following figure.



Research Highlights

Biochemical and structural studies of a Type III restriction-modification enzyme from the pathogen *Mycoplasma bovis* : Mycoplasma bovis is a major pathogen that causes many diseases, including pneumonia and arthritis in cows and calves, mastitis in dairy cattle and bovine tuberculosis. M. bovis is a host-adapted pathogen that has one of the smallest known genomes. The investigator group discovered that one of the genes in the M. bovis genome encoded for a Type III restriction-modification (RM) enzyme named MboIII. A Type III RM enzyme is a bacterial defence system that prevents entry of foreign DNA into bacteria by degrading the DNA (Fig. 3.31). Thus, the defence system protects bacteria from their viruses. Additionally, the enzyme prevents acquisition of foreign DNA from the environment that could make the bacteria antibiotic-resistant. In host-adapted pathogens, such as M. bovis, Type III RM enzymes are known to perform another important function – to alter gene expression. This helps the pathogen infect and multiply in its host.

Alteration in expression is achieved through a chemical process called DNA methylation that is carried out by MboIII in M. bovis. It has been shown that preventing the process of DNA methylation can affect the ability of a pathogen to grow inside its host. Prevention of methylation can be achieved through inhibitors that act against the Type III RM enzyme. However, to achieve this goal it is important to characterise and understand the functional properties of MboIII. Through this project, the group could understand in unprecedented detail how MboIII methylates and degrades DNA. The crystal structure was determined for the module of MboIII that methylates the DNA, called MboIII-Mod. The crystal structure revealed the three-dimensional architecture of MboIII-Mod bound to the small-molecule inhibitor singefungin (Fig. 3.32). It provided a model of the spatial position of atoms that make the molecule. The structure serves as a platform for identification and design of inhibitors or activators, which would specifically bind to MboIII-Mod and modulate its activity, towards drug discovery. The group also studied other restriction enzymes that can prevent bacteria from becoming antibiotic resistant.

105
Projects Sanctioned

46.39 cr
Expenditure
(New & Ongoing Projects)

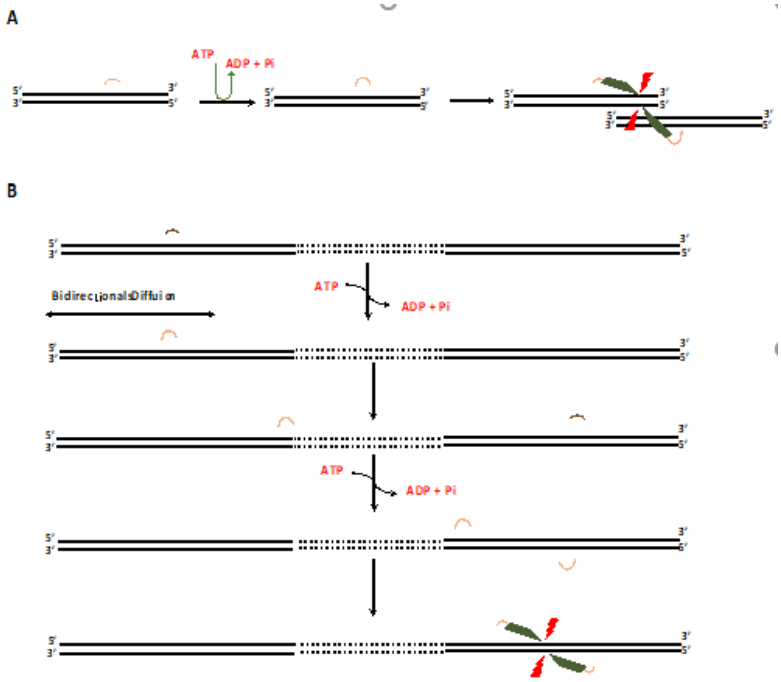


Fig. 3.31: Mechanism of DNA degradation by Type III RM enzyme.

Fig. 3.32: Structure of MboIII-Mod bound to the small-molecule inhibitor, sinefungin. (PDB Code: 7DSU).

The work was done at Indian Institute of Science Education and Research, Pune.

Utilization of textile industry sludge through application of vermitechnology: An insight on metal accumulation potential of earthworms: Textile industries produce metal-rich, toxic sludge and effluents as by-products and conventional treatment technologies are cost intensive. Earthworms efficiently bioaccumulate toxic metals and store them in benign form in intestinal tissues. The investigator group has made an effort to optimize the vermicomposting technology for transforming cotton and silk processing sludge into valuable soil conditioner for agricultural use. There were four major challenges: identifying sludge-tolerant earthworm species, reducing toxic metals in the end product, understanding the metal binding mechanism and increasing bioavailability of nutreints present in the sludge. Interestingly, textile sludge induced minimal toxic impact on Eisenia fetida among the three species used for vermicomposting. After two months of vermicomposting, significant accumulation of toxic metals like cadmium, chromium, lead and zinc by earthworms (Eisenia fetida and Eudrilus eugeniae) greatly reduced pollution risk in the textile sludge and enriched it with more nutreints (Fig. 3.33).

It is known from literature that earthworms efficiently detoxify metals by a small (~ 13 kDa) cysteine rich protein, metallothionein (MT). However, MT expression and the extent of metal accumulation often do not correlate, the reason behind such incoherence was unclear. Therefore, uorescence probed cadmium was used to navigate the metal transportation in vermibeds as well as in earthworm body. The study initially revealed that significant amount of cadmium was accumulated in different sections of the worm body. Eventually, molecular techniques facilitated to identify a few metal-induced high molecular weight proteins in cadmium exposed earthworms, out of which the most prominent one was purified. This protein is substantially large (150 kDa) and efficiently sequesters cadmium in Eisenia fetida. Eventually, microscopic analyses exhibited that the purified protein transports the bound cadmium to chloragogenous tissues, which function similar vertebrate liver, where the toxic metal is neutralized. Hence, this apparently novel 150 kDa protein is an important and promising heavy metal binding protein in earthworm (Fig. 3.34).

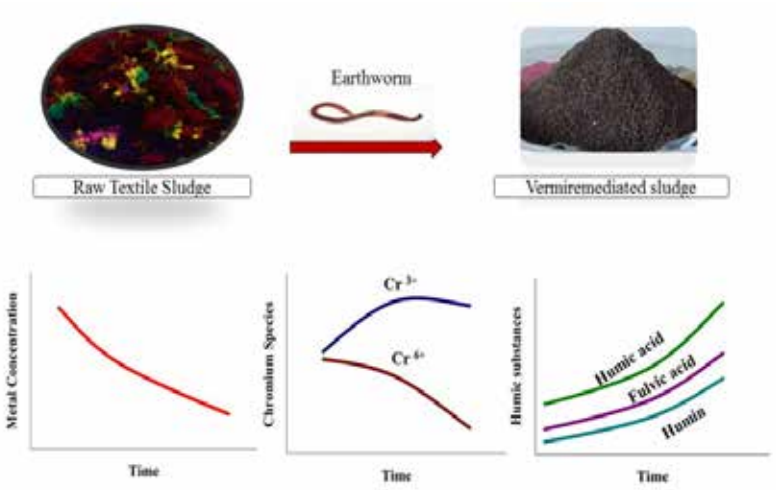


Fig. 3.33: Humic substance mediated metal reduction chromium speciation kinetics during vermicomposting of textile sludge

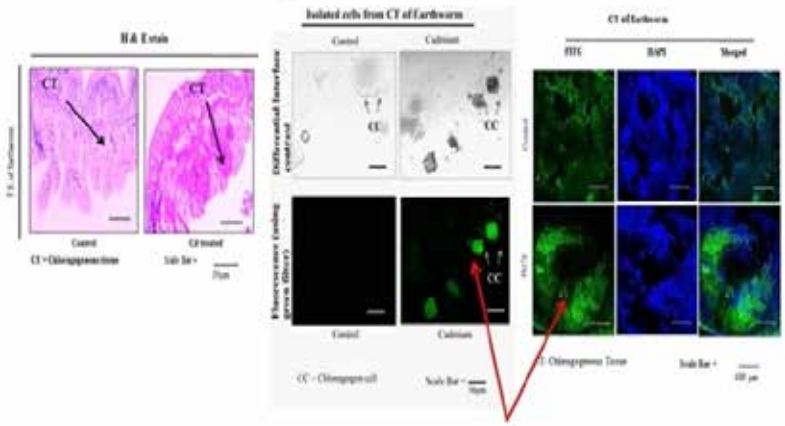


Fig. 3.34: Earthworms neutralize cadmium in chloragogenous tissue: confocal and fluorescence microscopic imagery

The work was done at Tezpur University, Tezpur.

Development and validation of an antibody-based multiplexing assay system for simultaneous detection of three major Alternaria mycotoxins: Evaluation of its application in various fruits/vegetables: Mycotoxins are the natural food contaminants, having very low molecular weight. They are non-immunogenic; therefore, conjugation with a carrier protein, BSA with of all three Alternaria mycotoxins was carried out and achieved successfully. These conjugates were emulsified with Freund's complete adjuvant and injected in Balb/c mice. After four subsequent booster doses, antibody titre for AOH-BSA >1:12800, for AME-BSA >1:51200 and for TeA-BSA conjugate >1:51200 was achieved. Splenocytes of mice, showed best titre among all the challenged mice and were successfully fused with sp2/0 myeloma cells. Simultaneously the clones having higher binding affinity to the respective conjugates, were further grown in HT medium to collect culture supernatant containing monoclonal antibodies. The monoclonal antibodies were successfully characterized and showed higher binding affinity for the respective antigen (AOH-OVA, AME-OVA and TeA-OVA) as compared to binding affinity with native protein (OVA) Figure 3.35. Monoclonal antibodies from each clone had been purified by Protein-A affinity column and isotyping of obtained monoclonal antibodies had been done and all identified as IgG2A subtype.

Further, for the simultaneous detection of three Alternaria mycotoxins by luminex suspension array system, generated antibodies were successfully coupled with the distinct microsphere beads. Coupling confirmation was successfully done by luminex analyser Figure 3.36. Successfully validated the presence of all three Alternaria mycotoxins in the spiked and real samples

(Sunflower oil). In this way, multiplex detection of three mentioned Alternaria mycotoxins in a single sample has been done successfully.

The work was done at CSIR Indian Institute of Toxicology Research, Lucknow.

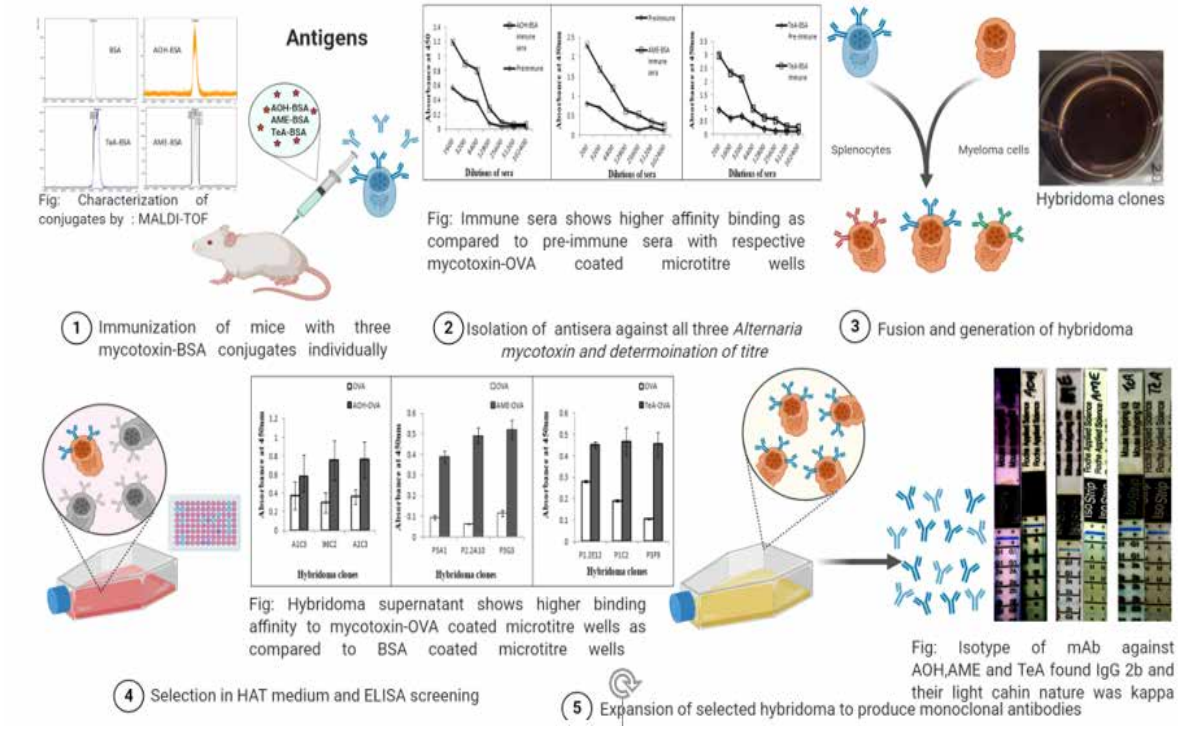
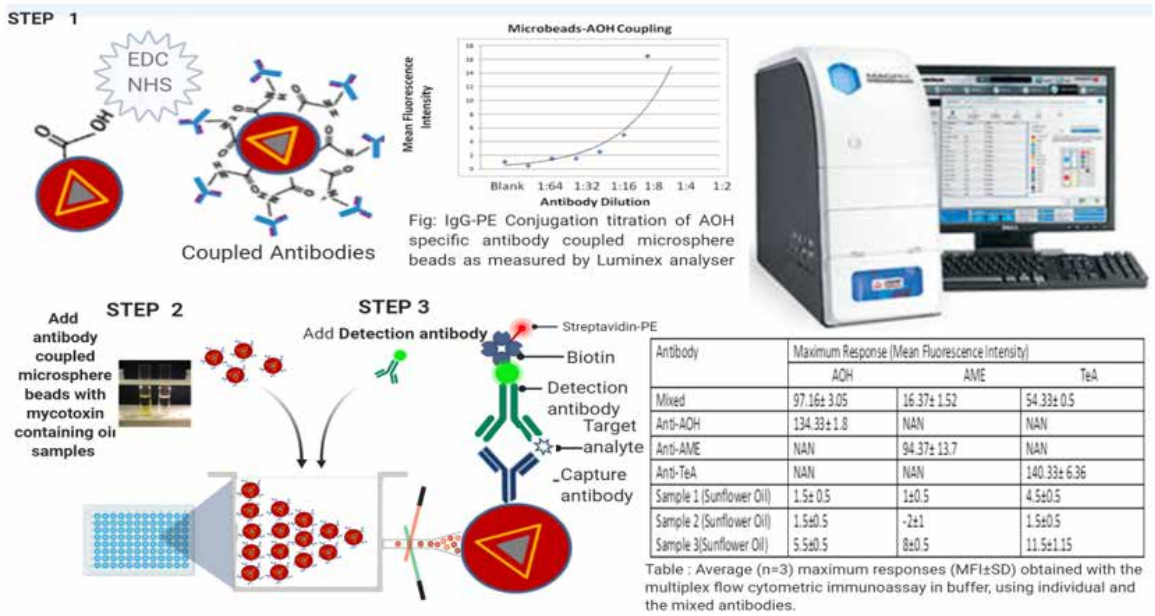


Fig. 3.35: Step1- Characterization of mycotoxin-BSA conjugates by MALDI-TOF. Step2- Immune sera shows higher affinity binding as compared to pre-immune sera with respective mycotoxin-OVA coated microtitre wells. Step3- Fusion and generation of hybridoma. Step4- Hybridoma supernatant showed higher binding affinity to mycotoxin-OVA coated microtitre wells as compared to BSA coated microtitre wells Step 5- Isotype of mAb against AOH,AME and TeA found IgG 2b and their light chain nature was kappa.



Antibody	Maximum Response (Mean Fluorescence Intensity)		
	AOH	AME	TeA
Mixed	97.16± 3.05	16.37± 1.52	54.33± 0.5
Anti-AOH	134.33± 1.8	NAN	NAN
Anti-AME	NAN	94.37± 13.7	NAN
Anti-TeA	NAN	NAN	140.33± 6.36
Sample 1 (Sunflower Oil)	1.5± 0.5	1±0.5	4.5±0.5
Sample 2 (Sunflower Oil)	1.5±0.5	-2±1	1.5±0.5
Sample 3(Sunflower Oil)	5.5±0.5	8±0.5	11.5±1.15

Table : Average (n=3) maximum responses (MFI±SD) obtained with the multiplex flow cytometric immunoassay in buffer, using individual and the mixed antibodies.

Fig. 3.36: Step1- IgG-PE Conjugation titration of AOH specific antibody coupled microsphere beads as measured by Luminex analyser. Step2- Addition of antibody coupled microsphere beads with mycotoxin containing oil samples. Step3- Table: Average (n=3) maximum responses (MFI±SD) obtained with the multiplex flow cytometric immunoassay in buffer, using individual and the mixed antibodies. NAN= Not a number (no analyte)

Bio-assay guided isolation, identification and elicitation of anticancerous bioactive compounds from *Nardostachys jatamansi*, *Psoralea corylifolia* and *Plumbago zeylanica*: Plant based natural products have a long history in the treatment of cancer and this gained momentum also due to the National Cancer Institute's drive to test various plant extracts against sixty human cancer cell lines on panel in the late 1980s. Various anti-cancerous compounds have already been commercialized for instance vincristine and vinblastine from Carharanthus roseus, taxol from Taxus brevifolia and the list is endless with many more in development and clinical trials. The project was aimed towards screening of anti-cancerous potential of important medicinal plants like: Nardostachys jatamansi D. C., Psoralea corylifolia L., and Plumbago zeylenica L. against different cancer cell lines and identification and elicitation of bioactive compounds. Some important observations were:

Nardostachys jatamansi (D. DON) DC. is reported to be the best medicine against various neurological disorders and brain related functions like cognition and memory. Roots and rhizomes of Nardostachys jatamansi are used to treat epilepsy, hysteria, mental weakness, insomnia and convulsions as mentioned in Ayurveda. Nardostachys jatamansi rhizome extract (NJRE) showed induce cell death by apoptosis in glioblastoma cells as decreased expression of caspase 3, caspase 9 and PARP was seen through immuno blotting assay.

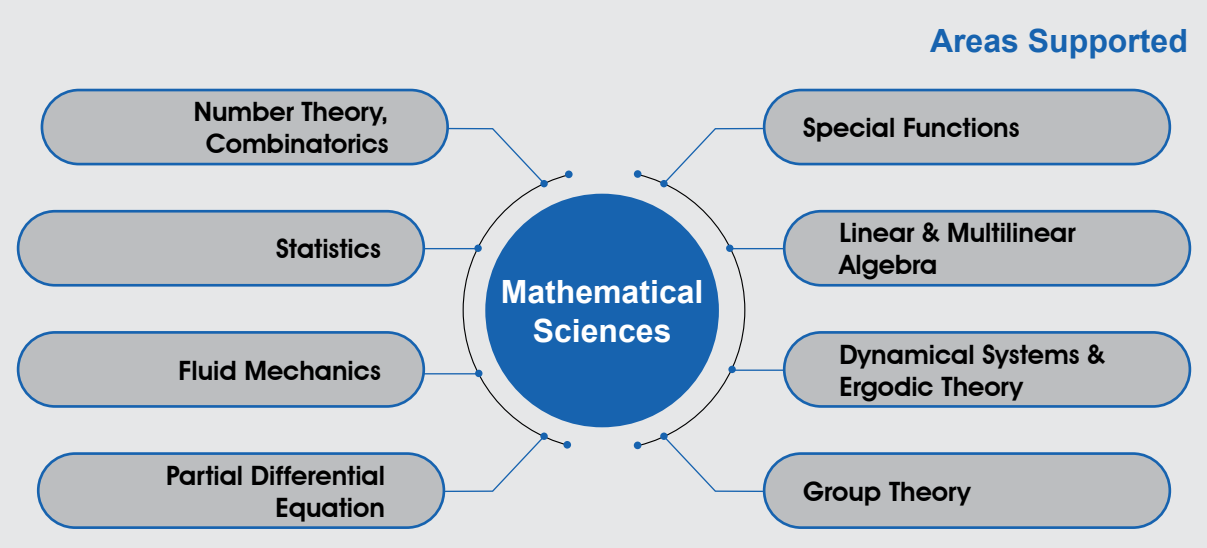
Cullen corylifolium (L.) Medik. (Syn: Psoralea corylifolia L.) has been used to treat various ailments related to skin like psoriasis, leucoderma, chronic skin disease, scabies, ringworm, vitilago, etc. and it is also effective against cancer and other diseases like leprosy. Immuno-blotting assay of green seed extract showed induced cell death by apoptosis in the U87 MG and U373 MG cells after 24 h of treatment. There was a decrease in the expression of caspase 3, caspase 9 and PARP in the treated cells indicating the activation of mitochondrial mediated intrinsic pathway of apoptosis in both the cell lines.

Plumbago zeylanica has been used to treat various diseases like dyspepsia, skin diseases, cancer and rheumatism. Plumbago zeylanica comprises set of chemical compounds which are responsible for various properties of this plant. Methanolic extract of P.zeylanica root showed cyto-toxicity against breast cancer, colon cancer. P. zeylanica root extract (PZRE) exhibited cyto-toxicity on Mia-pa-ca-2 (Human pancreatic cancer cell line) and Colo 320DM (Human colon cancer cell line) cells as evaluated through MTT assay, its IC_{50} values being 55.96 and 48.25 µg/mL, respectively, after 24 h of treatment. Tissue culture approach was also adopted for enhancement of plumbagin (secondary metabolite).

The work was done at University of Delhi, New Delhi.

3.1.1.13 Mathematical Sciences

In the reporting period, 25 new projects were sanctioned. The areas supported under CRG – Mathematical Sciences are shown in the following figure.



Research Highlights

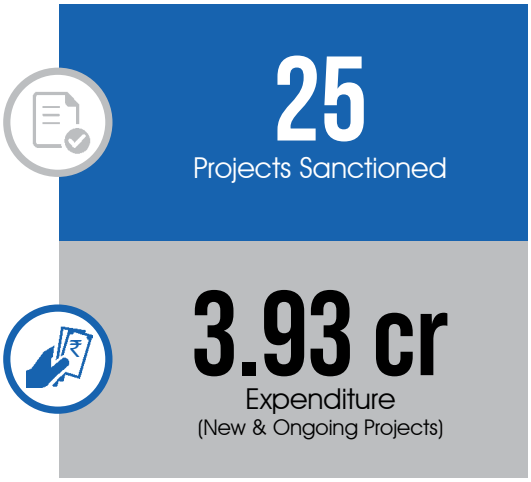
Estimation and prediction with constrained and unconstrained observations: In the present study, estimation of the scale parameter of a two-parameter exponential distribution on the basis of doubly censored data has been investigated. The classes of estimators, improving upon the minimum risk equivariant estimator under an arbitrary strictly convex loss function has been derived. Some existing dominating procedures are shown to belong to the proposed classes of estimators. Such estimation problems arise quite frequently in reliability analysis.

The inadmissibility of the best affine equivariant (BAE) estimator through a conditional risk analysis has been established. The dominance results for quadratic, linex and absolute value loss functions has been studied. Further, a class of dominating estimators is derived using the well-known integral expression of risk difference method. In sequel the generalized Bayes estimator is shown to improve the BAE estimator. Maximum likelihood and Bayesian approaches are used to obtain point and interval estimates of unknown parameters. Bayes estimates are derived with respect to informative and non-informative prior distributions when the loss function is squared error. Monte Carlo simulations and real data analysis are presented to study the performance of proposed methods.

Finally, optimal censoring plans based on the expected Fisher information matrix are investigated under different optimality criteria. By studying various inference problems under constrained and unconstrained observations one may frame guideline for selecting the better estimation methods among the different frequentist and Bayesian methods which would be of deep interest to applied statisticians/ reliability engineers.

The work was done at Indian Institute of Technology, Patna.

Study of Vector-borne diseases under the influence of environmental pollution: Environmental pollution, comprising of air, water and soil pollution, is one of the major causes of mortality across the globe and has attracted significant attention in the recent past. Regular exposure to environmental pollution results in suppression of immunity. The cumulative effect of pollution and climate change provide conducive conditions for the pathogen responsible for waterborne disease.



In this project, a compartmental mathematical model is proposed to study the impact of environmental pollution on the spread of waterborne diseases. An extensive numerical simulation is also performed to illustrate the role of environmental pollution on the spread of disease. The expression of the basic reproduction number R0 for the proposed model has been obtained. The global stability of the disease-free equilibrium is ensured if $R0 \leq 1$. When $R0 > 1$, the system tends towards the endemic equilibrium.

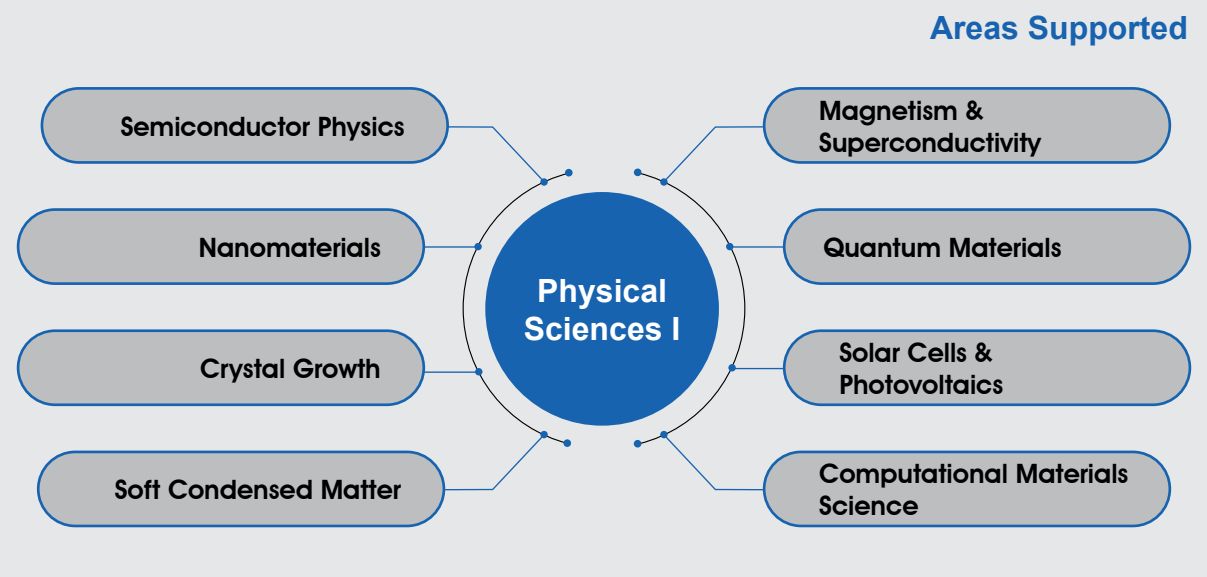
The proposed model is of four dimensions and hence it becomes little tedious to obtain the condition of global stability using compound matrix. As the number of individuals in the susceptible population affected by environmental pollution increases the disease becomes endemic. The basic reproduction number, which is considered as a threshold quantity in the disease modeling, also increases with the environmental stress. The basic reproduction number gives the number of secondary infections. Increasing the value of R0 results in more secondary infections.

The current study provides a detailed insight of impact of environmental pollution on the mechanism of infectious diseases. The present study is a first mathematical effort to understand the impact of environmental stress on the spread of infectious diseases. Both theoretical and numerical studies, demonstrated that the environmental pollution could play a key role in the spread of waterborne diseases and should not be ignored.

The work was done at Indian Institute of Technology, Mandi.

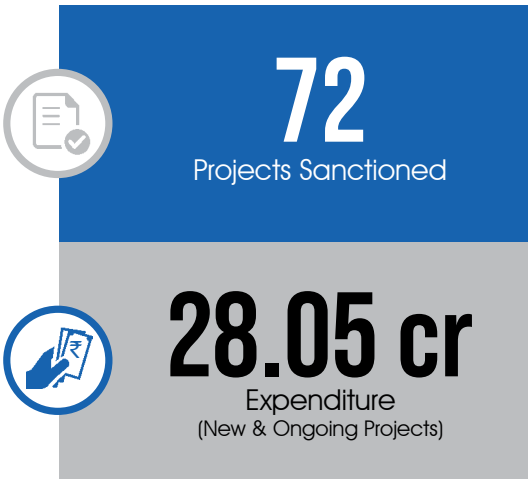
3.1.1.14 Physical Sciences I – (CMP & MS)

In the reporting period, 72 new projects were sanctioned. The areas supported under CRG – Physical Sciences I – (CMP & MS) are shown in the following figure.



Research Highlights

Development of Nano-composite Photocatalyst for Production of solar fuel (H_2) from water: In this project, the PI's group developed electrocatalyst and photocatalyst separately by implementing four different material engineering strategies and then integrating best among them to form nanocomposite photocatalyst for water splitting. Co_3O_4 electrocatalyst with single nano-dimensionality (0D nanoparticles (NPs), 1D nanowires, 2D nanosheets, and 3D nanocrystals) were synthesized and found that NPs showed the lowest overpotential and even lower than that of RuO_2 catalyst for OER. In search of bifunctional catalyst, they have fabricated Co-P-B electrocatalyst where inclusion of P in Co-B led to producing excellent HER and OER activity with required overall overpotentials comparable to Pt-RuO_2 system in 1 M NaOH (Fig. 3.37). Among Co-M-B electrocatalyst (where M = Fe, Ni, Cu, Mn, W, Mo or Cr) NPs, Co-Mo-B showed the best HER activity by achieving 10 mA/cm^2 at mere 96 and 66 mV (vs RHE) in pH 7 and 14, respectively. The optimized compound of bi-metallic phospho-boride (Co-Mo-PBO) electrocatalyst attained an outstanding OER activity of ~195 mV to achieve 10 mA/cm^2, in alkaline medium, with a minimal catalyst loading of 0.3 mg/cm^2 (Fig. 3.38). These unique contributions from each of the components result in an outstanding new benchmark mass activity of 666 A/g at 300 mV overpotential. Their work showed that transition metal boride are the ideal replacement as an electrocatalyst for noble metals (Pt and RuO_2) for overall water splitting in alkaline media. Nanostructured Urchin-like hollow V-N-codoped TiO_2 photocatalyst was developed, which showed around 5 times higher photocatalytic activity than



the pure TiO_2 powder. In case of Ag NPs decorated B and P-doped-gC_3N_4 nanosheet photocatalyst, three material engineering strategies (doping, nanostructuring, and decorating with plasmonic NPs) in gC_3N_4 were able to successfully produce over 5 times (B-doping) and 20 times (P-doping) higher H_2 production than unmodified bulk gC_3N_4. Co-Mo-B electrocatalyst loaded on nanoflakes of Ag-P-gC_3N_4/urchin-like hollow V-/N-doped TiO_2 photocatalyst was synthesized with integrating four material engineering (band gap-, interface-, cocatalyst- and nano-engineering) (Fig. 3.39). This composite was able to produce solar-to-hydrogen efficiency of 1.24%.

The work was done at Mumbai University, Mumbai

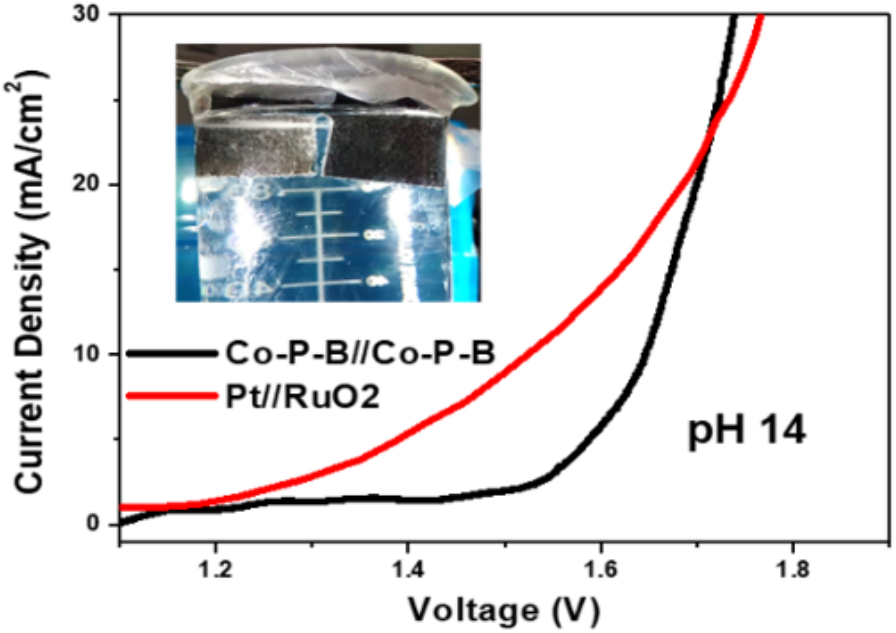


Fig. 3.37: Bifunctional property of Co-P-B

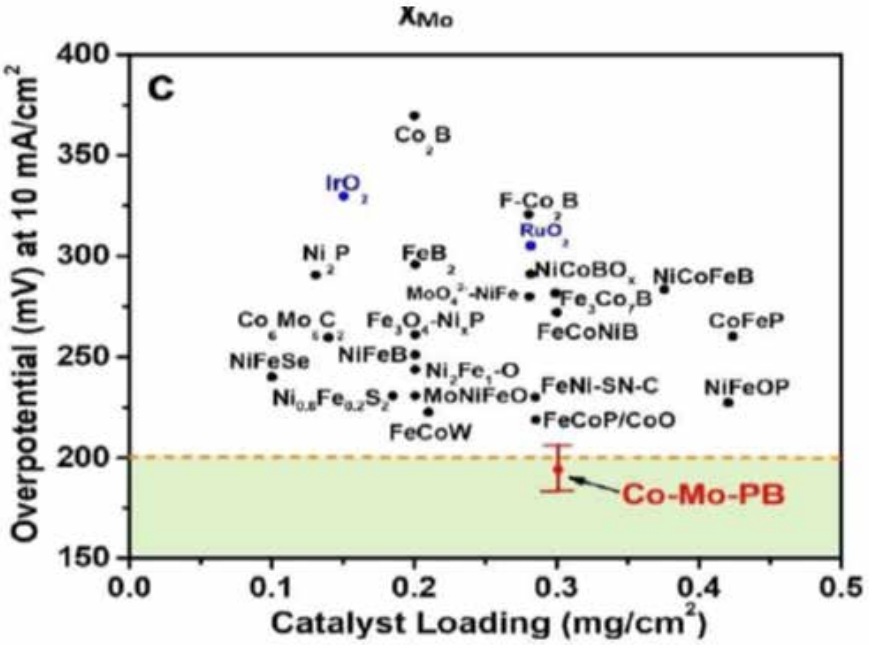


Fig. 3.38: Benchmark OER activity of Co-Mo-PBO

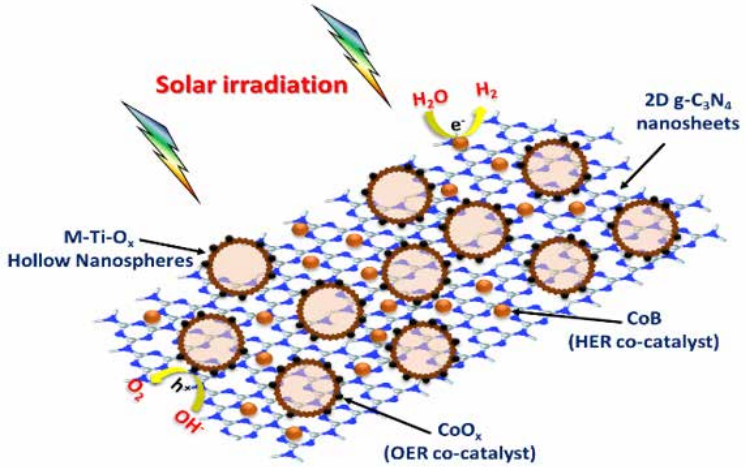
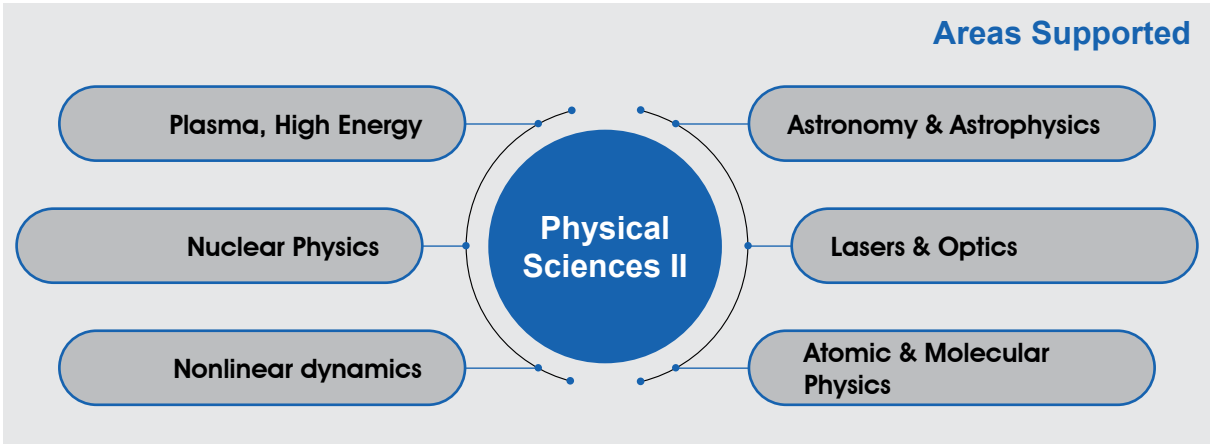


Fig. 3.39: Final nanocomposite of electrocatalyst and photocatalyst.

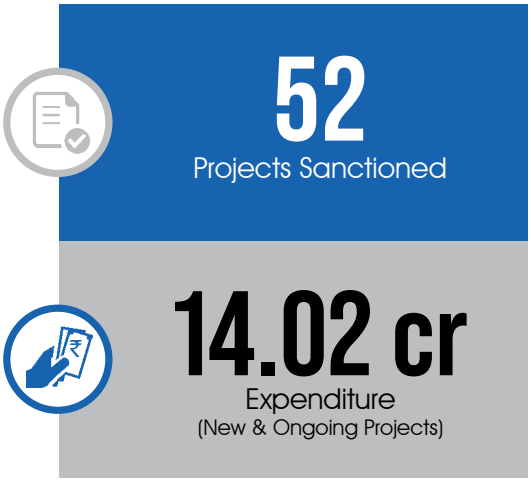
3.1.1.15 Physical Sciences II - (PHENNA-LOAMP)

In the reporting period, 52 new projects were sanctioned. The areas supported under CRG – Physical Sciences II - (PHENNA-LOAMP) are shown in the following figure.



Research Highlights

Electromagnetic metamaterials based ultra thin film sensors: The project study demonstrated that the odd order resonance modes in terahertz metamaterials offer higher Figure of Merit (FoM) towards thin film sensing as compared to the even order resonance modes. The set-up for terahertz time domain spectroscopy is shown in Figure 3.40. PI's group have experimentally demonstrated ultra thin deep sub wavelength film sensing using asymmetric metamaterials. They have attributed the observed highly efficient sensing to the excitation of dark modes. They have experimentally demonstrated that strong near field capacitive coupling can lead to sharp, high quality factor resonance modes. These modes can be useful in realizing ultra sensitive sensors. The excitation of such modes is attributed to resonance mode hybridization effects. Their investigations on polarization-independent PIT in graphene-based terahertz metamaterials have shown



excitation of strong, high Q resonance modes. These resonances could be an excellent platform to realize highly sensitive sensors. Their study has shown that suitably designed metamaterials can demonstrate ultrafast switching behavior. Such property can be useful to realize ultrafast switches for terahertz frequencies. PI's group have demonstrated excitation of Fano resonances in geometrically symmetric structures with suitably designed metamaterials. So far Fano resonance modes are excited in symmetry broken metamaterials only. However, this is the first time demonstration of Fano modes in geometrically symmetric meta structure. They have shown theoretically as well as experimentally Fano cavity based sensing in stacked metamaterials. Their investigation showed that such scheme can lead to the realization of novel thin film sensors. This is first time demonstration of thin film sensing in stacked configuration which can be useful to realize ultra sensitive sensors. Their technique was generic. Indian patent application has been filed.

The work was done at Mahindra Ecole Central, Hyderabad.

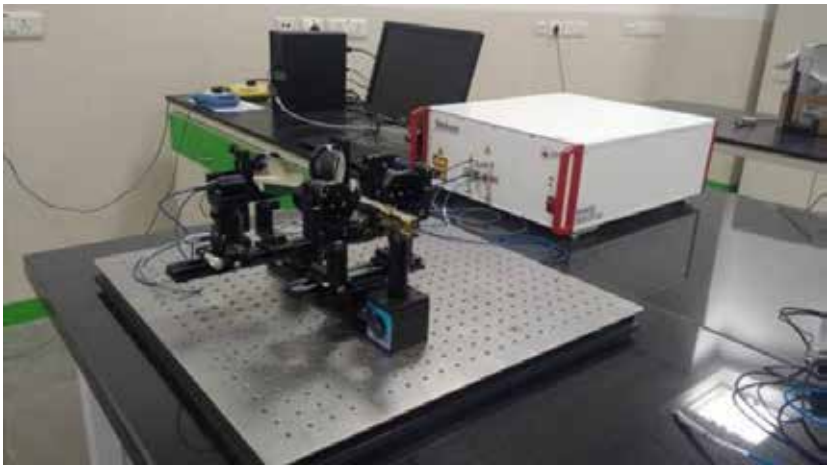


Fig. 3.40: Set-up for terahertz time domain spectroscopy

Design and development of optical microfiber based acoustic sensors for under/over water applications: The PI's group developed a working prototype of an optical fiber micro-tip based hydrophone for online and remote detection of acoustic signal. The packaged optical fiber hydrophone of dimensions 1.4 cm x 1.4 cm x 2 cm and shows a high sensitivity of 8.94 nm/mPa or -41.42 dB re 1 nm/μPa at 1 KHz. The hydrophone shows an excellent signal to noise ratio and the noise-limited minimum detectable pressure is as low as 0.388 μPa/Hz at 1 KHz which is better than the commercially available system. The linear working range of the hydrophone is 0-3950 Hz. The experimental results show that the proposed optical fiber hydrophone can very accurately detect the click trains produced by dolphins for echolocation. A patent has been filed. Also, they are in discussion with some of the Indian Companies for its prototype development and field trial. They demonstrated a fiber taper based in-line intermodal Mach-Zehnder interferometer (MZI) as a hydrophone with high performance, practical and economical system for low-frequency acoustic signal detection. The hydrophone shows a sensitivity of 14.02 nm/kPa and a minimum detectable pressure of 651 Pa/Hz in the low-frequency range (100 Hz).

A low-cost acoustic sensor using tapered fiber structure attached to a nitrile polymer was developed. The acoustic sensitivity and minimum detectable pressure at 2500 Hz are 36 mV/kPa and 21.11 Pa/Hz, respectively, for the sensor setup with tapered fiber waist diameter of 18.37 m. The sensor shows a reasonably flat response from 250 to 2500 Hz. Optical microphone consisting a single mode fiber (SMF) tapered micro-tip in cantilever configuration for detection of low frequency acoustic signals developed (Fig. 3.41). Acoustic wave of 100-2000 Hz was detected successfully using proposed microphone as shown in the previous figure. It was found experimentally that for a cantilever length of 15 mm, the probe has an acoustic sensitivity of 10.63 mV/Pa. A simple and high sensitive optical microphone/hyrophone based on S-shaped tapered (STF) fiber was demonstrated (Fig. 3.42). The sensor showed highest sensitivity of 3.07 mV/Pa, minimum detectable pressure of 36.48 mPa/Hz and a linear response upto 1300 Hz. Square Knot Resonator (SKR) is fabricated by carefully and systematically

intertwining two microfibers with each other. The reported SKR has an FSR of 0.505 nm and the Q-factor is more than 14500. The experimental results were in agreement with theoretical results. This shift in terms of sensitivity is 3.04 nm/m. The SKR shows a temperature cross-sensitivity of 3.2 pm/C. The multi-port micro-sensing system of the SKR can be used to cascade an array of sensors to enhance the spatial resolution. Further, for all the structures, depending on the applications, the performance parameters of hydrophones can be tailored as by user's requirement.

The work was done at Indian Institute of Technology, Bhubaneswar.

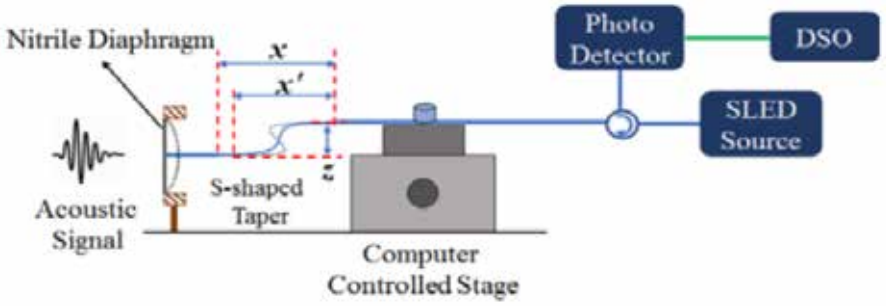


Fig. 3.41: The SMF taper is created by using in-house tapering station which is based on flame and brush technique. One side of the long taper is cleaved keeping a short pigtailed end and the other end is connected to one of the ports of the three-port circulator.

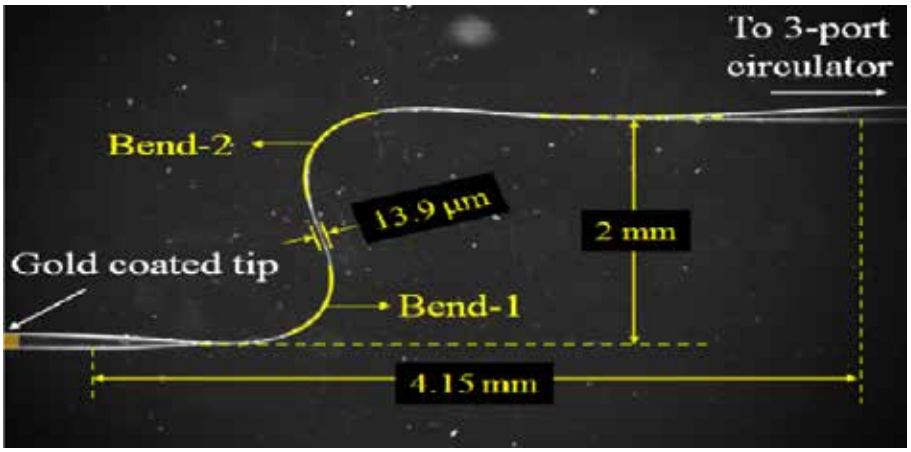


Fig. 3.42: The micrograph of the STF where the tapered fiber of 13.9 μm waist diameter and 6.4 mm length is kept in S-shaped configuration.

3.1.2 Start-up Research Grant (SRG)

It is of paramount importance to offer opportunities to young researchers to pursue exciting and innovative research in frontier areas of science and technology. SERB has created R&D platforms for young researchers to build their research career by launching Start-up Research Grant (SRG). This scheme helps the young scholars to jump-start their career in a new institution or university. It is a two-year grant for researchers to work in their areas of specialization. It motivates them to establish themselves and move on to the mainstream core research grant (CRG). Criteria for selection is based on the track record of the applicant and the proposed research plan. There are five discipline-wise verticals that are guided by individual Expert Committees.

The scheme functioned as Young Scientist Scheme (YSS) in the initial years. It was restructured into two schemes: Early Career Research (ECRA) award and National Postdoctoral Fellowship (NPDF). ECRA offered project grants for young researchers which was later restructured as SRG. The ongoing projects awarded under ECRA and YSS continue to be supported. The research highlights of some of the projects under ECRA, YSS and SRG programmes under various disciplines are provided below.

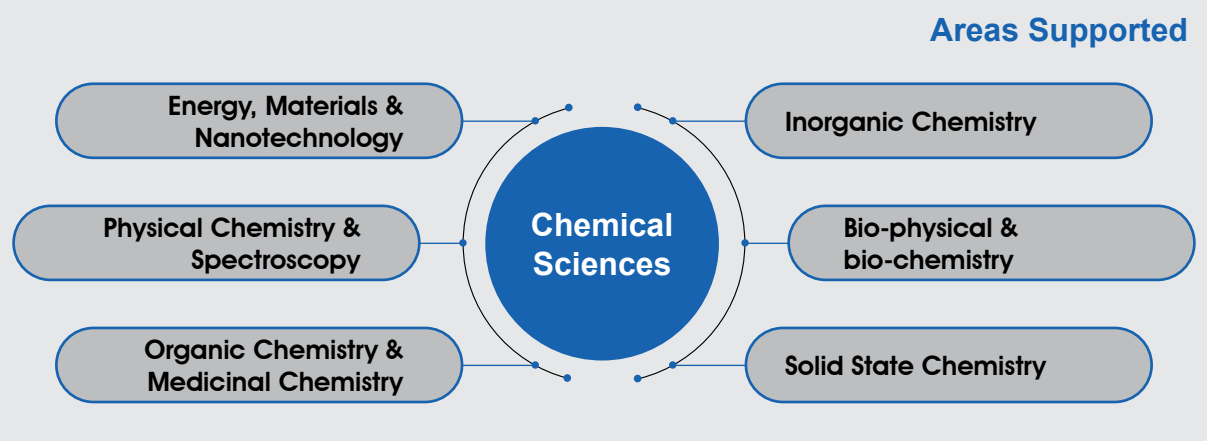
FEATURES

- SRG is a one-time-career research grant to young researchers
- Research grant of Rs. 30 lakh plus overheads for a period of two years
- Flexibility in proposing budget under various heads as per requirement

Website links
http://www.serb.gov.in/srgg.php
https://serbonline.in/SERB/srg

3.1.2.1 Chemical Sciences

In the reporting period, 74 new projects were sanctioned. The areas supported under SRG – Chemical Sciences are shown in the following figure.



Research Highlights

Design and synthesis of functionalized metal-organic frameworks for selective gas adsorption and heterogeneous catalysis: Adsorption of CO_2 under humid conditions is important, as flue gases contain some degree of moisture. However, implementing these aspects in metal–organic frameworks (MOFs) is rare and challenging due to their moisture instability. This project under Early Career Research grant, studied the pore-environment modulation in isostructural Zn-frameworks through variation of linker lengths (Fig. 3.43). Structural analysis shows narrow 2D-layer aperture blocks interpenetration and slanted linker orientation favoring criss–cross pillaring. Moisture stability experiment

74
Projects Sanctioned

20.37 cr
Expenditure
(New & Ongoing Projects)
(SRG, ECRA, YSS)

indicated increase in linker length and presence of N-functionality gradually increases CO_2/N_2 selectivity, but chances of water stability is weakened. Further, multicyclic CO_2 uptake showed that balance between high selectivity and recyclability is best reinforced in optimum-sized pore structure with narrow window.

The work was done at Central Salt and Marine Research Institute, Bhavnagar.

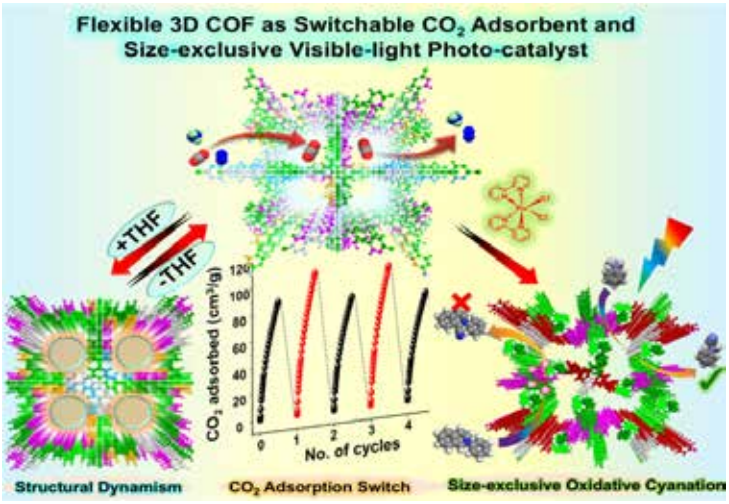


Fig. 3.43: Imine-based, diamondoid COF, that embraces one-dimensional porous channels.

Light-induced switchable molecular magnets based on 3d-5d heterometallic assemblies: Demand for magnetic materials used in recording media, hard disk drive, sensors and in magnetic random-access memory (MRAM) technology is very high. In a research project supported under the Startup Research Grant scheme, the group at the Indian Institute of Science, studied photo physical properties of magnetic materials, which can fulfill such demand. The group used a novel strategy, "complex as ligand", for designing the bifunctional magnetic materials with tuneable switching properties single molecule magnets (SMMs) and spin crossover (SCO), in solid state as well as in solution. One can control such switching properties by modifying ligands, linkers, matrix of the systems, solvents or by chemical modification.

As a part of this study, the cobalt(II)-based single molecule magnets (SMMs) were explored for investigation of magneto-structural chemistry in a series of mononuclear cobalt(II) complexes based on tridentate bbp ligand (bbp = 2,6-bis (1H-benzo[d]imidazol-2-yl) pyridine) (Fig. 3.44). Detailed physical characterization including X-ray structure analyses, magnetic measurements, EPR studies and theoretical calculations were undertaken to explore and tune the SCO properties of a series of cobalt(II) complexes via modulation of linear and nonlinear pseudohalides.

The reaction of Co(II) salt with two equivalents of NCX^- (X=N(CN), S, Se and $C(CN)_2$) and macrocyclic ligand L (N,N'-di-tert-butyl-2,11-diaza[3,3](2,6)pyridinophane) produce crystalline mononuclear complexes $[Co(L)(NCX)_2]$ (X=N(CN), S, Se, and $C(CN)_2$. Interestingly use of one equivalent of NCX^- (X= N(CN) and $C(CN)_2$) forms a 1D coordination polymer $\{[Co(L)(\mu_{1,5}\text{-dca})](BF_4)\cdot MeOH\}_n$ (dca = $N(CN)_2$) and a discreate dinuclear complex $[Co_2(L)_2(\mu_{1,5}\text{-tcm})_2](BF_4)_2$ (tcm=$C(CN)_3$), respectively.

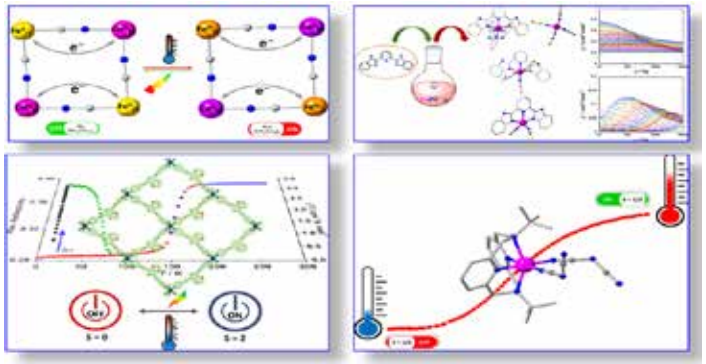


Fig. 3.44: Perspective view of switchable molecular magnetic materials

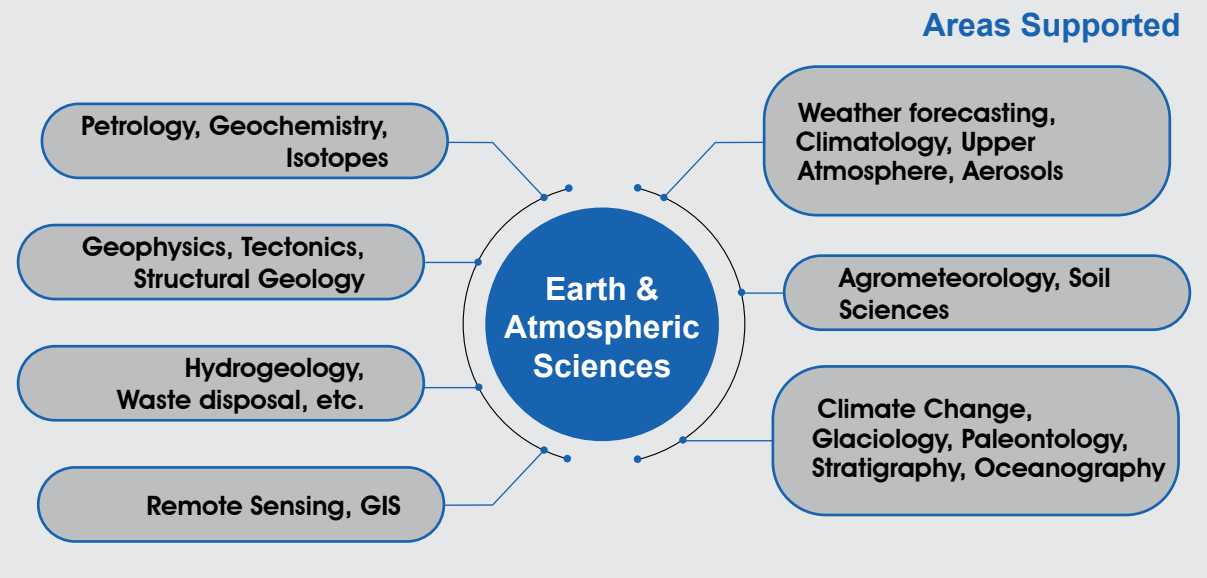
On the other hand, two-step thermo-induced metal-to-metal electron transfer and ON/OFF photo-switching in a molecular [Fe_2Co_2] square complex were also explored and reported ON/OFF photo-switching and thermo-induced spin crossover with cooperative luminescence in a 2D Iron(II) coordination polymer.

Most of the above-mentioned systems exhibit bistability and one can go from one state to another state selectively by applying an external perturbation such as light, temperature, pressure, magnetic field, etc. Therefore, some of these systems can be used as switches or sensors.

The work was done at Indian Institute of Science, Bangalore.

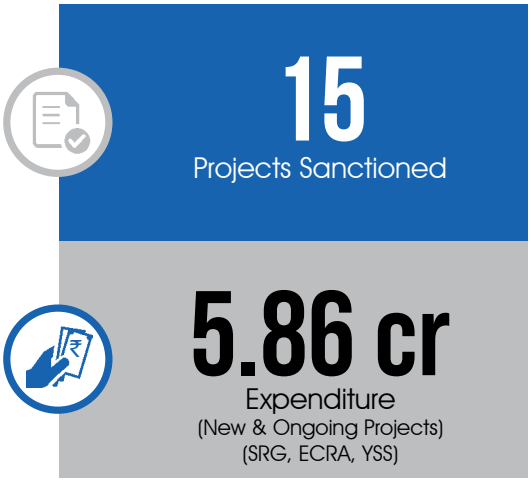
3.1.2.2 Earth and Atmospheric Sciences

In the reporting period, 15 new projects were sanctioned. The areas supported under SRG – Earth and Atmospheric Sciences are shown in the following figure.



Research Highlights

Understanding new aerosol particle formation in the atmosphere: Observation, modeling and comparisons: Using 21-months (December 2016 – September 2018) of continuous aerosol size distribution measurements from Ranichauri, Western Himalaya, the investigators established statistics on new particle formation (NPF) rates, growth rates, seasonal variability, survival probability and cloud condensation nuclei (CCN) formation rates of newly formed particles to climate-relevant aerosols (Fig. 3.45). This study, for the first time to the investigators' knowledge, linked NPF to climate-relevant aerosols in India.



NPF occurred more frequently in air masses with low black carbon concentrations (cleaner) than polluted air masses with faster growth rates and formation rates during cleaner event days. The survival probability to 50 nm particles ranged from 44 to 98%, with a mean and standard deviation of 82 ± 18%. On average, ~60% of the particles surviving to 50 nm survived to 100 nm, making the overall survival probability of 100 nm to 53 ± 31%. The uplifting of the planetary boundary layer to the elevation of the measurement site appeared to carry aerosol precursor vapors for particle growth at a

relatively lower background pre-existing particle concentrations. This indicates that the probability of nucleated particles growing to CCN-active sizes under a large source of condensing vapor (transported from nearby lower-altitude regions) and low pre-existing particle concentrations (background mountain site) is high compared to the previous studies elsewhere. These findings highlight the importance of the efficiency of aerosol nucleation events for producing CCN, which is a critical basis of aerosol indirect effects.

The work was done at University of Hyderabad, Gachibowli.

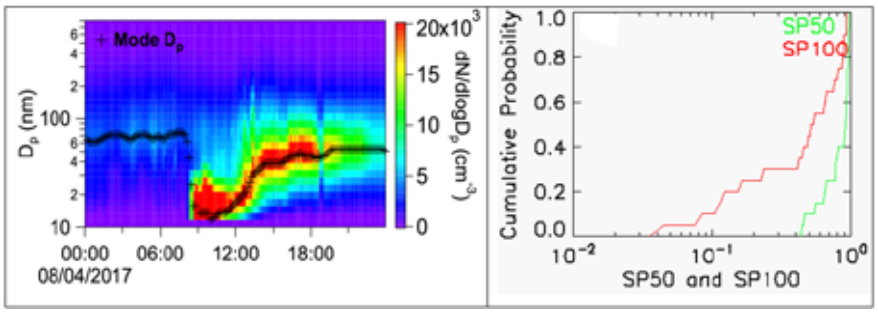
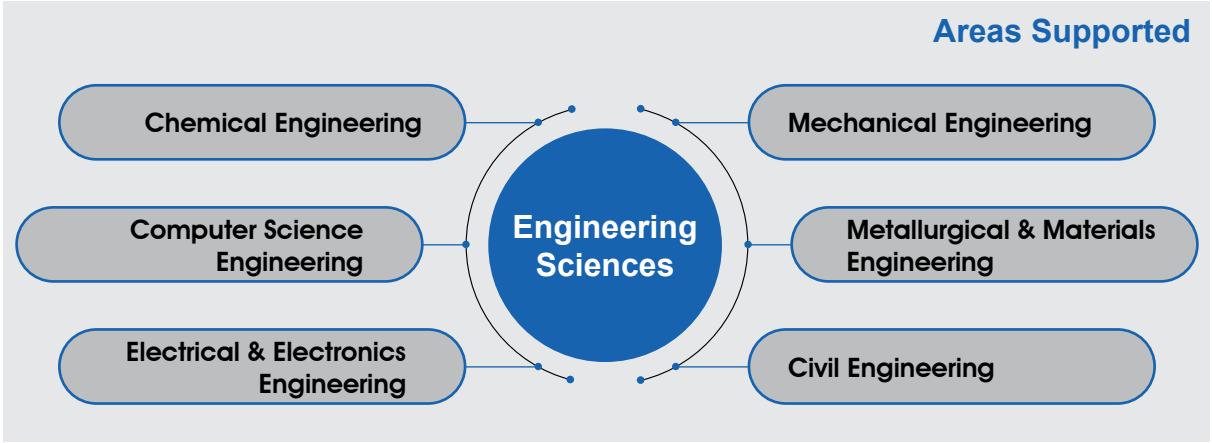


Fig. 3.45: Time-evolution of particle number-size distributions and particle mode diameter on a typical new particle formation event at Ranichauri (left). Cumulative probability distributions of survival probability to 50 nm and 100 nm particles (right).

3.1.2.3 Engineering Sciences

In the reporting period, 199 new projects were sanctioned. The areas supported under SRG – Engineering Sciences are shown in the following figure.



Research Highlights

Development of an advanced System on Chip (SoC) based embedded controller for power electronic converters: The primary focus of the project is to develop a System on Chip (SoC) based next generation embedded controller for advanced power electronic systems. The controller will provide: 1) large number of switching signals through optical interface 2) analog sensing and calibration 3) fault detection, protection and fault buffer data acquisition 4) a number of reconfigurable digital input and output channels 5) industry standard communication like MODBUS over TCP / IP.

199
Projects Sanctioned

52.89 cr
Expenditure
(New & Ongoing Projects)
(SRG, ECRA, YSS)

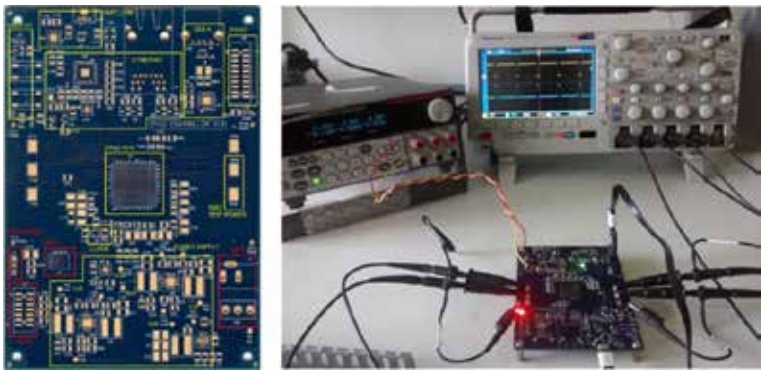


Fig. 3.46: Developed launchpad with SoC chip Zynq7010.

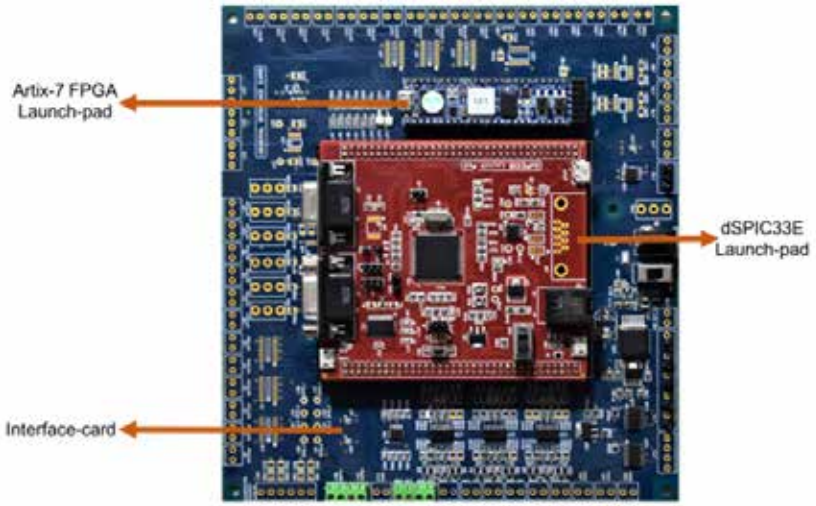


Fig. 3.47: The SoB based embedded controller for teaching laboratory

TA launch-pad around Zynq 7010 (SoC from Xilinx) was designed as shown in Figure 3.46. The Launchpad incorporates a set of SMPS with different voltage levels (1V, 1.8 V, 3.3 V etc.) capable of the required complex power sequencing process. A 33.33 MHz oscillator provides the main clock. Three different types of communication: Gigabit Ethernet, and USB are available. A large number of digital I/O's are brought out (100 from PL and 10 from PS). Zynq 7010 IC is a 400 pin high density Ball Grid Array (BGA) with a 0.8mm pitch; hence the layout involved tackling challenges associated with high speed, high density Printed Circuit Board (PCB) design. A 7-layer PCB was designed and sent out for manufacturing.

As SoC (System on Chip) is a complex and advanced platform, for teaching laboratory a SoB (System on Board) based embedded platform was developed where a DSC was connected to a FPGA chip through high speed parallel communication controlled by DMA (Dynamic Memory Allocator) of DSC and DP (Dual Port) RAM of FPGA as shown in Fig. 3.47. A launch-pad with dsPIC33E (A Digital Signal Controller, DSC, from Microchip) has been developed along with an interface-card, that integrates the DSC with an Atrix-7 (FPGA from Xilinx) housed in another launch-pad procured from an external vendor. The developed solution has the following features: a) 16 PWM channels, b) 4 digital to analog conversion channels c) 16 analog input channels d) high speed parallel communication between DSP and FPGA d) UART, SPI, I2C, USB OTG and CAN for communication.

The work was done at Indian Institute of Science, Bangalore.

Large scale synthesis of WO3-x nanowires for chemiresistive gas sensors: The primary goal of the project is to establish the milling parameters for alloying the tungsten with Magnéli phase forming elements so as to create the strained surfaces to promote the crystallographic shear phase formation and optimize the annealing temperature and atmospheric conditions with variable tungsten-based alloys to synthesize the tungsten oxide nanowires. Apart from it, to compare the effect of different alloying elements

and annealing conditions so as to make a guideline for best possible way to grow tungsten oxide nanowires at the larger scale.

After milling of tungsten powders, the aim was to synthesize non-stoichiometric tungsten oxide nanowires. The approach adopted was thermal annealing. The milled powders are sprinkled in to an alumina tray and placed in the uniform heat treatment zone of the tubular furnace. The initial heat treatments were carried out in Argon atmosphere at various temperatures. However, it was observed that the material turns in to tungsten oxide (WO_3) partially or completely based on the selection of tempearure regime. Higher temperatures mostly contributed to more oxidation. The SEM micrographs of the unmilled samples and milled samples after heat treatment showed particle nature and flaky nature respectively (Fig. 3.48).

The oxidation behaviour was significantly influenced by the crystallite size and lattice strain induced in the initial tungsten due to high energy ball milling (HEBM). The nanocrystalline nature of the M-WO_3 was as shown in Fig. 3.49. The nanocrystalline WO_3 (M-WO_3) showed increased band gap of 2.65 eV in comparison to bulk which is 2.58 eV. Such band gap alteration was attributed to the crystallite size and unit cell volume differences.

It was observed from the above results that, the nanowire growth depends on the atmosphere of the furnace and the nanowires can be synthesized at lower temperatures (~800°C) by maintaining appropriate furnace atmospheres. The H_2O vapour atmosphere during heat treatment was observed to be appropriate for the WO_{3-x} nanowire formation.

The work was done at Visvesvaraya National Institute of Technology, Nagpur.

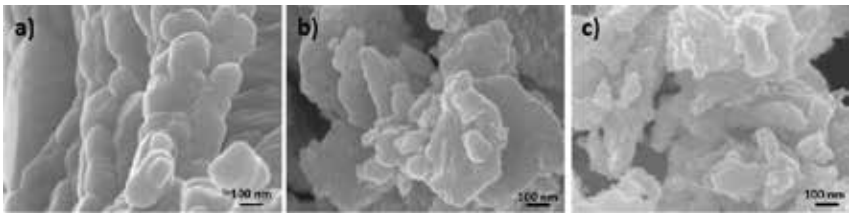


Fig. 3.48: SEM micrographs of a) Unmilled W heat treated at 800°C, b) 300-5:1-2h milled samples heat treated at 800°C and c) 500-30:1-2h milled sample heat treated at 700°C.

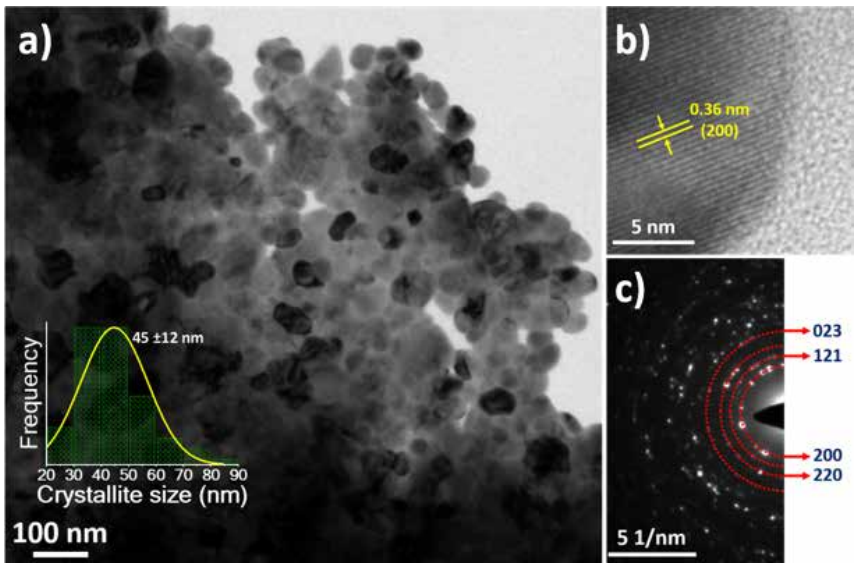
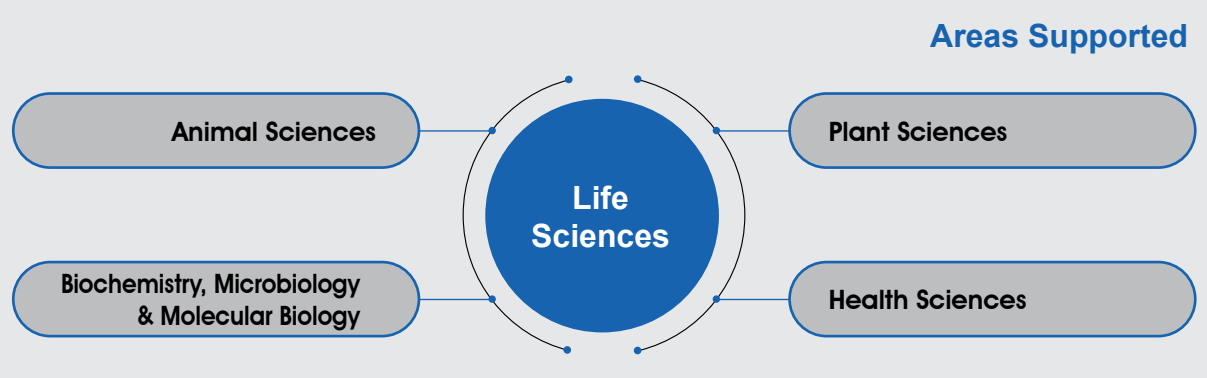


Fig. 3.49: a) The dark Field TEM micrograph of M-WO_3 showing the average crystallite size of 45±12 nm (inset: the histogram of crystallite size distribution), b) HRTEM micrograph indexed as (200) plane with measured d-spacing of 0.36 nm, and c) the SAED ring pattern.

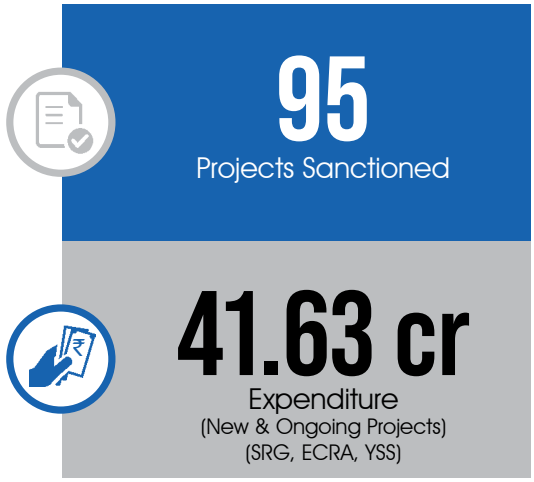
3.1.2.4 Life Sciences

In the reporting period, 95 new projects were sanctioned. The areas supported under SRG – Life Sciences are shown in the following figure.



Research Highlights

RhoC regulates cancer stem cells in cervical carcinoma : RhoC genes drive the maintenance of stem-like characteristics in cervical carcinoma Clonogenicity assay, a representative of stem-like phenotype, revealed increased colony forming capability in SiHa-R cells (RhoC overexpressing SiHa cells). Role of RhoC (an attribute of cancer stem cells) to radiation resistance in cancer therapy was tested by modulating RhoC expression and radiating SiHa cells. SiHa-R cells were seen to have significant survival advantage post irradiation at 8Gy while CaSki-dnR cells were seen to be sensitive to radiation as compared to control CaSki-N cells and SiHa-R cells also formed a larger number of clones post radiation. It was investigated whether cells with elevated levels of RhoC had better DNA repair machinery. As expected, there was increased levels of DNA repair proteins like MRE11 and RAD50 in SiHa-R cells, decreased RAD50 in CaSki-dnR cells and -H2AX was overexpressed in SiHa-R xenografts (Fig. 3.50).



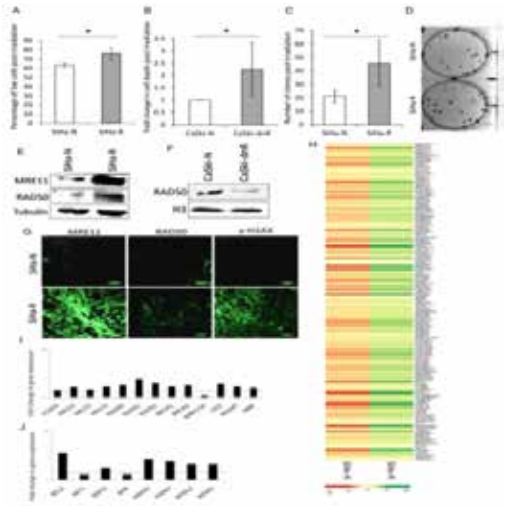


Fig. 3.50: Role of RhoC in response to radiation treatment resistance to therapy

To identify the downstream effectors of RhoC a transcriptomic study was performed on SiHa-R and SiHa-N cells. There is a differential expression of genes in SiHa-R cells. Analysis revealed that the genes involved in DNA repair, cell cycle and chromatin modeling were also up-regulated in SiHa-R. Downstream effectors of RhoC in stemness data thus far suggested a role for RhoC in stemness phenotype. The trancriptomic data analysis further revealed an upregulation of stemness associated genes. qPCR analysis of genes involved in stemness like Oct4, Nanog, CD49F, CD133 and Notch1 confirmed up-regulation in SiHa-R cells. siRNA mediated gene silencing of RhoC led to reduced expression of Oct4, Nanog, POSTN and ALDH9A1. The expression of stemness genes like CD49F, Notch1, Notch3, ABCG2, POSTN and ALDH9A1 were found to be depleted in CaSki-dnR cells. Immunoblot analysis confirmed upregulation of Nanog and ALDH in SiHa-R cells and reduction upon siRNA knockdown. Hoechst 33342 exclusion assay was performed and it was observed that SiHa-R cells had decreased intensity of Hoechst staining as compared to SiHa-N, reasserting their stem-like nature and Verapamil treatment further confirmed that SiHa-R cells had better efflux. These data confirm that RhoC modulates stemness in cervical cancer cells (Fig. 3.51).

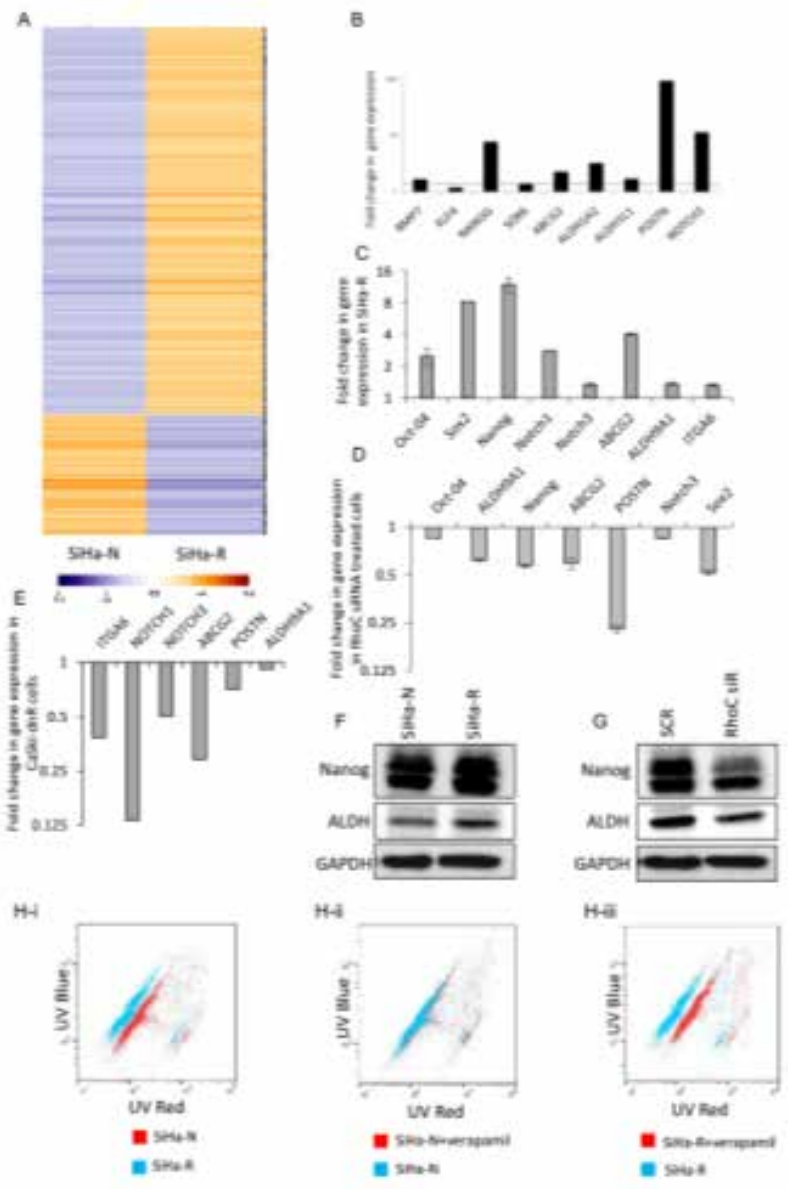


Fig. 3.51: Downstream effectors of RhoC in stemness

RhoC modulates expression of CD49F, a critical marker of stemness in cervical cancer flow cytometry and western blotting data showed increased expression of CD49F in SiHa-R cells and that the RhoC positive cells co-expressed CD49f. An over-expression of CD49f in CaSkidnR cells rescued the impaired stemness phenotype suggesting CD49F as a downstream effector of RhoC in maintenance of stemness in cervical cancer. RhoC modulates gene expression by regulation of transcription factors via the ERK pathway. Further, the mechanism of regulation of gene expression by RhoC was investigated. Expression analysis revealed that p-p53, CREB, p-CREB, E2F and cEBP were overexpressed in SiHa-R cells (Fig. 3.52) while E2F and cEBP in particular showed significant increase in nuclear expression. Alternatively, knockdown of RhoC resulted in reduction in expression and nuclear localization of E2F and cEBP. This was further confirmed by western blotting. Since both E2F and cEBP are prominent transcription factors regulated by the ERK pathway, it is hypothesized that RhoC could be modulating stemness via ERK signaling. Analysis of p-ERK levels in SiHa-N and SiHa-R cells revealed highly active ERK signaling in SiHa-R cells.

In conclusion, this work confirms RhoC's significant contribution to stemness maintenance in cervical carcinoma, and identifies ERK signaling and epigenetic modification as mechanisms of the same. The study then goes on to prove this hypothesis in patient-derived biopsies and shows co-expression of RhoC with markers of stemness in these samples, indicative that RhoC positive cells are indeed stem-like.

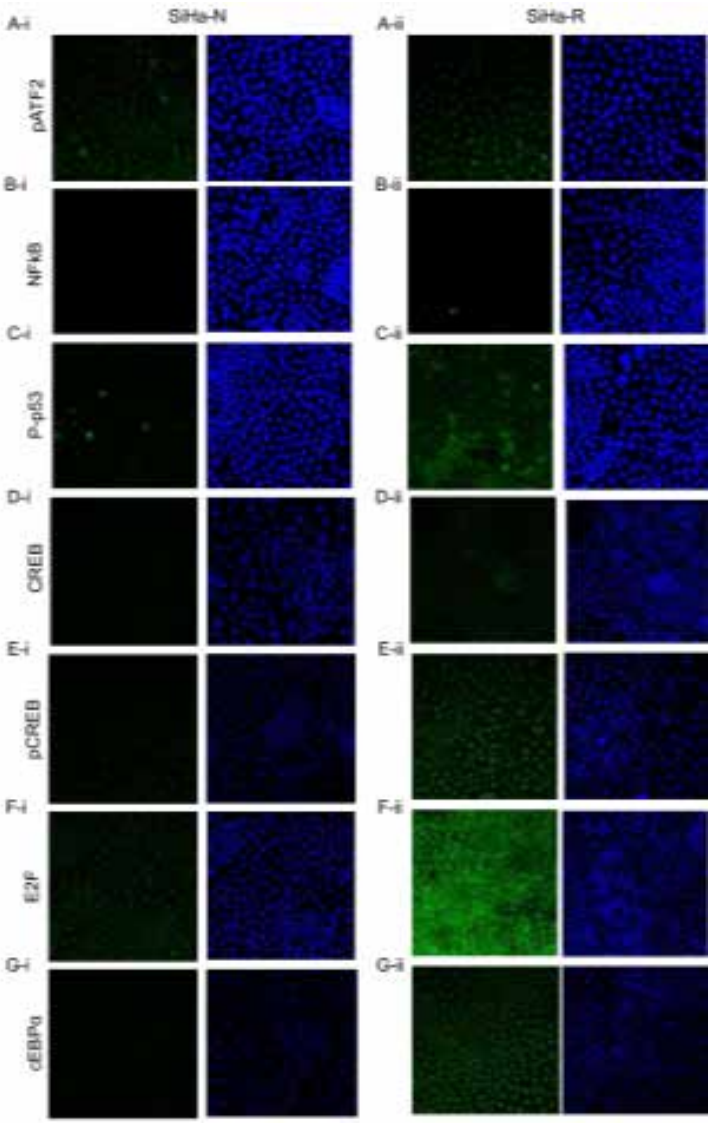


Fig. 3.52: RhoC modulated gene expression by regulation of transcription factors via ERK pathway

Expression, purification and structural characterization of LnmI, a non-ribosomal peptide synthetase-polyketide synthase from the leinamycin biosynthetic pathway : The present study successfully cloned, overexpressed and purified different constructs Cy1-Cy2 domains, A-PCP-Ox domains and module2 (Cy1-Cy1-A-PCP-Ox) of LnmI of Streptomyces atroolivaceous. Analytical gel filtration, SEC-MALS, Blue Native PAGE negative staining TEM and cryo-EM were performed to check the protein quality and oligomeric state of different constructs of NRPS of lnmI. NRPS (module2) is a part of lnmI hybrid (NRPS/PKS). Through biochemical and structural characterisation it is clearly indicated that different constructs of NRPS of lnmI forms dimer. This is the first report of dimeric NRPS. LnmI is a hybrid NRPS-PKS, and PKS is usually adopt a dimeric conformation for enzyme activity. NRPS (Cy1-Cy1-A-PCP-Ox) directly interacts with PKS to transfer the aminoacyl intermediate products PKS module from NRPS module through PCP domain. Therefore, this might be possible that the NRPS module interact tightly with PKS module to form a dimer complex and dimerization might be required to interact with downstream PKS module. Therefore, for the transfer of intermediate product from NRPS to dimeric PKS, there should be crosstalk between module2 (NRPS) and module3 (PKS) of lnmI which is possible only when NRPS is also dimer. Additionally Cy1-Cy1 and A-PCP-Ox separately forms a dimer, which indicates the full NRPS has two, Cy1-Cy1 and A-PCP-Ox dimer interface. Till now, there is no structural report homodimer NRPS of hybrid NRPS/PKS. Previous reports show that NRPS is forming monomer (21, 22) but it can form dimer only with the help of an enzyme which can act in either cis or trans form. There are several other studies indicate that hybrid NRPS/PKS (HMWP1 protein), can form monomer as well as dimer. The reason behind these mixed population is that in this hybrid NRPS/PKS, PKS does not contain a DH domain or dimerization α-helices of docking domains, the dimer interface of the KS domain alone might not be enough for the whole HMWP1 protein to maintain a dimeric state. However, LnmI NRPS has both DH and KS domain present in PKS module, which assists PKS to form a stable dimer. Therefore, this dimeric PKS also holds upstream NRPS strongly to form a stable dimer. Furthermore, these two extra dimer interface (Cy1 and A) also tightly holds NRPS to form a homodimer and communicate with dimeric PKS module. Additionally, was characterized a cryo-EM structure of Cy1-Cy2 domains at 7Å resolution (Fig. 3.53). A new method was developed to prepare cryo-EM holey grids coated with graphene oxide, which is extremely useful to visualize the small protein molecules like Cy1- Cy1 domain and A-PCP-Ox. Graphene oxide coated grids are transparent and stable in presence of electron beam, which is capable to absorb more protein molecules for cryo-EM imaging. Therefore, less amount of protein is required for data collection and structural characterization. Docking into the cryo-EM map is performed using rigid body fitting option in Chimera and docked structure clearly indicates that four VibH (1l3a) monomer units are fitted into the cryo-EM map, which supports the dimeric results of Cy1-Cy1 domains. There is no structural information of Cy1-Cy1 domain available. This is the first cryo-EM near-atomic resolution structure of Cy1-Cy1 domain of LnmI AT-less hybrid NRPS (Fig. 3.54).

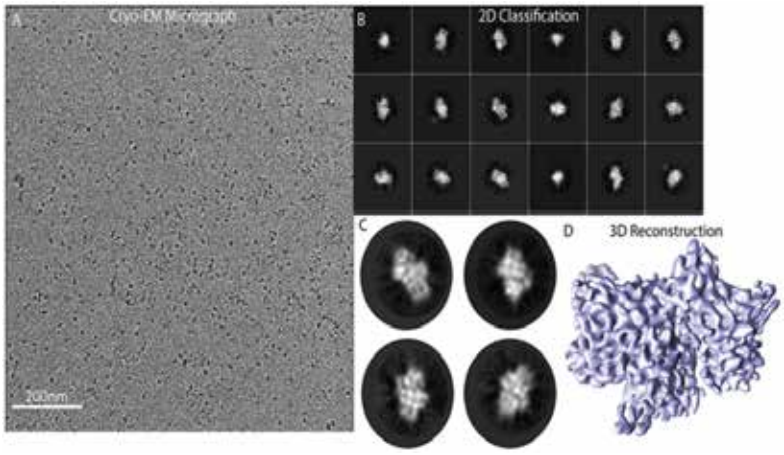


Fig. 3.53: Cryo-EM studies and structural characterization of Cy1-Cy1 domains. A. High resolution cryo-Em micrograph. B & C. Reference free 2D class averages indicates rectangular shate conformation. Enlarge view of 2D class averages of Cy1-Cy1 domains c. D. Cryo-EM structure of Cy1-Cy2 domain is determined at 7A resolution.

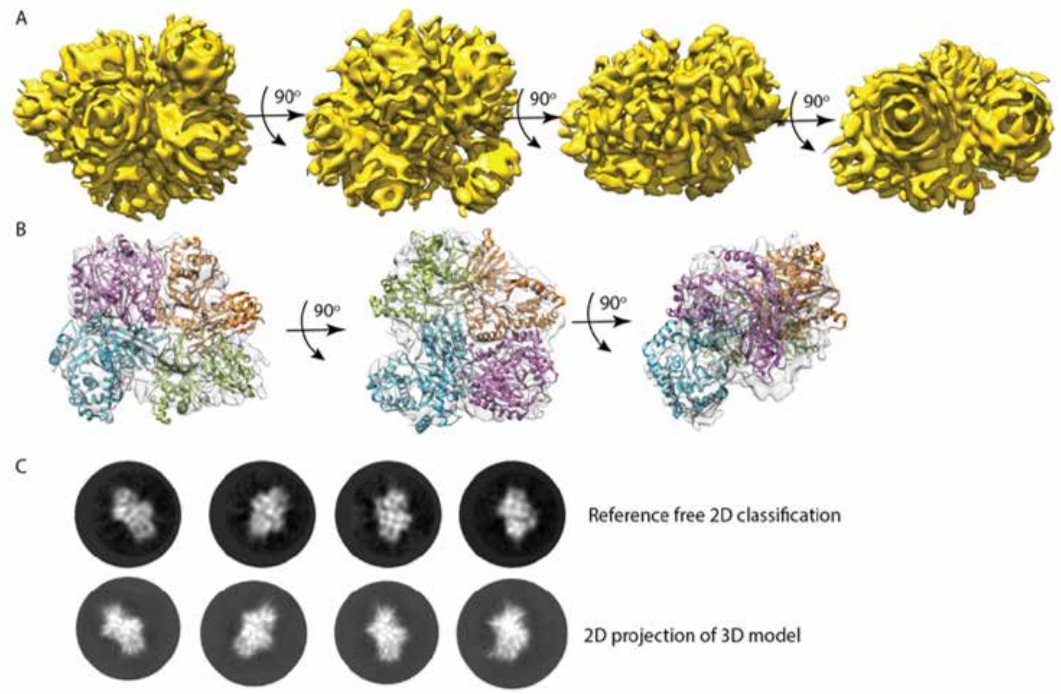


Fig. 3.54: Final Cryo-EM structure and docking of Cy1-Cy1 domains: A. High resolution cryo-EM micrograph of Cy1-Cy1 domains at different orientation. B. The pdb ID 1l3a, crystal Structure of VibH, an NRPS Condensation Enzyme is fitted into cryo-EM reconstruction of Cy1-Cy1. C. The comparison of reference free 2D classification and 2D projections of 3D reconstruction. This comparison clearly indicates that reference free 2D class averages and 2D projections of 3D reconstruction are rectangular shape conformation.

Exploration of azadirachtin targets in helicoverpa armigera by proteomics and genomics approach- a potent larvae killer from azadirachta indica: Helicoverpa armigera (Hübner) (Lepidoptera: Noctuidae) is a polyphagous and universal agronomically significant insect pest. H. armigera is accountable for about 50-90% yield losses in various cash crop plants like cotton and sunflower, pulses, ornamentals, cereals, etc. To manage this pest in the field, prolific use of synthetic pesticide is practiced. However, current strategies for the control of H. armigera have relied heavily on conventional chemical control, resulting in the development of resistance in H. armigera to almost all the insecticides. Considerable research has demonstrated the potential of insects to adapt to diverse phytochemicals and toxins. Man-made insecticides are extremely dangerous to human health and our ecology. This has placed abundant stress on bio-pesticide research and usage. Evolution of resistance in pests against Bt toxin has squashed their benefits.

In this study, metabolomics approach sheds light on the degradation/catabolism of AzaA by the H. armigera. The fragmentation pattern and products of AzaA has been proposed for the first time. The new 35 metabolites were identified after the catabolism of AzaA in larve of H. armigera and structure of those de novo catabolised products were converted into PDB file. Their interaction study was done by molecular docking approach. Molecular docking has been performed between above mentioned 6 enzymes and new metabolites using AutoDock 4.2. It is proved by in-silico analysis that all the derivatives showed insecticidal property and strongly bind to the active site of JHE. Unlike AzaA, the entire catabolized derivatives bind to various proteins indicate that the mode of action might exploit many different targets in the insect. Hence, pest will not become resistant to aforesaid metabolites (Figs. 3.55 and 3.56).

Most insecticides have a single highly conserved protein target, thereby not only harming beneficial insects but also facilitating resistance evolution in pests. Hence, a pesticide with multiple targets without harmful ecological effects is needed. AzaA's catabolised products/metabolites may have potential to accomplish this prerequisite. This study will help to develop ecofriendly, antifeedant and toxic new metabolites to cope up the key agricultural pest H. armigera, which has evolved resistance to most insecticides in current use.

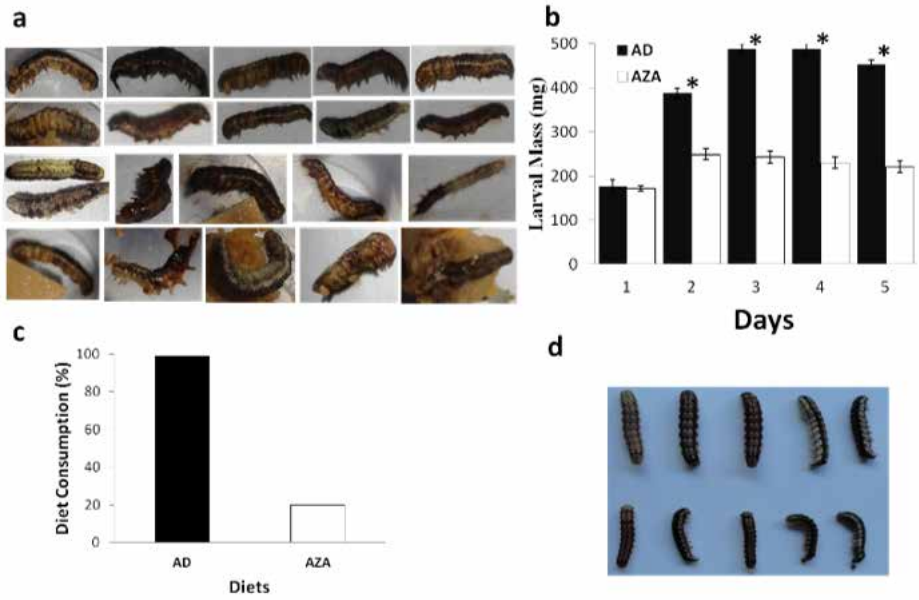


Fig. 3.55: Growth performance and phenotypic observations of H. armigera reared on AzaD and AD diets. (a) Phenotypic observations of AzaD fed H. armigera showing bursting of whole insect, seizing of molting and many more phenotypes. (b) Larval mass fed on AzaD (hollow bars) and AD diet (black bars). Graph shows average mass from each set of 15 larvae. Larvae were critically weighed after every 24 h. (c) Diet consumption data of H. armigera reared on AzaD and AD diets. Larvae fed on AD finished all diet (~99.99%) in four days (black bar) whereas insects fed on AzaD could consumed only ~20% of the total diet (hollow bars). (d) Photograph of larvae grown on an AzaD showing stunted growth (lower row) and AD diet showing normal growth (upper row).

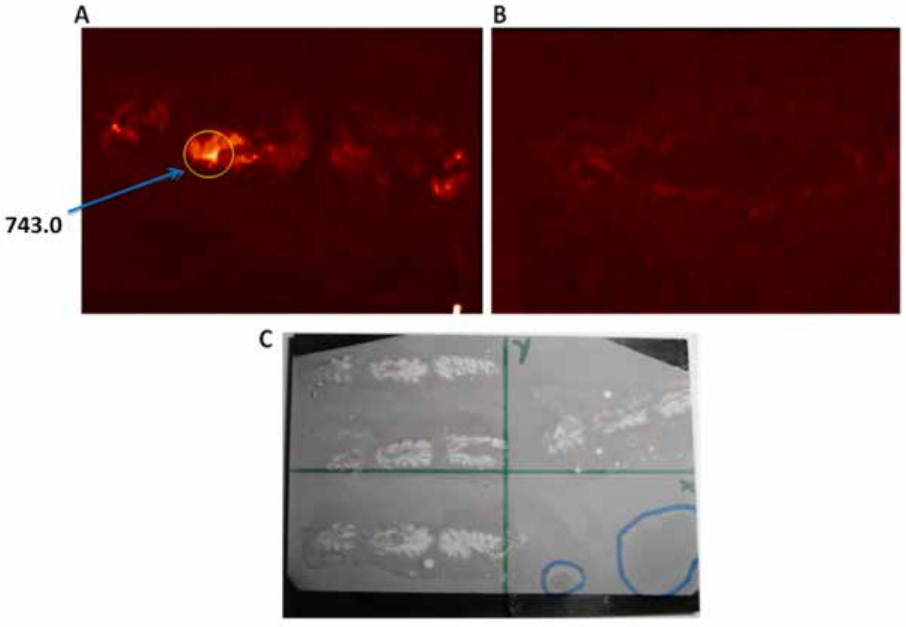
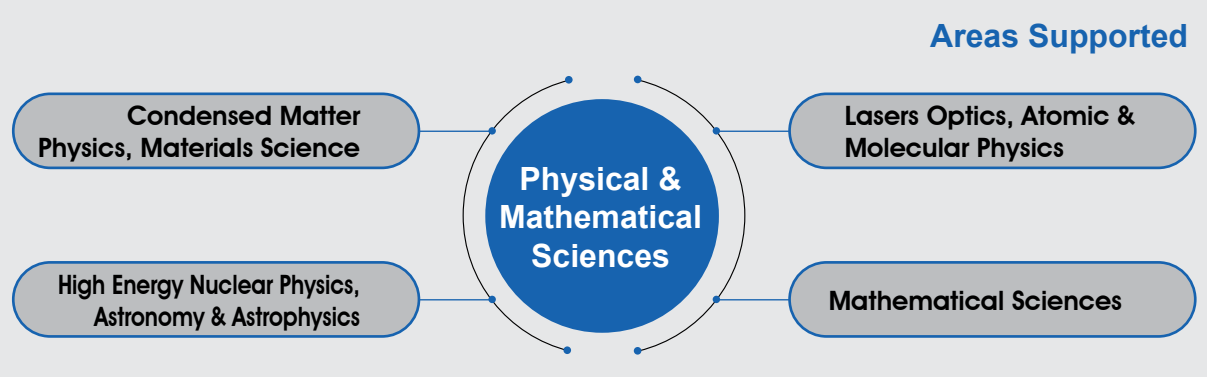


Fig. 3.56: Mass spectrometric imaging (LDI-TOF/MS) of H. armigera. (A) Photograph of the insect used for LDI-TOF/MS imaging mounted on a MALDI target plate. (B) MALDI imaging of H. armigera showing AzaA in midgut of AzaD fed insect (white area; (m/z 743 ± 0.5 [M+Na]+). (C) AD fed H. armigera did not show signal for AzaA after LDI-TOF/MS imaging.

The work was done at MITCON Foundation, Pune.

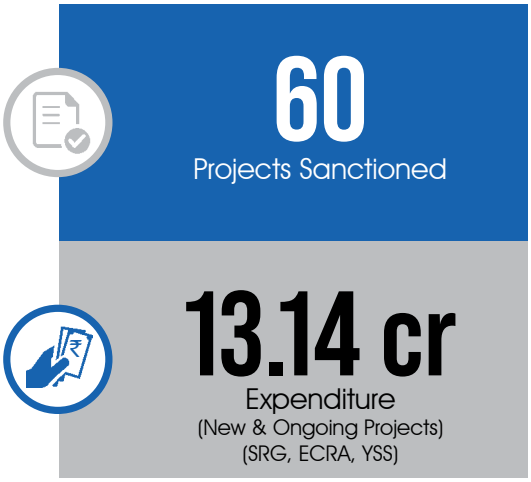
3.1.2.5 Physical and Mathematical Sciences

In the reporting period, 60 new projects were sanctioned. The areas supported under SRG – Physical and Mathematical Sciences are shown in the following figure.



Research Highlights

Development of high-performance energy storage devices with earth abundant materials: A one-step synthesis of carbon encapsulated Fe/Fe3C nanoparticles by pyrolyzing single source precursor of Prussian Blue (Iron (III) ferrocyanide) for its usage as anode material in high performance supercapacitors has been investigated (Fig. 3.57). The synthetic method produces 3D doughnut shaped porous structures comprising numerous interconnected Fe/Fe3C nanoparticles entirely encapsulated within layers of graphitic carbon. Such a porous structure facilitates electrolytic ion diffusion during charge storage on Fe/Fe3C nanoparticles through surface or near surface based faradaic reactions, while the metallic iron helps enhancing the electronic conductivity of the electroactive material. The material achieves a specific capacitance of 223 F/g at a scan rate of 10 mV/s along with compelling cycling performance exhibiting a little decay in capacitance over 20000 cycles. When coupled with activated-carbon cathode, Fe/Fe3C//activated-carbon asymmetric supercapacitor out-performs many recently reported supercapacitors.



In another study, one-step chemical synthesis of Co2P encapsulated N-doped carbon nanocages (Co2P@NCCs) is demonstrated with prospective application as potassium-ion battery (KIB) anode (Fig. 3.58).

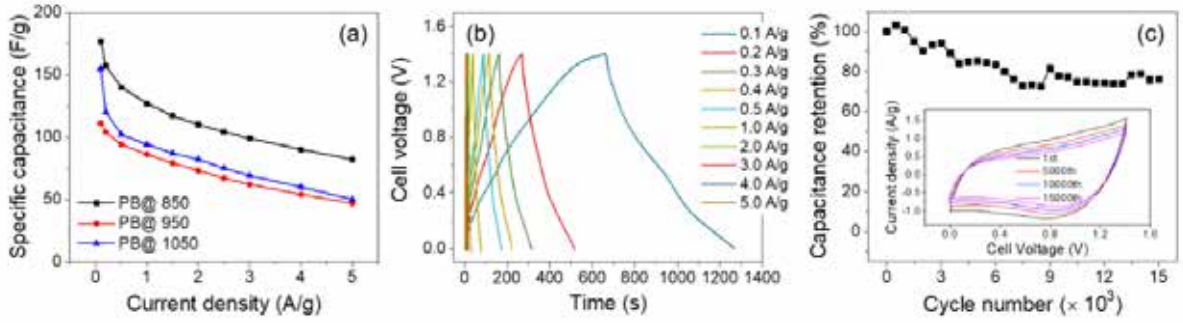


Fig. 3.57: (a) comparison of specific capacitances for the electrode materials at various scan rates, (b) Galvanostatic charge-discharge curves of the Fe/Fe3C//AC ASC at various current densities (c) cycling performance of the ASC at a scan rate of 100 mV/s, inset to Fig. shows a few CV loops recorded during cycling experiment.

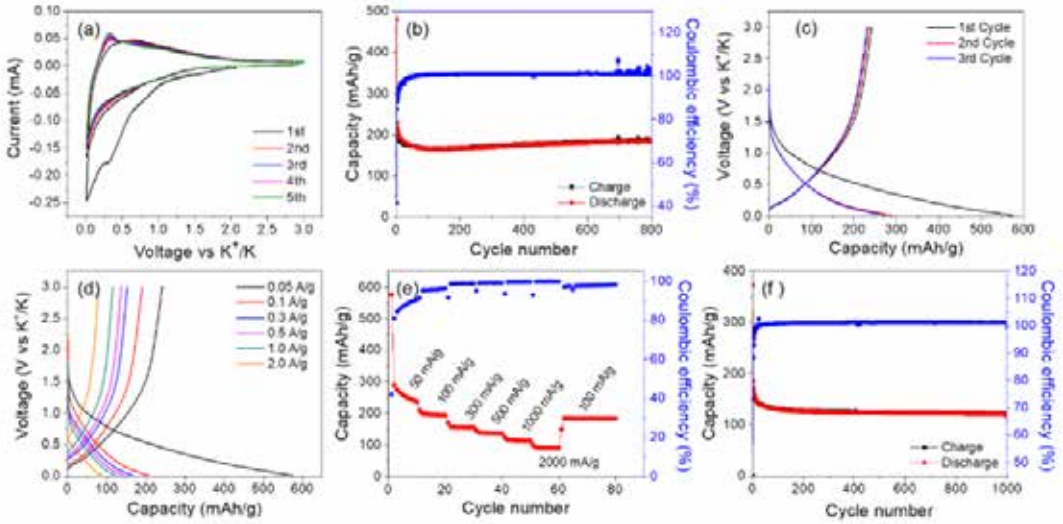


Fig. 3.58: Electrochemical analysis of Co2P@NCC electrode as KIB anode, (a) cyclic voltammetery (CV) data within the voltage range of 0.01-3 V at a voltage scan rate of 0.1 mV/s, (b) cycling performance of the electrode material at a current density of 100 mA/g, (c) first three galvanostatic charge-discharge curves of the electrode at a current density of 50 mA/g, (d) charge-discharge cycles of the electrode material at various current densities, (e) projection of discharge specific capacity at different current rates varying from 50-2000 mA/g, and (f) cycling performance at a high current density of 500 mA/g showing excellent structural stability of the electrode material.

In this case N-doping enhances electronic conductivity of carbon. N also acts as active sites for energy storage through redox reactions, producing bettered electrochemical performance as KIB anode as compared to many other conversion electrodes.

Low-cost chemical vapor deposition processed large area multidimensional lead halide perovskite lightemitting devices: In this study the metal halide perovskite LED device performance on conventional perovskite thin-film based devices has been investigated. The perovskite thin-films were spin-coated on the substrate. It has been observed that the mixed cation perovskites ($CsxRb_{1-x}PbBr_3$) doped with a certain level are more stable compared to bare perovskites ($CsPbBr_3$). The PL intensity was found to improve for mixed cation perovskites and the emission is green color (Fig. 3.59). LED devices (PeLED device structure: ITO/PEDOT:PSS/ perovskite thin-film/TPBi/Ca/Al) fabricated are not efficient due to high leakage current through the films. To improve the surface morphology, phenethylammonium bromide (PEABr) has been introduced into the perovskite precursor. The PL intensity has improved due to quasi-2D quantum well perovskite structure. The device performance and light intensity have also significantly improved. Light intensity above 6,000 Cd/m^2 and device efficiency of 4 Cd/A have been achieved.

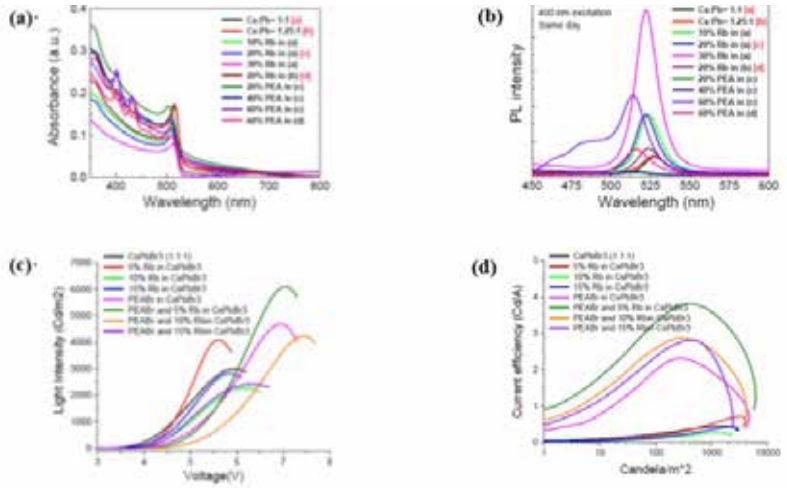


Fig. 3.59: (a) Absorbance and (b) PL spectra of quasi-2D CsxRb1-xPbBr3 thin-films as shown in legends. (c) Light-intensity-voltage and (d) device efficiency plots of PeLEDs fabricated from different quasi-2D CsxRb1-xPbBr3 perovskite thin-films as shown in legends.

3.1.3 MATRICS

A new scheme called Mathematical Research Impact Centric Support (MATRICS) was speicially designed to cater to the particular needs of Mathematical Sciences research as it is uniquely distinctive as compared with other disciplines which are mostly experimentally oriented. The scheme was initiated in the year 2017 to provide fixed grant support to active researchers with good credentials in Mathematical Sciences. Considering the overwhelming response for the fixed grant scheme and subsequent demand from researchers belonging to other Theoretical Sciences, SERB decided to extend the fixed grant scheme to other Theoretical Sciences including Quantitative Social Sciences.

FEATURES

- **Research grants to active researchers in the field of (i) Mathematical Sciences and allied areas; (ii) Theoretical Sciences and Engineering or (iii) Quantitative Social Sciences**
- **Submission of a simple 1-2 page mathematical/theoretical proposal**
- **Research grant of Rs. 2.00 lakh p.a. for a period of three years**

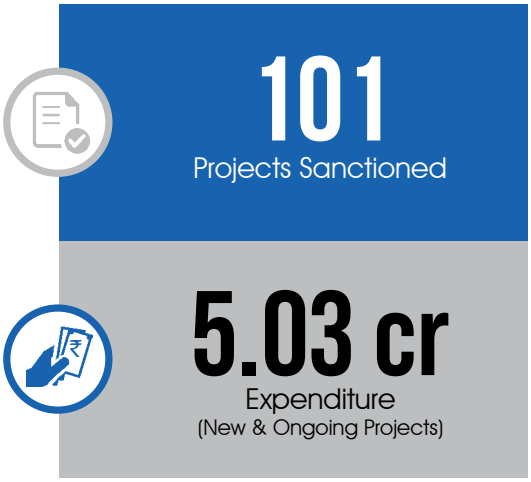
Website links
http://serb.gov.in/matrix.php
https://serbonline.in/SERB/matrics_new

Research Highlights

Symplectic eigenvalues and its properties: In the present study, properties of symplectic eigenvalues and its various applications in quantum information theory have been studied. Further, other matrix analysis techniques have been explored and applied it in the relevant areas.

The properties of stationary G-chains in terms of their generating functions have been investigated. In particular, an analogue of the Szego limit theorem for symplectic eigenvalues has been proved, the expression for the entropy rate of stationary quantum Gaussian processes has been derived. The distribution of symplectic eigenvalues of truncated block Toeplitz matrices has also been investigated. Using the theorem, exact formula of entropy rate of quantum Gaussian stationary chains has been calculated.

The concept of symplectic numerical range, analogous to that of numerical range has been introduced to study some of its basic properties, mainly in the context of block Toeplitz operators. Optimal schemes were presented, based on photon number measurements, for Gaussian



state tomography and for Gaussian process tomography. An n-mode Gaussian state is completely specified by 2n 2 + 3n parameters. The study requires exactly 2n 2 + 3n distinct photon number measurements to tomography of the state and is therefore optimal. Further, the optimal scheme is described to characterise Gaussian processes by using coherent state probes and photon number measurements. This

mathematical construction has applications in photonics-based quantum information protocols and identifying states and channels, which are one of the primary components in this research.

The work was done at Indian Institute of Science Education and Research, Berhampur.

Singularity reconstruction from broken geodesic ray transforms: In this project, the inversion of momentum ray transforms (certain weighted ray transforms with weights that are positive integer powers of the integration parameter) of symmetric m-tensor fields has been studied. In the current work, explicit range characterization of momentum ray transforms on symmetric m-tensor fields in dimensions 2 and higher was studied. The study of such transforms has important applications in the Calderon-type inverse problems involving polyharmonic operators.

In another study, the microlocal analysis of a restricted transverse ray transform of symmetric m-tensor fields in 3-dimensional Euclidean space was considered. The study of transverse ray transform of symmetric tensor fields is of significant importance in fields such as polarization tomography. The inversion of a restricted transverse ray transform was studied; restricted in the sense that the available transverse ray transform data is only lines passing through a fixed curve in 3-dimensional Euclidean space satisfying certain geometric conditions. Explicit inversion of such restricted ray transforms is close to impossible. The study is focused on an approximate inversion, that is, recovering the singularities of the tensor field from such restricted data. More precisely, it was shown that the wavefront set of the symmetric m-tensor field can be recovered modulo a known error term.

The light ray transforms are integral transforms along the lines on the light cones. The study of such light ray transforms has important applications in hyperbolic inverse problems involving time-dependent coefficients. The characterization of the kernel of light ray transform of symmetric 2-tensor fields defined on a bounded time-space domain in Euclidean spaces of dimension at least 4 (with one dimension for time) was studied. More precisely, the kernel of the light ray transform vanishing near a fixed direction at each point in the time-space domain was completely characterized in this study.

The work was done at Tata Institute of Fundamental Research, Bangalore.

3.1.4. Industry Relevant R&D (IRRD)

Industry Relevant R&D (IRRD) scheme was launched in the year 2015-16 with the objective to utilize the expertise available in academic institutions and national laboratories to solve industry specific problems for the larger benefit of society. IRRD aims to support joint proposal by academic and industry partner. The scheme is set to be revamped.

Website links
http://www.serb.gov.in/irrd.php
http://serbonline.in/SERB/IRR

Research highlights of project supported under the older version of IRRD scheme is provided here.

Microstructural engineering for improved hole expansion ratio in dual phase (dp) steel: The project aims to address industrial relevant problem as hole expansion ratio (HER) is a critical property for the dual phase (DP) steel. Dual Phase steel with primary bcc ferrite and secondary martensite phase at the triple junctions, is an important auto-steel grade. This grade provides reasonable strength, but often has limitation of HER. Therefore, it is important to understand the microstructural origin for HER. It is generally stipulated that HER values are determined by post neck ductility (PND).

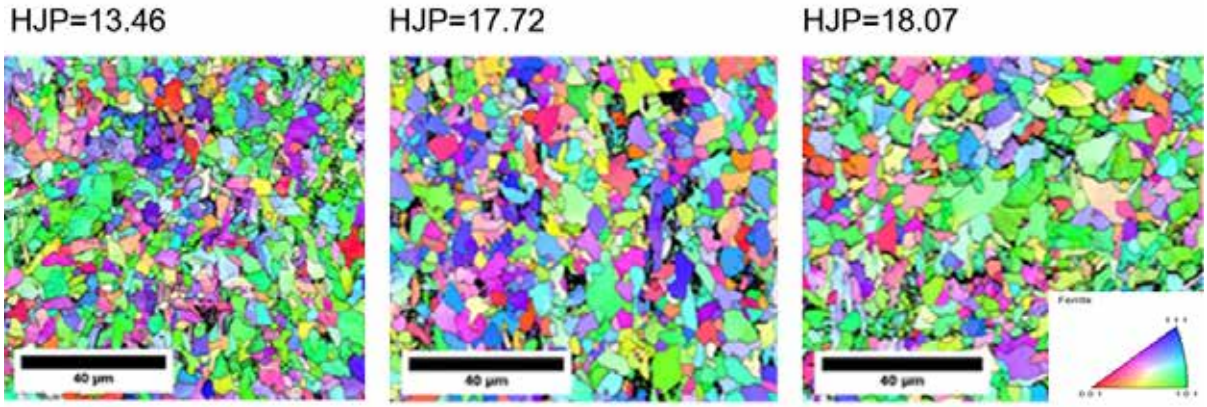
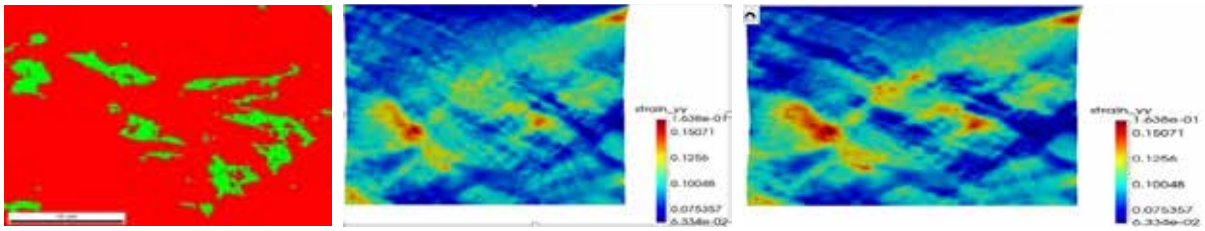


Fig. 3.60: Tempered microstructures of three tempered samples (HJP=13.46,17.72,18.07)



(a) (b) (c)

Fig. 3.61: (a) post-processed microstructure for CPFE calculations, spatial distribution of εyy at an overall strain of 10% for a difference in lattice friction value of (b) 50MPa, (c) 150MPa

The present study in collaboration with Tata Steel R&D aims to work on PND related to post-necking strain localizations which can be controlled by appropriate microstructural engineering.

Relationship between the relative plasticity of ferrite and martensite, strain partitioning characteristics and non-uniform elongation (εNU) were explored to see the impact on the HER. Two strategies were adopted:

Tempering-samples were heated at temperatures (T) ranging from 120-700C at varying times (t), and parameterized by the resulting Holloman-Jaffe (HJ) parameter.

High pressure torsion-samples were processed at different strains and parameterized by the equivalent/shear strain as and where necessary.

The tempered and high pressure torsioned samples were characterized by nano-indentation, electron back-scattered diffraction (EBSD) and uniaxial tension coupled with an optical DIC system to establish the impact of relative strength between the phases on the macroscopic strain-partitioning characteristic of the material via optical DIC and resultant εNU.

The effect of hardness/strength difference between the phases was also simulated using a crystal plasticity-based model by arbitrarily varying the strengths of the two phases in a 2-phase simulation and observing the change in stress/strain contours at the same global strains.

Figure 3.60 shows the tempered EBSD microstructures for specimens tempered with HJP=13.46, 17.72, 18.07. In the superimposed IQ+IPF maps, the dark (low IQ) regions which denote the martensite slowly disappear from the microstructure, indicating eventual transition of martensite into ferrite, with the excess carbon resulting in precipitation of Fe, Nb and Cr carbides. There is no reasonable coarsening of the ferrite grains or martensite blocks after tempering.

Nanoindentation measurements were done on the above tempered samples to quantify the hardness difference between the phases as a function HJP and observed that there is a drop in martensite hardness from 9.61±1.81GPa to 3.72±0.31GPa, culminating in no hardness difference between the two phases.

Figures 3.61 (b) and (c) show the εyy strain contours obtained via CPFE, showing the increased strain localization in the DP structure (2(a)) with larger difference in relative strength between the phases.

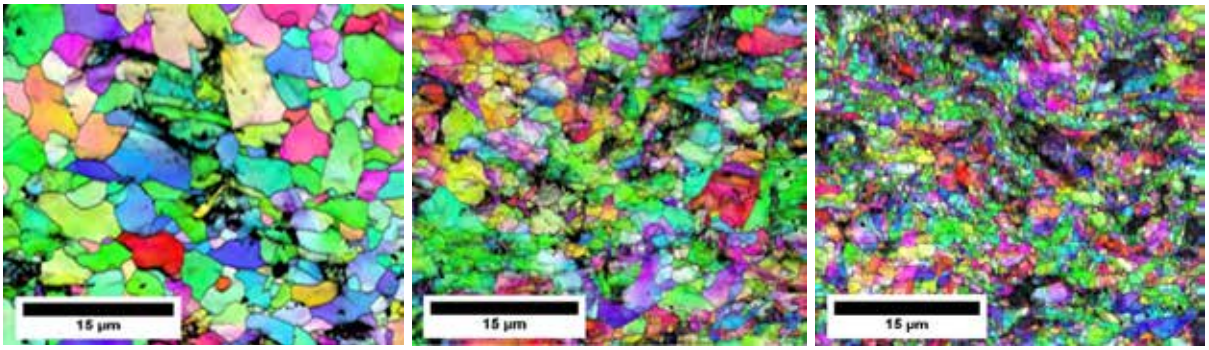
Figure 3.62 shows the refinement resulting from

HPT at varying γ. The average grain size of ferrite decreases from 4.41±1.96μm at the center of the disk to 1.25±0.85μm at a radial distance of 1.5mm (shear strain of 3.4), while the martensite colony size although fragmented did not show significant size variation.

The variation of phase hardness of individual phases is a function of shear strain γ. With increasing imposed shear strain, the martensite hardness does not change while that for ferrite increases significantly and approaches that of martensite, thus bringing down the hardness difference from 5.13 to 1.15 GPa. It is observed that with increasing amount of imposed severe plastic deformation, the strength greatly increases, while the overall ductility drops considerably.

The HER is important to an auto manufacturer as the holes in a wheel disc needs to be fabricated and cracking in such fabrication is not acceptable. The outcome of the research work under this project will help to resolve the Industry relevant problem.

The work was done at Indian Institute of Technology, Bombay.



(a) (b) (c)

Fig. 3.62: Deformed microstructures of the high pressure torsioned samples at the shear strain values of (a) 0, (b) 1.36 and (c) 3.39

3.1.4.1 Fund for Industrial Research Engagement (FIRE)

SERB intensely pursues different means to engage with industry to address the gap between knowledge economy that is driven by fundamental research and commercial economy driven by the market. This led to initiation of a programme called FIRE under IRRD. The program, Fund for Industrial Research Engagement (FIRE), intends to address the challenges in the research and innovation space in India, by creating an ecosystem that would accelerate the growth in the research work with national impact and drive the R&D landscape efficiently and effectively.

SERB signed a Letter of Intent (LoI) with a group of semiconductor industries, namely, Applied Materials India Private Limited, Intel Technology India Private Limited, Mentor Graphics (Sales & Services) Private Limited, NXP India Private Limited, Texas Instruments (India) Private Limited to create a research fund with the objective to collaborate on research problems that can have a ground-breaking impact on a large scale over the next five years. The partnership focuses on national and global problems and will fund high quality research with maximum industry impact potential, at a national scale with 50:50 monetary fund sharing.

3.2 PROMOTING INNOVATION

3.2.1 Intensification of Research in High Priority Areas (IRHPA)

IRHPA is a top down scheme designed to provide major support in high priority areas where multidisciplinary, multi institutional expertise may be required which will put our nation in international science map in that particular discipline. SERB identifies the priority areas and makes a national call for seeking proposals. The scheme has contributed significantly to augment general R&D capabilities in academic institutions and national laboratories by setting up of Core Groups, Centers of Excellence and National Facilities in frontline and emerging fields of

Science and Engineering. Several projects have been sanctioned under IRHPA scheme in the past which has augmented the research capability of the country in priority areas.

FEATURES

- **Top-down scheme supporting projects in priority areas**
- **The amount of grant is usually higher than regular projects**
- **Duration of the project is 5 years**

Website links
http://serb.gov.in/irhpa.php
http://serbonline.in/SERB/irhpa

Cryo-electron microscopy for macromolecular structures and complexes

Cryo-Electron microscopy revolutionized the structural biology to the next higher level in the advent of the 21st Century. The revolution in resolution resulted in understanding the Zika virus surface proteins closer to its atomic level, which provided the basis for structure based drug discovery. Cryo-EM has become a cynosure in structure determination, specifically of membrane proteins or large complexes. Cyro-EM is a burgeoning technology, which can help Indian researchers to contribute significantly in the field of biomedical research focusing on structural biology, enzymology, virology, cell biology, drug discovery, etc. The R&D activities in the above field will lead to better understanding of disease biology and develop possible interventions for diagnosis and treatment.

The existing facilities in the country are not enough to sustain the requirements of the researchers at the rate it grows in other parts of the world. Hence, SERB undertook the task of setting up Radical Cryo-EM Grid for proteins and other large complexes research, under the IRHPA scheme.

A call was made in this respect and a total of 23 proposals were received. After due consideration, stringent review and selection process by the taskforce and empowered committee, board has approved to setup four IRHPA Cryo Electron Microscopy Facility at IIT Chennai, IIT Bombay, IIT Kanpur and Bose institute Kolkata with a total outlay of Rs. 114.34 crores.

Title	Establishing the North India Facility for Cryogenic-Electron Microscopy (cryo-EM) at IIT Kanpur
PI Name	Dr. Arun K Shukla
Institution	Indian Institute of Technology Kanpur
Total Cost	Rs. 28.53 Cr

Title	Acquisition of State-of-the-Art Cryo-Electron Microscopy Instrument for Developing National Facility at IIT Bombay, Mumbai
PI Name	Prof. Ruchi Anand
Institution	Indian Institute of Technology Bombay
Total Cost	Rs. 28.60 Cr

Title	National Facility of Cryo-Electron Microscopy:Remotely Operable, 24x7 for Academia and Industry
PI Name	Prof. T. Pradeep
Institution	Indian Institute of Technology Madras
Total Cost	Rs. 28.60 Cr

Title	Setting up a State-of-the-Art CryoEM Regional/National Facility in Eastern Region at Bose Institute: Transforming the Structure-guided Drug Discovery and Therapeutics Research Landscape in India
PI Name	Dr. Smarajit Polley
Institution	Bose Institue, Kolkata
Total Cost	Rs. 28.60 Cr

Research Highlights of projects supported under IRHPA scheme are given below:

1	**National Interdisciplinary Centre for Cyber Security and Cyber Defense of Critical Infrastructures**
	Indian Institute of Technology Kanpur

OT Security Testbed - ICS Demo Kit

- To fulfill an immediate need for "PATCH testing" and a hands-on "OT security training" kit, the C3i center has designed and developed portable kits.
- Kits are rich with industrial protocols integrated with cybersecurity educational material. It will help critical infrastructures in patch management + in-house cybersecurity workforce development. Testing kits will allow various technocrats and professionals to get hands-on experience with available cyber technologies for OT and ICS environments (Fig. 3.63).

Fig. 3.63: ICS Demo Kit

Power Transmission

- Hard/Software in loop testing facility for the power transmission system (Fig. 3.64).
- The key features of the 'State of the Art' testing facility are its 100 km long zebra conductor lines as a pi model with a 1.1 KV 50 Hz supply. It will facilitate researchers for testing cybersecurity innovation.

Fig. 3.64: Power Transmission

C3i Malware Analysis Tool Pathways

Fig. 3.65: Malware Analysis Framework

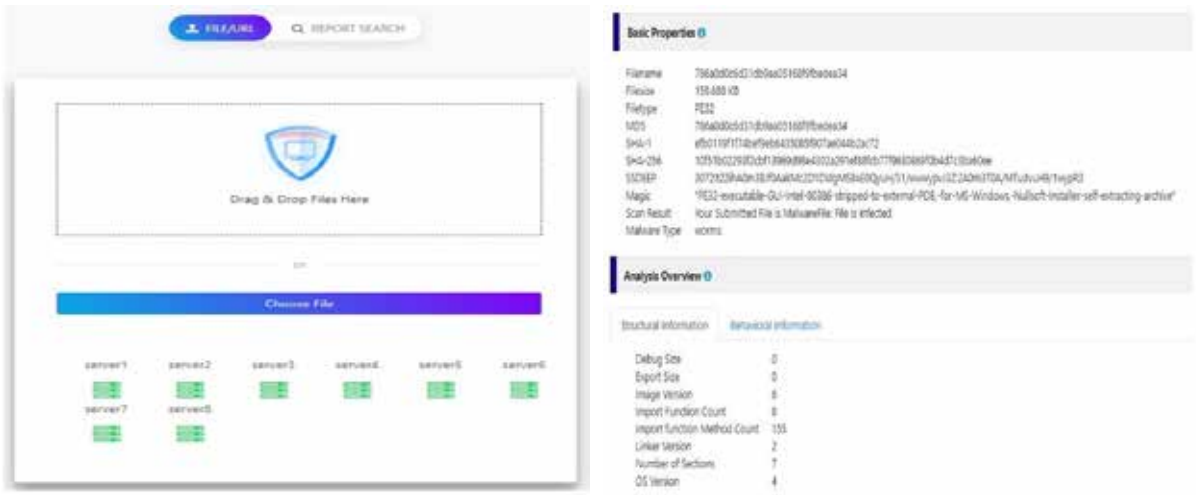


Fig. 3.66: Report format

Honeypots

- Malware Collecting Honeypots deployed in Cloud. Collected 1000+ binaries. Analysis for the same is going on in collaboration with the Malware Analysis team (Fig. 3.65).
- SEIM website security was enhanced by regular VAPT and solving the issues as per reports received from the VAPT team (Fig. 3.66).
- Orchestration engine backend developed which dynamically starts honeypots as per attacker behaviour inside the network (Fig. 3.67).
- Added 4 new protocols in SEIM
  - ❖ BACnet
  - ❖ TFTP
  - ❖ S7Comm
  - ❖ SNMP

Fig. 3.67: Honeypot

Network Intrusion Detection System (NIDS): NIDS project (still in the development phase) basically divided into two modules, i.e., "Infrastructure Mapper and Processor (IMP)" and "Data Acquisition, Analysis and Monitoring Server (DAAMS)".

IMP and DAAMS is a customized solution to enhance the cybersecurity of operational technologies (OT) networks. The solution Auto-discovers of all IoT and ICS assets and maintains a constantly up-to-date inventory of them along with associated vulnerabilities, a detailed dynamic network topology, classification of logs via machine learning, network intrusion results, etc. (Fig. 3.68).

This application can read packets (passive monitoring) from the network and extract useful information based on assets' information. The database comprises of latest vulnerabilities in OT environments shall be generated for patch management. The application shall have a feature to update the database for the new patches/ guidelines. The application shall notify the user of any detected anomaly, threat, or vulnerability which shall also be logged as an Event Log.

Dynamic topology: User will be able to visualize auto-generated graphical network topology, which provides all the basic information of assets, and by clicking on a specific node, detailed information (client name, device name, device type, firmware version, serial number, IP address, MAC address, etc.) shall be available with CVSS score (Fig. 3.69).

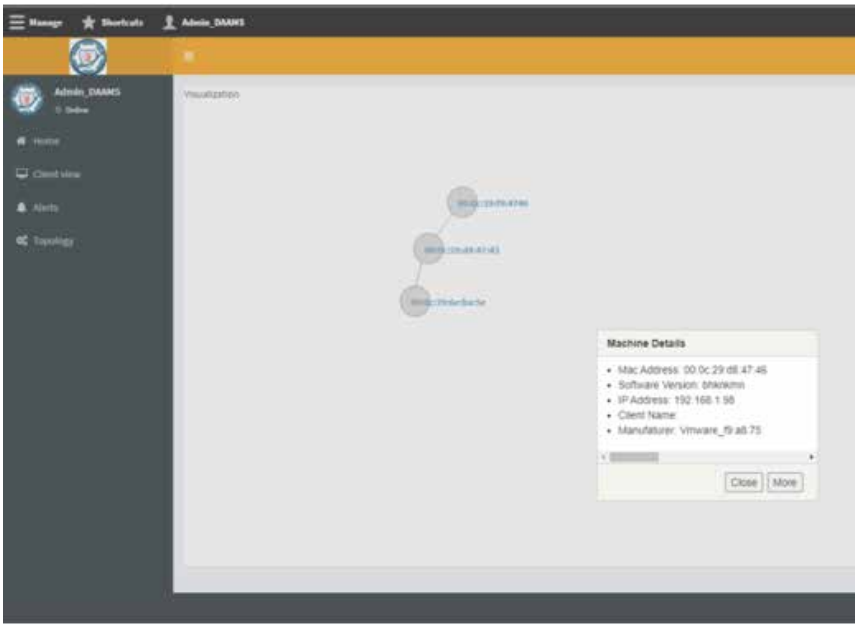


Fig. 3.68: Graphical Network Topology

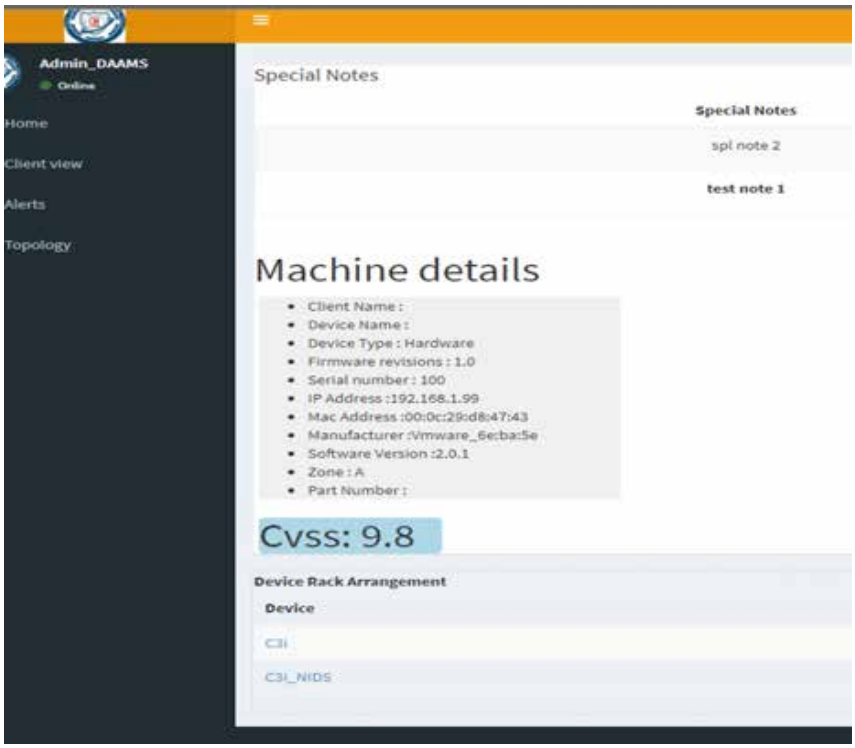


Fig. 3.69: Detailed Machine information with CVSS

Intrusion Detection System

- Developed two robust anomaly-based intrusion detection methodology for cyber-physical systems. Both the papers are currently under review. Pre-print of one of the paper: https://arxiv.org/abs/2009.02930
- Developed real-time network intrusion detection methodology (Fig. 3.70).
- Integrated weblog-based IDS with our SEIM tool.

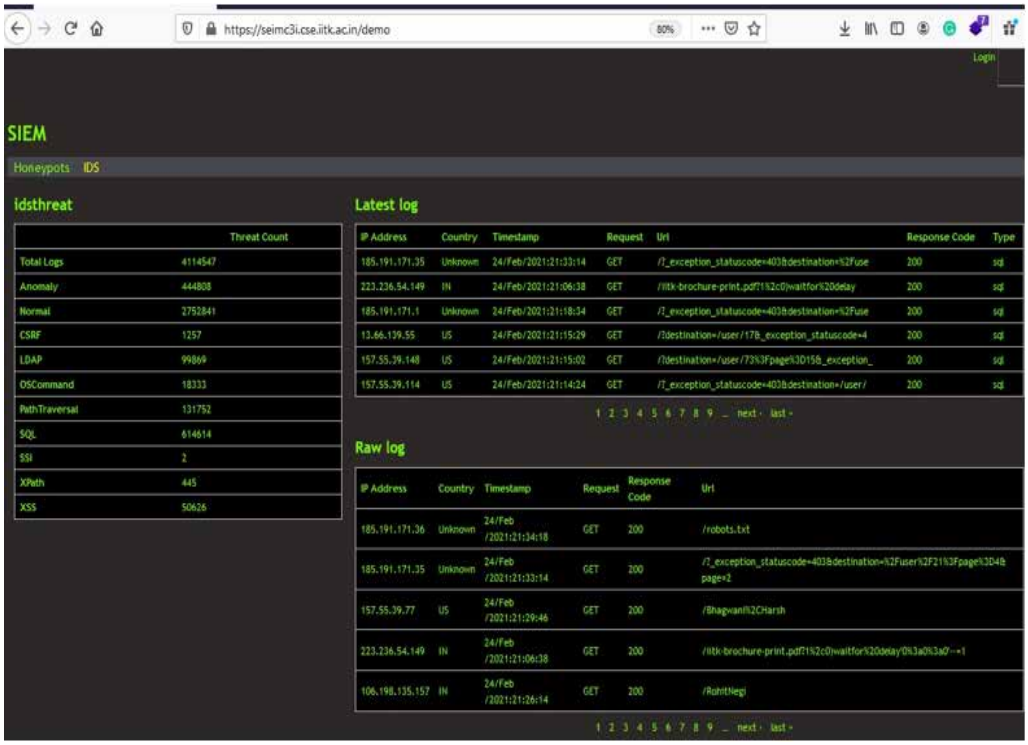


Fig. 3.70 : Intrusion Detection System

2	Development of Non-Transplant Therapeutic Strategies for Advanced Liver Diseases
	Institute of Liver and Biliary Sciences, New Delhi

In the past few decades there has been a significant increase in the incidence of liver disease due to life style changes in India, that leads to the development of end-stage chronic liver dysfunction for which liver transplant is the only available treatment at present. While there is a need for nearly 100,000 liver transplantation every year in India, only about 2,000 transplants are being done at present. The major challenges associated with liver transplant and management of these patients are immune dysfunction with sepsis, compromised native liver regeneration and lack of time for liver to regenerate. Development of new therapeutic approach to accelerate native liver repair and regeneration in cirrhosis (BM transplant).

The research team establish the proof-of principle that transplantation of healthy BM cells in cirrhotic bone marrow (intra-femoral route) rescue the BM-LT-HSC in cirrhotic primarily by inducing the repopulation of native cells. Most importantly they demonstrate that rescuing BM-stem cell reserve in cirrhosis accelerate the resolution of fibrosis and potentiate hepatocyte proliferation in cirrhotic animal (Fig. 3.71). The research team proposed that allogenic healthy BM stem cell transplant can serve as effect therapy to manage fibrosis and regeneration in cirrhosis and it may reduce the need for transplant in these patients.

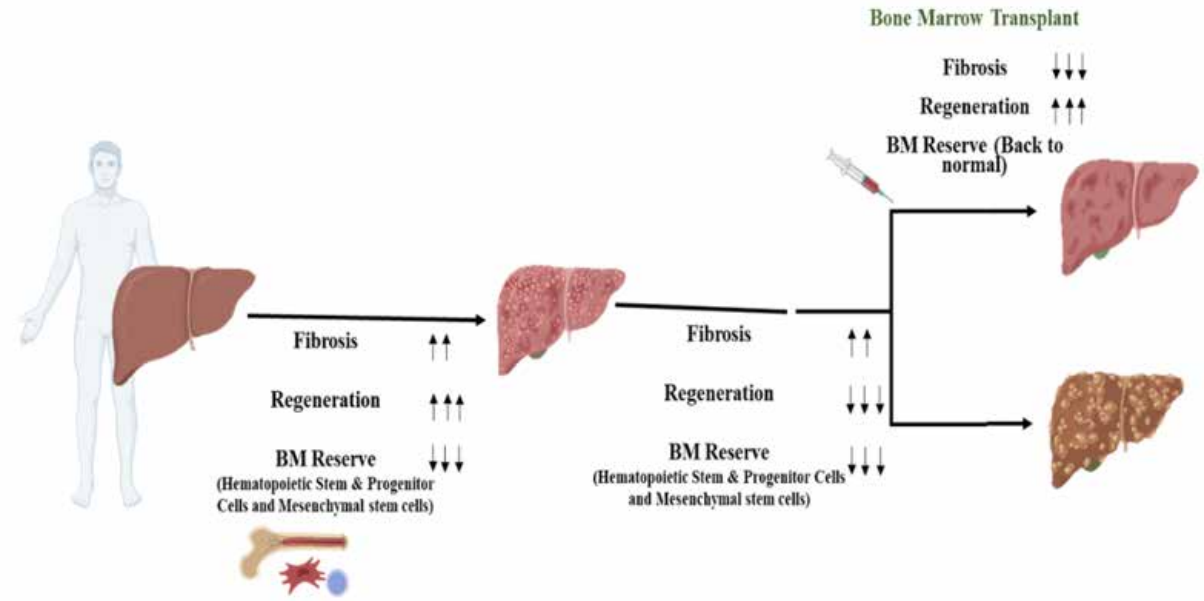


Fig. 3.71: Diagram showing potential link between BM failure and regeneration failure in cirrhosis and Healthy BM-stem cell transplant as new therapeutic strategy to manage liver fibrosis and regeneration in CLD.

Establishment of murine model of acute-on-chronic liver failure with multi-organ failure: Figure 3.72 shows the murine model of ACLF that showed most of the clinical and histological feature of human ACLF in terms of the presence of jaundice, ascites and acute tubular necrosis and renal dysfunction. It showed that perpetual presence of acute liver injury and endotoxemia triggers hepatocyte ballooning followed by massive hepatocyte necrosis. Though acute insult triggers regression of fibrosis failure of hepatocyte regeneration with progressive liver injury leads to liver failure and development of secondary organ injury.

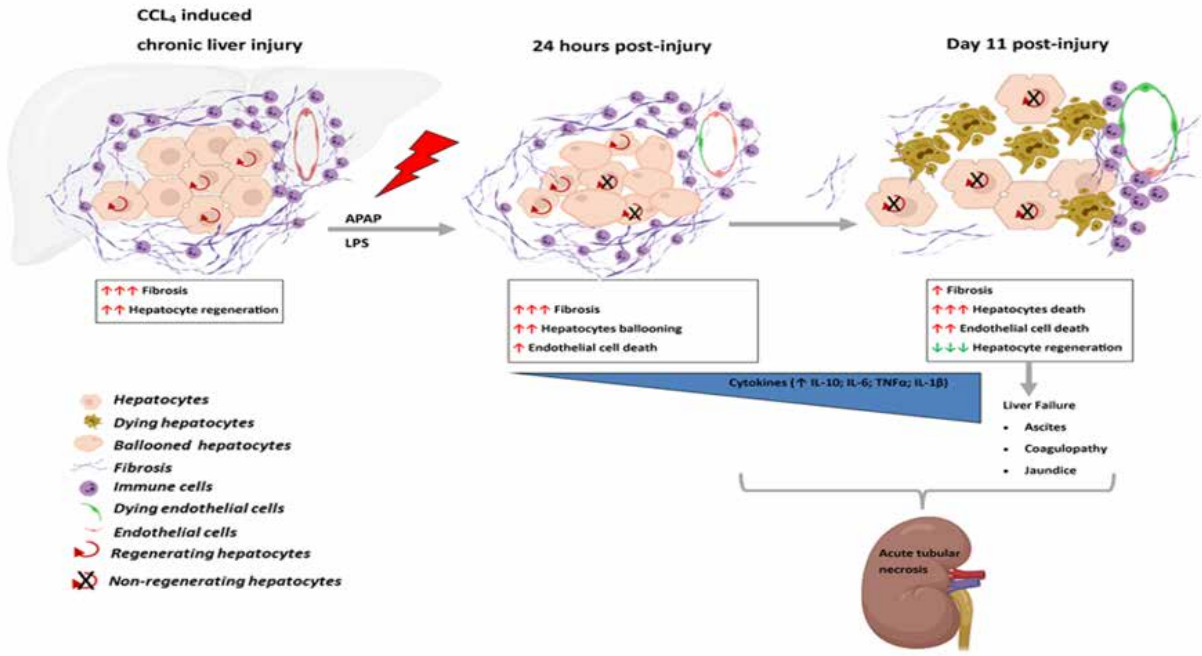


Fig. 3.72: Diagram showing progressive change in histology and biochemical parameter in course of APAP/LPS induce ACLF

Mesenchymal stem cell therapy for management of acute-on-chronic liver failure (ACLF): There is a dearth of treatment options in management of ACLF. The group has established the pre-clinical therapeutic efficacy (Fig. 3.73) of uCMSc in ACLF and showed that ucMSC therapy in ACLF augment innate immune cell function, prevent liver injury and potentiate hepatocyte regeneration. Hence, the research team proposed that clinical use of ucMSCs will be helpful for the management of ACLF both for augmenting infection control and liver injury regeneration.

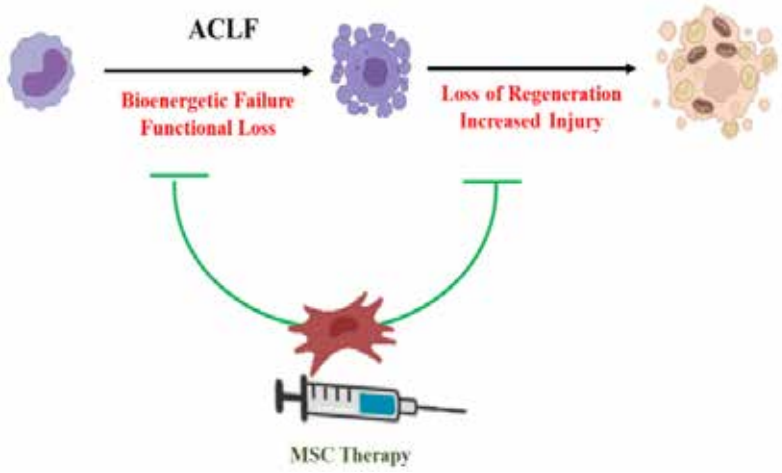


Fig. 3.73: Establish therapeutic efficacy of ucMSCs in management of innate immune function, liver injury and regeneration in ACLF

Development of extra-corporeal biological liver support system for bridge to transplant or native liver to regenerate : The research group demonstrated the repopulation of DLM with healthy human cells and showed that rat DLM can support the human cell survival. In summary (Fig. 3.74) using organ decellularization and recellularization approach, group was able to bio-engineer liver that preserve the spatiotemporal distribution of hepatocytes with the neighboring non-parenchymal cells like kupffer cells, cholangiocyte, etc. This is the first successful step towards development of bio-engineered liver for the development of extra-corporal liver support system. However extensive laboratory work is still needed to conform the functional capability and their clinical utility.

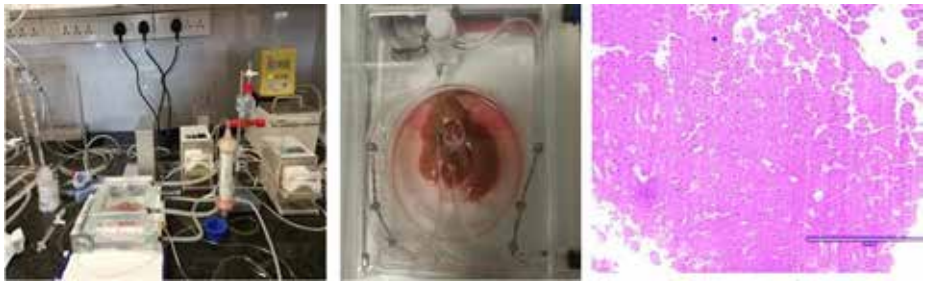


Fig. 3.74: In-vitro generated liver tissue showing spatiotemporal distribution of hepatocytes with the neighboring non-parenchymal cells like natural liver.

3	**Evolution of Indian Sub-continental Lithospheric Mantle: Insights from mineral chemistry of kimberlites, lamproites, lamprophyres, their entrained xenoliths/xenocrysts, mafic dykes and dyke swarms from Bastar and Eastern Dharwar Cratons**
	Banaras Hindu University, Varanasi

The funding to the project led to the establishment of two National facilities of Electron probe micro analyzer (EPMA; in 2016) and Scanning electron Microscope (SEM; in 2018) catering to the needs of mineral/material physico-chemical characterization at the Department of Geology, Banaras Hindu University, Varanasi. Nearly 100 papers in SCI journals have been published by the PIs and other users (~175 from across the country) using these facilities and ~25 interns/students worked on the machines for their dissertations and data generated has been extensively utilized in many PhDs by research scholars.

Some of the major findings published from data generated by these facilities during 2020-2021 include.

- Analytical protocol for high precision (< 3 % uncertainties on measured ages) U-Th-Pb chemical dating of xenotime from the TTG Gneisses of Bundelkhand craton, central India. The obtained age of 2923± 23 Ma is in agreement with the 2697± 3 Ma Pb-Pb zircon age from same area and validates the authenticity of method developed (Fig. 3.75).

- Rare vanadium-bearing titaniferous-magnetite mineralization has been reported from a Precambrian gabbroic dyke from the Simdega area, Chhotanagpur Gneissic Complex, Eastern India and favourable oxygen fugacity conditions have been deduced (Fig. 3.76).

- Petrography combined with mineral chemistry of the lamprophyres from the Late Cretaceous Mundwara alkaline complex in NW India brings out evidence of crystal fractionation, accumulation and corrosion in a complex magma chamber plumbing system for the first time from this domain (Fig. 3.77).

- Mineral chemistry of the olivine and pyroxenes from the peridotites and pyroxenites of the Suru–Thasgam ophiolitic slice along the Indus Suture Zone, Ladakh Himalaya, indicate supra subduction zone tectonic affinity.

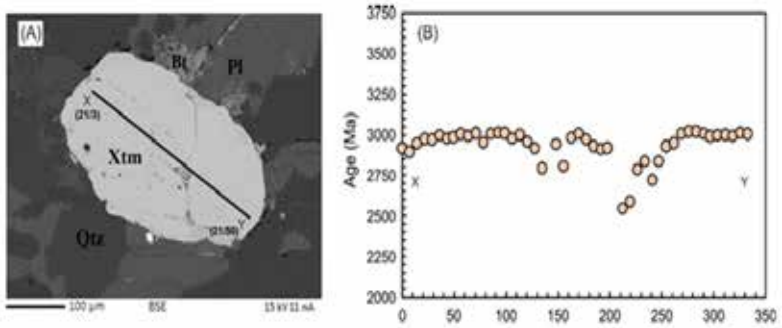


Fig. 3.75: (A) BSE image of the selected single xenotime grain (sample HC-36) for the line profile analysis and (B) the continuous age profile graph of 46 points for single xenotime grain of this study. Abbreviations: Xtm: Xenotime, Qtz: Quartz, Pl: Plagioclase, Bt: Biotite.

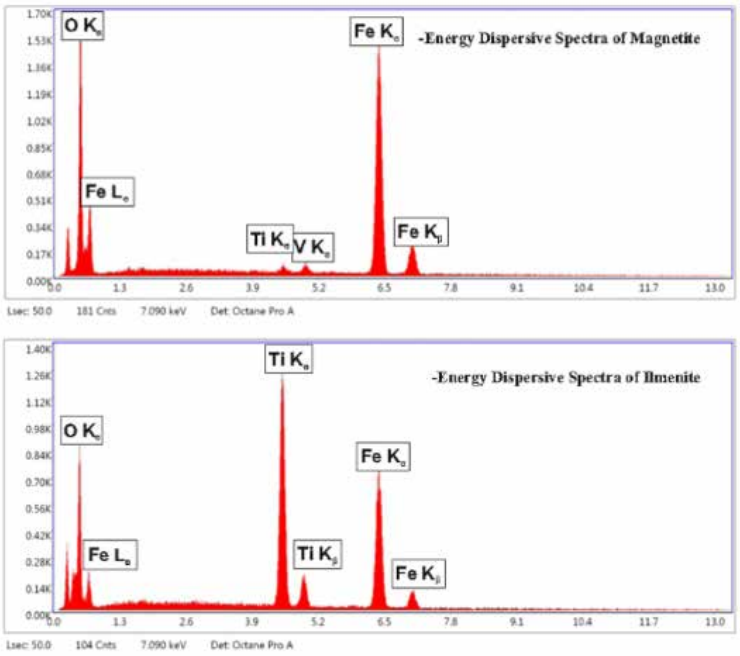


Fig. 3.76: A) Energy dispersive spectra (EDS) showing the presence of Fe, Ti, V. The Fe is very high relative to the Ti and V. (B) EDS spectra of ilmenite is showing the high amount of Fe and Ti with the absence of V.

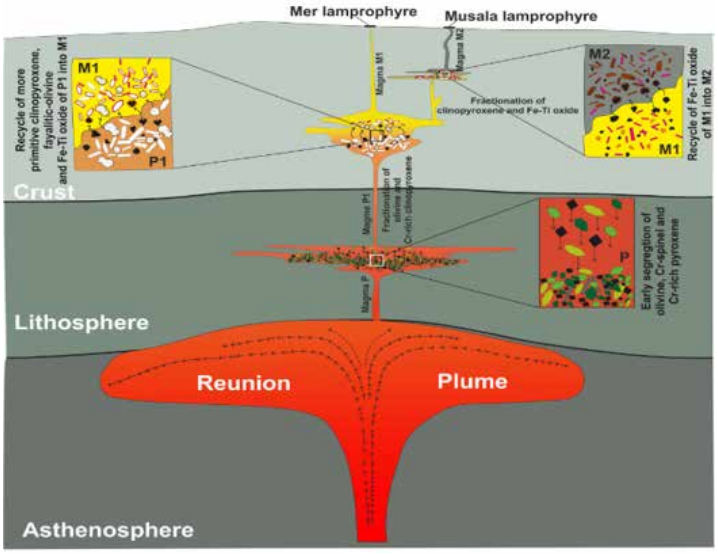


Fig. 3.77: Schematic model of magmatic plumbing system with compositionally zoned magma chambers showing closed system fractionation from primary parental magma to camptonite lamprophyres in Mundwara alkaline complex.

4	**Atmospheric Studies in the Geophysically sensitive Tropical to Sub-tropical transition region with ST Radar Facilities at Calcutta University.**
	Calcutta University

This indigenously developed state-of-the-art 53 MHz VHF Stratosphere Troposphere (ST) Radar is being established at Ionosphere Field Station, Haringhata, Culcutta (Figs. 3.78 and 3.79). It is at a very advanced stage with civil and electrical work at the radar site being underway following which installation and commissioning of the radar will take place. Once established, this radar would become a unique facility in the entire eastern and north-east parts of the country as well as the South-East Asian longitudes and will facilitate research on Stratosphere-Troposphere Exchange

processes, atmospheric dynamics, turbulence, development of models for forecasting severe weather events, role of atmospheric gravity waves in development of weather systems and ionospheric effects on radio signal propagation. The Pilot radar constructed as a proof-of-concept is shown in figure Figure 3.80.

Fig. 3.78: Radar area with antenna pedastals, cable trench, guard wall and perimeter road

Fig. 3.79 a: Radar Control Building

Fig. 3.79 b: Electrical Substation

Fig. 3.80: University of Calcutta ST Radar Pilot Array

5	Centre for precision and conservation farming machinery (CPCFM)
	CSIR - Central Mechanical Engineering Research Institute, Ludhiana

The network collaborative research programme – Centre for Precision and Conservation Farming Machinery (CPCFM) was established by DST/ SERB at Centre of Excellence for farm machinery (CoEFM), CSIR-CMERI, Ludhiana. The major aim of the centre is to enhance the agriculture productivity through machinery development to support precision and conservation agriculture.

Successful field testing of cotton-picking head encouraged the research team to develop a self-propelled two-row cotton picker using tractor as the main power source. For mechanizing the operations in orchards, an offset rotavator having automatic side-shifting capability has been developed to undertake the shallow tilling between the intra and inter-row spaces without damaging the tree trunks. All this equipment were extensively tested by state agricultural universities in farmers' fields and recommended for use through their Package of Practices.

Refinement of Straw Management System (SMS) - to cut and spread the straw residues from straw walkers in the center of the harvested area, is being carried out for efficient chopping of straw and its distribution with minimum power use. The design of blades (rotary and stationary) and its positioning along the rotor is refined and exhaustive field testing is completed in terms of power on the combine harvester, threshing efficiency, cleaning efficiency and germination of wheat crop sown. Multi-location trials with farmer participatory evaluation of the refined SMS system have completed in the last crop season. Continued use of rotavator (with L shaped blades) at a constant depth results in soil compaction and one of the alternatives to eliminate this problem is by using the traditional method of spades. The idea of using spades in preparation of seedbed has been converted into a tractor mounted spading machine (Fig. 3.81). Harvesting of crops/produce is a laborious, drudgerous, time consuming and costly farm operation and any intervention to mechanize this will lead to reduced cost of cultivation and thereby increasing the overall profitability of the farmers thus realizing the aim of doubling farmer's income. Self-propelled chilly harvester (Fig. 3.82) is developed to pick the ripened/matured chillies from the plant and the most advantageous feature in this equipment is that it will help the farmers to do multi-picking which is suited to most of the chilli varieties and the production practices. Implementing the precision agriculture concept in India require introduction of many associated technologies and variable rate fertilizer application is one of the key elements in increasing the input use efficiency. A sensor based variable rate fertilizer applicator is developed which can sense the nutrient requirement of the crop and accordingly dispense the required amount. It also has features of mapping the entire field for the crop nutrient requirement along with the application rate thus helping in developing prescription and application maps which can be used for management decisions in next cropping season.

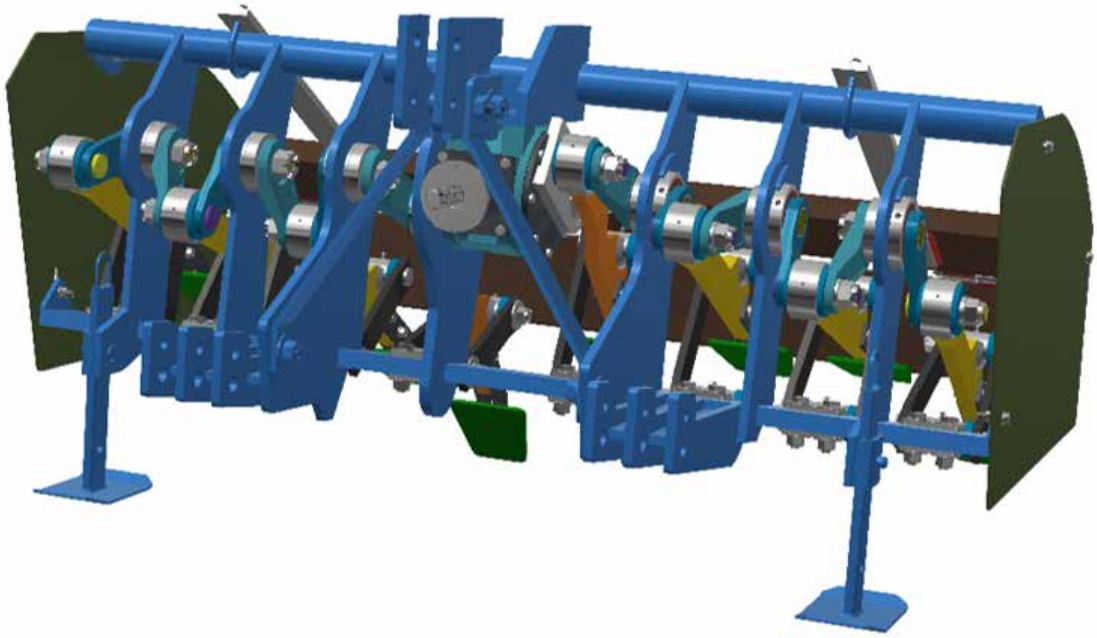


Fig. 3.81: Spading machine

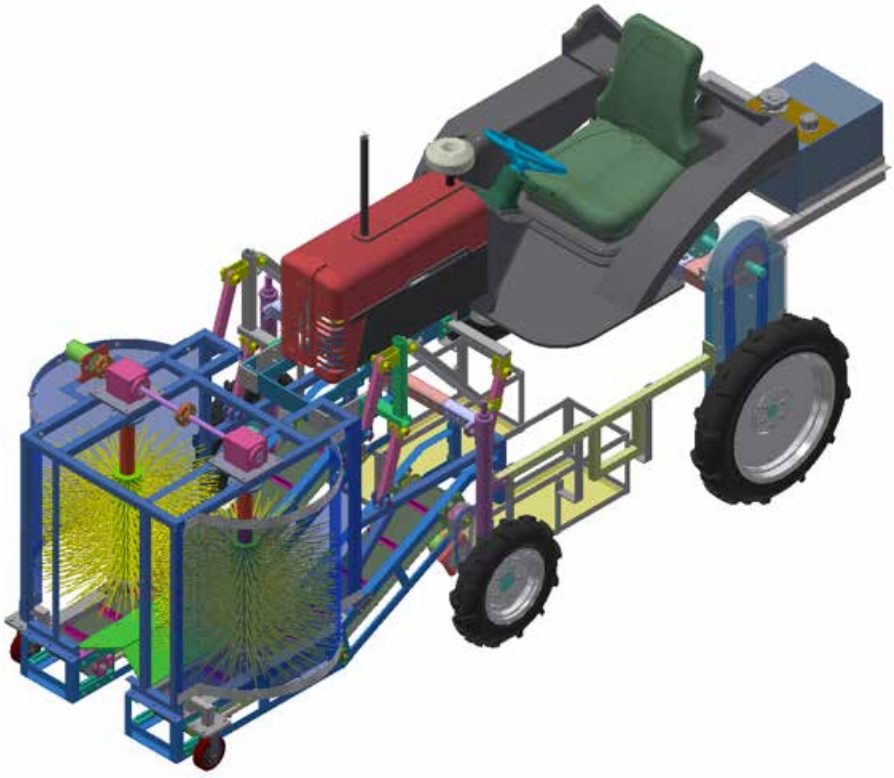


Fig. 3.82: Self-propelled chilli harvester

3.2.2 Scientific and Useful Profound Research Advancement (SUPRA)

SERB-SUPRA is one of the newly initiated scheme that seeks to explore new scientific breakthroughs, with long-term impact on our fundamental scientific understanding, and offer disruptive technologies at the cutting-edge research. Transformative and disruptive research concepts based on innovative and unproven hypothesis, possessing a high degree of uncertainty, yet having conviction to produce a lasting impact across discipline boundaries

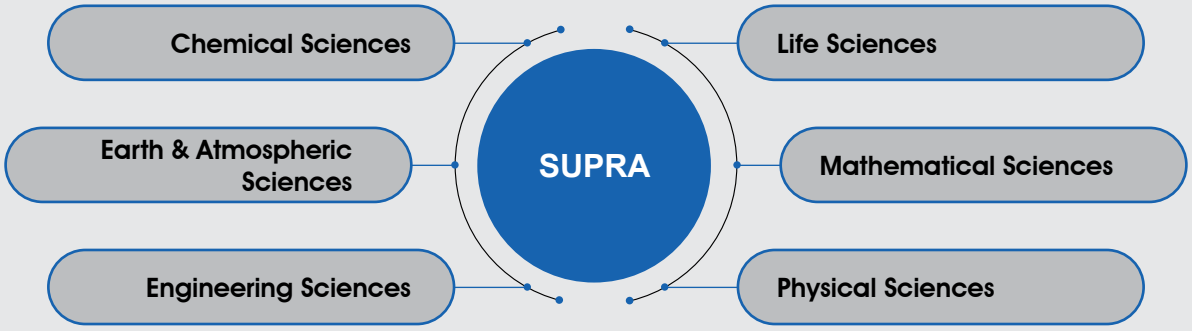
qualify for support under this scheme. It is envisaged that innovative SUPRA proposals will bring out breakthrough solutions in identified areas. Success of such proposals will ideally open up new opportunities in S&T and impact global science not only in terms of knowledge, but also in the form of delivered outcomes.

FEATURES

- **A scheme beyond normal core grants to support cutting edge research**
- **Research support to an individual researcher or a group of researchers working in a recognized institution**
- **Funding period is normally for three years, which could be extended to 2 years subject to performance evaluation**

Website links
https://serbonline.in/SERB/Supra

Areas Supported



Research Highlights of one of the proposal supported is given below:

Integrated capture and conversion of co_2 to methanol using protic catalysts: The main aim of the project, is to develop an efficient CO_2-to-methanol conversion methodology and to enable the integrated capture and utilization of CO_2 using protic catalysts. The first component of the project is to fabricate new proton responsive catalysts and to demonstrate their catalytic efficacy for (de)hydrogenation reactions. In this context, PI developed a set of proton-responsive Cp*Ir(III) complexes and utilized these for catalyzing (de) hydrogenation type reactions. A Cp*Ir(III) complex (1) bearing a proton-responsive, hydroxy unit on an annulated imidazo [1,2-a][1,8] naphthyridine based mesoionic carbene scaffold (Fig. 3.83) was synthesized by two different synthetic routes.

36
Projects Sanctioned

35.91 cr
Expenditure
(New & Ongoing Projects)

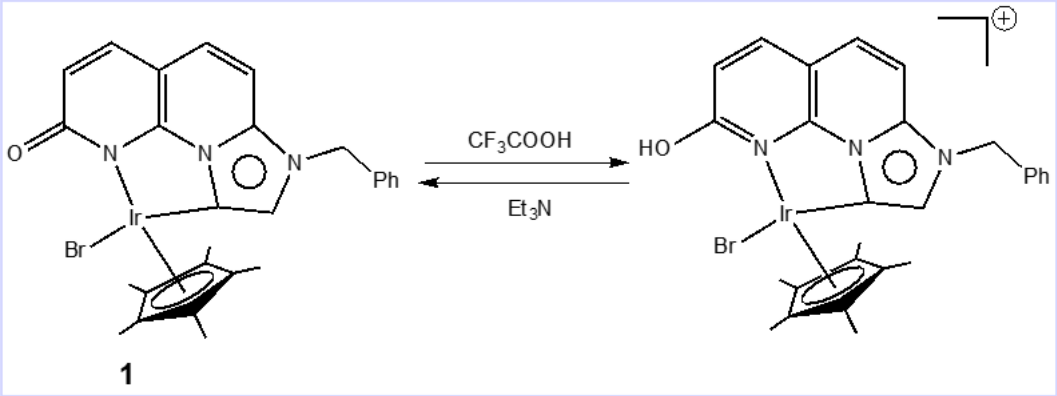


Fig. 3.83: Proton-responsive character of catalyst 1.

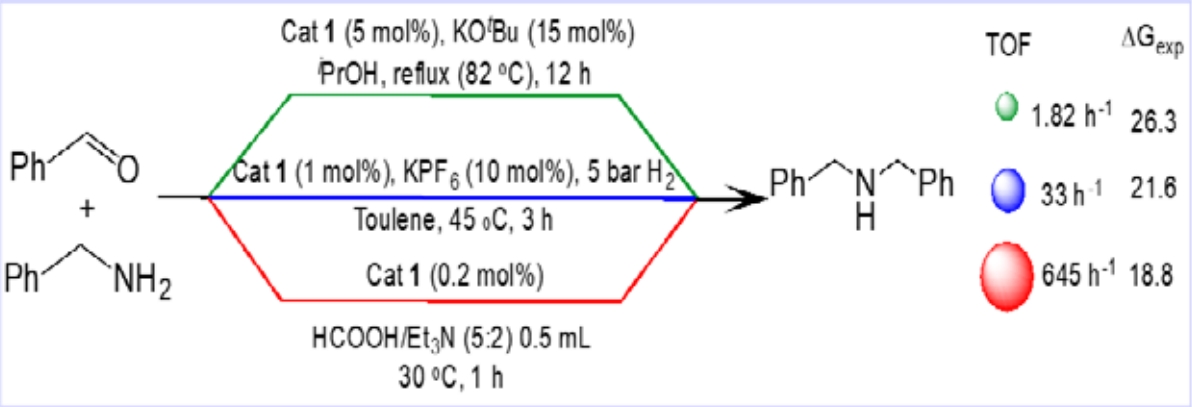


Fig. 3.84: 1-catalyzed reductive amination of benzaldehyde using benzylamine.

The molecular structure of 1 revealed an anionic lactam form of the ligand. The acid–base equilibrium between the lactam-lactim tautomers on the ligand scaffold was examined by ^{1}H NMR and UV–vis spectra. The pK_a of the appendage –OH group in the lactim form of 1 was estimated to assess the proton transfer property of the catalyst. The catalytic efficacy of 1 for reductive amination of aldehyde was evaluated by utilizing three different hydrogen sources: molecular H_2, ^{i}PrOH/KO^{t}Bu combination, and HCOOH/Et_3N (5:2) azeotropic mixture (Fig. 3.84).

The HCOOH/Et_3N (5:2) azeotropic mixture protocol was found to be the best among the three different hydrogenation methods. Catalyst1hydrogenates imines chemoselectively over carbonyls under the reaction conditions. A range of aldehydes was reductively aminated to the corresponding secondary amines using the HCOOH/Et_3N (5:2) azeotropic mixture. Further, catalyst 1 showed high efficiency for the reduction of a wide variety of N-heterocyclic imine derivatives. The lactam-lactim tautomerization of the ligand system is proposed for direct hydrogenation, whereas only the lactam form operates in the strongly basic medium (iPrOH/KOtBu). Under HCOOH/Et_3N (5:2) conditions, the lactam scaffold is not protonated; rather, an outer-sphere hydride transfer from formate to the Ir is proposed, which is supported by ^{1}H NMR and DFT calculations. Finally, ligand-promoted hydride transfer from metal-hydride to the protonated imine affords the corresponding amine. A close agreement between the experimentally estimated and computed thermodynamic/kinetic parameters gives credence to the metal-ligand cooperative mechanism for the imine hydrogenation reaction using the HCOOH/Et_3N (5:2) azeotropic mixture.

For the hydrogenation of CO_2 with H_2 gas by the proposed proton-responsive catalysts, it is a very important requirement that the designed catalysts are able to cleave H_2 efficiently. The uracil-based proton-responsive Ir complexes 5-8 were examined for the anticipated 'bifunctional' heterolytic cleavage of H_2 through the cooperation of the proton-responsive unit with the metal centre. Delightedly, these systems efficiently activated H_2 heterolytically at atmospheric pressure and ambient temperature conditions where the proton part (H^+) was captured by the ligand and the hydride part (H^-) was bound to the Ir centre, as supported by ^{1}H NMR spectroscopy in CD_3CN solution (Fig. 3.85).

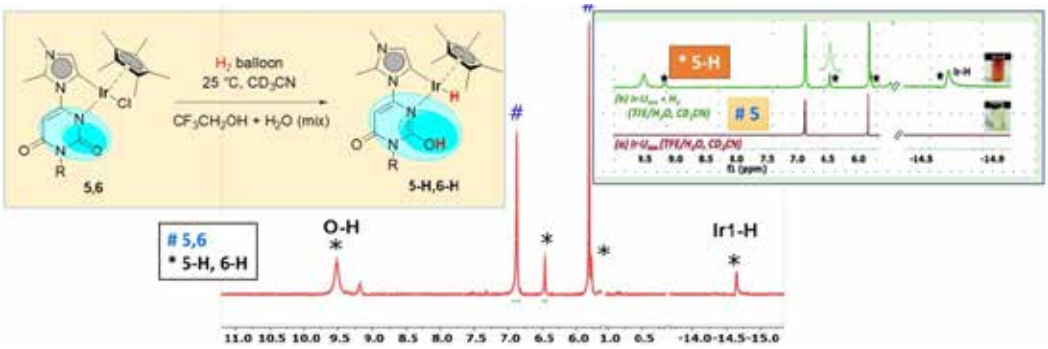


Fig. 3.85: Efficient heterolytic cleavage of H_2 by the proton-responsive catalysts 5-8. Representative results are shown herein.

Further, another class of our proposed and designed proton-responsive bifunctional catalysts were explored to convert CO_2 to an intermediate reduced product, viz., formate, HCO_2^- (or formic acid) with the help of an H_2-storage reagent, NH_3BH_3 under ambient conditions (1 atm., 30 °C). It exhibited an initial TOF of 686 h^{-1} and a high TON of ≈1300 in just 4 h. Most significantly, the catalyst was durable enough for maintaining a long-term activity and just by periodic recharging of NH_3BH_3, it furnished a total TON of >4200 in 10 h (Fig. 3.86).

In summary a set of proton-responsive Cp*Ir(III) catalysts were constructed and their catalytic efficacies were demonstrated for (de) hydrogenation/transfer hydrogenation reactions. One class of such catalysts were exploited to cleave H_2 successfully to generate the active Ir-H, a key species for hydride transfer to CO_2. Moreover, conversion of CO_2 to formate (HCO_2^-) with a hydride-transfer reagent, NH_3BH_3, was achieved with benzimidazolato-based proton-responsive catalysts.

The work is being carried out at Indian Institute of Technology, Kanpur

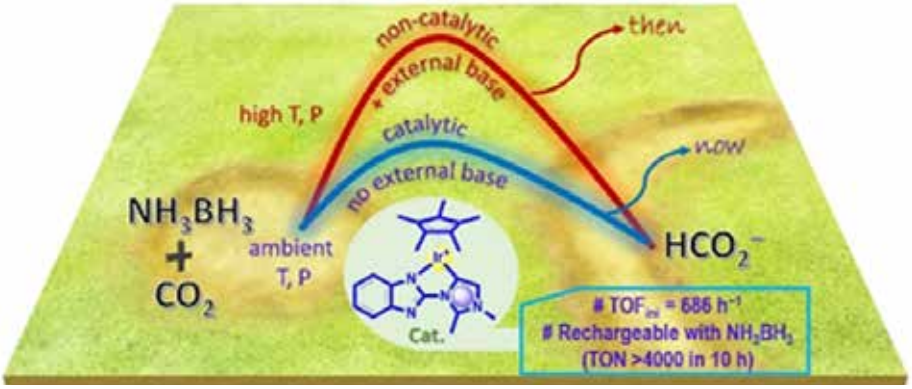


Fig. 3.86: Conversion of CO_2 to formate (HCO_2^-) with NH_3BH_3 as hydride (H^-) source under ambient conditions by proton-responsive "(benzimidazolato)Ir(III)–abnormal NHC"catalyst.

3.3 GENDER AND SOCIAL INCLUSIVENESS

3.3.1 Promoting Opportunities for Women in Exploratory Research (POWER) Grant

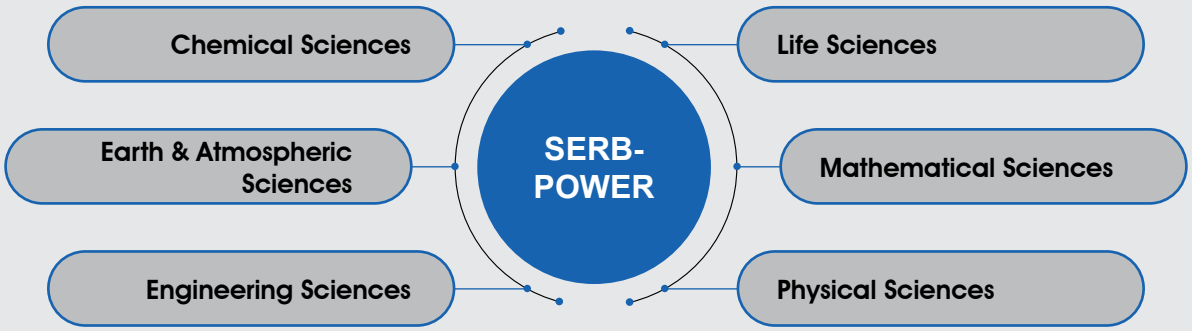
A new scheme SERB-POWER (Promoting Opportunities For Women in Exploratory Research) was launched to promote women scientists. This scheme aims to encourage emerging and eminent women researchers for individual-centric and competitive mode of research funding to undertake R&D activities in frontier areas of science and engineering. POWER Grant programme is aimed to bridge the gender gap in science and engineering research funding in various S&T programs to ensure equal access and weighted opportunities for Indian women scientists engaged in R&D activities.

FEATURES

- **Project support for women researchers in regular position**
- **Funding is under two categories. Level 1 : 60 lakh for three years for PIs from National and Central institutions. Level II : 30 lakh for three years for PI from State Universitities / colleges and private academic institutions**
- **Duration of support is for three years**

Website links
http://serb.gov.in/power_research_grant.php
https://serbonline.in/SERB/serbPowerInstructions

Areas Supported



First call for proposals under SERB-POWER grant was made during November, 2020 – January, 2021 and proposals submitted by women scientists which were not recommended under CRG-2021 call were also considered in this POWER call. A total of 2880 proposals were received out of which 99 proposals were granted funding across all disciplines of science and engineering.

Highlights of some of the proposals supported are given below:

A secure and interpretable machine learning framework for medical image analysis: The project proposes to identify vulnerabilities in the algorithms used for explanations or interpretations and propose a secure explainable framework which can be used for the analysis of medical images. The first step in the project will be to analyze security vulnerabilities in the data and the algorithms used for prediction and analysis in the medical domain. Initially, retinal fundus images will be used for this step. The second step in the project will be to identify adversarial attacks on explainable algorithms and to analyze the impact of adversarial attacks on explainable algorithms. Finally, a secure and explainable framework using rough set theory will be developed. This framework can be used for

21
Projects Sanctioned

4.73 cr
Expenditure
(New Projects)

further research in the area of security for explainable algorithms. This will improve confidence in medical experts and doctors for using AI based image analysis systems.

The work will be done at Anna University, Chennai.

Functionalized long wavelength light emitting donor-acceptor systems: Though a variety of materials having emission in longer wavelength region have been reported yet several venues are not much explored such as control of emission/ energy transfer processes of assembled materials in aqueous media and interrelation between morphology/redox potential (ground state and excited state) of red emitting materials and molecular recognition/catalytic event in aqueous media. In the present investigation, investigator is planning to develop donor-acceptor systems using PBI/pyrazine as the core. These materials (designs A and B) will be explored to understand various different mechanistic pathways for detection of organophosphate 'nerve agents'. The role of synthesized materials as acetylcholinesterase enzyme (AChE) inhibitors will also be examined. By tuning the energy difference between lowest excited singlet state and triplet state, PI plans to synthesize TADF materials (design C) as photoredox catalytic systems for construction of C-C/C-N bonds. Further, PI plans to synthesize donor-acceptor (D-A) systems (designs D and E) having sufficient potential to generate reactive oxygen species upon irradiation. The catalytic efficiency of these materials will be explored in various organic transformations.

The work will be done at Guru Nanak Dev University, Amritsar.

3.3.2 Empowerment and Equity Opportunities for Excellence in Science (EMEQ)

FEATURES

- **Project grant for researchers belonging to Scheduled Caste and Scheduled Tribe in regular position**
- **Support across all disciplines of Science and Engineering**
- **Funding is provided up to a maximum of 50 lakh for a period of three years**

Website links
http://serb.gov.in/emeq.php
http://serbonline.in/SERB/Weaker_section

The scheme, EMEQ is aimed at providing research support to scientists belonging to the Scheduled Caste and Scheduled Tribe in undertaking research in newly emerging and frontier areas of science and engineering and thus to involve them in the National Science and Technology development process. The scheme was initiated in the year 2013 and more than 1550 researchers have received support till date.

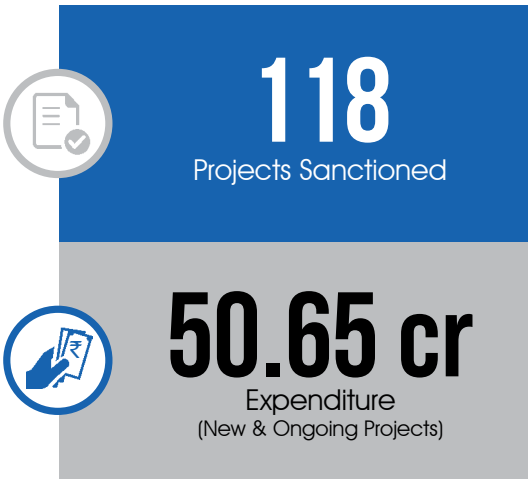
Research Highlights

Development of pulse electrodeposited Ni-W, Ni-Mo alloy coating for hard chrome replacement: Work in the project led to development of environment benign process for deposition of completely new coating composition (Fig. 3.87) (Indian Patent No. 337108, dated 20/05/2020) having both tribological and corrosion resistance properties better than conventional hard chrome coatings and commercial composite coatings.

The coating composition is competitive globally in terms of environment protection, corrosion and wear performance (Fig. 3.88) and have applications in automotive and engineering industry. In this project, PI has developed an ecofriendly process of Ni-W and Ni-Mo coatings for hard chrome process replacement. In addition to this, the corrosion performance of Ni-W and hard chrome coatings were also analyzed and the

rationale behind the better corrosion performance of these Ni-W and Ni-Mo coatings with respect to hard chrome is presented. For wear performance, Ni-Mo coatings are suitable and for both wear and corrosion performance, Ni-W coatings can act as best alternative for hard chrome replacement.

Utilizing the extended scale of operations, various sizes and geometries of components (Fig. 3.89) including the internal area coating on larger parts are being currently provided with a variety of alloy and nanocomposite coatings to meet the functional requirements. The technology developed at ARCI through this project is readily available for industry in India and abroad for commercial exploitation in terms of application development and technology transfer.



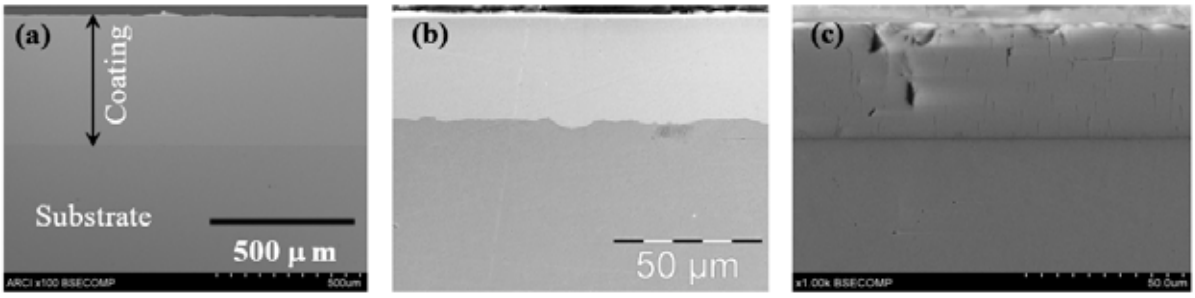


Fig. 3.87: Ni (a), Ni-W (b) without cracks, porosity free and conventional hard chrome coatings (c) with numerous cracks, porosity present in it.

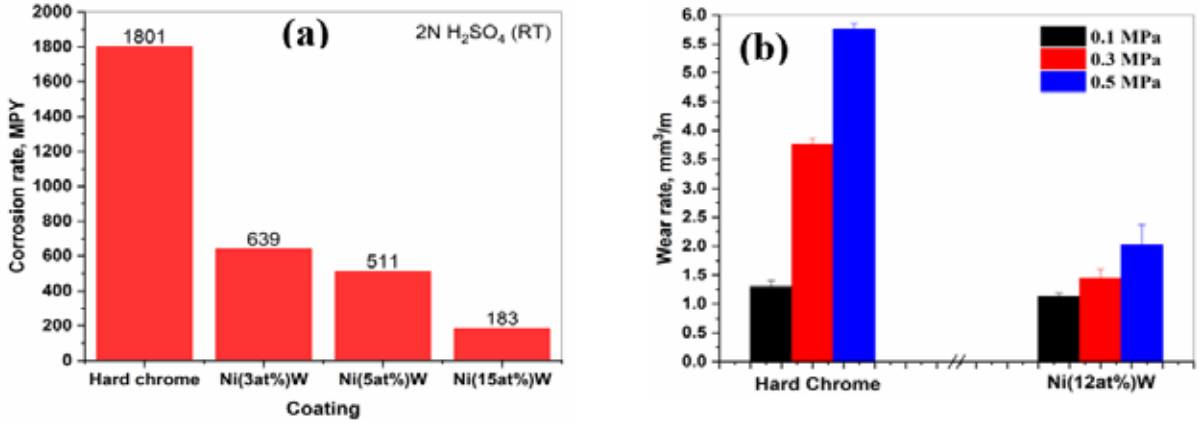


Fig. 3.88: (a) Corrosion and (b) wear performance of Ni-W alloy coatings in comparison with hard chrome.

Fig. 3.89: Automotive engine cylinder bore coated with Ni alloy

The work was done at International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad.

4

AWARDS AND FELLOWSHIPS

One of the vital activities of SERB is to provide recognition to brilliant young scientists, active superannuated scientists, exemplary woman scientists and researchers through several fellowships and awards for their remarkable contributions in the field of Science and Engineeering. The goal is to motivate the scientists to aspire for excellence in scientific R & D.

These fellowships and recognitions cover a broad spectrum of basic, translational and applied research initiatives encompassing the specialities across all areas of Science and Engineering. The thrust is towards generating an ecosystem where quality research is recognized, supported and empowered - be it in enabling the active eminent superannuated scientists to continue their research (National Science Chair) or inspiring young dynamic researchers by bringing their impactful research to the forefront with prestigious awards (SERB-STAR Science and Technology Award for Research and Swarnajayanti fellowship). While recognitions such as J.C. Bose Fellowship and Abdul Kalam Technology Innovation (AKTIN) Fellowship are awarded for accomplished scientists and engineers for their exemplary performance, SERB Technology Translation Award acknowledges and supports PIs who have successfully conducted research with translational potential.

Special impetus schemes that focus on human capacity building, such as National Post-Doctoral Fellowship provide support to young researchers, paving way for their dedicated research career. SERB recognizes the imperative need to make opportunities for skilled researchers trained abroad and willing to return to India to build a career in scientific R&D. Ramanujan Fellowships facilitate such young Indian minds from across the globe. Schemes such as SERB Research Scientist scheme, is designed to assist young researchers in transitioning to regular positions in research institutions.

The need to bridge the gap between the premier institutes and private or state universities, is recognized in schemes such as Teachers Associateship for Research Excellence. Also recognized is the importance of steering youth to take on the challenges of doctoral research in the design of Prime Minister's fellowship programme for doctoral research.

SERB is at the forefront in recognizing women scientists of extraordinary potential who have contributed immensely in transforming the scientific landscape. The SERB POWER Fellowships along with Women Excellence Awards honour eminent women scientists for their incredible contributions across disciplines in Science and Engineering.

In line with SERB's approach of being synergetic and inclusive, relevant organizations are partnered for specific awards, to ensure sharing of domain expertise and coordinate efforts. Notable partner agencies include, Indian National Academy of Engineering (INAE), Federation of Indian chambers of commerce and industry (FICCI) and Confederation of Indian Industry (CII).

4.1 RECOGNITION FOR EMINENT SCIENTISTS

4.1.1 National Science Chair (NSC)

The main aim of the scheme is to recognize active eminent senior resident Indian superannuated scientists for their outstanding contributions both nationally and internationally, in the area of Science, Technology, Engineering, Mathematics (STEM) and Medicine, and leverage their knowledge and experience to promote excellence in R&D. NSC is implemented in two modes. Under Mode 1: Scientific Excellence, the support is extended to senior eminent scientists who after superannuation continue to be active in research but do not possess a formal supporting arrangement. Mode 2 recognizes outstanding superannuated scientists to establish a benchmark for stature, value, and eminence in national and international Science & Technology communities as a R&D leader.

The earlier schemes, Year of Science Chair Professorship (YoSCP) and SERB Distinguished Fellowship (DF) for recognition of senior scientists after superannuation were merged as National Science Chair in the year 2019.

Awardees of National Science Chair are:

Mode 1:

1. **Prof. Sankar Kumar Pal**
   Indian Statistical Institute Kolkata
2. **Prof. Biman Bagchi**
   Indian Institute of Science Bangalore
3. **Prof. M. Vidyasagar**
   Indian Institute of Technology Hyderabad
4. **Prof. Partha Pratim Majumder**
   National Institute of Biomedical Genomics Kalyani

Mode 2:

1. **Prof. Roddam Narasimha**
   Jawaharlal Nehru Centre for Advanced Scientific Research Bangalore

FEATURES

- **Fellowship of Rs 1.5 lakh per month under both modes**
- **The Research Grant in case of Mode-1 and Mode-2 are Rs 25 lakh and Rs 5 lakh per annum, respectively**
- **The period is for 3 years, extendable to a maximum of another two years**

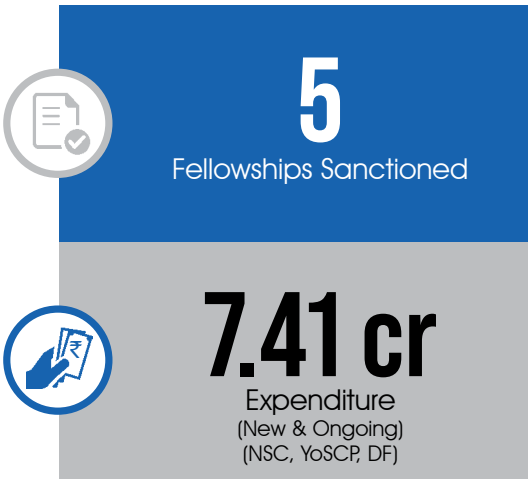
Website links
http://serb.gov.in/nsc.php

Research Highlights

In collaboration with JNCASR Bangalore, a research group at IISc led by the Year of Science Chair Professor showed experimentally that both single and multiple mechanical memories can be encoded in amorphous bubble raft, a prototypical soft glass, subject to an oscillatory strain. In line with numerical results, they found that multiple memories can be formed sans external noise. By systematically investigating memory formation for a range of training strain amplitudes spanning yield, signatures of memory even beyond yielding were found. Most strikingly, the extent to which the system recollects memory is largest for training amplitudes near the yield strain and is a direct consequence of the extent over which the system reorganizes during the encoding process. The study further suggests that evolution of force networks on training plays a decisive role in memory formation in jammed packings (Fig. 4.1).

Research undertaken by a SERB Distinguished Fellow at Cotton University, Guwahati, in collaboration with scientists at the Indian Institute of Science shows that all Indian monsoon droughts are predictable, some being associated with the El Nino and Southern Oscillation (ENSO) while the rest being associated with the Atlantic Multi-decadal Oscillation (AMO) (Science, December 11, 2020).

Further, the study elucidates a sub-seasonal atmospheric bridge through which the North Atlantic Sea surface temperatures (SST) influence the Indian summer monsoon rainfall (ISMR). This is important because in addition to tropical SST such as the ENSO, the extra-tropical SST could also add predictability for ISMR. A research study led by the Fellow at Cotton University demonstrated that the multi-decadal oscillation of ISMR is also strongly linked with multi-decadal oscillation of the North Atlantic SST (the AMO) and that the same sub-seasonal atmospheric bridge also connects the North Atlantic SST and ISMR. A study by the Fellow unravelled that a large fraction of sub-seasonal fluctuation contribution to the ISMR is predictable, contrary to conventional wisdom. The three complementary studies provide pillars for an emerging framework for much higher predictability of ISMR than previously thought (Fig. 4.2).



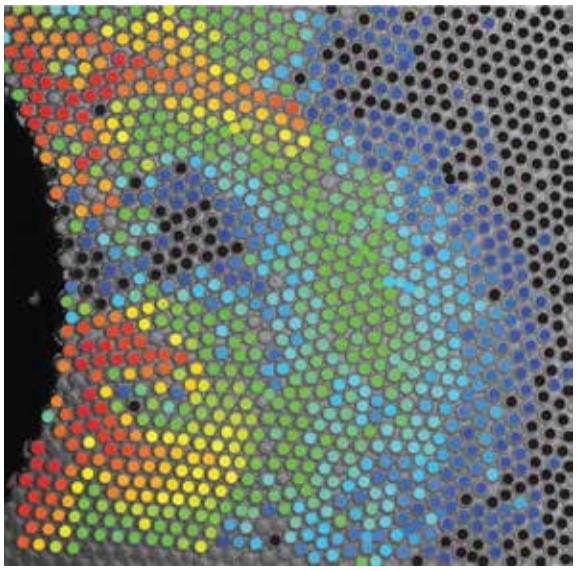


Fig. 4.1: Displacement map of bubbles after writing the mechanical oscillatory shear at the yield strain of the bubble raft.

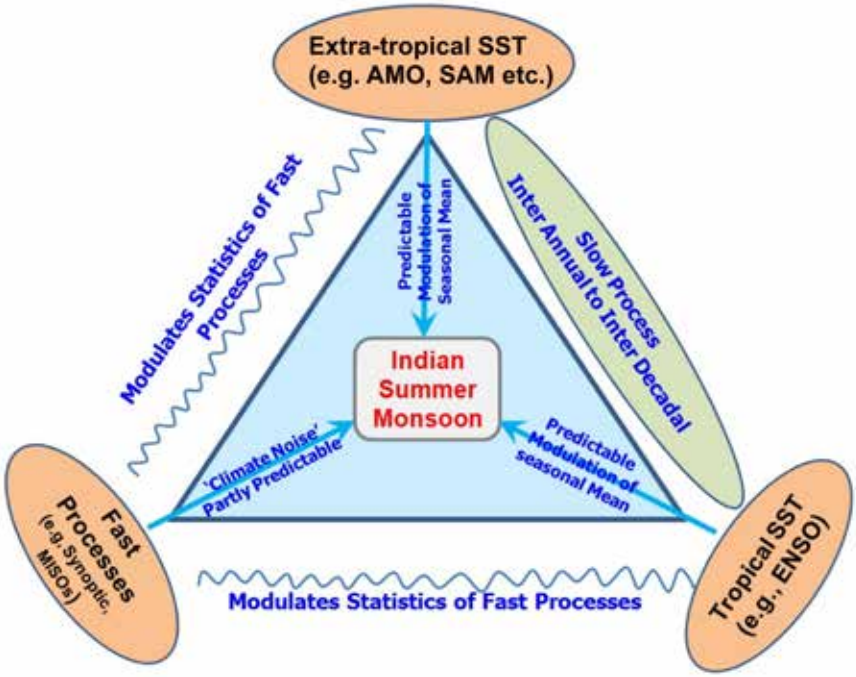


Fig. 4.2: The predictability of the Indian summer monsoon arises from 'external' drivers associated with slowly varying tropical SST (e.g., the ENSO) and extratropical SST (e.g., the AMO). Modulation of the variances of sub-seasonal fluctuations by the predictable 'external' drivers makes a part of 'internal' contribution to ISMR also predictable adding to the predictability of ISMR.

4.1.2 J C Bose Fellowship

The J C Bose fellowship is awarded to active Indian Scientists and Engineers in recognition of their outstanding performance and significant contribution towards scientific research. The scheme was initiated in the year 2006 to recognize eminent scientists and engineers in all areas of Science and Engineering. The fellowship is scientist-specific and very selective.

FEATURES

- **Support consists of (i) fellowship of Rs. 25,000 per month, (ii) research grant of Rs. 15 lakh per annum and (iii) Overhead of Rs.1 lakh per annum**
- **The duration of the fellowship is initially for five years which may be extended for a subsequent term of five years based on rigorous assessment**
- **A fellow can avail the fellowship up to 68 years of age only**

Website links
http://serb.gov.in/jcbn.php
https://serbonline.in/SERB/jcbose_fellowship

Research Highlights

A research group led by a J C Bose fellow evaluated the performance of reanalysis data and satellite products to represent extreme rainfall and associated flood over Upper Ganga basin (Fig. 4.3). The inferences drawn from the evaluation, highlights that fine resolution datasets do not always produce better rainfall simulations.

Impacts of climate change and land use change on the water quality across industrialised Kanpur region along Ganga River were also assessed (Fig. 4.4). It was found that dissolved oxygen is more sensitive towards climate, while nutrients and faecal coliform concentrations are sensitive to land use change. The study further investigated the impact of urbanization on hydro-meteorologic variables across seven selected cities across the world, including the Bangalore city in India. The results indicated that changes in the short-duration precipitation and temperature are prominent in the recent past. Influence of threshold selection in modelling extreme rainfall under non-stationary scenario was performed and it was found that threshold uncertainty is higher for high return period events.

46
Fellowships Sanctioned

30.26 cr
Expenditure
(New & Ongoing)

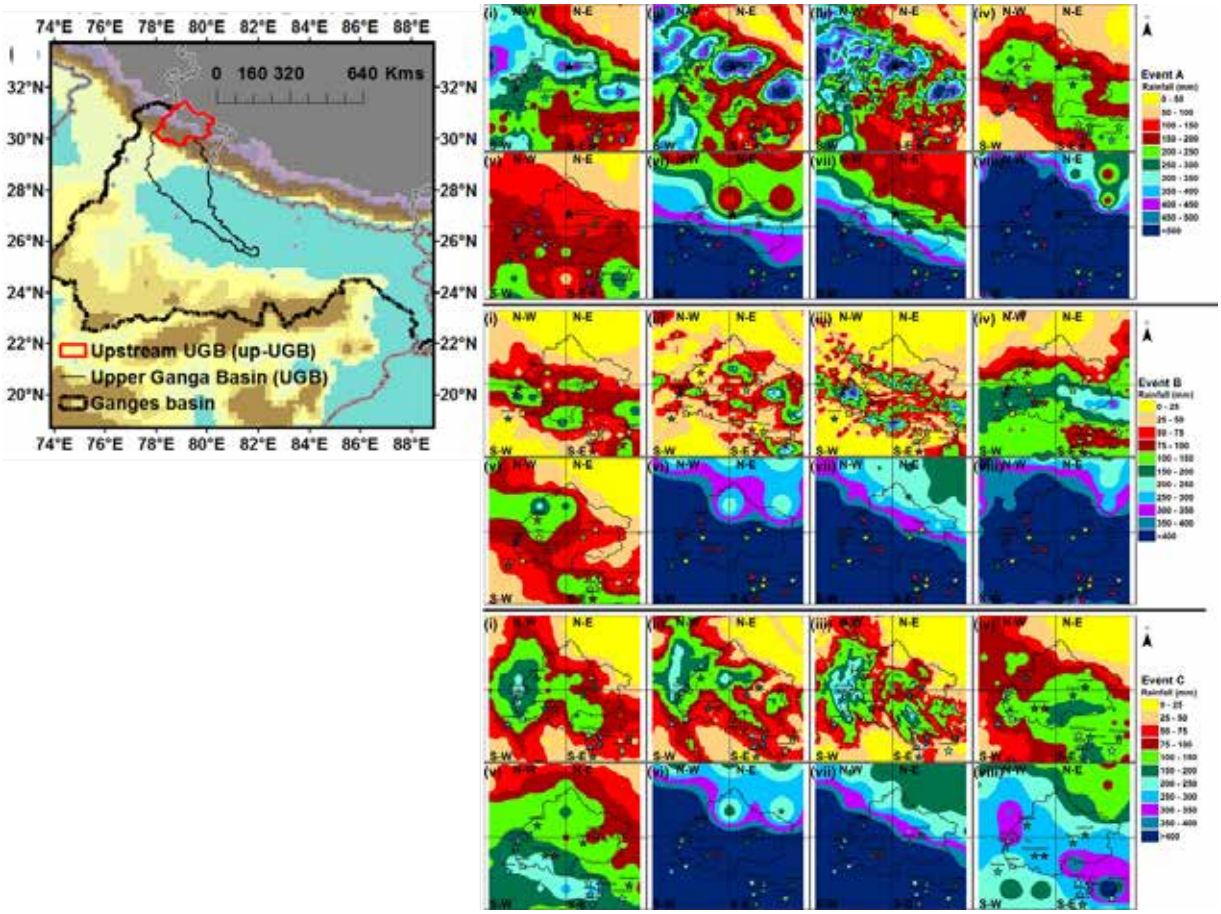


Fig. 4.3: Spatial variation in the cumulative rainfall over the up-UGB region for Event A (top panel); Event B (middle panel); and Event C (bottom panel) in (i) WRF D01 (27 km), (ii) WRF D02 (9 km), (iii) WRF D03 (3 km), (iv) TMPA (0.25°), (v) CFSR (0.5°), (vi) FNL (1°), (vii) JRA (0.562°), and (viii) MERRA 2 (0.5° × 0.625°) datasets.

The predictive capability and ability to represent key hydrologic processes in three hydrologic models - GWAVA (Global Water Availability Assessment), SWAT (Soil Water Assessment Tool) and VIC (Variable Infiltration Capacity) were investigated on upper reaches of Cauvery River basin. It was concluded that multiple models can offset input uncertainty and poor reservoir operation functionality within individual models.

A comprehensive review of uncertainties in water resource modelling from an Indian perspective was then performed based on the concepts of probability, fuzzy and grey/inexact simulation, optimization, and multi-objective analyses. The challenges in modelling uncertainties, missing links in integrated systems approach, along with directions for future research were provided.

The research was conducted at Indian Institute of Science, Bangalore.

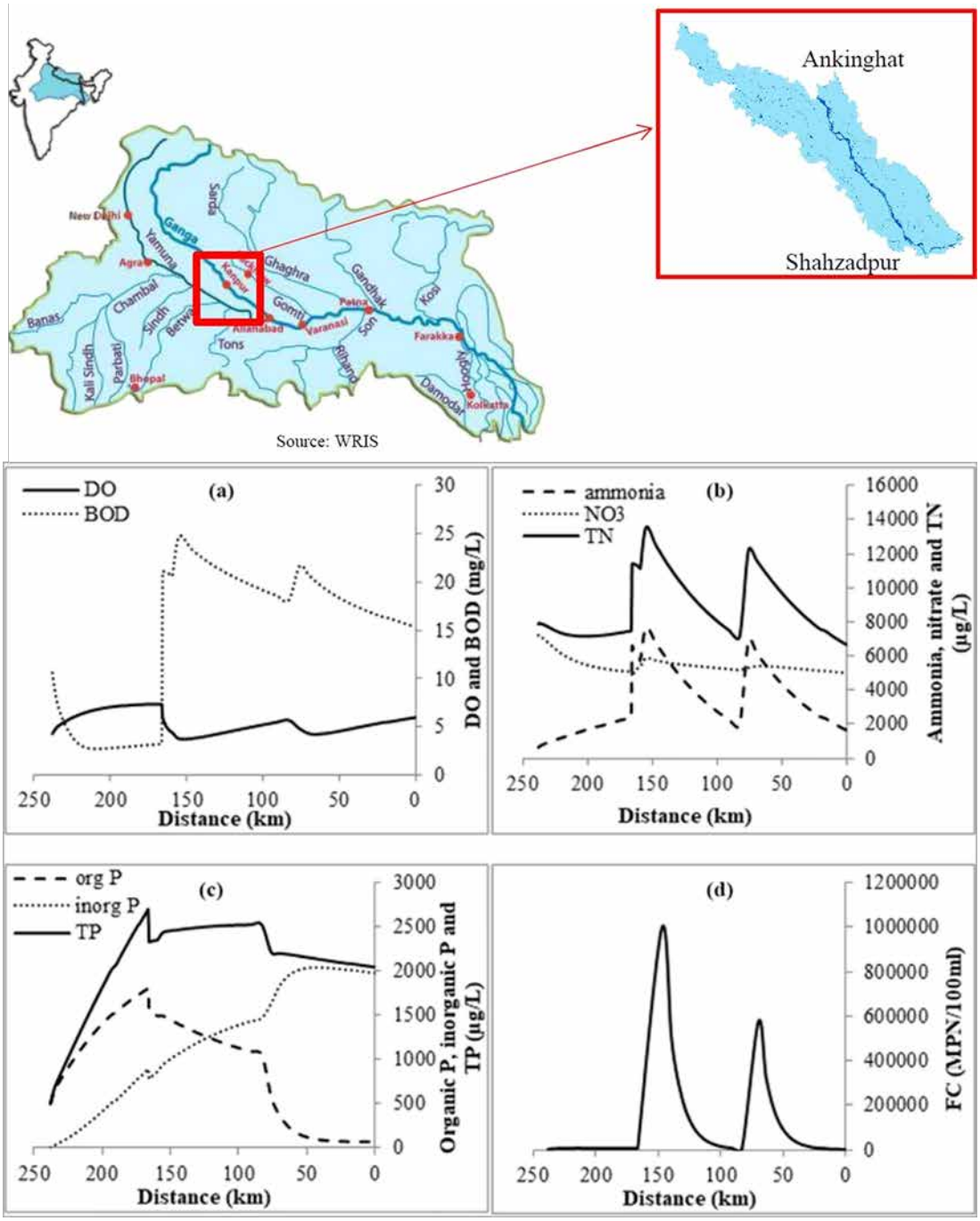


Fig. 4.4: (a) Dissolved Oxygen (DO) & Biochemical Oxygen Demand (BOD) profile, (b) ammonia, nitrate & total nitrogen (TN) profile (c) Organic phosphorous (P), inorganic P & total phosphorous (TP) profile and (d) faecal coliform (FC) profile along the river stretch (with Ankinghat at 238 km to Shahzadpur at 0 km) in the study area.

In another study by the group of a JC Bose fellow, tomato leaf curl New Delhi virus (ToLCNDV) which is a major constraint to tomato production world-wide was studied. This study embarked upon exhaustive investigation on ToLCNDV and established that the virus induced gene silencing of ToLCNDV responsive E3 ligase (SlARM)18 leads to susceptibility against ToLCNDV in the tolerant tomato cultivar H-88-78-1. (Fig. 4.5)

Analysis of SlARM promoter showed the presence of W-box elements. Interestingly, SlWRKY41 which was also upregulated upon virus infection, could bind to the W-box region of SlARM promoter and regulate its expression. The study also demonstrated that SlARM18 interacted with a viral pathogenesis determinant AC4 and facilitated its in-vivo degradation that was inhibited in the presence of 26S proteasomal inhibitor MG132.

Beside this, the group also worked on discovering 'Synergistic antiviral effects against SARS-CoV-2 by plant-based molecules." The work was one of the Springer Nature 2020 highlights (Fig. 4.6)

(https://www.springernature.com/gp/researchers/campaigns/highlights/plant-biology).

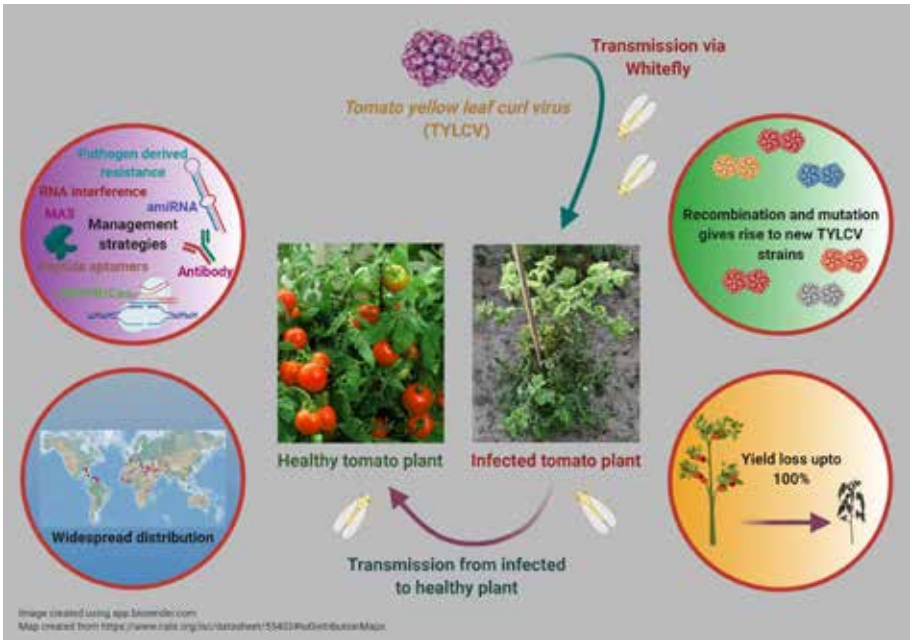


Fig. 4.5: ToLCNDV transmission, worldwide distribution and pathogen derived resistance summarized.

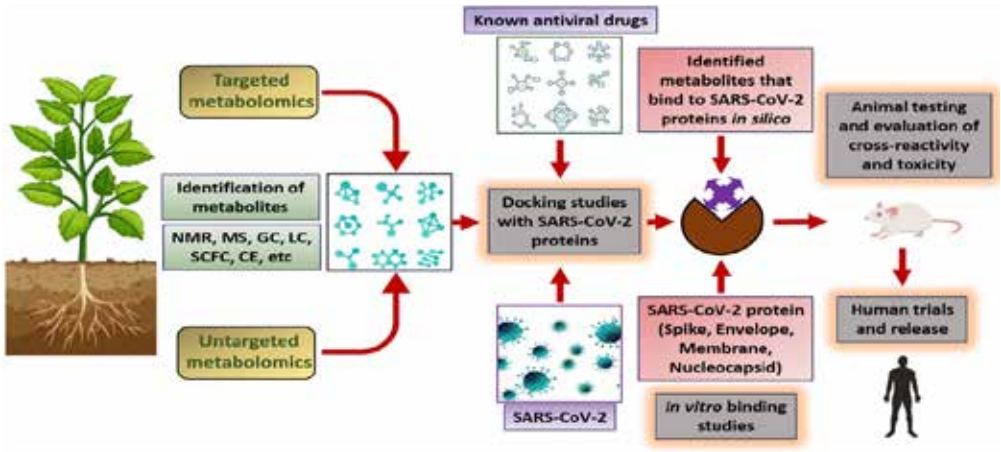


Fig. 4.6: A possible route of identification of antiviral drugs against SARS-CoV-2.

4.1.3 Abdul Kalam Technology Innovation National (AKTIN) Fellowship

Abdul Kalam Technology Innovation National Fellowship was launched by SERB in 2017 to recognize, encourage and support translational research by Indian Nationals. Indian National Academy of Engineering (INAE), in association with SERB, coordinates and awards Abdul Kalam Technology Innovation National Fellowships to outstanding engineers to recognize, encourage and support translational research of excellence in the fields of engineering, innovation and technology development across all fields of studies.

FEATURES

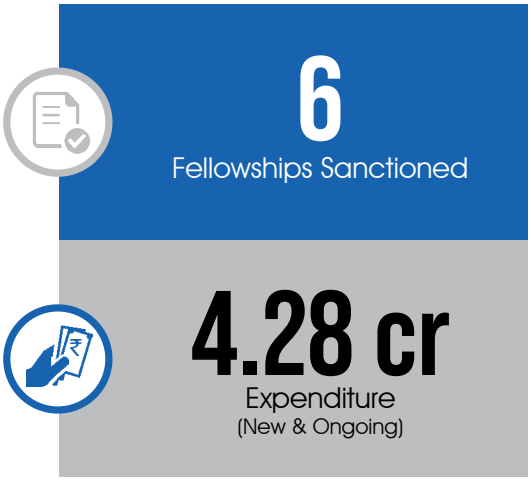
- **To promote high calibre research in Engineering domain**
- **The fellowship amount is Rs. 25,000 per month, in addition to regular income. Research grant is Rs. 15 lakh per annum and an overhead of Rs.1 lakh per annum**
- **Duration of fellowship is three years which may be extended by up to two years depending on performance**

Website links
www.serb.gov.in/kalam.php

Research Highlights

Ultrasonic Waveguide Sensor Systems: The research group led by an AKTIN Fellow is involved in developing Ultrasonic Waveguide Sensor Systems. In this study of ultrasonic waveguide technology, thin wires or strips made of appropriate materials are developed into unique, novel and robust sensors. The ultrasound is generated at one end of the waveguide and travels along the waveguide. Using embodiments as reflectors of the ultrasound, the reflected signals are employed for characterizing the surrounding temperatures (using time of flight between the reflected signals), rheology (using amplitude of the signals), flow properties, fluid levels, etc. Additionally, custom built electronics as part of the ultrasonic instrumentation, that are cost effective and robust are being developed. Initial focus was based on developing waveguide sensor configurations for 3 applications, namely, Skin Temperature Sensor for high temperature process tubes in refineries, Fluid Rheology-Temperature Sensor, and Fluid Level Sensor.

The technology for skin-temperature and rheology-temperature sensors was slated for field trials at BPCL refinery (August 2020) while the fluid rheology- Temperature sensor (Fig. 4.7) technology field trials are underway in Saint Gobain Research India (SGRI) laboratory currently with the field trials at their manufacturing sites proposed in 2021.



The novelty of the proposed sensor is the simplicity of the concept that provides a low cost, robust and versatile waveguide sensor that has several applications over a wider range of industrial applications and hence commercially feasible.

Four product prototypes have been developed during this period for the waveguide-based sensors technology and the respective TRL. Beneficiaries are the petrochemical industries and manufacturing industries. Few clients already acquired are: BPCL, Mumbai/Noida, IOCL, Faridabad, RIL, Mumbai/Jamnagar, SGRI, Mora, SGRI, France, LAM Research, San Francisco, LAM Research, Bangalore. The technology transfer process is already underway with XYMA Analytics, an IIT Madras start-up leading the efforts under a licence agreement with IIT Madras. Also, 3 Indian Patents, 2 Foreign patents and 2 PCTs were filed, out of which 1 Indian Patent and 1 Foreign Patent granted.

The study was carried out at Indian Institute of Technology, Madras.

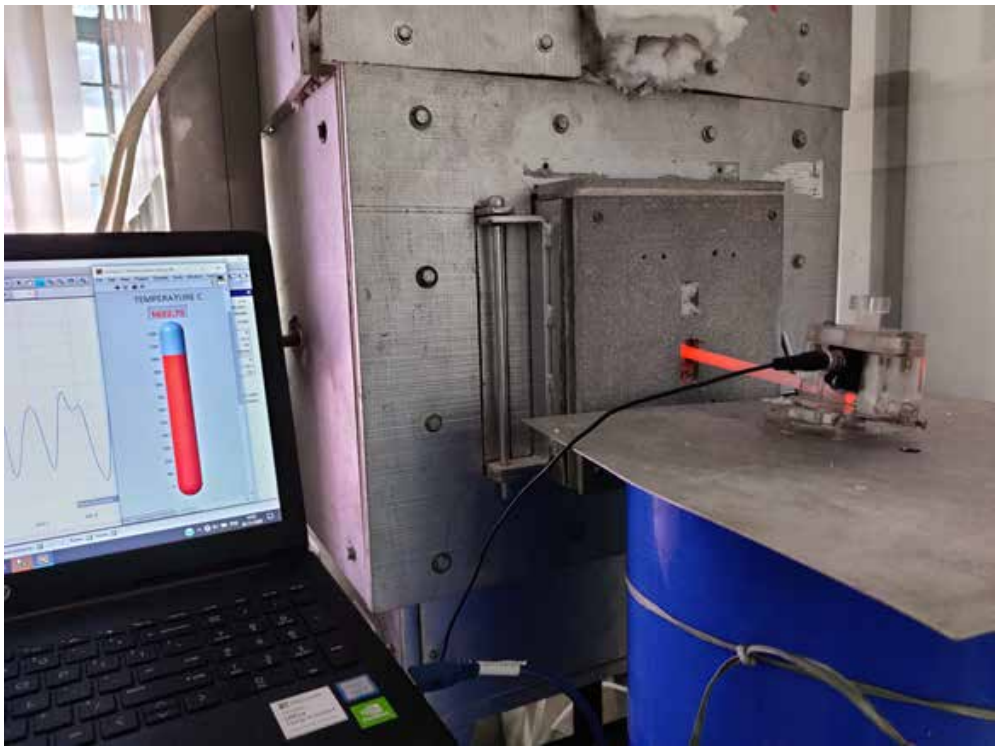


Fig. 4.7: Portable Rheology and Temperature Sensor' (PoRTS), developed by Xyma Analytics, an IIT Madras Incubated Startup, detecting the temperature.

Development of soil-moisture sensor, intracranial pressure sensor, and an assistive chair for the elderly and arthritics: The study focuses on development of soil-moisture sensor, intracranial pressure sensor, and an assistive chair for the elderly and arthritics. The group led by an AKTIN fellow has developed a soil-moisture sensor that uses much less power than competing technologies, is least affected by organic and chemical matter in the soil, is calibrated for soil density and ambient temperatures in various parts of India and is commercially viable in India. These soil-moisture sensors are designed and prototyped, complete with wireless communication, battery electronics board that are integrated with the sensor element based on dual-probe-heat-pulse technique.

This group has also developed a remarkable intracranial pressure sensor. The design details, microfabrication process flow, and the packaging were transferred to a DRDO lab, A-STAR, Bengaluru. This indigenously developed and affordable implantable sensor can also compete in the global market. Novelty of the design lies within minimizing the connecting wires that come out of the brain and solve the biocompatibility issues with suitable packaging as it is an implantable sensor.

Another innovation that came out of this research group is a cost effective and unique all-mechanical assistive chair that is customizable to individual needs. Central to this innovation is a novel compliant hinge mechanism that consists of a pair of open section shell-beams that bend and twist simultaneously. This one-piece mechanism provides a virtual axis of rotation for the chair-seat. Bending can be tailored, with a pair of replaceable cams, to give any torque-angle characteristic. The industrial design and clinical testing of assistive chair for the elderly

and arthritics to help in sitting and rising and possibly simple exercises, are in progress and will be completed this year. For the technology transfer from this study, a company is incubated in IISc under the Technology Business Incubation (TBI) of the Govt. of Karnataka.

4.2 FOSTERING YOUNG SCIENTISTS

4.2.1 SERB Science and Technology Award for Research (SERB-STAR)

SERB Science and Technology Award for Research (SERB-STAR) is a prestigious award instituted by SERB to recognize and reward outstanding performance of Principal Investigators (PIs) of SERB Projects. SERB-STAR is an initiative to acknowledge exemplary contributions in research and to motivate the PIs of ongoing projects for outstanding performance. The former SERB-Distinguished Investigator Award (SERB-DIA) has been reformulated as SERB-STAR award. The highlights of research work supported under SERB-DIA and SERB-STAR are given below.

FEATURES

- **To reward excellence in SERB projects**
- **Fellowship of Rs. 15,000 per month, research grant of Rs. 10 lakh per annum and Rs.1 lakh per annum as overhead charges for a period of three years**
- **Up to 30 awards per year and not more than 90 at any time**

Website links
http://serb.gov.in/star.php
https://serbonline.in/SERB/Star

Research Highlights

NIR-Light responsive systems: Single and Dual (simultaneous and sequential) release of anticancer drugs: In this project mitochondria-localized in situ generation of Rhodamine photocage with fluorescence turn-on enabling cancer cell-specific drug delivery triggered by green light (Fig. 4.8) has been studied.

Further, a two-photon responsive naphthyl tagged p-hydroxy phenacyl based drug delivery system was carried out where uncaging of anti-cancer drug in the phototherapeutic window with real-time monitoring has been studied (Fig. 4.9).

The research was carried out at Indian Institute of Technology, Kharagpur.

14
Awards Sanctioned

2.31 cr
Expenditure
(New & Ongoing)
(SERB-STAR, SERB-DIA)

Elucidating Vitamin B12-driven diet-gene interactions that regulate food choice and longevity: The ability to forage on a wide range of diet is evolutionarily advantageous as organisms would flourish even when their preferred diet is depleted. Nutritional inputs play an indispensable role in maintaining cellular activities, and as a result, in sustaining life history traits like

development, reproduction and aging. Diet generally comprises of macronutrients but is also an important source for micronutrients such as vitamins that function as metabolic cofactors. As animals are exposed to food of varying nutritional qualities, they have evolved intricate mechanisms to maintain homeostasis and normal life history traits, including life span, in response to the varied dietary cues. However, the underlying molecular mechanisms are less explored. This group is using a genetically tractable nematode, C. elegans to understand how an organism regulates life history traits while feeding on diets with different Vitamin B12 quantity. This is primarily because the metabolically active intestinal microbiota of C. elegans, a major source of micronutrients, provides a relatively less complicated and genetically well-regulated model to analyse the direct as well as bacterial feed-mediated effects of diet on life span.

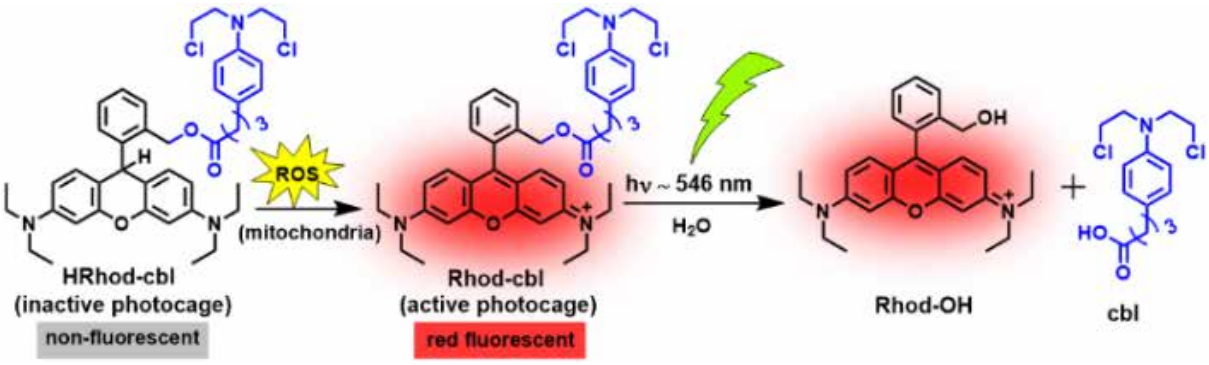


Fig. 4.8: Schematic presentation of the mitochondria-localized in situ generation of rhodamine-based photocage with fluorescence turn-on for photoinduced anticancer drug delivery selectively in the cancer cells.

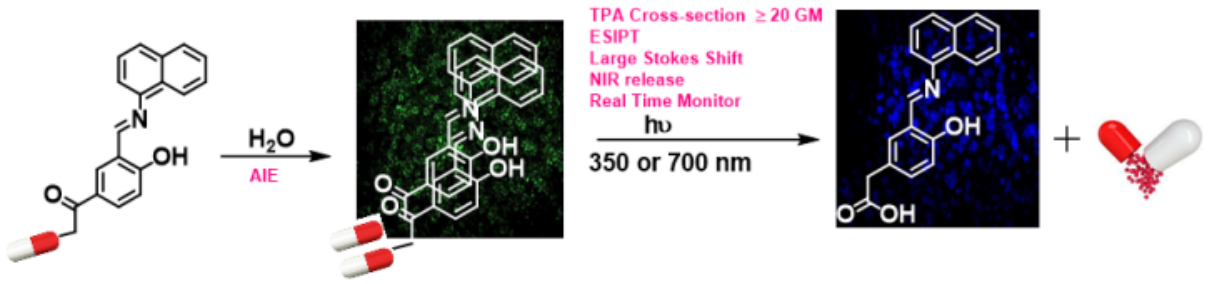


Fig. 4.9: Working protocol of the DDS pHP–Naph–Cbl in the phototherapeutic window.

This adaptive capacity to different diets is maintained by genes that have mostly been identified serendipitously. When any of these genes is mutated, the worms fail to maintain homeostasis in various aspects of cellular physiology and start displaying altered life history traits on one diet and not the others. These "gene-diet pairs" have been instrumental in our understanding of how quality of food influences life span and health. Recently, a diet-gene pair was serendipitously discovered in our lab where a serine-threonine-specific kinase gene (flr-4) mutant displayed diet-responsive increase in life and health span. The kinase dead flr-4(n2259) lives longer when grown on E. coli HT115 but not on E. coli OP50. In flr-4(n2259) grown on HT115, the p38-MAPK pathway was found to be activated, leading to higher expression of cytoprotective (CyTP) xenobiotic detoxification genes through the Nuclear Hormone Receptor-8 (NHR-8) transcription factor. This suggested that flr-4(n2259) mutants become sensitive to the presence of a molecule(s) in HT115 to mount a specific response, whereas wild-type worms can maintain homeostasis. In this current study, it was established that E. coli HT115 has more Vitamin B12, and the flr-4(n2259) mutant is sensitive to the micronutrient (Fig. 4.10). This study further showed that supplementing E. coli OP50 with Vitamin B12 can reproduce all the beneficial effects of HT115, like activating p38 MAPK, upregulating cytoprotective genes and increasing stress tolerance as well as life span in flr-4(n2259). On the other hand, an E. coli mutant of Vitamin B12 levels of bacteria, as determined by targeted metabolomics studies. Consequently, knocking down any component of the One Carbon metabolism suppresses increased CyTP gene expression, osmotic tolerance, and life span of flr-4(n2259) grown on HT115 or Vitamin B12-

supplemented OP50 (Fig. 4.11). Thus, this study has established flr-4 as a gene that maintain adaptive capacity to different diets based on specific micronutrient content.

The study was done at National Institute of Immunology, New Delhi.

A

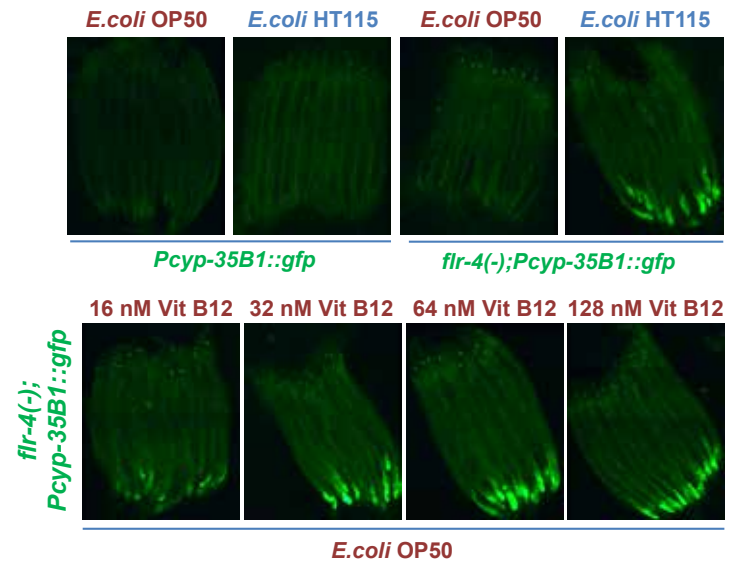


Fig. 4.10: The expression of gfp in flr-4(n2259);Pcyp-35B1::gfp grown on OP50 was enhanced with increasing concentrations of Vitamin B12. Pcyp-35B1::gfp is a transgene where the promoter of a cytoprotective gene cyp-35B1 drives the expression of gfp. No change in expression observed in case of Pcyp-35B1::gfp

B

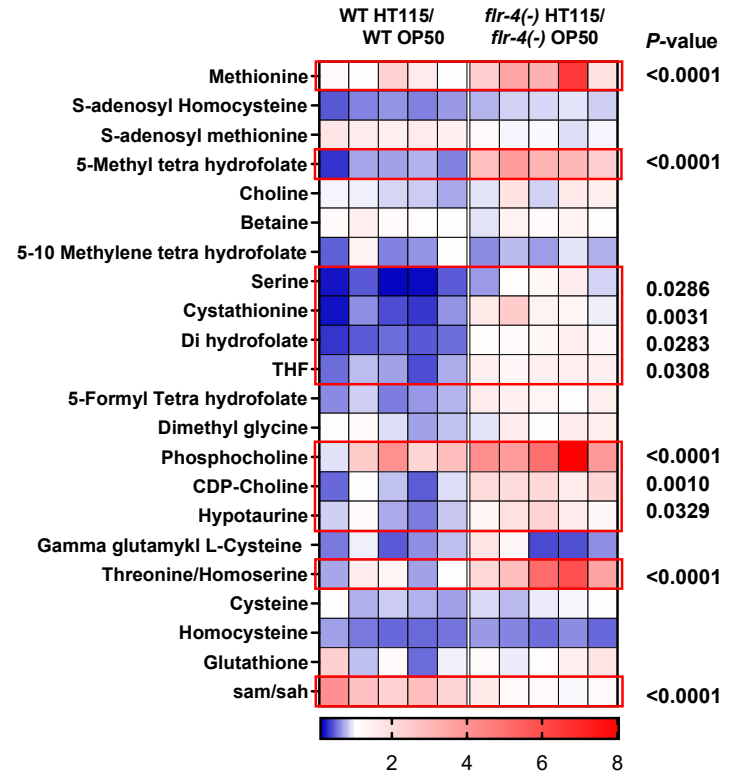


Fig. 4.11 : Metabolomics analysis of WT and flr-4(n2259) grown on E. coli OP50 or HT115. Each box represents one of five biologically independent replicates. Differences are highlighted using red boxes.

4.2.2 Swarnajayanti Fellowship

Swarnajayanti Fellowship is a flagship scheme of DST. The scheme was initiated in the year 1997-98 to commemorate the 50th year of India's independence. The scheme entails fellowships and research grants to young scientists in contemporary areas of science and technology. Presently, DST is executing the scheme, and candidates are selected based on a three-tiered peer-review system. SERB will be providing additional funding to meet the required expenditure pertaining to the research objectives enumerated in the proposal submitted by the awardee.

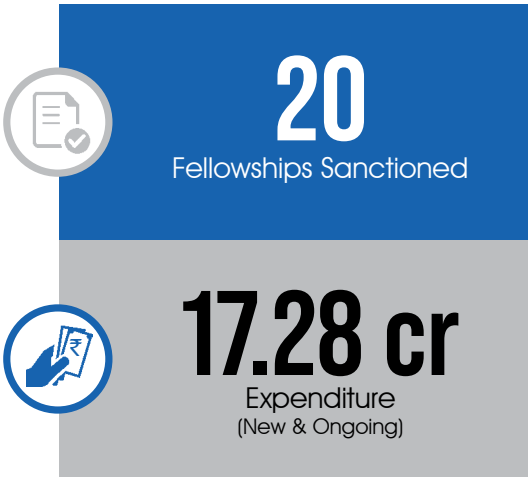
FEATURES

- **Prestigious fellowship awarded annually by DST for notable and outstanding research by young scientists**
- **The award consists of a Fellowship of Rs 25000 per month in addition to the salary drawn from the parent Institute for a period of five years**
- **The fellows selected along with projects will be considered for funding by SERB**

Website links
https://dst.gov.in/scientific-programmes/scientific-engineering-research/human-resource-development-and-nurturing-young-talent-swarnajayanti-fellowships-scheme

Research Highlights

What compensates the masking effects of aerosols on global warming? Atmospheric aerosols have been gaining scientific attention in the recent decades, mainly due to its potential to influence the regional/global climate and adverse effects on human health and air quality. The direct interaction of the atmospheric particles with solar and terrestrial radiations and indirect interactions through altering cloud microphysical properties are estimated to compensate almost 50% of the global mean warming due to anthropogenic carbon dioxide. Numerous studies have also highlighted that the surface cooling and atmospheric absorption due to aerosols play a crucial role in hydroclimate at regional scales. Considering the high values of columnar aerosol loading, water vapour content and cloud cover, the cooling due to aerosols is expected to compensate or overwhelm the recent warming trend in surface temperature due to greenhouse gases over the Indian region. However, long-term measurement of surface temperature over the Indian region depicts a warming trend, which is nearly similar to the global mean value. Hence, the effects of the large decrease in surface reaching solar radiation due to aerosols on surface temperature trend are insubstantial, especially over heavily aerosol laden Indo-Gangetic Plain. The lack of significant masking effects of aerosol-induced cooling on surface temperature trend over South Asia raises serious concern on the fundamental understanding on the various forcing pathways of climate system. The observations indicate that there exists an additional forcing pathway which partly compensates the surface cooling effects of aerosols.



Understanding these unrecognized pathways on energy balance is the major objectives of this Swarnajayanti proposal. Major hypothesis that would be tested in this study is the presence of an external forcing, probably indirectly driven by aerosols itself, which compensates the cooling effects of aerosols on surface temperature. One of the important contributors, which could partly compensate the aerosol cooling, is the cloud feedbacks or aerosol induced cloud modifications. Aerosol-cloud interactions and masking effect of clouds on aerosol forcing is not investigated in detail over this region. The time dependency of the climate sensitivity of aerosols, role of water vapour and atmospheric warming due to carbonaceous and mineral dust aerosols may also contribute to lesser masking effect of aerosols on surface warming (Fig. 4.12). To address this 'missing link' which unmask the effect of aerosols on surface temperature, a holistic approach is proposed by making use of potential advantages of climate modelling supplemented with in-situ observations and satellite data. This study will provide the fundamental understanding on the various forcing pathways, which contributes significantly to maintain the surface temperature trend over the Indian region as close to global mean value against the cooling due to aerosols.

The research will be carried out at Vikram Sarabhai Space Centre, Thiruvananthapuram.

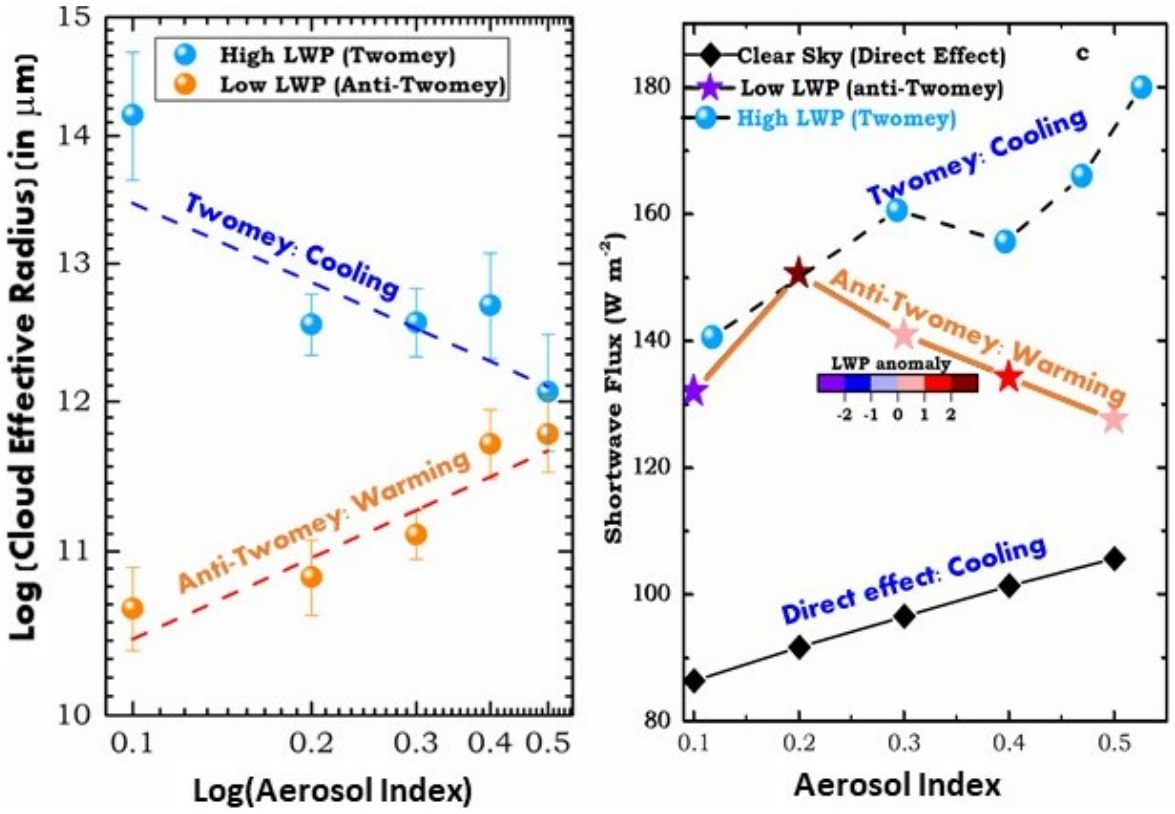


Fig. 4.12: Masking effects of aerosols on global warming

Exploring the emergent topological properties of graphene hybrids: In the last century, the electronic phases are being understood using Landau's approach, which characterizes the states in terms of underlying symmetries that are spontaneously broken. However, over the decades, physicists are using a different classification paradigm based on the notion of topological order. In a topological phase, certain fundamental properties are insensitive to smooth changes in material parameters and can't change unless the system passes through a quantum phase transition. These topological phases can be engineered into topological superconductor, which is predicted to host Majorana Fermions (MFs). The idea of MFs originated from particle physics in late nineteen thirties. These refer to fundamental fermionic particles that are their own anti-particles. The observation of MFs type excitation in tabletop condensed matter experiments is exciting and promising because these newly discovered excitations may have very strong influence in shaping the future area of quantum computers. So far, these emergent topological properties have been explored on topological insulators (TIs) and superconductor

(SC) interface, but due to the limited quality of the topological insulators as well as interfaces (TI-Sc) the true creation of MFs is hindered.

The recent demonstration of 'Universal quantized thermal conductance in graphene' using a new probe of heat flow measurements has shown exciting possibilities to detect the MFs. The goal of this proposal in the first phase will be to achieve the fractional QH states with even denominator QH plateaus in ultra-clean graphene (mobility > 10^5 cm^2/Vs), where the graphene will be encapsulated by hexagonal boron nitrides (hBN) followed by both sides graphite gating. The second phase will focus to identify the exotic MFs quasiparticles, their fractional charge and elusive topological neutral modes by heat flow, compressibility, and quantum noise measurements.

Furthermore, the project at Indian Institute of Science, Bangalore will study the emergent superconductivity and Mott insulator behaviour in the flatland of magic angle twisted bilayer graphene having a phase diagram reminiscence of high-temperature superconducting families, which has motivated unprecedented research activities worldwide. It has been shown theoretically such a flatland can be described by fractional topological order parameter without any external magnetic field. These topological properties of twisted bilayer graphene will be explored experimentally in the current proposal.

In order to study the topological properties of graphene hybrids, one has to achieve ultra clean graphene devices and setting up the new types of probes like heat flow, compressibility and shot noise measurements, the schematics for which is given in Figure 4.13.

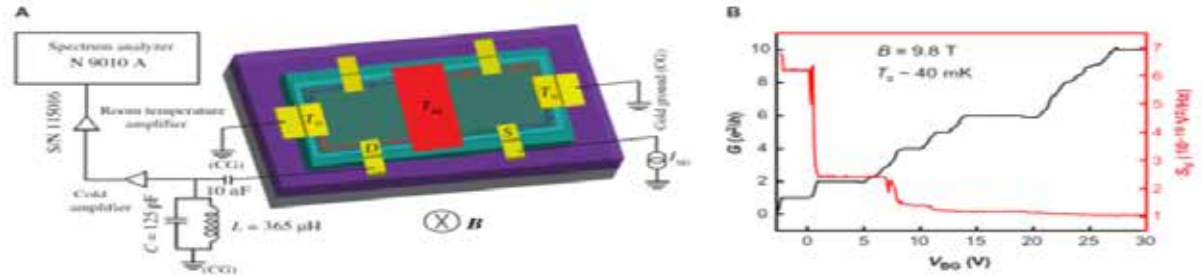


Fig. 4.13: Device configuration and QH response. A) Schematic of the device with measurement setup. B) Hall conductance measured at the conductance S using lock-in amplifier.

4.2.3 Ramanujan Fellowship

Ramanujan Fellowship is meant for brilliant Indian Scientists and Engineers working abroad who aspire to take up scientific research positions in India.

FEATURES

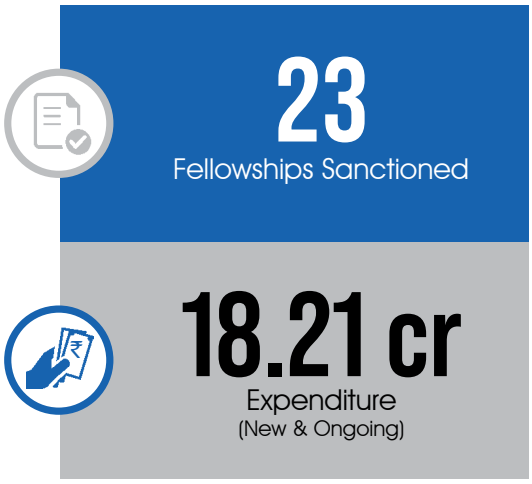
- **The Fellowship amount is Rs. 1,35,000 per month (consolidated including HRA)**
- **Each Fellow will receive a research grant of Rs.7 lakh per annum and Rs.60,000 per annum as overhead charges**
- **The duration of the fellowship is for five years, and not extendable**

Website links
http://serb.gov.in/rnf.php
https://serbonline.in/SERB/Ramanujan_fellowship

Research Highlights

Growth of van der Waals materials for optoelectronics and blue energy: The research group led by a Ramanujan Fellow at Indian Institute of Technology, Madras utilized their experience on the growth of several 2D materials including Graphene, h-BN, TMDs and topological insulators using chemical vapour deposition (CVD) for making van der Waals heterostructures (vdW HSs) out of these materials for different interlayer rotation by mechanical stacking of one layer over another as shown in Figure 4.14. Using semiconducting HSs assembled from incommensurate molybdenum Di selenide ($MoSe_2$) and tungsten disulphide (WS_2) monolayers, The group demonstrated that excitonic bands can hybridize, resulting in a resonant enhancement of moiré superlattice effects. These findings underpin strategies for band structure engineering in semiconductor devices based on vdW HSs.

The research being carried out involves the synthesis of single crystal monolayer and bilayer TMDs and explore their optical and electronic properties. Single crystals of monolayer MoS_2, $MoSe_2$ and WSe_2 have been successfully synthesized using CVD, which is one of the most promising methods of producing large-area and high quality TMD thin films. Artificially stacked bilayer WSe_2 flakes have been constructed by mechanical transfer of as-grown monolayer flakes on sapphire onto Si substrate using PMMA transfer process (Fig. 4.15). Optical responses such as vibrational mode, optical band gap, exciton dynamics, interlayer coupling of the above materials are studied employing Raman and Photoluminescence spectroscopy.



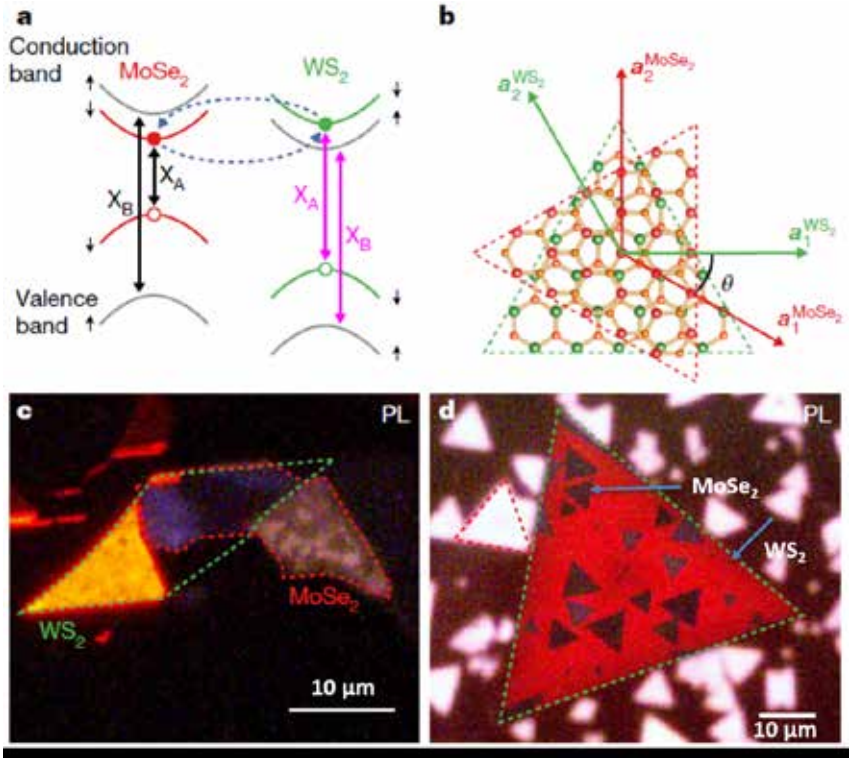


Fig. 4.14: Twisted MoSe2/WS2 heterobilayers. (a) Schematic of staggered band alignment in MoSe2/WS2 HS.(b) Real-space configuration of the heterobilayer.(c) Photoluminescence image of mechanically exfoliated MoSe2/WS2 HS (d) Photoluminescence image of CVD grown MoSe2/WS2 HS for different interlayer rotation. [Nature 567 (2019) 81–86] [Note: The work was highlighted in "The Hindu BusinessLine"]

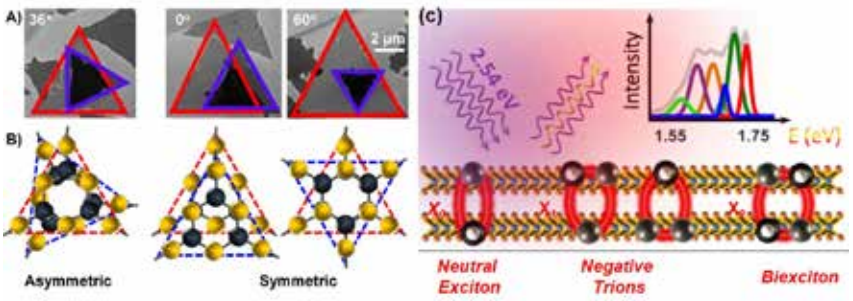


Fig. 4.15: (a) SEM images and (b) Schematic of selected WSe2 bilayers with twist angles in the range (0°-60°). (c) emergence of higher order excitations for symmetric stacking (60°). [Nanophotonics 9(2020) 3881-3887].

In the race to find novel transparent conductors for next-generation optoelectronic devices, graphene is supposed to be one of the leading candidates, as it has the potential to satisfy all future requirements. However, the use of graphene as a truly transparent conductor remains a great challenge because its lowest sheet resistance demonstrated so far exceeds that of the commercially available indium tin oxide. The possible cause of low conductivity lies in its intrinsic growth process, which requires further exploration. This group approached this problem by controlling graphene nucleation during the chemical vapor deposition process as well as by adopting three distinct procedures, including bis(trifluoromethanesulfonyl) amide doping, post annealing, and flattening of graphene films. Additionally, van der Waals stacked graphene layers have been prepared to reduce the sheet resistance effectively. The results demonstrated an efficient and flexible transparent conductor with the extremely low sheet resistance of 40 Ω/sq., high transparency (Tr~90%), and high mechanical flexibility, making it suitable for electrode materials in future optoelectronic devices [Nanoscale Advances, 1(2019) 1215-1223].

4.2.4 SERB Research Scientist (SRS) Scheme

The INSPIRE Faculty Scheme of DST and Ramanujan Fellowship Scheme of SERB offer opportunities for young scientists to initiate and sustain research careers in various field of Science and Engineering. These schemes do not offer extension of the fellowship after completion of five years. The support link is broken after the end of the tenure of the respective fellowships. To provide a platform for sustainment of their research for some more time, SERB initiated a scheme called SERB Research Scientists (SRS) Scheme in 2018-19 for the awardees of INSPIRE Faculty scheme and Ramanujan Fellowship, who fail to secure regular positions after completion of the regular tenure of five years in the respective schemes. The scheme provides an opportunity for them to continue their research activities and to explore for regular positions during the intervening period.

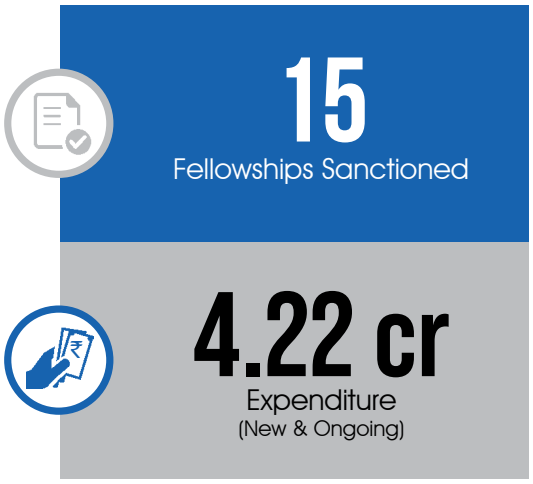
FEATURES

- **Fellowship scheme to sustain research careers of INSPIRE Faculty and Ramanujan Fellow for two more years**
- **Fellowship of Rs. 1,35,000 per month (consolidated including HRA), a research grant of Rs.7 lakh per annum and Rs.1 lakh per annum as overhead charges**
- **The duration of the fellowship is two years**

Website links
http://serb.gov.in/srs.php

Research Highlights

Lithospheric stabilization and crustal growth processes in the Karwar block, part of western Dharwar Craton, India: Constraints from geochemical and geochronological studies of precambrian litho-assemblages of Goa: The central idea of the study funded under SERB-Research Scientist scheme, is pivoted on deciphering the diverse tectonic styles and mantle processes involved in generation, maturation, accretion, and preservation of continental crust in the Precambrian earth. The crustal evolution of the earth is primarily translated in terms of thermo-tectonic transition of protocontinents to supercontinents through vertical and lateral accretion of juvenile crust and repeated cycles of assembly and dispersal of continents synchronized with emergence and closure of ocean basins, parallel arc amalgamation, arc-continent collisions, and plume-arc cohabitation. The ancient accretionary and collisional orogens nested in Archean cratons around the world preserve relics of ancient ocean basins and recycled continental crust that collectively provide a comprehensive time window to decipher the geochemical and geodynamic evolution of the earth in terms of terrane accretion and continental growth.



The Precambrian lithological associations exposed at different parts of Goa, a part of the Kawar Block along the west coast of India represent remnants of ancient Earth's crust that were derived through variable mantle processes and accreted under diverse geodynamic conditions at oceanic and continental realms. The tonalitic-trondhjemitic-granodioritic (TTG) basement gneisses, volcano-sedimentary supracrustals, ultramafic-mafic enclaves and granitic intrusions comprise distinctive lithological components of the Karwar Block and posit unequivocal implications for mantle evolution and melt extraction processes; crustal growth, reworking and recycling; terrane accretion and continental reconfigurations in the Precambrian Earth during 4.0Ga to 2.5Ga. This proposed study at Goa University aims for the first-time integrated geochemical-isotopic-geochronological study of basement gneisses, volcanic supracrustal and ultramafic-mafic complexes of Goa (Fig. 4.16) for a comprehensive understanding of their origin, evolution and implications in Archean crustal growth, lithospheric stabilization and craton building processes.

Fig. 4.16: A). Field photograph showing an outcrop of deformed tonalite trondhjemite granodiorite (TTG) gneiss near Palolem, Goa. B). Photomicrograph showing occurrences of alternate felsic quartzo-feldspathic (Q-F) and mafic bands in TTG. C). Filed photograph showing an outcrop of serpentinized cumulate peridotite new Bondla, Goa. D). Photomicrograph showing the presence of olivine orthopyroxene and clinopyroxene in cumulate olivine gabbro.

4.2.5 Teachers Associateship for Research Excellence (TARE)

This scheme aims to facilitate mobility of faculty members working in a regular capacity in State Universities / Colleges and in private Academic Institutions to carry out research work in an established public funded institution such as IITs, IISc, IISERs, National Institutions (NITs, CSIR, ICAR, ICMR labs and other central institutions) and Central Universities, located preferably nearer to the institution where the faculty member is working. Research work is planned in a manner such that PI continues to work in the host institute as well as in the parent institute on mutually agreed terms between the PI and the mentor.

FEATURES

- **Support to young faculty working in State Universities, college, and private academic institutions to carry out research in national institutions**
- **Fellowship of Rs. 60,000 per year, Research grant of Rs. 5 lakhs per annum (50% each to host and parent institution) and overheads**
- **Duration is for 3 years**

Website links
http://serb.gov.in/tare.php
http://serbonline.in/SERB/Tare

Research Highlights

Estimation and validation of seasonal snow cover maps using Ku-band SCATSAT-1 data over the Western Himalaya, India: The Ku-band (13.5 GHz) based scatter meter is the main sensor onboard ISRO - SCATSAT-1 satellite. The SCATSAT-1 satellite sensor provides daily updates on the conditions of atmospheric, oceanographic, agriculture, and cryospheric parameters. Moreover, it delivers data products (Level 1-4) in form of different parameters (Sigma-naught, Gamma-naught, brightness temperature BT, wind vectors, and velocity) at two different polarization modes (HH and VV). Since launch, several studies have been carried out to explore the potential of the SCATSAT-1 satellite sensor for remote observation of the ocean as well as the land surface at the global level. Present study at Chitkara University, Solan attempted to evaluate the potential of Ku-band SCATSAT-1 for quantification of spatiotemporal variability in snow cover area (SCA) over the Himalayas (Himachal Pradesh) India.

The SCA has been measured using dual-polarized (HH and VV) backscattered SCATSAT-1 data. Two classification approaches, i.e., Linear Mixer Model (LMM) and Artificial Neural Network (ANN) model have been used for the present study. Both available backscatter coefficients sigma-naught σ0 and gamma-naught γ0 have been considered for the estimation of SCA. To compute the seasonal snow cover trends for winter (2016-2017 and 2017-2018), a post-classification comparison (PCC) based change detection approach has been demonstrated on the classified dataset as shown in Figure 4.17. The SCA maps have been validated using reference

84
Associateships Sanctioned

10.83 cr
Expenditure
(New & Ongoing)

snow cover maps generated from the Moderate-resolution Imaging Spectroradiometer (MODIS) sensor. The final change-category maps have effectively mapped the snow cover variations with accuracy in between 83.01% and 95.33%. The results indicate the suitability of SCATSAT-1 for estimating the magnitude of snow extent over the Himalayas.

The present study also discloses the invention related to a hand-held or portable device to determine the position of a spot in an area of interest. The user can determine the positions of various spots in the AOI from a single location, no need to switch the position as shown in Figure 4.18. A user interface is configured with the device to assist the user in performing different functions, and a display unit is configured with the device to display the sensed one or more parameters and provides assistance in transmitting the sensed one or more parameters to the one or more mobile computing devices.

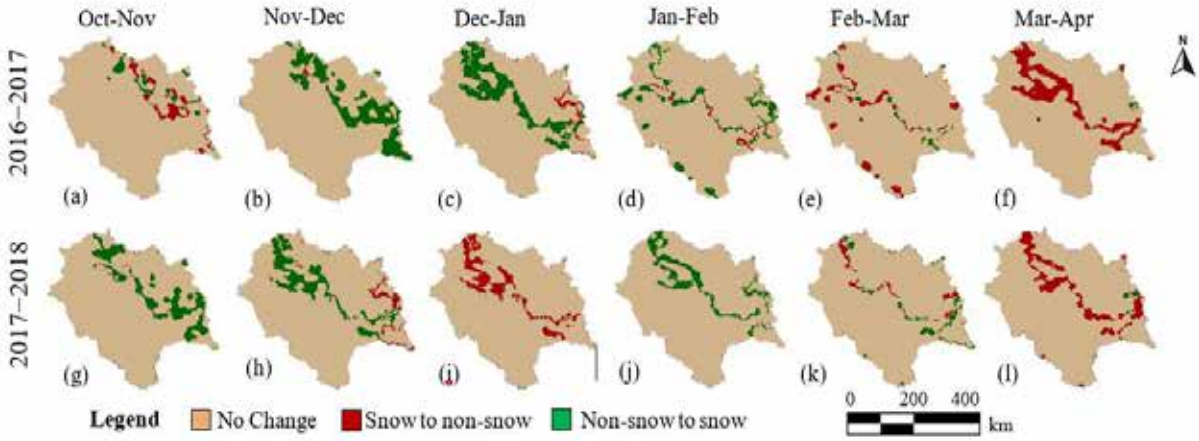
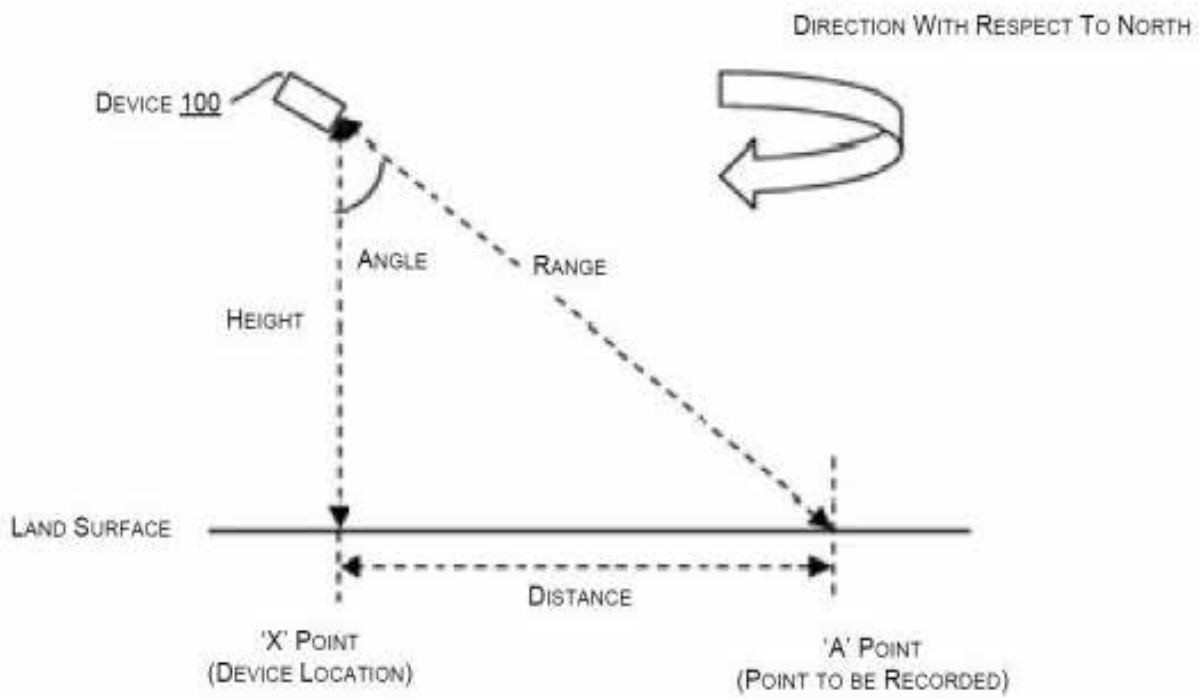


Fig. 4.17: Representation of seasonal snow cover change maps generated from the SCATSAT-1 dataset during the period: (a-f) 2016-2017; and (g-l) 2017-2018.



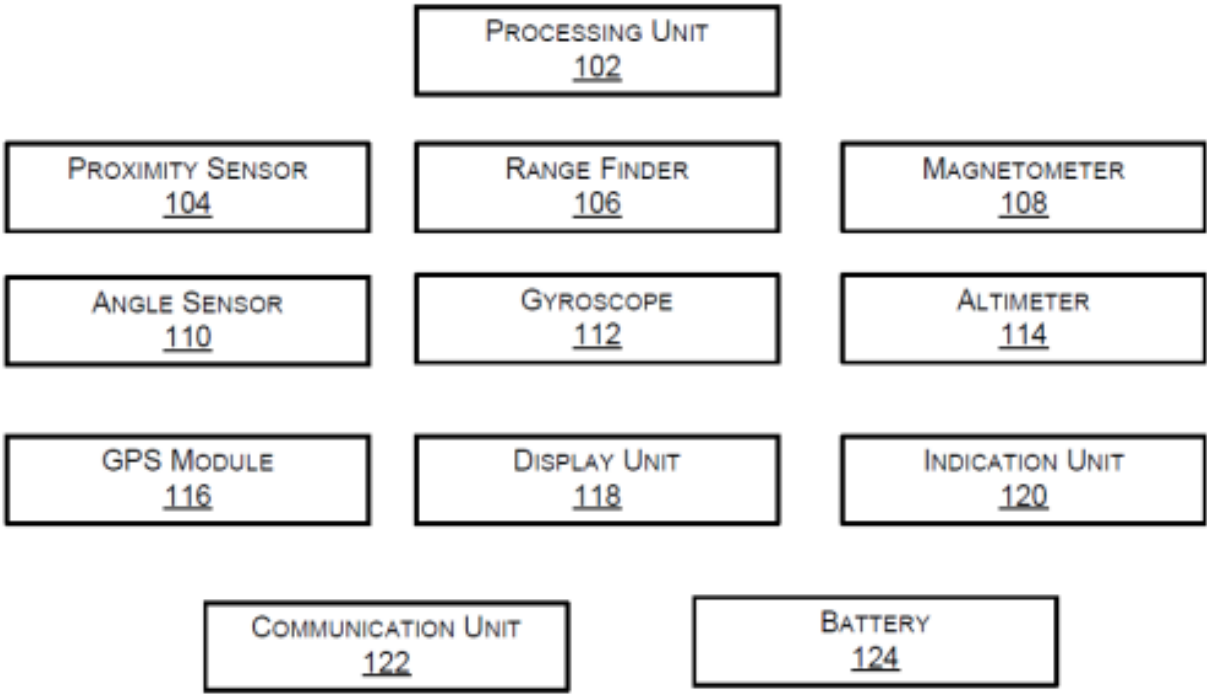


Fig. 4.18: A glimpse of the proposed device to determine the position of a spot in an area of interest (AOI).

Mechanistic anti-tumour activity of Vernodalin isolated from Centratherum anthelminticumon colorectal cancer cells: Compounds of natural origin have been targeted for their antioxidant and anticancer properties for therapeutic uses. Hence, vernodalin was chosen for this study since this compound could be found in the seeds of Centratherum anthelminticum. The study at B.S. Abdur Rahman Institute of Science and Technology, Chennai proves that the anticancer property of vernodalin was mediated through induction of apoptosis which was evidenced by staining of DNA by PI and apoptotic marker Annexin V. Defect in apoptosis-inducing pathways might cause a number of human malignancies, therefore there is need for anti-cancer agents to induce apoptosis in cancer cells which could be beneficial in chemotherapy.

The cells were treated with vernodalin for 24 h and induced cell death in a dose-dependent manner, with IC50 values of 7.17 µg/ml for HT-29 cells and 3.17 µg/ml for HCT116 cells respectively. Vernodalin was able to induce cell death at a lower concentration in HCT116 cells as compared to HT-29 cells. The apoptosis effect of vernodalin on human colon cancer cells was analysed using Annexin V / propidium iodide (PI) staining. PI is impermeable through cell membrane hence it binds to DNA of lysed cells whereas Annexin V binds to the surface of apoptotic cells. Vernodalin dose-dependently induced apoptosis in HT29 and HCT116 cells after 24 h of treatment. Apoptosis inducing effect of vernodalin was significantly higher on HCT116 cells at the dose of 10 µg/ml as compared to HT29 cells at the dose of 15 µg/ml. Western blot analysis on apoptosis regulating proteins was in agreement to these results. The results support that, vernodalin has induced apoptosis in human colon cancer cells through elevation of Bax/Bcl-2 ratio and expression of apoptosis inducing factor caspase 3.

Fluorescence microscopic analysis was carried out on HT29 and HCT116 cells upon vernodalin treatment to identify the ROS formation. Hoechst 33258 was used to stain nuclei of cells whereas DCFH-DA staining helps to identify cells which are under oxidative stress. The non-polar DCFH-DA is absorbed into cells and converted by esterases to polar DCFH and eventually oxidized by ROS into DCF which gives a bright green fluorescence (Fig. 4.19). The data obtained from fluorescence microscopy confirmed that, HT29 and HCT116 cells were under oxidative stress due to vernodalin treatment which was observed for 12 h. Blue fluorescence of cellular nuclei exhibited necrosis and apoptosis in several HT29 and HCT116 cells which could be attributed to the ROS formation due to vernodalin treatment.

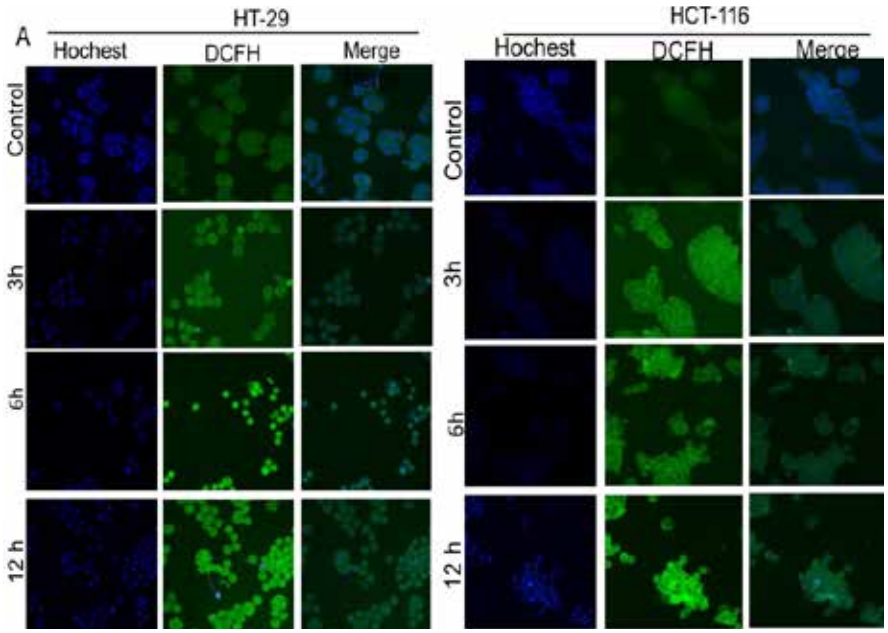


Fig. 4.19: The green DCF fluorescence indicating ROS formation was prominently increased with time compared to control, in both HT29 and HCT116 cells

4.2.6 National Post-Doctoral Fellowship (N-PDF)

The SERB National Post-Doctoral Fellowship (N-PDF) is aimed to identify motivated young researchers and provide them support for undertaking research in frontier areas of science and engineering. The fellows will work under a mentor, and it is hoped that this training will provide them a platform to develop as an independent researcher. There are five discipline-wise verticals that are guided by individual Expert Committees.

197
Fellowships Sanctioned

55.14 cr
Expenditure
(New & Ongoing)

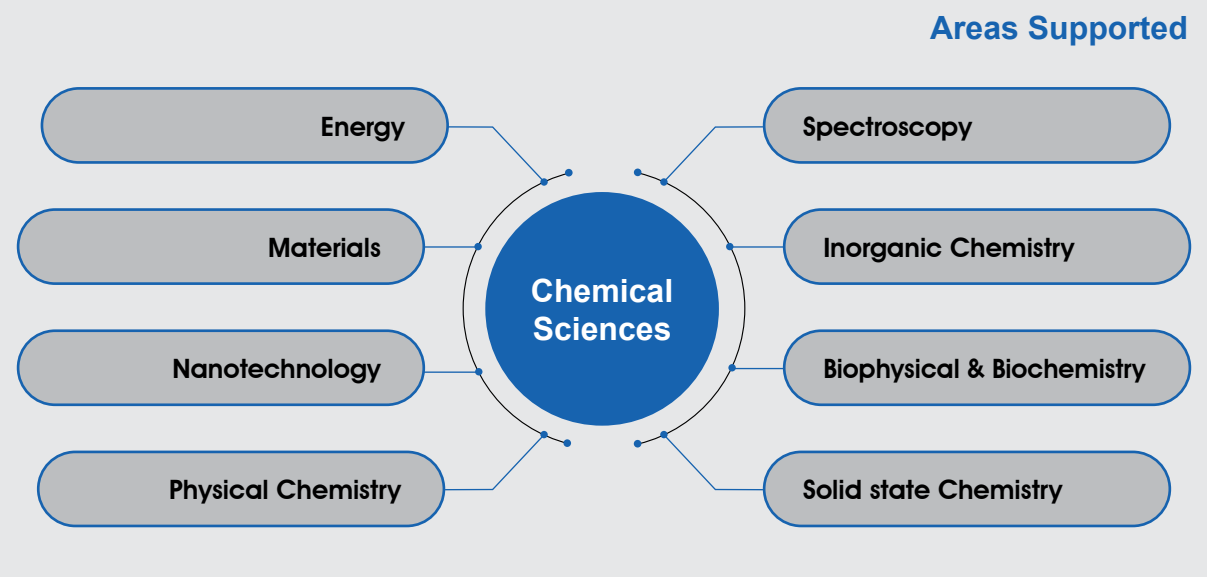
FEATURES

- **To train and inspire promising young researchers in conducting cutting-edge research with guidance from established scientists**
- **Fellowship amount is Rs. 55,000 per month plus HRA and research grant is Rs. 2 lakh per annum plus overhead of Rs.1 lakh per annum**
- **Duration of fellowship is two years**

Website links
http://serb.gov.in/npdf.php
https://serbonline.in/SERB/npdf

4.2.6.1 Chemical Sciences

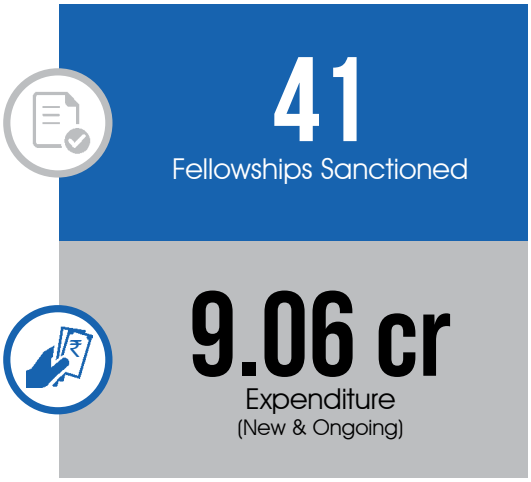
In the reporting period, 41 new fellowships were sanctioned. The areas supported under NPDF – Chemical Sciences are shown in the following figure.



Research Highlights

Delayed fluorescence, room temperature phosphorescence, and mechanofluorochromic naphthalimides: differential imaging of normoxia and hypoxia live cancer cells: Fluorescence imaging has emerged as one of the most powerful techniques to monitor targets and biological processes in the context of a living system with high temporal and spatial resolution. Hypoxia, which is caused by an inadequate oxygen supply, is an important feature of various diseases, including cancer, cardiopathy, ischemia and vascular diseases. Therefore, hypoxia-specific molecular probes would be useful as diagnostic agents. Luminophores showing delayed fluorescence/temperature assisted delayed fluorescence (TADF) and phosphorescence characteristics at ambient conditions have received a lot of attention owing to their potential applications in lighting and display technology, imaging, and sensing.

In a research project supported under NPDF scheme, the group at Indian Institute of Science, Bangalore explored brighter luminophores by tweaking the molecular conformations in dyads, triads, and polyads. The effect of electronic coupling between donor amine and acceptor NPI in a series of D-A systems was studied. The electronic coupling between acceptor NPI and the donor amine was modulated by judiciously varying the donor strength as well as the molecular flexibility/rigidity of these systems.



Depending upon the electronic coupling between NPI and amine moieties, the newly synthesized systems show DF in the solution state with different delayed times and RTP in the solid state. Since the delayed emission is sensitive to molecular oxygen, these molecules are utilized for differentially imaging normoxia and hypoxia cancer cells.

The newly synthesized molecules (Fig. 4.20) have unique characteristics, i.e., cytotoxicity in longer incubation time and luminescence in lower incubation time. Thus, these compounds can be used in theragnostic application, meaning that one can use them for diagnosis (imaging) as well

as therapy (killing cells) for cancer. Furthermore, the PL characteristics of the newly synthesized molecules sensitive to the concentration of O_2. Thus, these compounds were utilized for imaging cells in hypoxia conditions (decreased oxygen concentration) with an expectation that these compounds may selectively light up the cells under hypoxia conditions. Live HeLa cells were treated with 10 μM of these compounds and incubated independently under normoxia condition (20% O_2, 5% CO_2) and hypoxia condition generated by using an AnearoPack (0.1% O_2), for 30 min. After 30 min incubation time both cells were subjected to confocal imaging studies. As expected under hypoxia conditions, cells with these compounds showed 4- and 5-fold stronger luminescence, respectively, as compared with cells under normoxia conditions Thus, these compounds could be used as imaging agents to differentiate cells in normoxia and hypoxia conditions.

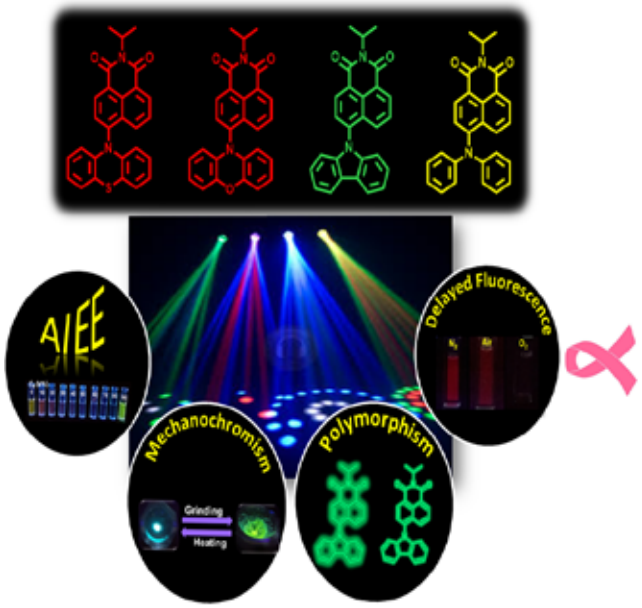


Fig. 4.20: Summary of multifunctional properties of the newly synthesized dyads.

Blinking of 2D nanostructures of Pb-free perovskite halide: The fascinating optical properties of all-inorganic lead (Pb) halide perovskites make them valuable for optoelectronic devices. However, the toxicity of Pb and thermal instability increase serious concerns for forthcoming commercial developments. Thus, the advancements toward the Pb-free perovskites with two-dimensional (2D) structure have fascinated substantial attention due to their stellar set of intriguing properties.

In a study supported under NPDF scheme, the group at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCSAR), Bangalore explored the synthesis of nanocrystals (NCs) and ultrathin 2D nanosheets (NSs) of layered mixed halide, $Cs_3Bi_2I_6Cl_3$ by a facile solution-based hot-injection approach by varying solution-temperature. The formation of NCs was evidenced at lower reaction temperature (120 ^{0}C), whereas the higher temperature (180 ^{0}C) favoured the formation of 2D NSs. Morphology-controlled photoluminescence (PL) using time-resolved PL dynamics and single-particle fluorescence microscopy in terms of "PL blinking" events were demonstrated (Fig. 4.21).

Narrow band-edge and defect-free PL emissions were evidenced. Both NC and NS showed luminescence at green region along with the localized blinking events at millisecond time scale. Each NC repeatedly undergoes dynamical fluctuations in PL emission (i.e., blinking), which indicates high photostability of the NCs. Super-resolution image of single NC displayed large number of discrete star-type blinking dispersed over entire crystal. On the other hand, NS showed temporal PL intensity fluctuations within localized domains of the crystal. In addition, super-resolution optical image of the NS from localization-based method showed spatial inhomogeneity of the PL intensity within perovskite crystal.

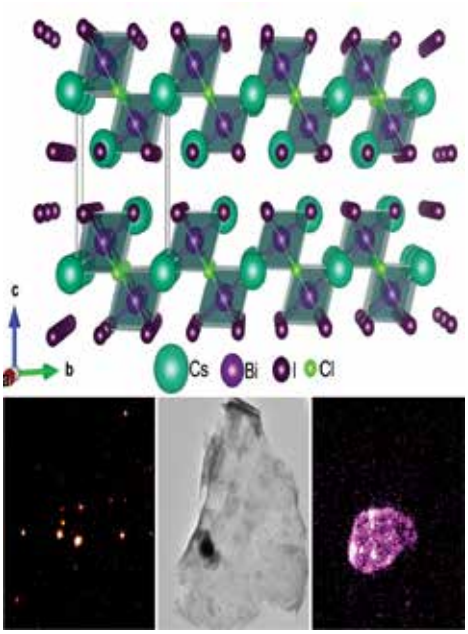
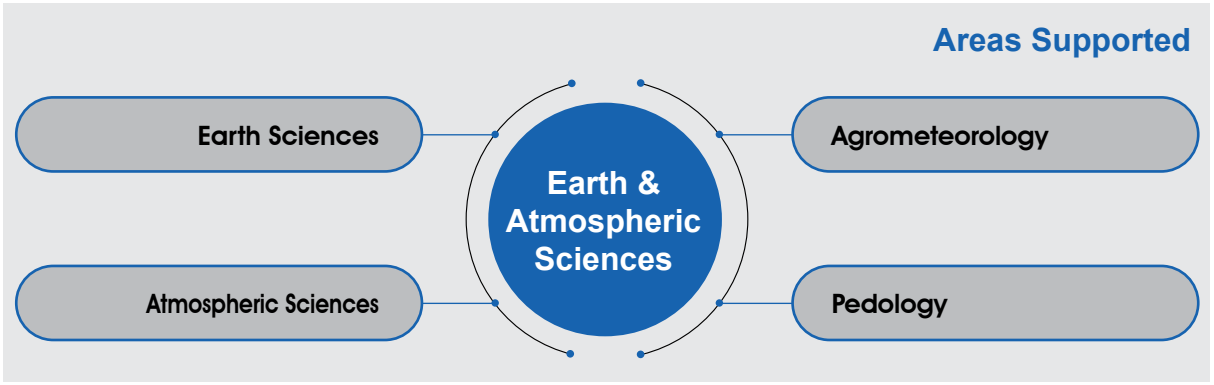


Fig. 4.21: Localized photoluminescence blinking of lead-free 2D nanostructures of Cs3Bi2I6Cl3 perovskite.

4.2.6.2 Earth and Atmospheric Sciences

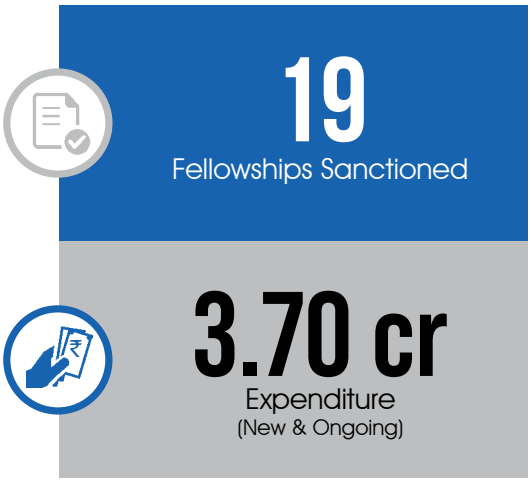
In the reporting period, 19 new fellowships were sanctioned. The areas supported under NPDF – Earth and Atmospheric Sciences are shown in the following figure.



Research Highlights

Modelling the crustal deformation of Himalaya by utilizing the information on subsurface structures: In this study, 2D crustal deformation modelling was done to estimate the slip rate and interseismic coupling for understanding of ongoing crustal deformation and developed stress field in the Central and Northwest Himalaya. This study at Indian Institute of Technology, Kanpur helped in understanding the limits of fault parameters and initial boundary conditions for the finite element approach.

The estimation of crustal deformation is based on GPS observations in the Himalaya and the site velocity has been estimated in the ITRF08



reference frame. Tectonic and non-tectonic displacement components have been estimated using MATLAB program. The Central and NW Himalaya has been divided into three segments with the varying structural trend, and a uniform dip (7°) of the Main Himalaya Thrust (MHT) has been used for the estimation of slip rate (and coupling) on the MHT. Each segment has been divided into small elements of size 40 (along strike) × 30 (along dip) km^2 and thus entire segments consist of 378 elements. The slip rate on each element has been estimated using inversion of observed site velocity for the fault parallel (strike-slip) and fault perpendicular (dip-slip) components while assuming a uniform long-term slip rate of 18 mm/yr in the Himalaya.

The fault perpendicular and fault parallel slip rate was calculated on Main Himalayan Thrust (MHT) in the Central and NW Himalaya based on GPS observations. It was noticed that the calculated site velocity was consistent with observed velocity indicating slip rate on MHT varies from 0-18 mm/yr. The annual slip on the frontal part of MHT was found to be small representing locked part plate interface and the northernmost part of MHT slips aseismically with a rate of 18 mm/yr. The strike-slip motion on MHT in the central Himalaya and Garhwal Kumaun Himalaya was insignificant (< 2 mm/yr.) and a significant dextral slip motion was observed in the Kashmir Himalaya.

A strong coupling (>0.5) in the frontal part of MHT i.e., up to 90 km from Main Frontal Thrust which suggests a large rate of strain accumulation in the frontal part of MHT (Fig. 4.22). Coupling is uniform along the structural trend in the Nepal Himalaya, Kumaun Garhwal Himalaya, Himachal Himalaya, and Kashmir Himalaya. A denser coverage of GPS site in the Kumaun Garhwal Himalaya provides a well-resolved slip rate estimate (Fig. 4.23) and the results suggest that the Garhwal region is strongly coupled as compared to Kumaun region. A heterogeneous distribution of slip rate or nonuniform coupling value is helpful in the detection of the potential zone for future major to great earthquakes. The Himalayan microseismicity belt coincides with a zone where coupling values vary from 0.3 to 0.5, representing transition zone of rigid upper crust and ductile lower crust. The contour curve of 3.5 km topographic elevation coincides with the transition zone or Himalayan microseismicity belt.

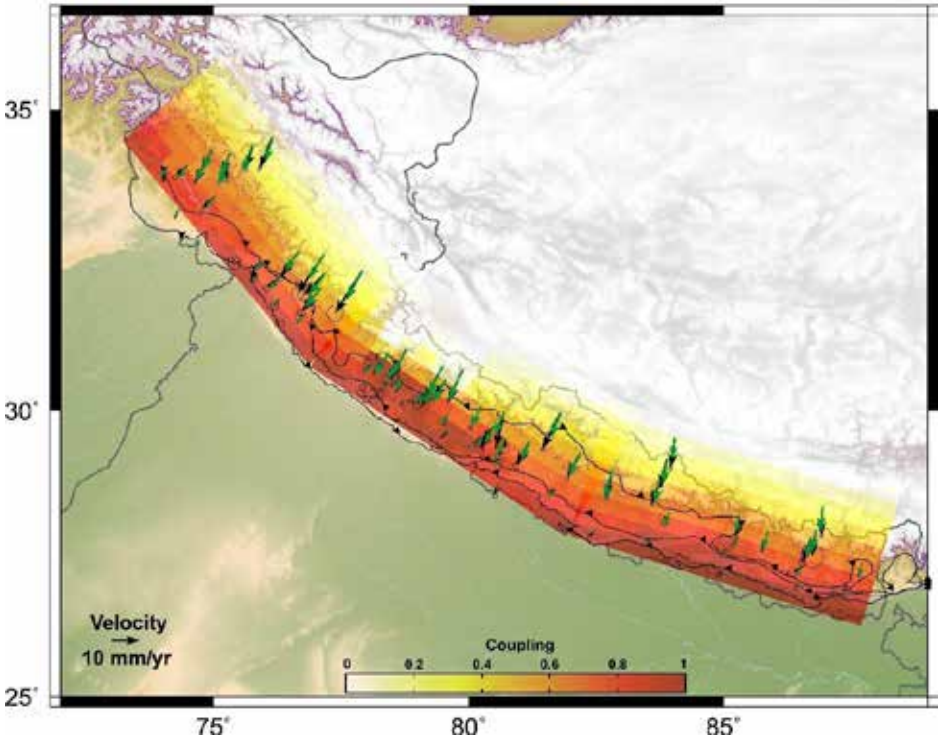


Fig. 4.22: Interseismic coupling map of Central, and NW Himalaya based on GPS observations. The violet curve shows the contour of 3.5 km topographic elevation. Black colour vector represents the observed site velocity and green colour vector represents the calculated site velocity in fixed India reference frame. Grey colour circles show the earthquake since 1970 (from USGS earthquake catalogue).

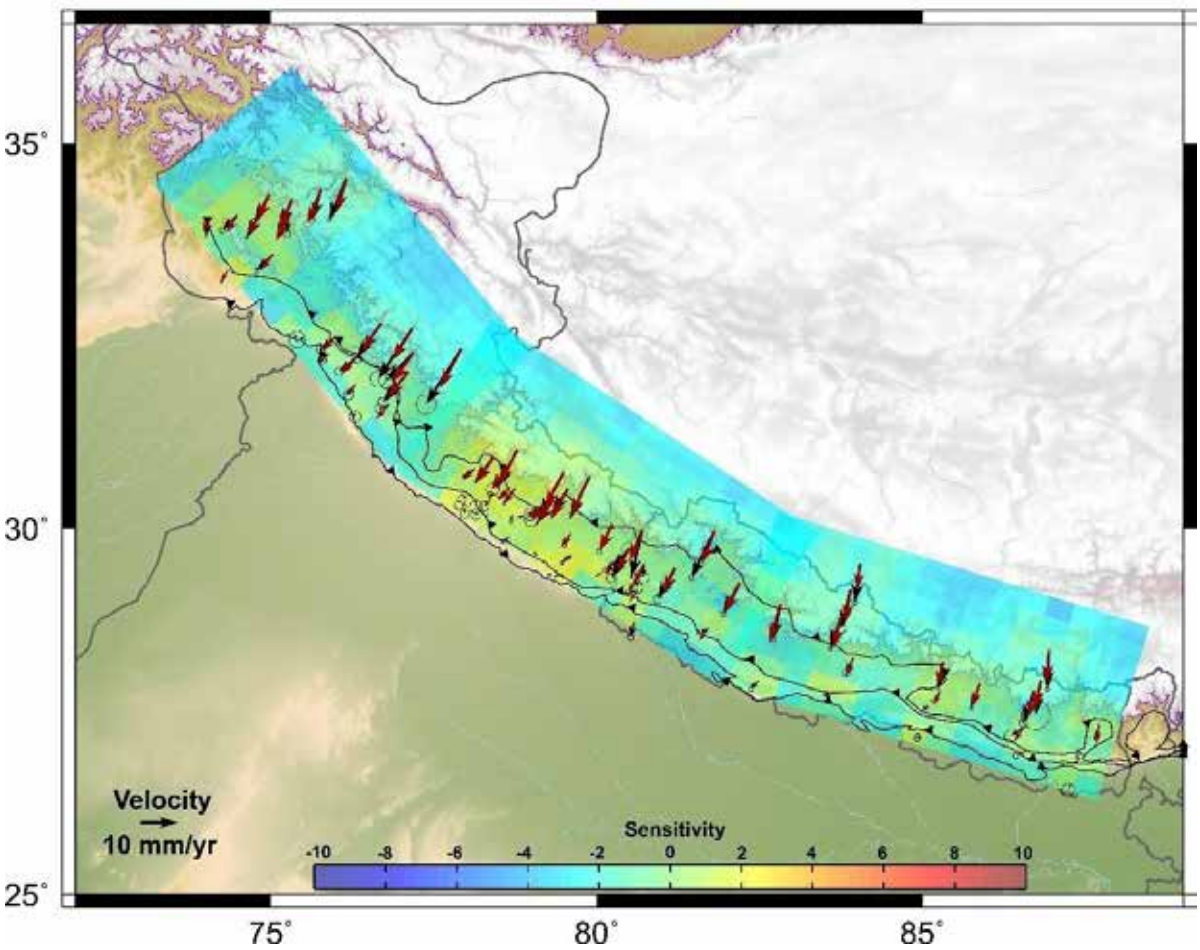
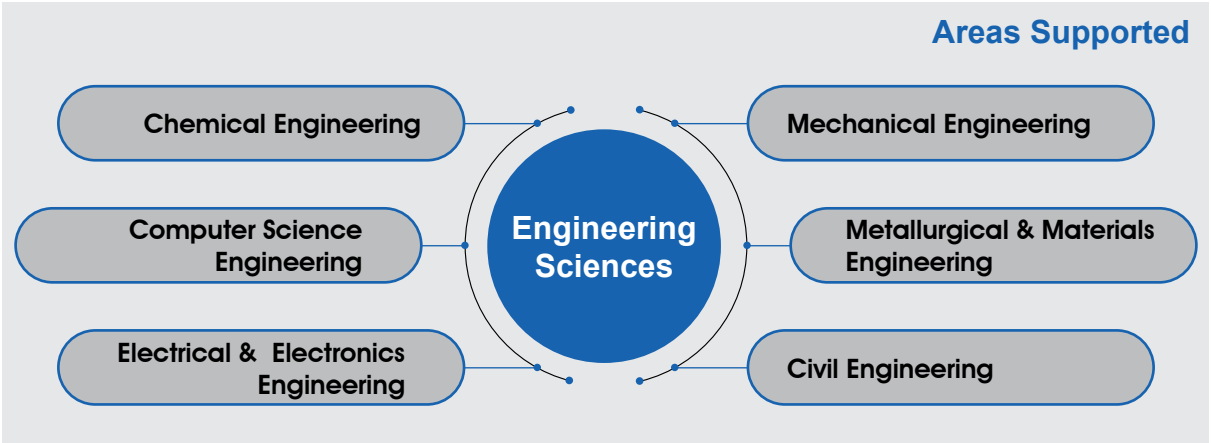


Fig. 4.23: Sensitivity map of calculated site velocity in the Central and NW Himalaya based on GPS observations. Black colour vector represents the observed site velocity and brick red colour vector represents the calculated site velocity in fixed India reference frame.

4.2.6.3 Engineering Sciences

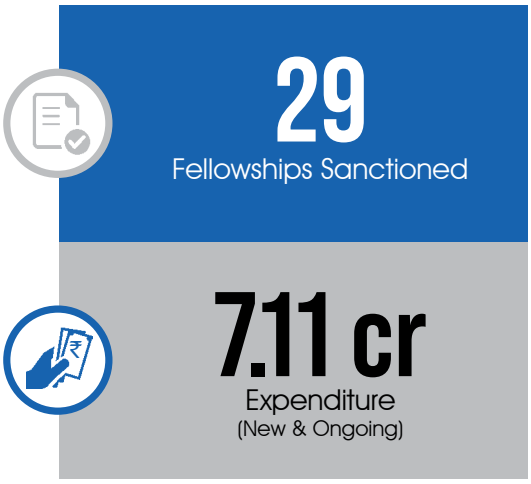
In the reporting period, 29 new fellowships were sanctioned. The areas supported under NPDF – Engineering Sciences are shown in the following figure.



Research Highlights

Multifunctional biocompatible aqua dispersed nano-carrier: A novel strategy for targeted therapy of tumours arising from Arsenic species: In the present study done at Indian Institute of Science, Bangalore, biopolymer coated in situ ceria, post coating ceria and MDA MB 231 breast cancer cell membrane cloaked ceria nanoparticles camouflaged was successfully formulated and those were confirmed by different spectroscopy and morphological analysis. The inherent cytotoxicity of targeted and non-targeted ceria NPs was found to be exempted at lower ranges of particles. The therapeutic efficacy of tubulin binding paclitaxel drug and DNA intercalating doxorubicin drug was found to increase in ceria NPs system as compared to that of free Dox or Ptx drug. However, the membrane cloaked drug-ceria NPs camouflaged exhibited significant antitumor effect and immune escape ability as compared to non-targeted delivery system, demonstrating the better internalization of nanoparticles through homotypic binding phenomenon.

The drug loading efficiency [DLE] and drug encapsulation efficiency [DEE] were calculated to be 5.1± and 90± according to standard curve-based equation UV-vis absorption method. The UV-visible spectra of the drug loaded ceria NPS also confirmed the successful entrapment of drug molecules into the ceria-based crystal geometry. (Fig. 4.24) shows the time and pH dependent cumulative release percentage of Dox drug. Initially, at lower time points, the pH condition triggered a similar trend of release percentage [7-15%] in both membranes coated ceria NPs dox entrapped ceria nanoparticles. But, with increasing of incubation period, the membrane coated ceria NPs [m@Ceria NPs] exhibited around 20-30% of dox release whereas 50-60% of dox release was recorded for the only dox entrapped ceria nanoparticles. Cellular uptake assay: In vitro cellular uptake assays against MDA MB 231 cancer line and macrophage, RAW 264.7 cell lines were assessed through Fluorescence microscopy in (Fig. 4.25). In case of nontargeted drug delivery, the ceria NPs-drug systems exhibited significant antitumor activity even at lower ranges dox concentration as compared to free Dox. The drug loaded camouflaged system also exhibited higher antitumor activity as compared to vehicles control membrane coated in-situ and post CeNPs treatments at all doses of drug concentration. As compared to non-targeted drug delivery system, the paclitaxel loaded camouflaged system demonstrated the dose-dependent antitumor activity after 48 hours of incubation time, which is attributed to the sustained release of Ptx or Dox from membrane coated Ptx/Dox-ceria NPs system. Therefore, the breast cancer cell membrane cloaked ceria NPs camouflaged would deploy a promising delivery of anticancer drug toward breast cancer cells.



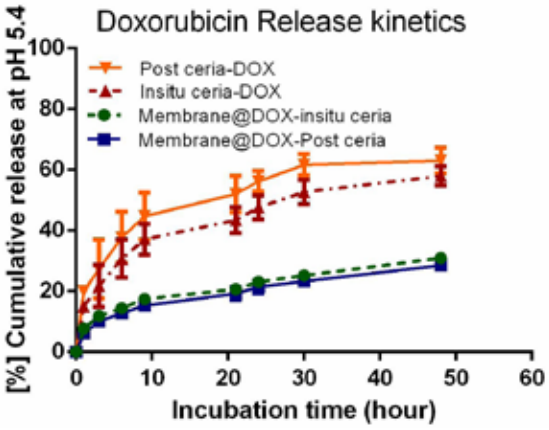


Fig. 4.24: Doxorubicin release kinetics

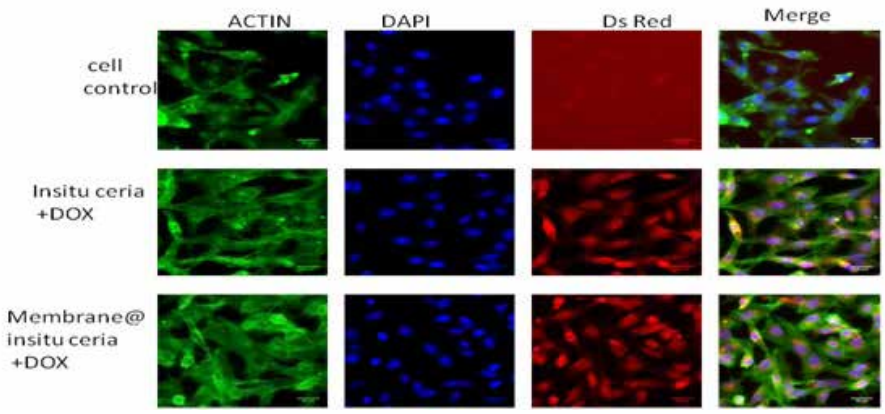
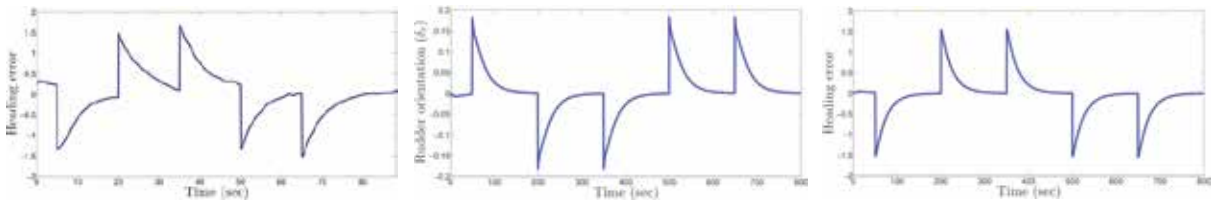


Fig. 4.25: In vitro cellular uptake assays against MDA MB 231 cancer line and macrophage, RAW 264.7 cell lines assessed through Fluorescence microscopy.

Control of surface vehicles in surf zone for shallow water bathymetry mapping: This work supported by NPDF at National Institute of Oceanography, Goa, focused on the development of control algorithms for path following of an Autonomous Surface Vehicle by appropriately capturing its dynamics. A system identification technique was employed for modelling of ASV dynamics in real-time. An RNN model of an ASV was developed and its model parameters were adapted online using the Recursive Extended Least Square algorithm. Subsequently, an adaptive state feedback controller was developed to accomplish the waypoint tracking control task of an ASV. The control structure comprised of integral structure in order to minimize the external effect due to wave and wind disturbances. Simulation studies were pursued using MATLAB environment to verify the waypoint tracking performance of the proposed adaptive controller in the presence of disturbances. From the results, it was envisaged that the RNN model based Self-tuning Adaptive Control exhibits good tracking performance.

The ASV dynamics is categorized into two parts i.e., heading motion and depth motion. The heading motion includes sway and yaw equation of motion whereas depth motion includes heave and pitch equation of motion. Although for identifying the ASV dynamics, a neural network modelling approach was presented in the literature for real-time implementation Nonlinear Auto-Regressive Exogenous (NARX) identification is more suitable. However, in view of capturing a more accurate model dynamics of ASV, Recurrent Neural Network structure (RNN) model was attempted. Two separate Recurrent Neural Network models were used to identify the ASV dynamics. Heading motion includes sway equation of motion and yaw equation of motion and depth motion includes a heave equation of motion and pitch equation of motion. In this work, a Recursive Estimated Least Square (RELS) method for identifying the Recurrent Neural Network model was adopted. The attached results showed the implementation of the control algorithm for following a desired Line-of-Sight path (Fig. 4.26). The control law generated for rudder and results related to heading motion was also studied.

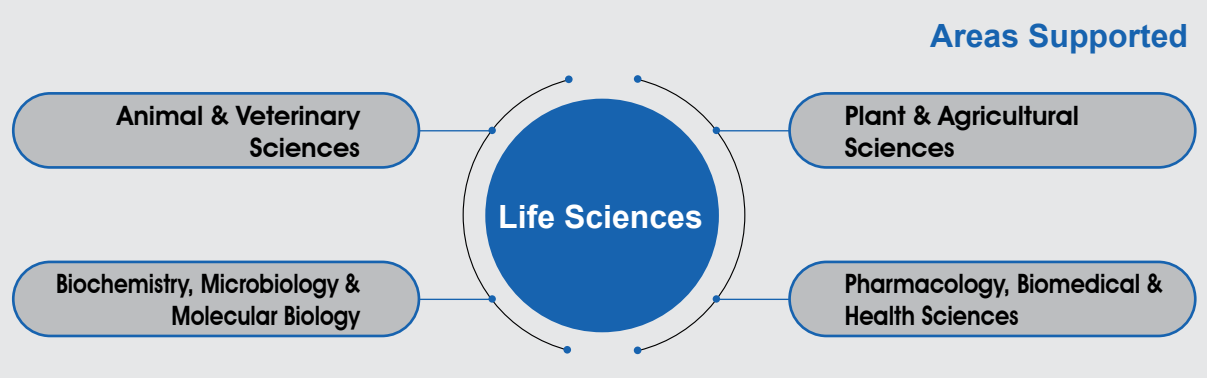


[A] *[B]* *[C]*

Fig. 4.26: [A] Rudder orientation [B] Yaw orientation while following the desired path [c] Heading error

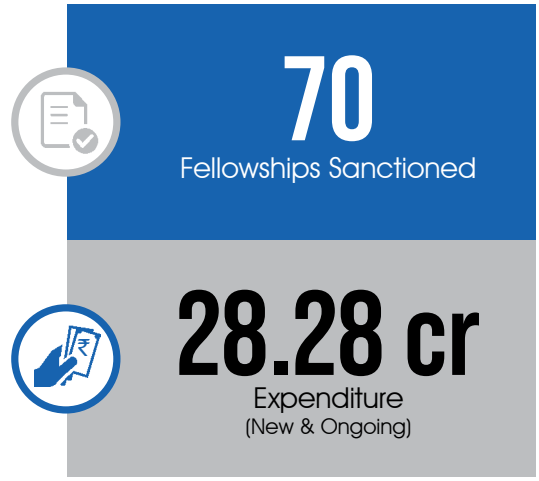
4.2.6.4 Life Sciences

In the reporting period, 70 new fellowships were sanctioned. The areas supported under NPDF – Life Sciences are shown in the following figure.



Research Highlights

A functional genomics approach to decipher strategic modification and regulatory mechanisms involved in drought stress avoidance in groundnut: In the present study done at International Crops Research Institute for the Semi-arid Tropics (ICRISAT), Hyderabad, the groundnut JL24 and ICGV91114 genotypes were used to study the effect of drought stress and the modification acquired by the tolerant plant for survival. Water deprivation induced wilting of susceptible genotype JL24, whereas ICGV91114 was found turgid. Under continuous reduced watering condition, the chlorophyll levels were significantly reduced, and leaf was tuned to pale green in the susceptible JL24 genotype, however, it was significantly maintained in the leaves of tolerant genotype ICGV91114. This suggests better performance of ICGV91114 under drought stress. Canopy temperature is more reliable indicator of crop stress as it is a direct measure of the energy being released by a plant. Monitored by infrared temperature sensors, canopy temperature can provide continuous information on water status, water use and how a plant is functioning metabolically. Usually, canopy temperature of no irrigated plants is 2-4 °C higher than that of the irrigated plants during peak time of day. In this study, monitoring the thermal dissipation or leaf canopy temperature through infrared image detector insight suggested ~2 °C rise for the JL24 plants under water deprived condition as compared to ICGV91114 which showed no significant change (Fig. 4.27). More interestingly, it was observed reduced stomata abundance in ICGV91114 that might be contributing to low transpiration rate as compared to JL24 which showed higher stomata abundance and drooping of leaves under reduced watering. Further, to relate water loss with the cuticle, cuticle was isolated from groundnut leaves and subjected for GC-MS analysis.



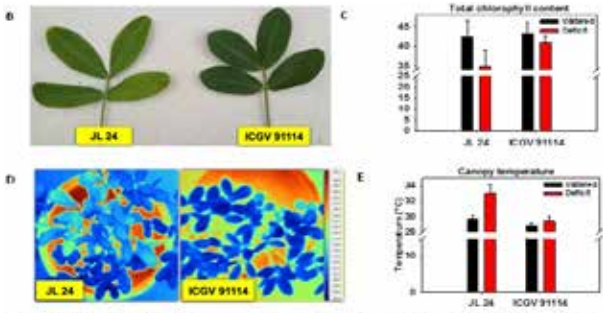


Fig. 4.27: Effect of water deprivation on the groundnut genotypes JL 24 and ICGV 91114. A. Wilting of drought susceptible genotypes JL 24 was observed under reduced watering. B. Leaf phenotype of JL 24 and ICGV 91114. C. Chlorophyll content in the leaves. D. Thermal infrared image of plant under drought stress. E. Canopy temperature under control and drought stress.

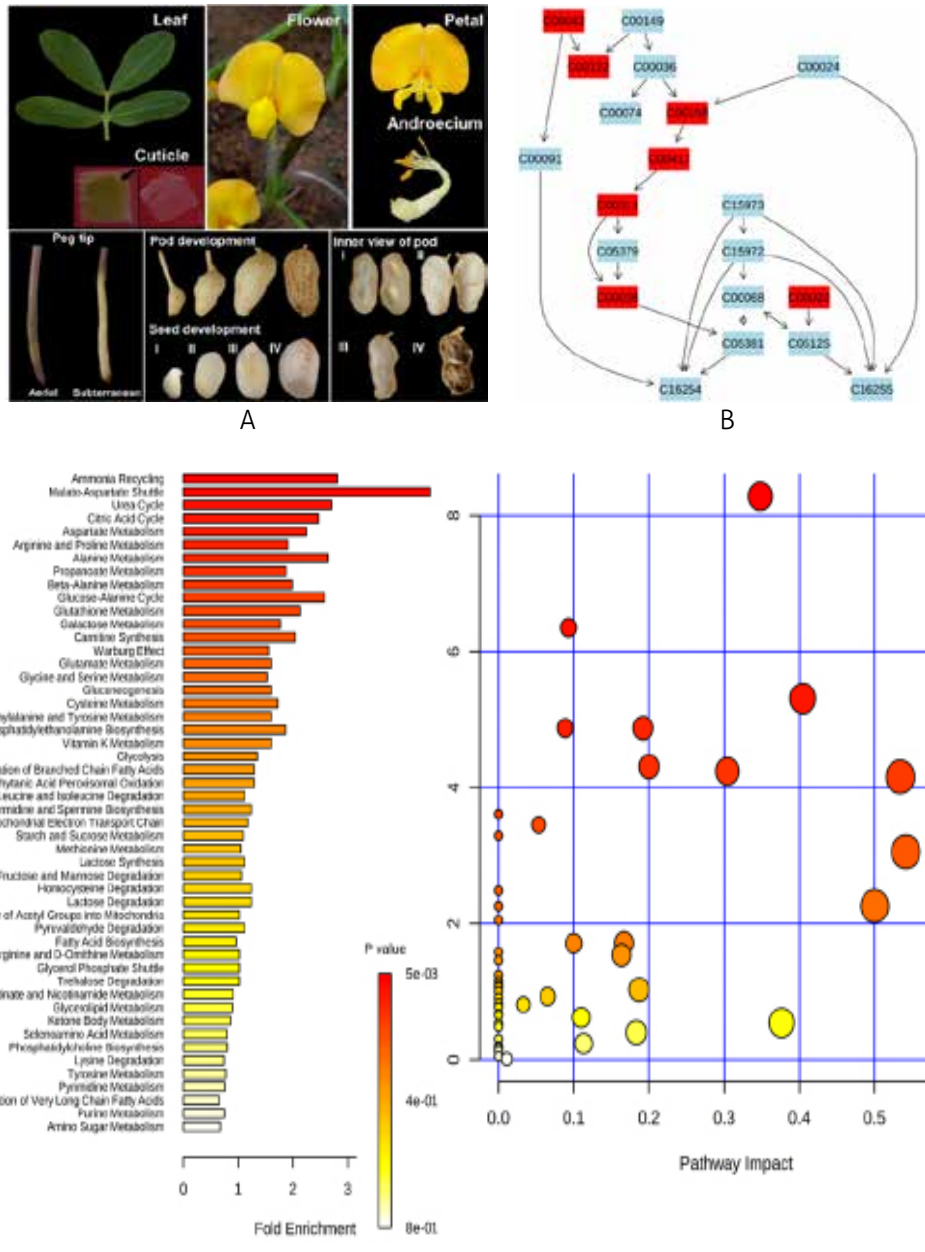


Fig. 4.28: A. Different stages of organ / tissues harvested for metabolome study. B. Enrichment of citrate cycle pathway metabolites. C. Pathway enrichment analysis of top 50 pathways

The preliminary analysis led to identification of several compounds which shows spatiotemporal speciation / modulation and majority of them clustered based on type of the organ and their developmental stages (Fig. 4.28). The comprehensive analysis, by comparing the data with genomics and proteomics data available in the public domain will be followed by analysing the impact of stress on the metabolic profile of individual tissue of the groundnut and changes at the level of tissue lipid profile, which will help in the developing better understanding of metabolic network and related traits.

Role of vinculin in nuclear mechanotransduction: All cells throughout the evolutionary spectrum are mechanosensitive. Mechanical forces applied to cells, transmit signals ~40-fold faster than diffusion of chemical signals. From determining the shape of multicellular organisms to maintaining the homeostatic state of adult tissues requires a fine tuning of the cell-cell junction responses and transmission of the applied mechanical load at these junctions to its niche. Recently, there has been a great deal of interest generated by the finding that these adhesion foci contribute to initiate cell signalling pathways modulated by the magnitude of the forces exerted on them which in turn determine the cell function and fate. However, how cells respond and adapt to the mechanical properties of neighbouring cells, transmit forces, and how the mechanical cues are converted into intracellular signalling cascades that impinge on gene expression changes still remain open and pose a set of interesting questions. Thus, deciphering the molecular details involved in the crosstalk between the cell exterior with the cytoplasm and the nucleus would not only lead to better insights into normal cell biology but may also pave the way for novel therapies for the many diseases caused when mechanotransduction goes awry.

1) Vinculin null and alpha catenin null cells showed weaker junctional stability in the biophysical junction strength measurement assay 2) Vinculin null, Beta1 integrin null and alpha catenin null cells shows delay in zippering up their AJ 3) Vinculin null and alpha catenin null cells do not recruit vinculin at AJ however, Beta1 integrin null even though they delay in zippering the AJ they are able to recruit vinculin in the AJ 4) Vinculin null and alpha catenin null cells showed abnormal nuclear envelope architecture. 5) Vinculin null and alpha catenin null cells showed defects in the localization of SUN1 and SUN2 LINC complex proteins. 6) Similar to vinculin KO cells beta1 integrin null cells also showed defects in their spreading and focal adhesion formation however they do not show any abnormality in their nuclear envelope architecture. 7) Staining with another important nuclear envelope protein MAN1revealed crumpling in the nuclear envelope in vinculin KO keratinocytes as compared to the WT keratinocytes. 8) Ectopic expression of vinculin in a vinculin null background is able to rescue the nuclear envelope defect. 9) Thus, absence of vinculin a mechanotransducer, affects the normal crosstalk between the cell periphery and the nuclear envelope (Figs. 4.29 and 4.30).

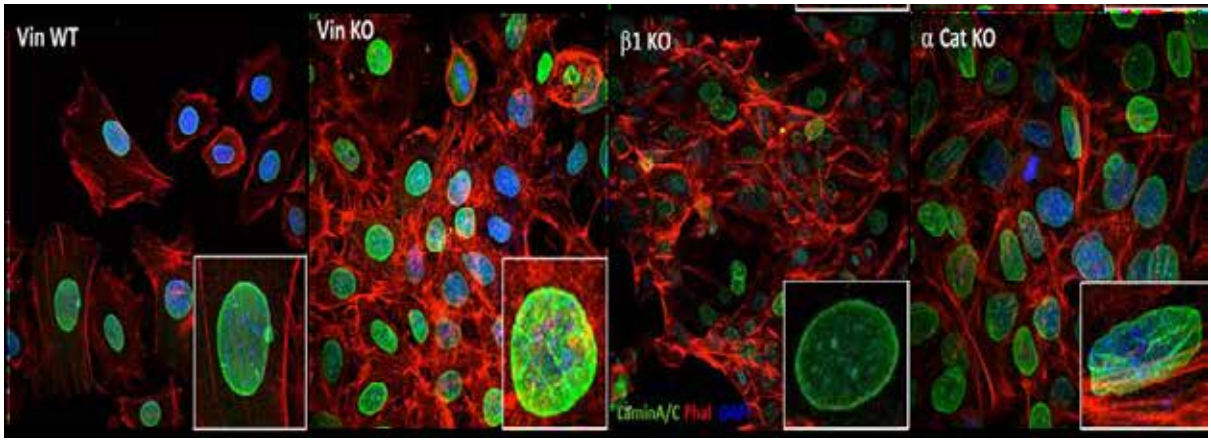


Fig. 4.29: Crumpled nuclear lamina in vinculin KO and alpha catenin KO keratinocyte- Immunofluorescence staining of Lamin B (green) decorates the nuclear lamina showed crumpling of the nuclear lamina which renders a floppy nuclear morphology in vinculin KO and alpha catenin KO keratinocyte but not in beta 1 integrin KO keratinocytes. Inset showed individual nuclei stained with lamin B.

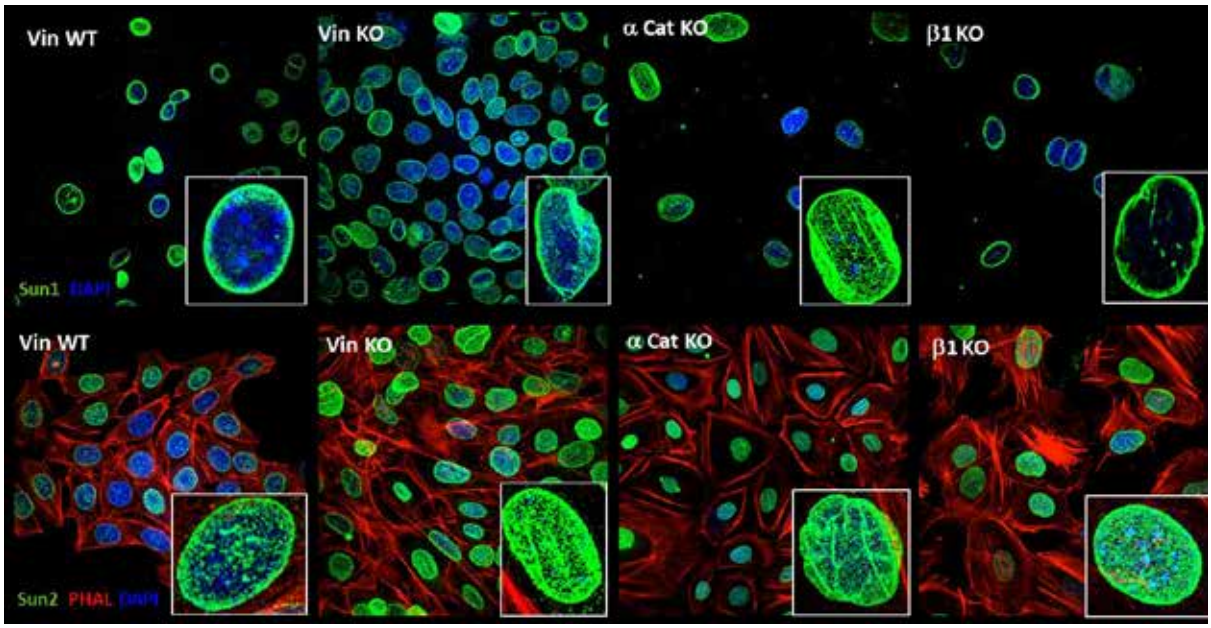


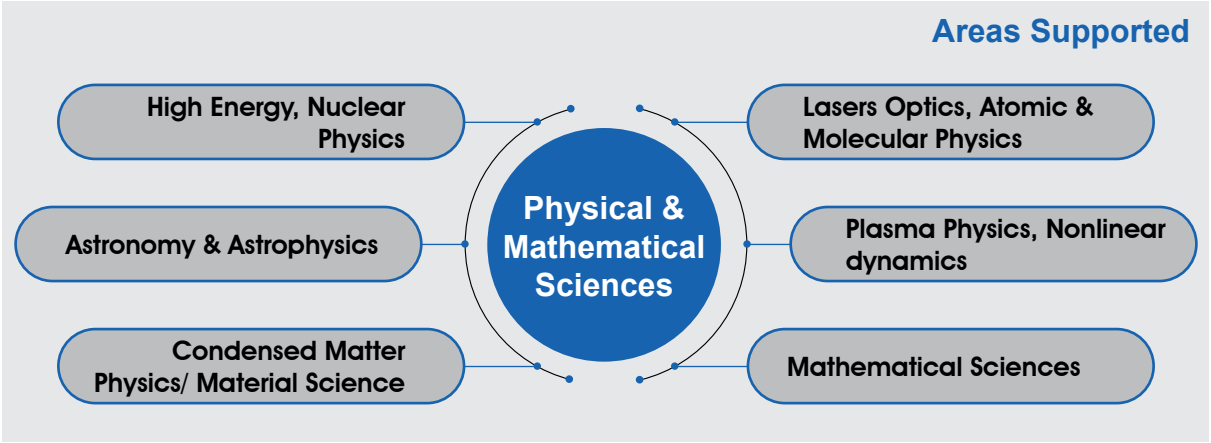
Fig. 4.30: Abnormal localization of LINC complex protein in vinculin KO and alpha catenin KO nuclear envelope. A) Sun1 (Green) and B) Sun2 (green). Panel represents the accumulation of the SUN1 and SUN2 in the invaginated regions of nuclear envelope in vinculin and alpha catenin null keratinocytes

Results from this study helped to elucidate how the mechanical stimuli from niche might be transmitted to the nucleus of the cells which further determine their fate. The study revealed that loss of adherens junction stability can be directly linked to abnormal nuclear morphology as shown by nuclear lamina staining. SUN domain proteins are miss localized in these adherens junction KO keratinocytes. This knowledge can be further applied for a better understanding of the mechanism involved in 'mechanobiological gene circuit' which controls the gene expression based on the mechanical cues perceived by the cell.

This study was conducted at Institute for Stem Cell Biology and Regenerative Medicine, NCBS, TIFR, Bangalore.

4.2.6.5 Physical and Mathematical Sciences

In the reporting period, 38 new fellowships were sanctioned. The areas supported under NPDF – Physical and Mathematical Sciences are shown in the following figure.

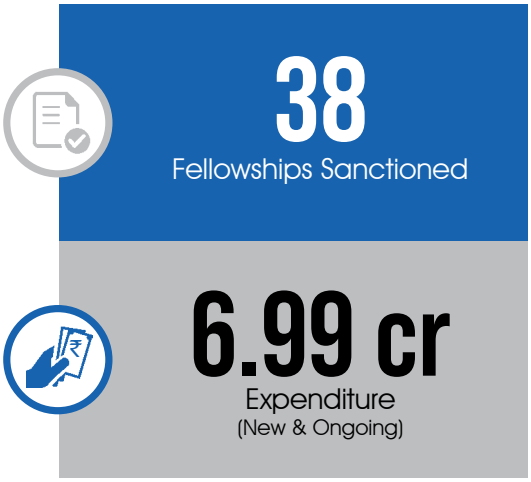


Research Highlights

Optimisation of polymer-2D material composite properties for barrier, thermal conductivity, and UV degradation applications: Polyethylene terephthalate (PET) has emerged as one of the most important polymers of the polyester family, with a wide range of commercial applications including food packaging, automotive parts, fabrics, electronics and more. The PET-based nanocomposites found to improve the polymer performance. Because of numerous industrial scale applications, nanocomposites of polymers have attracted researchers worldwide.

In this present study at Indian Institute of Science, Bangalore, 2D nanosheets of layered materials were prepared with the existing technique of liquid phase exfoliation (LPE). The Thermal property was studied on polymer-BNNs nanocomposite films employing Differential scanning calorimetry (DSC). The mechanical property enhancement of polymer-BNNs nanocomposite films employing nanoindentor in ambient conditions was studied. Figure 4.31 shows SEM images of PET: BNNs composite films. The SEM images show that the agglomeration of nano sheets increases with concentration of fillers in PET. SEM images taken for higher infusion concentration of BNNs showed agglomeration of BNNs. The presence of BNNs in PET was further confirmed by taking the Raman spectra of the PET: BNNs composite films.

The heating cycle of DSC curve for pure PET showed broader melting temperature peaks compared to the composites, indicating the wide distribution of crystallite sizes in pure PET when compared to the composites (Figs 4.32(a) and (b)). The melting temperature for composite films increases with increasing BN concentration. This trend can be an indication of the rigidity in chain mobility and hence requirement of higher energy to break bonds in the composite films when compared to pure PET.



The composite films of PET: BNNs were subjected to nanoindentation measurements in a A Hysitron TI 900 TriboIndenter. A sharp tip of known geometry was indented on the polymer/ composite film surface at either constant load or constant displacement controls. Based on the maximum load applied, indentation depth and tip area, the material properties like elastic modulus, hardness, indentation depth, etc. can be deduced from the load versus indentation depth (P-D) curve. For a constant load, the reduction in indentation depth becomes function of increased concentration of BNNs filler in PET matrix.

Figure 4.32 (c) shows the P-D curves for control PET and various concentrations of BNNs infused PET. The corresponding variation in modulus (E) and hardness (H), as a function of BNNs filler concentration were calculated. The average value of E of plane PET is measured to be 4.8 GPa, whereas 6.4 GPa for PET:BNNs composite with 2 wt% infusion of BNNs. After the infusion of BNNs, the E value of the PET composite increased up to 33.3%. Similarly, the value of H measured for plane PET and PET:BN composite with 2 wt% infusion of BNNs is 311 MPa and 412 MPa respectively, indicating 32.4% enhancement in material hardness.

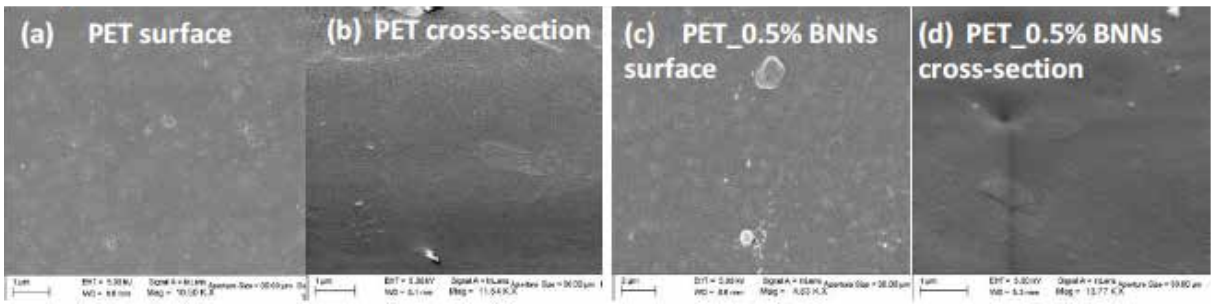


Fig. 4.31: SEM images of (a) control PET-surface, (b) control PET cross-section. (c) PET with 0.5% BNNs infusion-surface, (d) PET with 0.5% BNNs infusion cross-section, a BNNs flake infused perpendicular to the PET surface can be seen, The scale bar is shown on respective images.

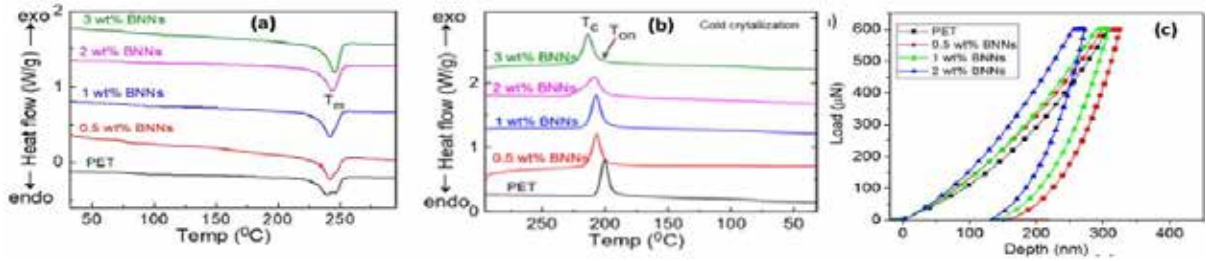


Fig. 4.32: DSC data and Load vs Indentation depth curves for control PET and its composites with BNNs. (a) DSC data for Endothermic-heating cycle, (b) DSC data for Exothermic – cooling cycle, (c) Load vs indentation depth for control PET and its composites.

Enhancement in E and H in PET: BNNs composite suggests a good load transfer between polymer and BNNs in the composite film, in turn suggesting good interfacial interaction between BNNs and polymer chains.

As PET is one of the widely used polymer with huge industrial scale applications at present there is a large scope of increasing the potential applications. Enhancement in mechanical and thermal properties of PET polymer can add greater advantage to numerous applications in the field of food and beverage packaging, smart textiles, and device applications.

Engineering of highly efficient Perovskite solar cells integrated with photonic crystals: Photonic crystals (PCs) are novel class of optical media represented by natural or artificial structures that have characteristic ability to control, confine, manipulate and guide light. These properties lead to several potential applications including efficient radiation sources, sensors, filters and optical computer chips and other future products with high-speed and wide bandwidth. The photon management concept turns out to be an emerging topic in which the light harvesting efficiency in solar cell is enhanced by coupling photonic crystals (PCs) with photovoltaic devices.

The present study aims to achieve enhancement in light harvesting and photocurrent efficiencies by integrating methyl-ammonium lead iodide perovskite solar cells with one-dimensional photonic crystals (PCs). The introduction of PCs as a light reflection layer in the solar cell's attributes to the increase in light harvesting efficiency and photocurrent density, which can be tuned by controlling the PC parameters such as the number of layers and layer thickness.

Introduction of a thin Au/Ag layer on top protects the hole transporting layer and helps in containing the light reflected from the PC layer into the device for further harvesting. Figure 4.33 shows the optical absorptance or LHE and reflectance R, transmittance T spectra with optimized parameters of the complete solar cell structures. The effects of layer thickness of the perovskite, hole transporting, and metallic contact layers on solar absorption enhancement and photon-to-current efficiency (IPCE) are studied to achieve high power conversion efficiencies. The area under the IPCE vs. wavelength curve decreases with increasing layer thickness of electrode as can be seen in Figure 4.34. The proposed optimum structural parameters of the solar cell structures provide the required guidance and further opportunities in the design of organo-metal halide perovskite solar cells coupled with PC structures.

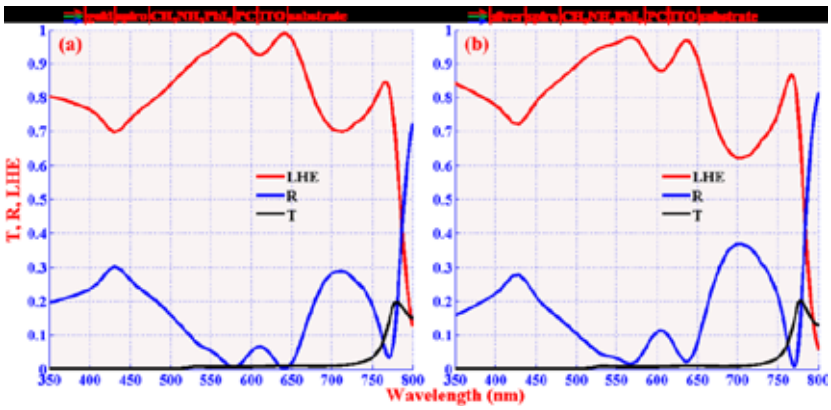


Fig. 4.33: Reflectance (R), transmittance (T) and light harvesting efficiency (LHE) spectra of a CH3NH3PbI3 perovskite solar cell containing a 1-D PC (five unit cells) and comprised of (a) gold and (b) silver as metallic contact layer.

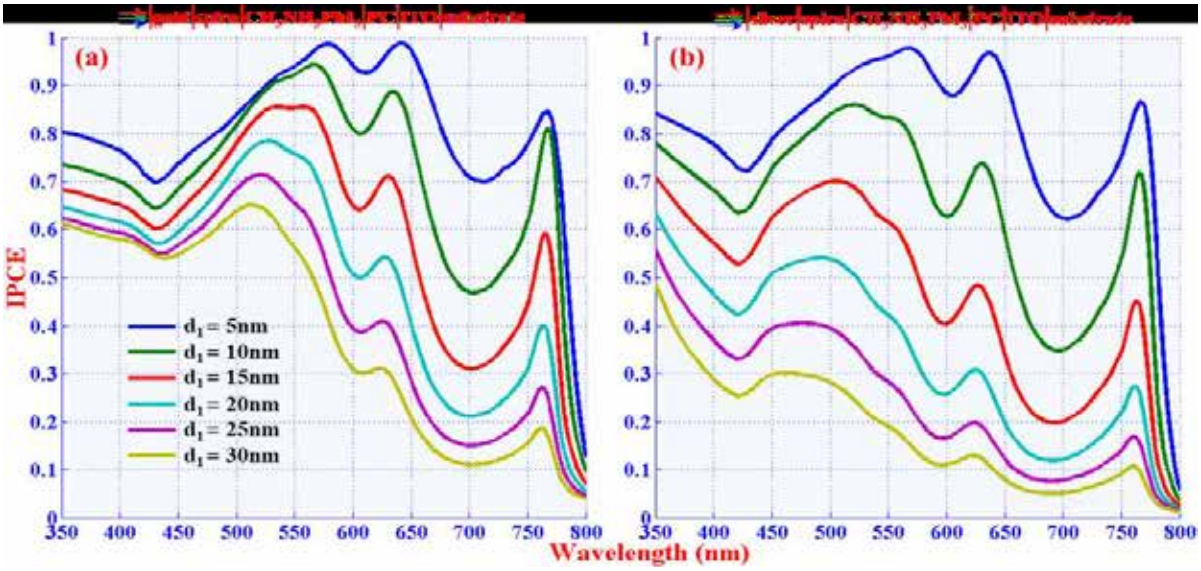


Fig. 4.34: Dependence of IPCE on the layer thickness of the metallic contact layer (a) gold and (b) silver, and the incident wavelength.

Double graded-index 1-D photonic crystals for highly efficient light trapping and controlling photonic devices in terms of tuned and controlled photonic band gap performances have also been demonstrated. Operational frequencies and number of PBGs of the double graded-index photonic crystals can be tuned by controlling layer thickness, grading profiles, and grading parameters of the constituted graded layers. The changes in the grading profiles of the graded layers modulate the operation frequencies and the number of PBGs.

The study of composite perovskite with Au/Ag nanoparticles is important for the selection of matched concentration and size of gold or other metallic nanoparticles to design the efficient plasmon-enhanced organic-inorganic halide perovskite based solar cells and other optoelectronic devices. The proposed PCs and plasmonic metal nanoparticles coupled solar cell models may offer to design high performance and stable solar cells. The introduced graded PC structures can be implemented to design tunable filters, mirrors sensors, detectors, and other photonic devices.

The work was done at Indian Institute of Technology, Roorkee.

4.2.7 Prime Minister's Fellowship Programme for Doctoral Research

Prime Minister's Fellowship for Doctoral Research scheme is a prestigious initiative of SERB towards the advancement of university research engagements in line with industry requirement. This scheme is aimed at encouraging young, talented, enthusiastic, and result-oriented scholars to take up industry-relevant research. Under this scheme, full-time PhD scholars get double the JRF/SRF as scholarship. While one-half of this scholarship comes from the government, the second half comes from a partner company which also works closely with the candidate on the research project. The first batch commenced in 2013. The scheme is implemented in partnership with CII and FICCI.

FEATURES

- **Support for full-time Ph.D. scholars for carrying out industry-relevant research**
- **The scheme has the provision to award up to 100 new scholarships every year**
- **Scholarship is given for a maximum period of four years, 50 per cent of which comes from SERB and 50 per cent from the partner company**

Website links
http://serb.gov.in/pmfdr.php
www.primeministerfellowshipscheme.in

Research Highlights

Leveraging the external resources and meta-data to highlight the gap between a program's implementation and its documentation: GitHub hosts several library projects that have overlaps in their functionalities. These overlaps have been of interest to developers from the perspective of code reuse or the preference of one implementation over the other. Through an empirical study, the research work by one of the PM Fellow present the extent and nature of the existence of these similarities in the library functions. Scope for effectively using the mining of test suites from the perspective of revealing defects in a programme or its documentation was identified. The work automated the entire process in METALLICUS (Fig. 4.35), a test mining and recommendation tool that returns a test suite for the given input of a query function and a template for its test suite. On a dataset of query functions taken from libraries implemented in Java or Python, METALLICUS revealed 46 defects. This work, titled as "Mining Similar Methods for Test Adaptation", was accepted in the upcoming issue of the Transactions on Software Engineering (TSE).

To understand the introduction of inconsistencies between a program's implementation and its documentation, this PM fellow at Indraprastha Institute of Information Technology, Delhi present a study on the prevalence of function documentations that are indirectly or implicitly dependent on entities other than the associated function. The work comprehensively analysed the nature of documentation updates made in 1302 commit logs from 11 open-source repositories from GitHub and studied patterns, such as referential relation, call-graph relation, inheritance relation, and interface relation, to reason about the cause of dependency in the documentation. The observations made in this study may find a direct use case for developers in the form of a recommendation system to suggest methods (the targets) for which code or documentation should be altered when a developer makes code changes to other entities (the sources). This would help prevent documentation inconsistencies that arise as a project evolves.

1.80 cr
Expenditure
(New & Ongoing)

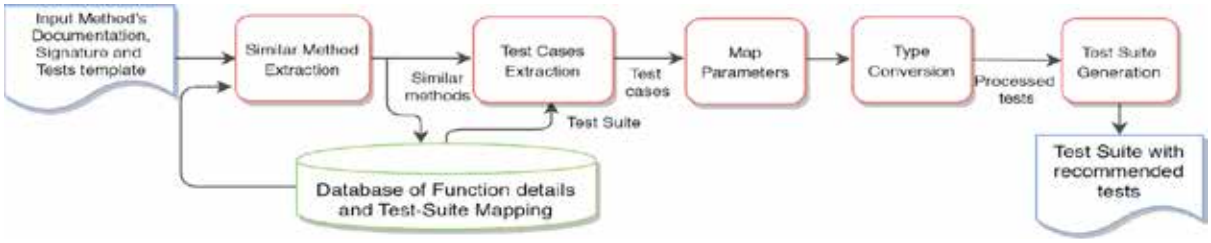


Fig. 4.35: Architecture of METALLICUS

4.3 RECOGNITION FOR WOMEN SCIENTISTS

4.3.1 SERB Women Excellence Award

SERB Women Excellence Award is a one-time award given to women scientists below 40 years of age, and who have received recognition from any of the following national academics in Science and Engineering.

1. Indian National Science Academy, New Delhi
2. Indian Academy of Science, Bangalore
3. National Academy of Science, Allahabad
4. Indian National Academy of Engineering, New Delhi
5. National Academy of Medical Sciences, New Delhi
6. National Academy of Agricultural Sciences, New Delhi

In the year 2020-21, four women researchers received the Women Excellence Award. The awardees are Dr. Shobhna Kapoor, Assistant Professor at Indian Institute of Technology Bombay, working in the area of Chemical Biology with expertise in 'Host-Pathogen Interactions and Membrane Biology, Chemical Biology and Biophysics', Dr. Antara Banerjee, Scientist B National Institute For Research In Reproductive Health, Mumbai, Maharashtra from the Health Sciences area with expertise in Signal Transduction, Biology of Reproduction and Endocrinology, Dr. Sonu Gandhi Scientist D from National Institute Of Animal Biotechnology, Hyderabad from Bio nanotechnology area focusing on Nano sensors, Design and Fabrication of Label-free Biosensors and Dr. Ritu Gupta, Assistant Professor at Indian Institute Of Technology Jodhpur, Rajasthan working on Nanotechnology with expertise in Materials Science, Nanodevices and Sensors, Health & Energy. The awards were presented on National Science Day 2021.

FEATURES

- **Annual award for young women researchers in recognition of their outstanding achievements**
- **Support consists of a research grant of Rs.5. lakh per annum**
- **Duration is 3 years**

Website links
http://serb.gov.in/wea.php
https://serbonline.in/SERB/Women_excellence

Research Highlights

Studies on plasmon-coupled emission at the interface of metal nanostructures and supramolecular systems: The interaction of fluorophores with metallic surfaces and nanostructures provides many interesting opportunities for tailoring emission properties. One important effect that can be achieved by fluorophore-plasmon coupling is the modification in the spatial distribution of fluorescence and conversion of isotropic fluorescence to directional emission. Identification of the parameters responsible for controlling the colour, intensity and angular divergence of the emitted light was the main objective of this work. The symmetric Ag-PVAAg-glass substrate provides the best emission intensities perpendicular to the substrate with narrow angular divergence and simulations studies revealed that the colour of the light emitted perpendicular to the substrate can be tuned by changing the metal composition. This finding can be useful for optical imaging and lighting technology.

Another notable achievement of this study was the demonstration of dye location dependent emission patterns from the MDM substrates. It was observed that dye molecules placed within the dielectric layer in the MDM substrates, showed beaming emission due to coupling with the cavity mode. On the other hand, dye molecules placed on the top metal surface showed emission at angles away from the surface normal due to efficient coupling with the surface-plasmon mode. It was also observed that a variety of spatial emission patterns can be obtained by changing the design parameters of the substrates in a flexible manner. This can be anticipated that the ability to control the flow of emitted light in the nanoscale will lead to the development of a new generation of fluorescence–based assays, instrumentation, portable diagnostics, and emissive devices.

8
Awards Sanctioned

1.42 cr
Expenditure
(New & Ongoing)

C-dots are emerging as attractive luminescent materials due to their simple and inexpensive synthesis, high photostability compared to traditional fluorophores and low toxicity, which makes them suitable for various applications in bioimaging, light harvesting, optical sensing. As part of this work, fabrication of luminescent carbon dots through a one-step synthesis procedure was carried out. These C-dots when conjugated with macrocycles like α-cyclodextrins showed tremendous increase in their emission intensity (Fig. 4.36). This is a very novel and valuable observation and further work is in progress to explore and understand this remarkable phenomenon. Coupling of C-dots with plasmonic structures will also be studied.

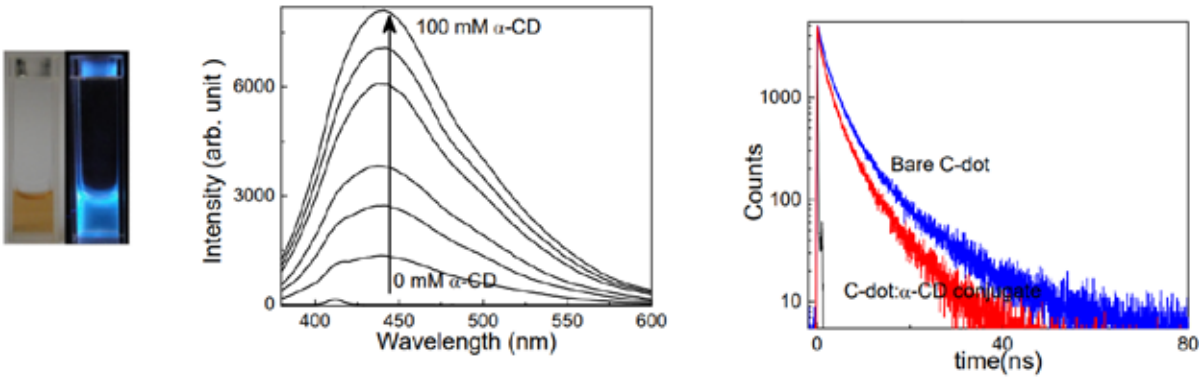


Fig. 4.36: Images of the prepared luminescent C-dot emission spectra of the C-dots with increasing concentration of *α*-cyclodextrin and the intensity decay traces of the C-dots in the absence and the presence of *α*- cyclodextrin.

An optical set-up for angle-resolved emission measurements instrument was also developed (Fig. 4.37). A miniature spectrometer will be procured and coupled with this set-up using a fibre optic connector, to complete the device. This user-friendly, in-house assembled device will be a versatile platform to carry out emission studies with a variety of substrate materials and at desired angles of excitation and emission. Such measurements are not possible with the commercially available fluorescence instruments. It will also be possible to monitor the polarizability of emission with this developed set-up. This instrument will be extensively used in our ongoing fluorescence-based research programmes.

The work was done at Bhabha Atomic Research Centre, Mumbai.

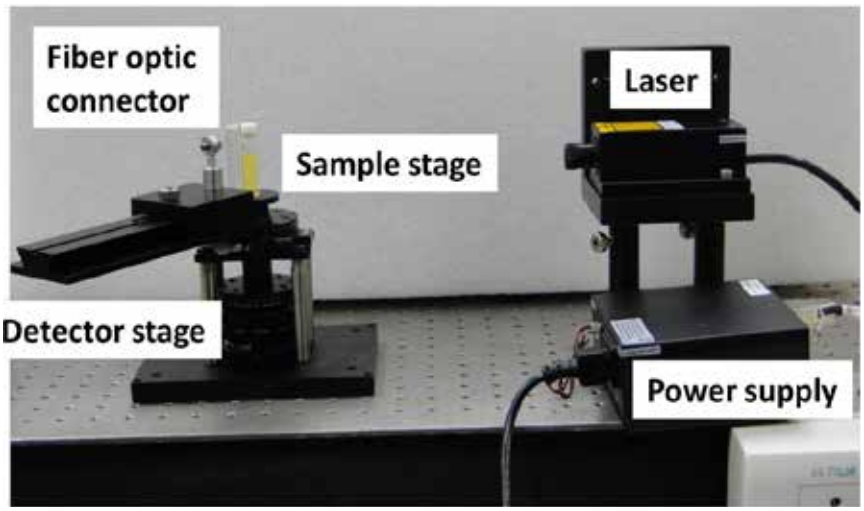


Fig. 4.37: Photograph of the optical set-up developed for angle resolved fluorescence measurements.

Photochemical reduction of CO_2 via visible light promoted homogeneous redox catalysis: The graphene oxide immobilized cobalt phthalocyanine as an effective, recyclable, and cost-effective photocatalyst for the photoreduction of CO_2 to methanol was demonstrated in this work. The grafting of CoPc to the graphene oxide surface plays an important role and provides methanol conversion rate upto 3781.8881 μmol.gcat^{-1} under visible light irradiation for 48 h. These conversion rates are much higher than that of GO. The chemical attachment of CoPc on GO surface provides the higher yield of the desired methanol as compared to the physical mixing of the GO and CoPc in 1:1 ratio. Attachment of CoPc to GO prohibits the recombination of hole and electron (Fig. 4.38). In addition, CoPc rapidly transfers excited electrons to the conduction bands of the GO, which provides the efficient photoreduction of the CO_2 with water to produce methanol.

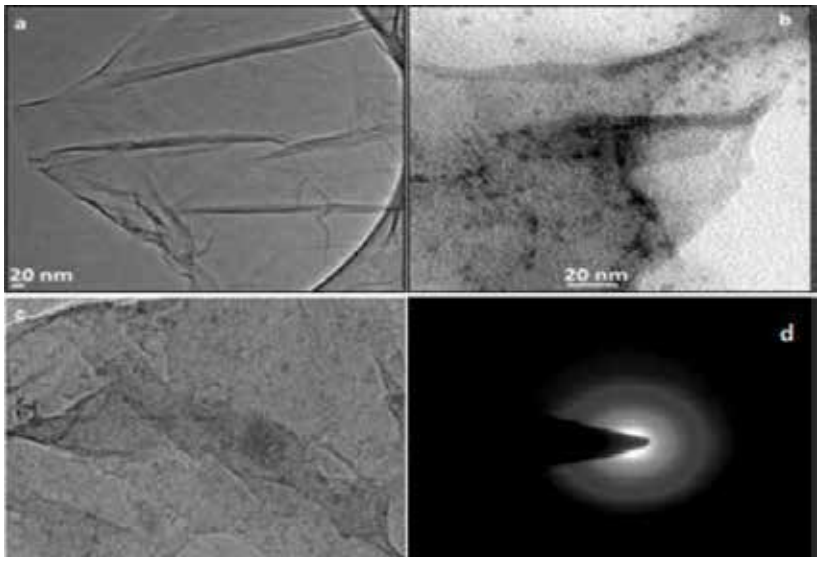


Fig. 4.38: TEM image of a)GO, b) GO-CoPc, c) GO-COOH and d) SAED pattern of GO-CoPc

A novel hetero-structured SnPc@CeO_2 photocatalyst was successfully developed by the immobilization of tin (IV) phthalocyanine to mesoporous ceria through axial position by taking advantage of hydroxyl groups presented on the surface of meso-CeO^2. The synthesized photocatalyst exhibited good photocatalytic activity under visible light irradiation and afforded methanol and carbon monoxide as major products. The developed catalyst was found to be more efficient as compared to the meso-CeO_2 as well as homogeneous $SnPcCl_2$ with the added benefits of facile recovery and consistent activity for recycling runs. With the use of SnPc@CeO_2 (Fig. 4.39), the yield of methanol and CO after 24 h was attained as 2342 µmol.$gcat^{-1}$ and 840 µmol. $gcat^{-1}$with quantum yields (φMeOH = 0.0223) and (φCO = 0.0026) respectively. The attained product formation rate for methanol (RMeOH) and CO (RCO) by using SnPc@CeO_2 was 97.5 µmol.$gcat^{-1}$ and 35.0 µmol.$gcat^{-1}$. The superior photocatalytic activity of the heterostructured catalyst was defined on the basis of better charge injection in the conduction band of meso-CeO_2.

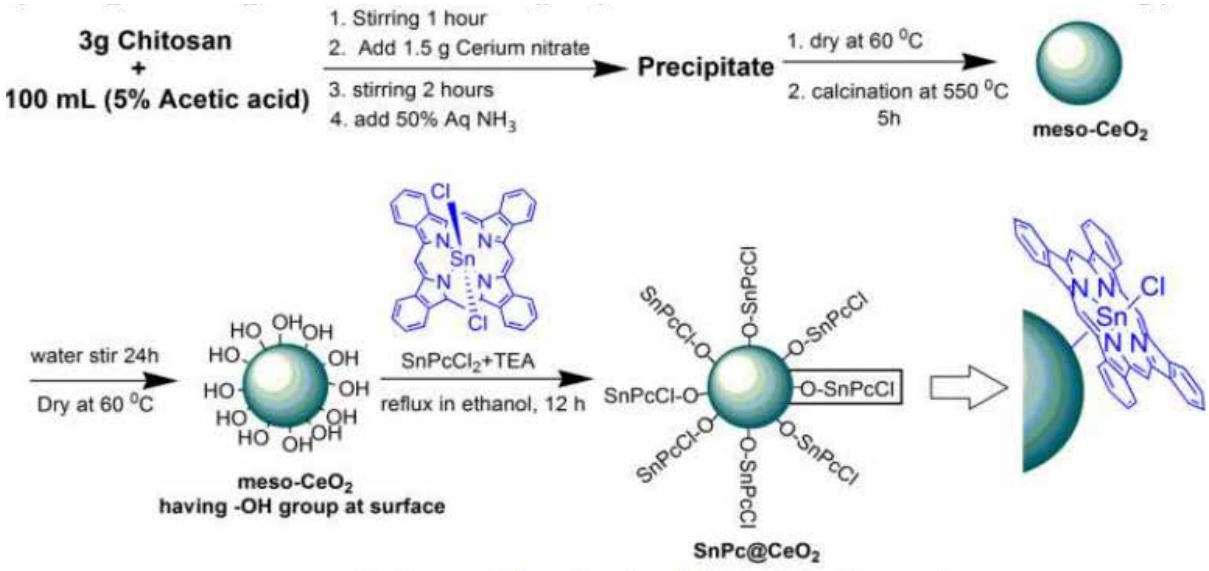


Fig. 4.39: Synthesis of SnPc@CeO2 catalyst.

A novel heterogeneous graphene oxide immobilized trinuclear ruthenium photocatalyst for the reduction of carbon dioxide to methanol under visible light irradiation was observed. Owing to the wide band gap, graphene oxide alone does not provide excitation in visible light. Ruthenium complex because of its better visible light absorbance facilitates the transportation of electrons from ruthenium macromolecule to GO's conduction band. After 48h of irradiation, the yield of methanol was found to be 3977.57 $\mu mol.gcat^{-1}$ ruthenium complex immobilized to graphene oxide. This value is much higher than that of GO alone (2201.4 $\mu mol.gcat^{-1}$). The results reported in the present work will open new possibilities to develop efficient heterogenized homogeneous molecular photocatalysts for production of high value products from CO_2 in a sustainable way.

The work was done at CSIR–Indian Institute of Petroleum, Dehradun.

4.3.2 SERB POWER Fellowship

POWER Fellowship Scheme aims to identify and reward outstanding women researchers and innovators working in Indian academic institutions and R&D laboratories, in any branch of Science and Engineering. POWER Fellowship is a one time fellowship for 3 years for women researcher within 35-55 years of age.

The scheme was initiated in 2020-21 and the first call was made in November 2020. 25 POWER Fellowships were awarded out of 100 nominations. Research Highlights of some of the proposed work that are supported are given below:

FEATURES

- **Fellowship for women researchers in regular service in academic and research institutions**
- **Support consists of Fellowship of Rs. 15,000 per month in addition to regular income, research grant of Rs. 10 lakh per annum along with Rs. 90,000 overhead for host institute**
- **Fellowship duration is three years**

Website links
http://serb.gov.in/powerfellow.php
https://serbonline.in/SERB/serbPowerInstructions

Intelligent flexible electronics using oxide TFTs for storage temperature monitoring of critical medicine (COVID 19 Vaccine): Almost from a year whole world is severely suffering with COVID 19. Almost 79.9 million people got infected and more than 1.75 million people have died across the globe. Whereas, in India almost 10.2 million people got infected and 0.15 million people have died according to the official reports. This pandemic resulted a serious impact on every society (educational, economical, political, agricultural, psychological levels and many more). At this stage everyone is looking towards COVID 19 vaccine to save lives from this infection. Many vaccines are under active research and trail stages. Few examples of vaccines are Pfizer BioNTech (-60 to -90°C), Moderna, Sputnik V,

25
Fellowships Sanctioned

3.18 cr
Expenditure
(New & Ongoing)

AstraZeneca Oxford (+2 to +8 oC) with cold chain. Especially maintaining right temperature during the supply chain and storage of this vaccine is essential for proper functionality. Monitoring this storage or supply chain temperature is an open challenge, as different vaccines have specific requirements. This work is proposing smart or intelligent electronics, which can be included on the vaccine packaging to monitor the storage temperature with flexible electronics using oxide TFTs. In case, if the vaccine is not stored at the right temperature, that information will be made available to the user to minimize the health risks. The proposed idea can be applicable to storage conditions monitoring of different drugs, virus, chemicals, and frozen meat.

The research will be carried out at Indian Institute of Science Education and Research, Bhopal.

Functionalized long wavelength light emitting donor-acceptor systems: Though a variety of materials having emission in longer wavelength region have been reported yet several venues are not much explored such as control of emission/ energy transfer processes of assembled materials in aqueous media and interrelation between morphology/redox potential (ground state and excited state) of red emitting materials and molecular recognition/catalytic event in aqueous media. In the present project, the investigator at Guru Nanak Dev University, Amritsar is planning to develop donor-acceptor systems using PBI/ pyrazine as the core. These materials (designs A and B) will be explored to understand various different mechanistic pathways for detection of organophosphate 'nerve agents' . The role of synthesized materials as acetylcholinesterase enzyme (AChE) inhibitors will also be examined. By tuning the energy difference between lowest excited singlet state and triplet state, PI plans to synthesize TADF materials (design C) as photo redox catalytic systems for construction of C-C/ C-N bonds. Next, PI plans to synthesize donor-acceptor (D-A) systems (designs D and E) having sufficient potential to generate reactive oxygen species upon irradiation. The catalytic efficiency of these materials will be explored in various organic transformations.

4.4 ENABLING INNOVATION AND TECHNOLOGY DEVELOPMENT

4.4.1 Technology Translation Award (TETRA)

SERB-TETRA (Technology Translation Award) is a new scheme for catalysing technology translation in academic setting. SERB-TETRA will challenge scientists executing SERB grants, such as CRG, to establish an effective, functional, and synergistic working collaboration with an industry partner to elevate their breakthrough results and technologies to TRL level 5 and beyond. It is envisaged that a well-defined strategy to augment research innovation, via technology incubators, will add value to the CRG and other funding mechanisms supported by SERB.

First call for proposals under SERB-TETRA was made during January-February 2021. Total of 90 proposals were received out of which 10 were selected for the award.

FEATURES

- **Funding support to kickstart new venture processes**
- **The funding will be provided normally for a period of two years**
- **The award will entail an unstructured budget up to Rs. 15 lakh per year**

Website links
https://serbonline.in/SERB/Tetra

Highlights of some of the proposals supported are given below:

Precision engineering of antibody-drug conjugates for targeted cancer chemotherapeutics: Antibody-drug conjugates (ADCs) provide state-of-the-art technology for targeted cancer chemotherapeutics. There is an urgent technological demand for technologies that can provide PRECISE control on the engineering of bonds between a monoclonal antibody, linker, and toxin (or drug).

With the first modular chemical technology in hand, investigator at Indian Institute of Science Education and Research, Bhopal is looking forward to translating it and synthesize a library of ADCs with systematic control over the variables. Library will be screened through in-vitro assays for shortlisting the leads for the final round of assessment and data generation for the IND application. Additionally, this technology can go beyond ADCs for HER-2 positive breast cancer and establish a comprehensive platform for a diverse portfolio of antibody-based therapeutics.

Device for Tuning Laser Output: Supercontinuum lasers are referred to as sources which are as bright as a laser and as broadband as a lamp. They are extensively used in various applications in spectroscopy, metrology, LIDAR and in test and measurement. Currently, supercontinuum fiber lasers are high end sources with over an order of magnitude or more cost than high power lasers at the same power level. This has limited their adaptation substantially. Alternately, conventional transmission fibers used for optical communications are very cheap and achieve a very robust operation over extended fiber lengths. If such sources can be used for supercontinuum generation, the system will be very economical and robust.

Investigator has recently developed a technique by which they convert existing fiber laser sources to any other previously inaccessible wavelength band such as 1310 nm using cascaded Raman nonlinearities. This conversion can be achieved with very high efficiency and power scalability. This enables the new mechanism of supercontinuum generation at high powers using simple off the shelf components. The proposed goal is to take this exciting technology and productize it by a combination of optical design optimization, mechanical and electrical design and reliability.

The research work will be carried out at Indian Institute of Science, Bangalore.

5

SYNERGETIC PROGRAMMES

Programmes with intra and international linkages are key to harness untapped potential in value-added research and innovation. Partnership programmes have the ability to create a wide spectrum of possibilities to innovate and solve practical problems, generate skilled manpower, and drive economic growth. International programmes are innovation platforms for catalysing cutting edge research, adapting global best practices, and enhancing research productivity. These synergetic programmes aid to create a globally competitive research environment in the country for accelerated development of scientific and technological progress.

SERB, in its commitment towards strengthening research in the country, implements partnership programmes in cooperation with other Ministries, Departments and Industries in identified scientific areas. While SERB has enormous outreach and connectivity with researchers, strong programme management prowess and robust ePPMS platform, other Ministries and Industries have identified needs and linkages with end users. Partnership with other Ministries allows to leverage the complementary strengths which will aid to connect the need with the expertise thus enabling ground breaking research that could solve complex problems. Presently two partnership programmes, Impacting Research, Innovation and Technology (IMPRINT) and the Uchhatar Avishkar Yojana (UAY) are being implemented jointly with the Ministry of Education (previously Ministry of Human Resource Development). The other joint initiatives such as Cell Tower and Mobile Radiation programme with Department of Telecommunication, Ministry of Communication and Information Technology to study the possible impact of electric and magnetic forces (EMF) exposure from mobile towers and handsets on life humans, living organism, flora, fauna and environment and research and development Scheme in the area of food processing with Ministry of Food Processing Industries have been successfully completed.

Considering the importance of International mobility in research and the benefits it offers in fostering young researchers and strengthening country's international competitiveness in scientific excellence, SERB has been implementing international programmes such as SERB Overseas Visiting Doctoral Fellowship for young researchers and VAJRA Faculty Scheme to attract the expertise of overseas scientists as visiting faculty to undertake high quality collaborative research in public funded academic and research institutions in India.

5.1 NATIONAL PARTNERSHIP PROGRAMMES

5.1.1 Impacting Research Innovation and Technology (IMPRINT-II)

A unique national initiative called IMPacting Research, INnovation, and Technology (IMPRINT) was launched few years back by the the Ministry of Education (previously Ministry of Human Resource Development), Government of India (GoI) to address all major engineering challenges relevant to India through an inclusive and sustainable mode of translational research steered by the top engineering institutions in the country. Ten technology domains were identified under IMPRINT that could substantially impact the quality, safety and security of life both in urban and rural areas. IMPRINT-II with a revised strategy was initiated by MHRD in equal partnership with DST/SERB which is being implemented by SERB since 2016. The principal objective of IMPRINT-II is to address all major engineering challenges faced by the nation by translating knowledge into viable technology (product/process).

A modified consortium approach (IMPRINT-IIC.2) was initiated in the IMPRINT IIC programme to include strong and complementary expertise from across different disciplines to address major technological breakthrough in designated areas of societal/industrial importance. It is expected that the consortium upholds inter-disciplinarity that brings the power of togetherness from diverse knowledge and competence; complementarity that brings the uniqueness of the partners for collective benefit and is ready to work under one leader as PI. At least two Institutes/Universities along with the involvement of Industries in the Consortia were essential in these projects. It was required that at least 25% of the project cost should be supported by the industry out of which at least 10% of the project cost was to be cash.

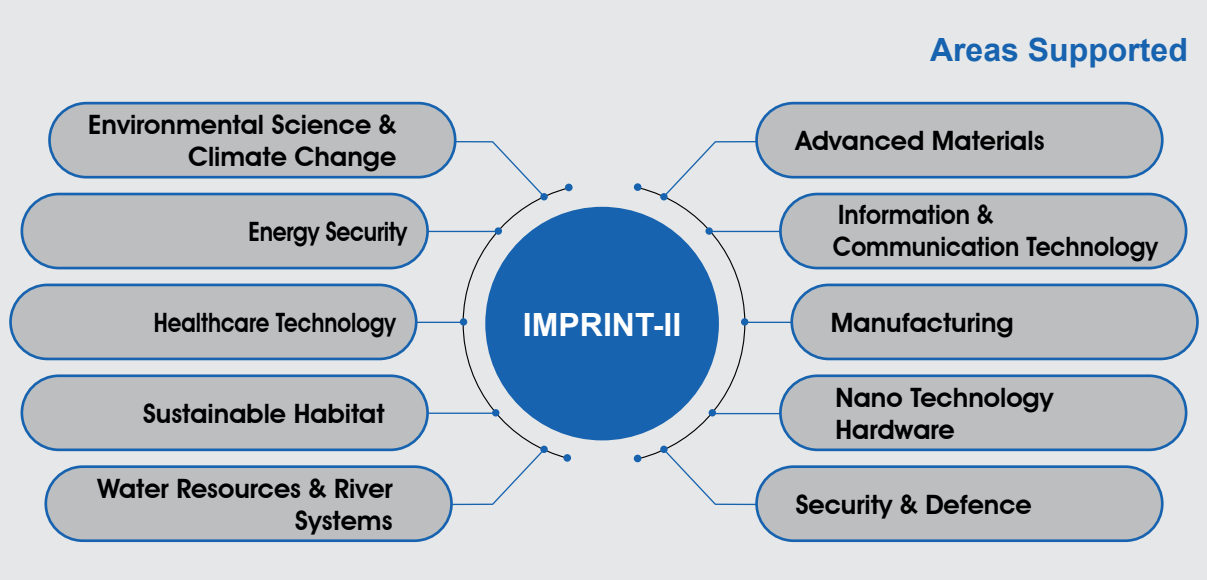
SERB had announced the themes and challenges which the scientific community had to undertake. The lead institute was also needed to illustrate a sustainability plan in the proposal beyond the approved duration for the long-term impact of the consortium. Forty three proposals were submitted under different domains against this initiative.

IMPRINT-II programme is being implemented through SERB online portal https://www.serbonline.in/SERB/IMPRINT2C. The Knowledge Portal for IMPRINT-II programme was improved further and is available in the public domain.

FEATURES

- **Joint initiative by MoE and DST which is being implemented by SERB**
- **Principal objective is to translate knowledge into viable technology**
- **Industry support is mandatory**

Website links
https://serbonline.in/SERB/IMPRINT2C



Research Highlights of some of the projects supported under IMPRINT-II are given here.

Designing and fabrication of indigenous anti-hail guns and evaluation of their effectiveness to combat hailstorms for sustainable apple production in Himachal Pradesh : Under the Domain "Environment and climate change", parametric studies were conducted on the 3m long scaled-down model of the anti-hail gun. In this study an Arduino controlled ignition system has been developed to achieve a precise control over the ignition of mixture. Acetylene detonated easily and early inside the gun as compared to LPG, for all equivalence ratios. While LPG detonated between 1 m and 2 m for rich mixtures and the peak pressure obtained for LPG is around 18 bar at ϕ = 1.2 whereas for acetylene, it was 55 bar at ϕ = 1.0. While detonation wave velocities for both the fuels have comparable values and increase with increasing ϕ, the deflagration to detection transition (DDT) time are varying between 25-30 ms and 10-12 ms for LPG-Air and Acetylene-Air respectively (Fig. 5.1).

14.21 cr
Expenditure
(Ongoing Projects)

The work was done at Indian Institute of Technology, Bombay.

Fig. 5.1: Detonation wave obtained with LPG/air mixture at φ = 1.2

Multi-crop residue processing technology package for production of fuel and fertilizer: In another project under the domain "Energy Security" a process-based technology for pre-treatment of multi crop residues of varying characteristics into standard feedstock for anaerobic digestion (AD) has been developed. The preliminary tests on locally available lingo-cellulosic biomass in the lab as well as with field stationed plant (Fig. 5.2) have been initiated. The experimental results showed the production of methane rich biogas (70%). Different pre-treatments such as shredding, alkaline pre-treatment, steam explosion and microbial digestion techniques were developed for enhancing anaerobic digestibility. A device for online measurement of methane gas (composition), temperature and humidity, gas production of bio-gas reactor has been developed and tested (Fig. 5.3). Testing to make the data available on local user network is being continued.

The work was done at Tezpur University, Assam.

Fig. 5.2 : Field experimental station I (Small reactor) with locally available lingo-cellulosic biomass

Fig. 5.3: LCD display of the ambient parameters

A low power SoC with neuromorphic co-processor for intelligent devices: In another project under the domain "Information & Communication Technology" a low power neuromorphic hardware engine, which will execute machine learning (ML) algorithms, on edge devices is being built. As part of the project, an initial prototype of the Field Programmable Gate Arrays (FPGA) based SoC board has been built. This board (called tiny Brain) is capable of doing edge level computation at ultra-low power. The design of the board includes a Microcontroller interfaced with a low power FPGA. All the peripherals (such as monochrome camera, microphone, accelerometer) are interfaced directly with the FPGA (Fig. 5.4). The FPGA chip used in the board is one of the best in terms of power efficiency, which is one of the key factors for edge computing applications. However, the available computational resources on the board are very limited. This requires developing hardware optimized ML algorithms. A series of novel hardware optimized algorithms have also been successfully built.

The work was done at Indian Institute of Science, Bangalore.

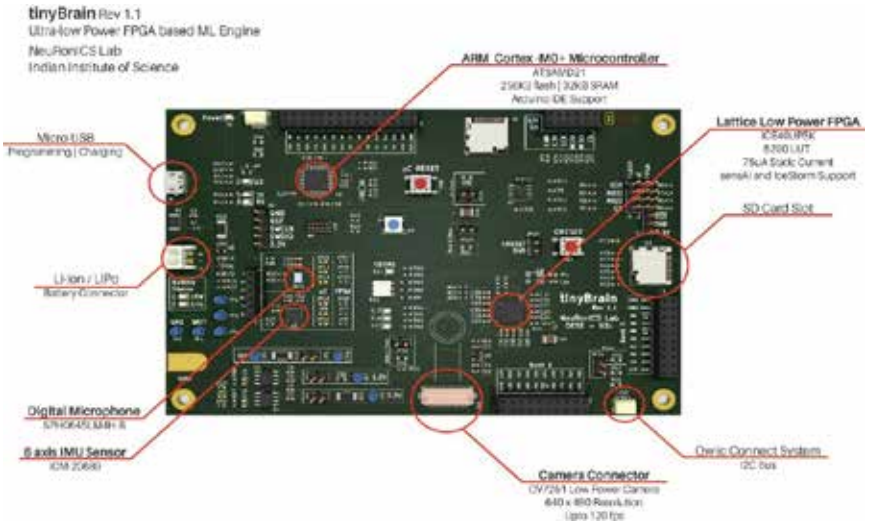


Fig. 5.4: tinyBrain is an ultra-low-power FPGA based neuromorphic system being designed and developed at the NeuRonICS Lab IISc, Bangalore, for machine learning applications on edge devices. The tiny Brain development board has onboard microphone and Inertial Measurement Unit (IMU).

Development of a diverse lab-on-a-chip platform for plastic electronics, micro catalysis, and biosensing applications using microlithography by directed self-assembly driven by laser induced microbubbles: In one of the projects under "Advanced Materials" progress has been made on microbubble lithography – biosensing, catalytic microchips, and development of electronic devices. In biosensing, successful patterning of a heavy molecular weight protein (Green Fluorescent Protein-GFP) has been demonstrated and proved that it retains its activity by carrying out a reaction with its corresponding antibody (anti-GFP), and finally with a secondary antibody (secondary GFP antibody) respectively on the pattern surface. This is the first instance where a protein has been controllably patterned on a glass substrate preserving its activity, and an antigen-antibody has also been successfully carried out (Fig. 5.5).

In the catalysis aspect of the project, they have patterned a catalyst comprising of a PV3W9O40 type component, carbon nanotubes and Polypyrrole, and carried out selective oxidation of an array of diverse anilines into nitrobenzenes efficaciously. In the electronic device's direction, the group has patterned the conducting polymer PSS-PEDOT on glass and PDMS substrates, and developed heterostructures to show clear transistor action of the device. Two patents have already been filed in this project.

The work was done at Indian Institute of Science Education and Research, Kolkata.

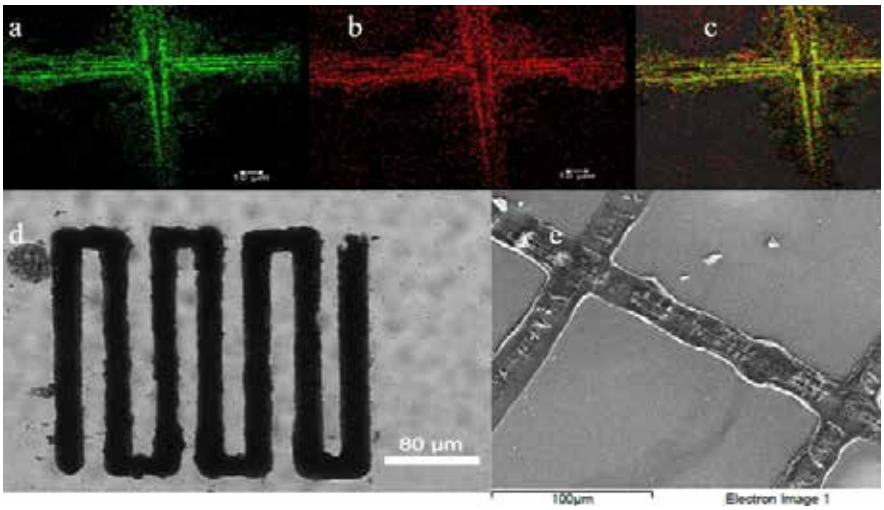


Fig. 5.5: a) Green fluorescence due to attached GFP at 488nm excitation, b) anti-GFP and secondary antibody (red fluorescence 522nm) present, c) merged images of a, and b, d) Microscopic image of MWCNT/PPy/POM catalysis, e) SEM image of PSS-PEDOT on a glass substrate.

Design and development of a blood cell counter: Complete blood cell count (CBC) is one of the most common and the most valuable tests performed in clinics and hospitals to assess the health of an individual. All automated CBC tests in India are performed on imported and expensive hematology analyzers. There are essentially two different technologies to determine the size and number of cells in blood. In the impedance technology, the cells are distinguished by the electric resistance imposed by their size when they flow through an orifice with a diameter equivalent to that of a human hair. Electrodes placed on either side of the orifice measure an increase in resistance when cells pass through the orifice. In the light scattering technology, a laser light is focused on cells and the intensity of the reflected light carries information regarding their size.

The project under "Healthcare Technology" was supported to design and build hematology analyzer by using impedance and light scattering technologies indigenously in India. The prototypes by employing novel designs for the electronics and the flow chamber are currently being tested at the laboratory scale (Fig. 5.6), the proposed device will be compact and economical with measurement accuracies similar to imported bench-top instruments.

The work was done at Indian Institute of Technology, Bombay.

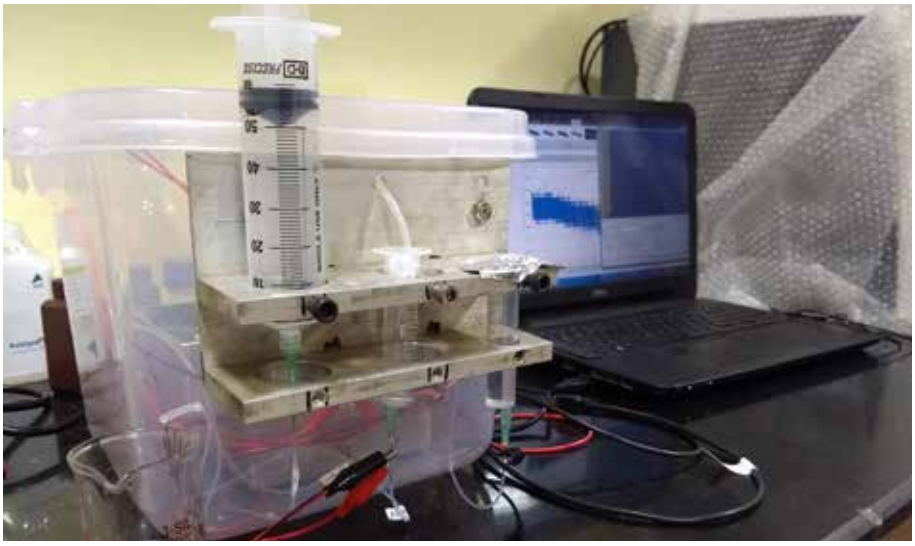


Fig. 5.6: The lab scale prototype of Hematology analyzer.

5.1.2 Uchhatar Avishkar Yojana (UAY)

The Uchhatar Avishkar Yojana (UAY) was launched by the Ministry of Education (previously Ministry of Human Resource Development) with a view to promote innovation of a higher order that directly impacts the need of the industries, thereby improving the competitive edge of Indian manufacturing capabilities. Industry-sponsored, outcome-oriented research projects are funded under this scheme. While MoE funds 50% of the project cost, industry and other participating Ministries share the balance project cost (25% each). SERB is partnering with MoE in funding UAY projects. Financial sanctions were issued for 39 projects under UAY-Phase-I and Phase-II during the financial year.

Research Highlights

Agricultural waste based gasifier heating system: Agriculture contributes a major share to the gross domestic product (GDP) of India. A significant portion of this including vegetables and fruits require robust preservation systems. The farmers witness losses and exploitation due to unavailability of adequate cold storage units due to lack of inexpensive physical infrastructure and insufficient and expensive grid power. These issues lead to high wastage and bunched-up supply. Hence there is an urgent need with a viable market for small off-grid cold storage facilities that can store the farm produce till it is sent higher up in the supply chain. Cold storage units employing the adsorption refrigeration cycle is a viable solution, which requires hot water to run the thermodynamic cycle which depend on both renewable and non-renewable power sources. Usage of fossil fuels is costly and also not environment friendly.

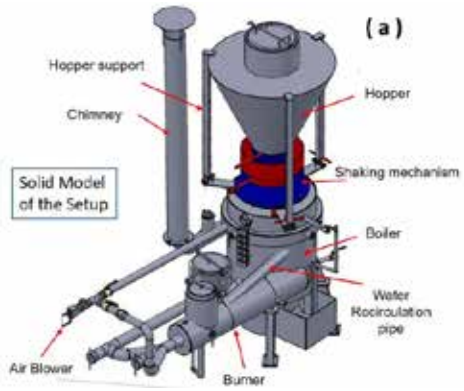


Fig. 5.7: Model GreenCHILL™ off-grid cold storage.

To address this key problem, an agriculture waste-based gasifier heating system was developed by the team at Indian Institute of Technology, Patna in collaboration with their industry partner New Leaf Dynamic Technologies. The crucial innovation includes developing a gasifier based boiler with a spiral heat exchanger. This not only reduces the emissions but also increases the efficiency of the gasification process two-folds. The developed technology (Fig. 5.7) has already been incorporated in an existing GreenCHILL™ off-grid cold storage developed by the industry partner New Leaf Dynamics under the aegis of the Ucchatar Aavishkar Yojana (UAY) project. At the moment, the system consumes less than 10 kg of biomass to generate cooling equivalent to 3 Tons capacity. Biomass as a resource is a useful waste to value concept. The demonstrated technology of gasification based heating has a potential to solve a number of problems arising due to field burning of biomass waste. In particular, issues related to green-house gas emission, soil quality degradation, smog formation and associated health impacts are worrisome. The current problem of smog in and around NCR region is primarily due to the field burning of crop residues. This problem primarily arises due to the fact that the biomass residue from crops does not have an economic value and is a waste for farmers. Hence, before the start of a new season, farmers burn them in open air causing immense pollution, which is amplified due to wind patterns in winter and is primarily responsible for the smog problem we see in our country. While there is a great demand for cold storage within the country, the amount of biomass generated is also high and this can in turn feed into the economy as a resource. The technological developments in this domain at Indian Institute of Technology, Patna pave way for such end applications.

The demonstrated application of the gasifier based heating system in GreenCHILL™ off-grid cold storage utilizes biomass to produce refrigeration without any significant emissions. This creates a value and market for biomass waste. While the system is primarily designed for off-grid refrigeration in remote locations, it can also be used to generate hot water for various process industries as well as normal household heating applications during winter, when refrigeration is not required.

Low cost sensor based urban air quality monitoring network (SENSurAIR): The current need is to carry out research studies on Air Pollution in order to understand more about it and to enable us to work on the preventive and control measures for abating Air Pollution. With the help of the sensor network, these studies on the health effects can bring more reliable information about the exposure to the contaminants present in the atmosphere and the effect of different concentration levels on the humans. Metal oxide-based nano-structured gas sensor with high efficiency and selectivity for particular gas have high sensors response, fast response/recovery time, low power consumption, low operating temperature along with its nano-scale fabrication and low manufacturing cost. Gas sensing mechanism is a surface phenomenon which strongly depends on nature of surface reaction with adsorbs and desorbs reactive species and show change in resistance.

Presently, some sensors for CO, NO_2 and $PM_{2.5}$ are mostly available in the western international markets. The inherent constraints of these sensors are with respect to their applicability in tropical climatic condition like India. These sensors are calibrated according to the requirements of country specifics which are different than Indian

environmental conditions and the stability of these sensors depends upon the temperature, humidity and climatic conditions. SESNurAIR is indigenously designed so as to remove the constraints in the market available sensors. This integrated system including semiconductor materials-based sensors and light scattering based particle counters for monitoring of NO_2, CO and $PM_{2.5}$ along with development of hardware, electronic circuit and software for integration and assembly of sensors and online monitoring (Fig. 5.8) unit helps urban air quality monitoring.

This project is aimed to develop a $PM_{2.5}$ sensor which works on the principle of bright field (BF) and holographic imaging. The sensor is comprised of an air sampler, LED light source, mini vacuum pump followed by a bright field or holographic imaging unit. Fiber coupled LED light source (core diameter ~ 50µm) is connected at central portion of sticky cover slip to record BF images of the test specimens. The central wavelength of the LED source is 632 nm having spectral bandwidth ~ 40 – 50 nm. The pump is switched on to drive the air into the chamber for the deposition of particulate matter (PM) at transparent sticky cover slip (Fig. 5.9). The PM is imaged using a 100x objective lens followed by a tube lens at the detector's plane. The images are then captured by CCD camera and further post processed using MATLAB for the measurement of particle's size and number of particles deposited in the field of view of the compact BF microscope.

The work was carried out by a team comprising of scientists from Indian Institute of Technology, Delhi, Indian Institute of Technology, Madras and Envirotech India Pvt. Ltd., Delhi.

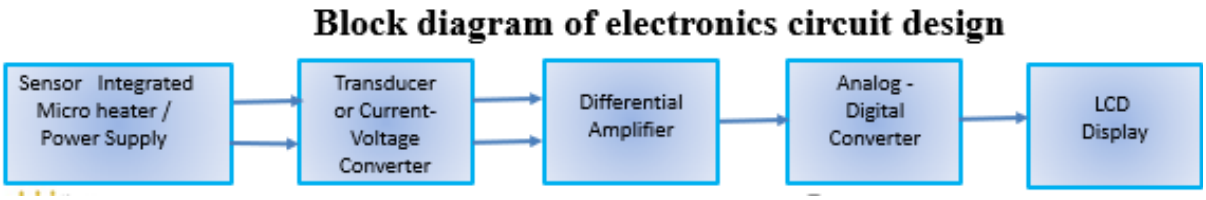


Fig. 5.8: Block Diagram of electronic circuit design for Semiconductor based Gas sensors

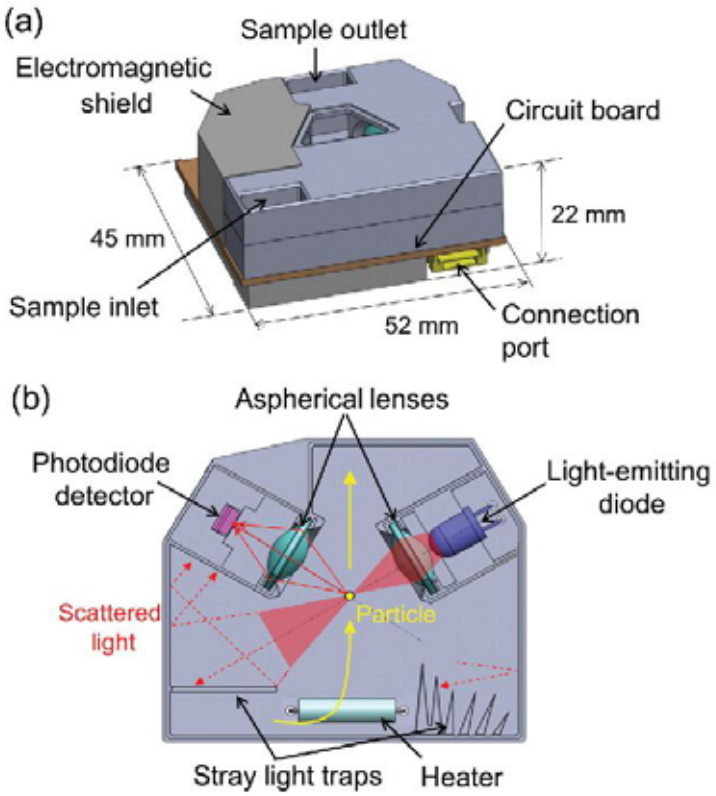


Fig. 5.9: Scattering based particle monitoring $PM_{2.5}$ sensor

5.2 INTERNATIONAL LINKAGES

5.2.1 Visiting Advanced Joint Research (VAJRA) Faculty Scheme

VAJRA Faculty Scheme aims to tap the expertise of overseas scientists including Non-resident Indians (NRIs) and OCIs. It offers visiting faculty positions to overseas scientists and R&D professionals to undertake high quality collaborative research in public funded academic and research Institutions in India. The scheme facilitates collaborative research in frontier areas of S&T including the interdisciplinary areas of national priorities such as energy, water, environment, health, security, nutrition, waste processing, advanced materials, high performance computing, cyber-physical systems, smart machines and manufacturing, etc. and stimulate the latent potential of our academic and research sector.

FEATURES

- **The scheme strives to bring an international dimension to the R&D ecosystem of India by leveraging expertise of overseas scientists**
- **Initial assignment is for one year extendable to subsequent years based on collaborative outcome and interest. Residency period is one to three months per year**
- **VAJRA Faculty are provided US$15000 in the first month of residence and US$10000 in each of the subsequent month**

Website links
http://serb.gov.in/vajra.php
https://serbonline.in/SERB/vajra

During the reporting period 21 accomplished scientists have been offered VAJRA Facultyship.

Significant research leads out of the engagements are given below:

- VAJRA team at IIIT-Hyderabad has initiated research in the areas of biometric quality estimation, spoof detection and large-scale matching, primarily focused on the core biometric modalities of fingerprint, iris and face. The collaborative work has resulted in the development of highly accurate spoof detection systems that surpass state-of-the-art results in the presence of limited training data. IIIT-Hyderabad has made significant strides in the development of a synthetic iris generation system, which is critical to the training of modern machine learning algorithms that use iris.
- Key technical results were obtained by VAJRA team at IIT Madras on the work of injected CO_2 in deep saline aquifers. The results show that the cap rock is subjected to dissolution during saturation due to ion exchange between cap rock minerals and cations in the pore fluid changing the brine elemental composition. Supercritical carbon dioxide ($scCO_2$) permeability significantly reduces at high salinity concentrations in brine due to deposition of different types of evaporites in rock pores which significantly depends on the elemental concentration of brine and cap rock-brine interaction.

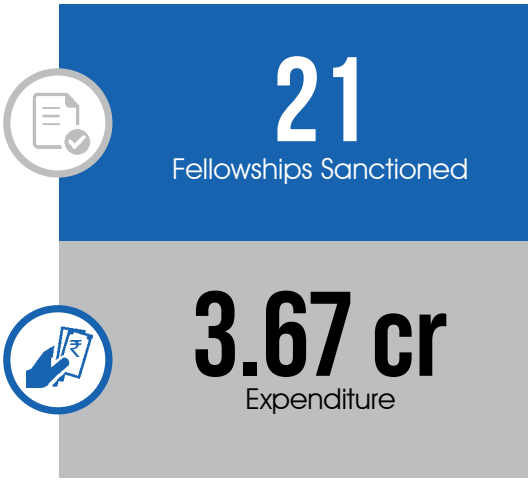
0.40 cr
Expenditure

- VAJRA team at NCBS Bengaluru created a FLP-FRT based genetic tool for conditionally excising sequences encoding the disordered domain (IDR) of ataxin-2 from the genomes of targeted cells in vivo. Using TRIBE, identified

a large number of mRNAs that associate with Ataxin-2 through an IDR-dependent mechanism. Via co-immunoprecipitation and mass spectrometry, identified several protein and mRNA chaperones that associate with Ataxin-2 following cellular stress and appear likely participate in neurogenerative disease. It is also that Ataxin-2 is required for retinal degeneration in Drosophila rdgb mutants.

5.2.2 SERB Overseas Visiting Doctoral Fellowship (SERB OVDF)

The scheme aims to build national capacity in frontier areas of Science and Engineering, which are of interest to India by providing research training to Ph.D. students admitted in the Indian institutions in overseas universities / institutions of repute. It also aims to provide opportunity to performing Indian research students to gain exposure and access to top class research facilities in academia and labs across the world thus creating opportunities to build long-term R&D linkages and collaborations with accomplished scientists and technologists from around the world. The SERB OVDF also envisages to tap the expertise gained by these young scientists to strengthen/initiate national programmes in their domain knowledge.



FEATURES

- **For students registered for full-time Ph.D. degree in any of the recognized Institutions / Universities in India in STEM disciplines**
- **The duration of the research training is up-to a period of twelve months**
- **Monthly fellowship of US $ 2000, one-time Contingency / Preparatory allowances of Rs. 60,000/- and round-trip air fare are provided**

Website links
https://serbonline.in/SERB/ovdf

A total of fifteen fellowships were sanctioned during this financiaL year which includes six students to visit Purdue University, USA and nine students to visit University of Alberta (UoA), Canada.

Significant research outcome out of the engagements are given below:

- A combined research work of IIT Roorkee and UoA undetook studies on dissolution of δ-ferrite and its effect on mechanical properties of P92 steel welds, dissolution of Laves phase by re-austenitization and tempering of creep strength enhanced ferritic steel and prediction of preheating temperature for a given thickness of thin plates by using Rosenthal equation and effect of cooling rates on retained δ-ferrite in Grade P92 steel welds. Two high impact papers are published out of this fellowship.

- A simple solution process using hot injection method was adopted for preparing an All Inorganic Perovskite, $CsPbBr_3$. Additionally, monolayer graphitic carbon nitride sheets were mixed to make a composite with the perovskite. The significant work was in collaboration with UoA and University of Calgary.

- A synthetic sequence of 15 steps was developed for taking a commercially available amino acid and converting it into an advanced intermediate that is poised to form the second and most complex ring of a structurally complicated natural product (called MPC1001) which has very significant anti-prostate cancer activity. Another sequence of 8 steps was also developed for the same purpose by OVDF fellow from Madurai Kamaraj University in collaboration with UoA.

- Under the research visit between IIT Hyderabad and Purdue University, the work was aimed to study the Na/K-ion storage kinetics in various anode materials including antimony/antimony oxide, tungsten sulphide, and terephthalate salt-based compounds. Further, the Na-ion diffusivity into the electrode was determined using common electrochemical techniques such as CV, EIS, and GITT. The study is on progress to synthesize these electrode materials using low-cost microwave irradiation / Reaction under Autogenic Pressure at Elevated Temperature (RAPET)-based reaction method, which could be beneficial from the commercial point of view.

6

COVID-19 R&D INITIATIVES

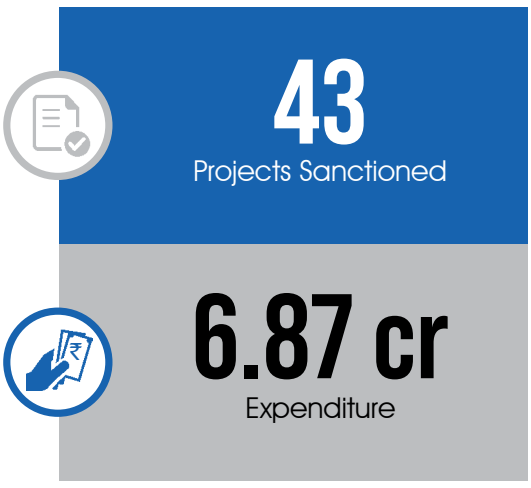
The novel coronavirus disease 2019 (COVID-19) created severe public health catastrophe with substantial morbidity and mortality across the globe. As the novel coronavirus continued to spread worldwide, the World Health Organization (WHO) on March 11, 2020 declared COVID-19 a pandemic and developed a blueprint for global strategy and preparedness towards R&D activities in terms of effective testing, vaccines, medicines, etc. In response to the unprecedented situation, SERB ramped up national R&D efforts to bridge the gaps in diagnosis, treatment, prevention and other aspects of disease etiology to combat COVID-19. The strategy was to mobilize the research expertise and scientific infrastructure of the country for finding solutions to the pandemic. SERB, in its endeavour to support priority research, launched a series of special calls soliciting proposals in identified areas under various funding schemes such as Core Research Grant (Chemical Sciences and Life Sciences), Intensification of Research in High Priority Areas (IRHPA – Life Sciences) and MATRICS.

The details of the Special Calls and other R&D initiatives in response to COVID-19 are presented in this chapter.

6.1. SPECIAL CALLS ON COVID-19

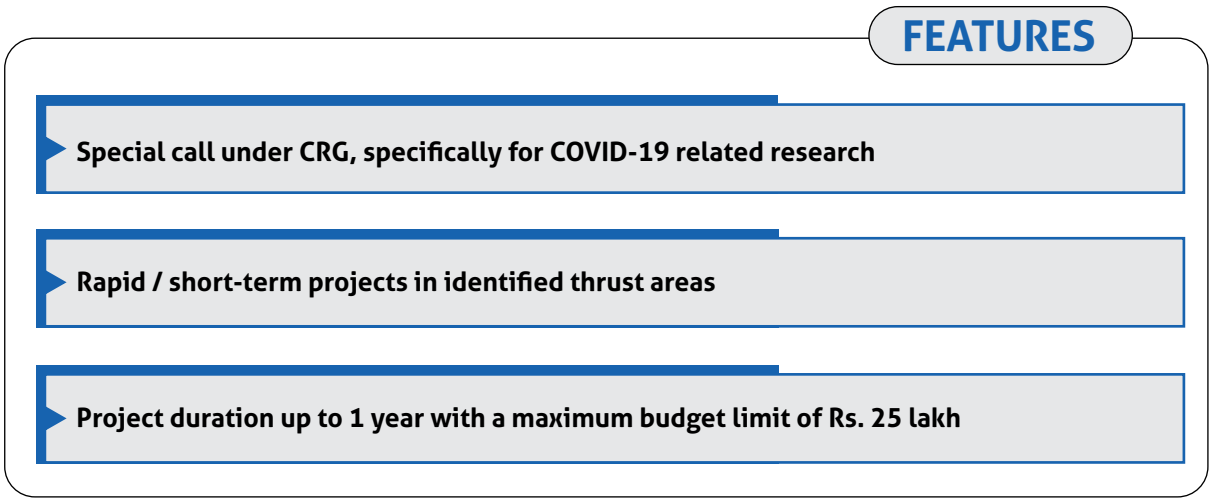
6.1.1 CRG Short-term Special Call on COVID-19

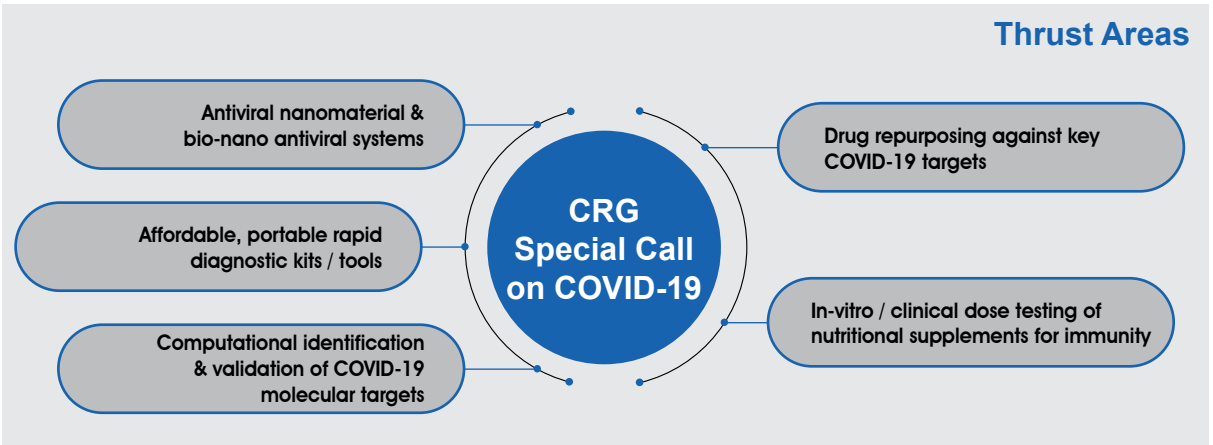
Under the CRG Short-term special call on COVID-19, proposals were invited for developing preventive chemical approaches to combat viral infections in health care settings through advanced chemical approaches to sanitize inanimate surface, effective (repurposed) antivirals, cost-effective antiviral breathing masks, diagnostic platforms, etc. under chemical sciences discipline. Concurrently, under Life Sciences, research proposals were solicited for affordable diagnostic kits, computational identification and validation of molecular targets,



drug repurposing, etc.

Under this special CRG-COVID-19 call, 1121 proposals were received, and 43 proposals were supported for one year.





Highlights of some of the projects supported are given below:

Anti-microbial coatings: The project aims to develop an antimicrobial coating that can kill bacteria, fungi, and viruses. The coating can be achieved through one-simple step such as brush-, dip- or spray-coating of the organo or water solutions of compounds developed through this research. Various surfaces, such as rubber, cotton, polyethylene, paper, acrylate, nylon, leather, polyurethane, surgical mask, gloves, head-cap have been coated using this technique. The coated surfaces killed different drug-resistant bacteria and fungi (Fig. 6.1). The coating killed human influenza viruses (H1N1) completely within 30 minutes of contact. In recent studies, it showed 100% killing of SARS-CoV-2, the virus responsible for ongoing COVID-19 pandemic. The easy one-step curable nature of the coating eliminates the need of any trained personnel. Masks, gowns, face shields and other protective tools that doctors, nurses, patients use can be coated with this compound which can save the lives of many.

The work is in progress at Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore.

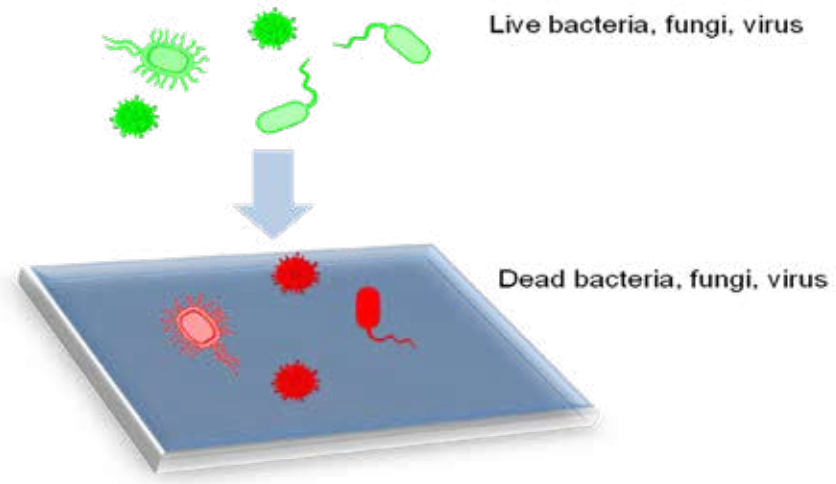


Fig. 6.1: Schematic for the design of virucidal coating on common fabric material.

Virucidal Agents for Antiviral Applications: Like flu viruses such as influenza, SARS-CoV-2 nanoparticles transmit through liquid droplets exhaled or emitted by an infected person within an incubation time of 2-10 days. These virus-containing droplets adhered on contaminated hands and inanimate surfaces are subsequently transmitted upon touch. The persistence of endemic human coronaviruses is 2-9 days on common inanimate surfaces like steel, plastic, fabric, etc, causing virus transmission even without any direct contact. This is critical in healthcare settings where the chances of such transmission are high, and the common healthcare equipment such as surgical masks, medical wear made of plastic, fabric, etc. are susceptible to contamination. This can be prevented by coating these essential equipment with antimicrobial materials and virucidal drugs/agents. The PI and team are involved in developing the coating using a combination of common polymers containing anti-microbial properties and the re-purposable anti-viral molecules and materials used would make it a cost-effective solution. The virucidal coatings will be designed using polymers which can resist attachment of bacteria and virus. An additional protection will be included in the polymer coating using molecules that can either destabilize and/or neutralize corona virus and other viruses like influenza (Fig. 6.2). The combination of anti-microbial polymer coating and functionalized drugs is expected to provide a synergistic antiviral effect. The work is in progress at Indian Institute of Technology, Kanpur.

Point-of-care fiber-optic biosensor device for rapid detection of COVID-19: The project aims to develop a novel point-of-care (PoC) strategy for simpler, safer and rapid diagnosis of COVID-19 antigens from saliva samples as an alternative to time-consuming RT-PCR and low sensitivity LFIA kits. This is based on the recently established plasmonic fiberoptic absorbance biosensor (P-FAB) platform. It consists of a disposable probe cartridge with a U-bent fiberoptic sensor and gold nanoparticles (AuNP) reagent, each coated with capture and recognition antibodies against nucleocapsid protein, respectively. The saliva sample is collected using a convenient saliva swab and loaded into a syringe to deliver only the non-mucous sample, which is added to the reagent and mixed. After 5 minutes, a probe cartridge is loaded onto a readout device and after an initial calibration, the U-bent sensors are exposed to the mixture. For the next 10 minutes, a sandwich immunoassay is formed on the sensor surface with AuNP labels. The device displays the changes in the intensity of light passing through the U-bent sensor probe indicating whether the sample is positive (a significant drop in light intensity due to binding of AuNP labels because of sandwich immunocomplex on the probe surface) or negative (a lesser drop due to non-specific binding), based on a pre-calibration data stored in the device.

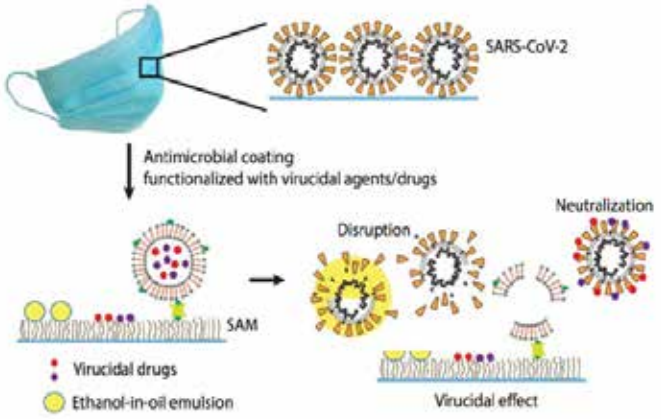


Fig. 6.2: The scheme depicts surface functionalization and activation of the virucidal coating for disrupting or neutralizing surface bound virus particles.

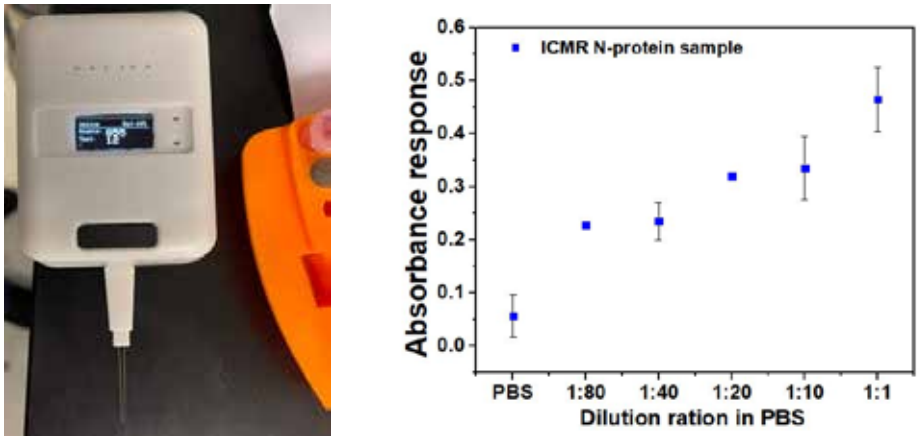


Fig. 6.3a: Photographic image of P-FAB device (10x6x3 cms) with the probe cartridge (6x1 cm) and a U-bent fiber optic probe. b. A proof-of-concept for N-protein detection (down to sub-ng/mL) using the sensor with a standard reference from ICMR (Courtesy: VoxturBio, Mumbai) obtained using the lab set-up.

Towards the realization of the COVID-19 PoC device, significant progress has been made in the opto-electro-mechanical instrumentation for the U-bent fiberoptic sensor probe fabrication as well as design and fabrication of the disposable probe cartridge and a suitable optical readout device (Fig. 6.3). Investigations on the probe functionalization and assay strategies for a reliable and sensitive analysis are under progress. AuNP label optimization studies, device validation, clinical sample analysis, identification of clinical diagnostic partners with established capabilities for continuous supply of consumables for the proposed P-FAB based COVID-19 antigen test will be carried out by the PI and team, subsequently.

The work is in progress at Indian Institute of Technology, Chennai.

Genomic Studies: In a study supported by SERB, scientists are working on genomic sequences of SARS-CoV-2 to identify genetic variability and potential molecular targets in virus and humans. The project team has developed a web-based COVID-Predictor to predict the sequence of viruses online and offline on the basis of machine learning and analysed 3000 Indian and more than 10000 global (excluding India) SARS-CoV-2 genomes, to find the genetic variability in terms of point mutation and Single Nucleotide Polymorphism (SNP). The present study has mainly identified 27 (out of 41) and 29 (out of 40) non-synonymous Signature SNPs in coding regions of Indian and Global SARS-CoV-2 genomes as shown in Figure 6.4. In majority of virus population, the most frequent and common signature SNPs between India and global (excluding India) are C14408T (P323L), A23403G (D614G), G28881A (R203K), G28881T (R203M) and G28883C (CG204R) in RdRp, Spike and Nucleocapsid, respectively. While for India, the other unique frequent signature SNPs are G1820A (G339S), G1820T (G339C), C5700A (A994D), C6310A (S1197R), C28854T (S194L), G28878A (S202N), G28878T

(S202I) and G28878C (S202T) in NSP2, NSP3 and Nucleocapsid, respectively. Investigating team also identified potential synthetic based epitope vaccine after analysing Indian SARS-CoV-2 genomes.

Research has also been extended for more than 10000 sequences around the globe, (including India) and found 19055, 17800 and 3067 unique mutation points in SARS-CoV-2 globally (including India), globally (excluding India) and only for India, respectively. Out of this, 59.08% mutation points in Indian SARS-CoV-2 genomes are common with global excluding India SARS-CoV-2 genomes. Research team has also developed online and offline applications for predicting SARS-CoV-2 genomes using machine learning and web application for searching the mutation points in SARS-CoV-2 genomes, globally and country wise. The web link that was designed to predict the SARS-CoV-2 genomes is http://www.nitttrkol.ac.in/indrajit/projects/COVID-Predictor/index.php. The weblink to detect the mutation in SARS-CoV-2 genomes is: http://www.nitttrkol.ac.in/indrajit/projects/COVID-Mutation-10K/

The work is in progress at National Institute of Technical Teachers Training and Research, Kolkata.

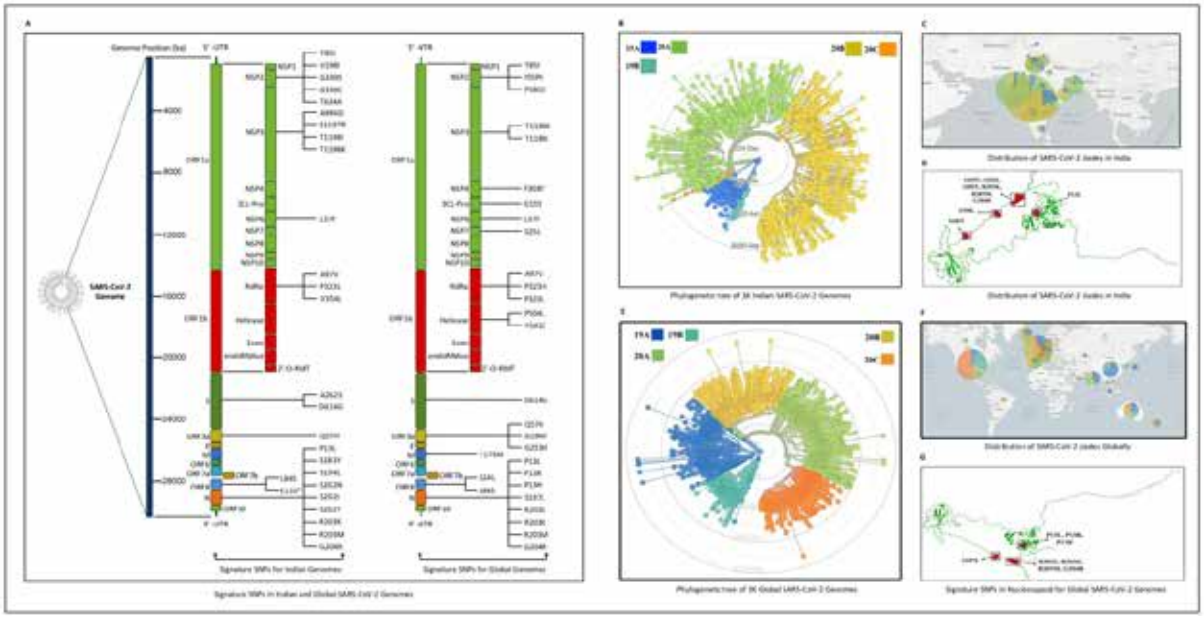


Fig. 6.4: (A) Signature SNPs in Indian and Global SARS-CoV-2 Genomes, (B)-(D) Phylogenetic tree of 3K Indian SARS-CoV-2 Genomes, Distribution of SARS-CoV-2 clades in India, Signature SNPs in Necleocapsid for Indian SARS-CoV-2 Genomes, (E)-(G) Phylogenetic of 10K Global SARS-CoV-2 Genomes, Distribution of SARS-CoV-2 clades Globally, Signature SNPs in Necleocapsid for Global SARS-CoV-2 Genomes.

6.1.2 IRHPA Short-term special call on COVID-19

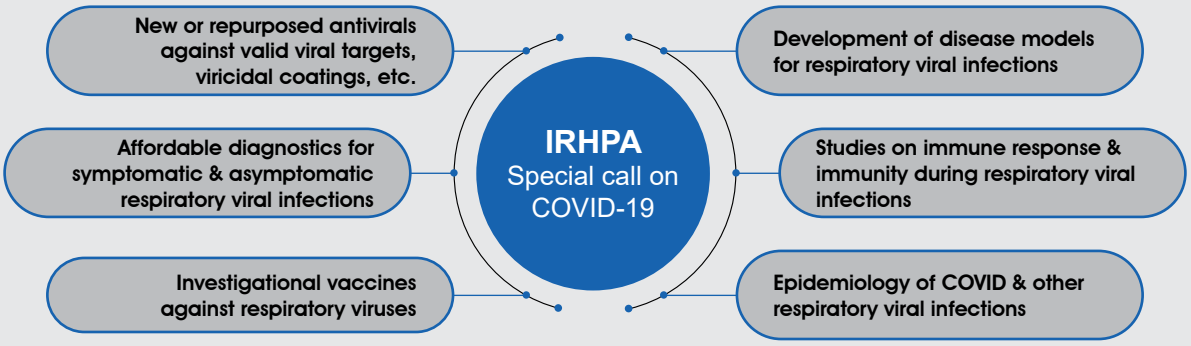
Given the lack of efficacious vaccine and availability of suitable chemotherapeutic interventions for COVID-19, the global population was badly affected. Considering the urgent need to intensify the National R&D efforts for new antivirals, vaccines, and affordable diagnostics, SERB announced a special IRHPA call specifically for COVID-19 and related respiratory viral infections. Academic and research institutions were encouraged to submit competitive proposals with a strong interdisciplinary component between chemists, biologists, virologists, immunologists and clinicians. It was also expected that one of the participating institutions should have access to BSL-3 and above facilities along with expertise of handling respiratory viruses as per WHO/Government of India protocols.

Under this special call, 310 proposals were received and 13 proposals were supported.

FEATURES

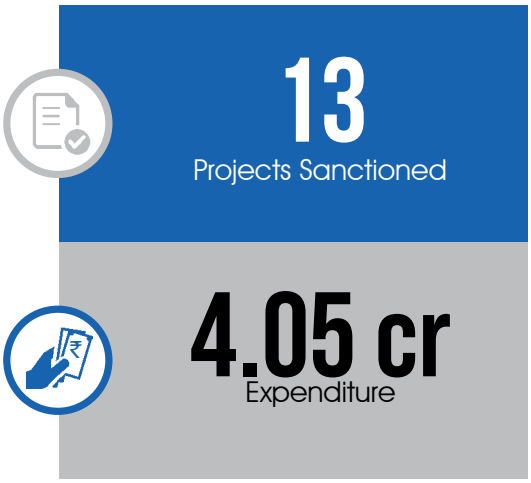
- Special call under IRHPA for COVID-19 related research
- Rapid/short-term IRHPA projects in identified thrust areas
- Project duration is three years

Thrust Areas



Highlights of one of the proposals supported is given below:

Discovery of structure-based antivirals against SARS-CoV2 targeting key viral genome replication enzymes: SARS-CoV-2 is the etiological agent responsible for the global COVID-19 pandemic. Across the globe, R&D activities by various agencies were initiated towards identification of clinically effective vaccine or specific antiviral drugs or drug repurposing strategy to combat the COVID-19 infections either in the form of prevention or treatment. In this line, a project was sanctioned to Indian Institute of Technology, Roorkee towards identification of structure-based potential antivirals against SARS-CoV2.



The main aim of this project is to discover small molecule inhibitors targeting the most important viral replication enzymes: viral proteases (papain-like protease & 3CLprotease), RNA dependent RNA polymerase (nsp12) and the MTase (nsp14). A computer-based high throughput virtual screening approach will be used to identify antiviral molecules from different compound libraries that will be experimentally validated for antiviral potential. The collaborators from Indian Institute of Technology, Roorkee and from Indian Veterinary Research Institute, Bareilly will help in experimental testing and evaluation of the antiviral efficacy of the identified antiviral molecules against SARS-CoV-2 virus.

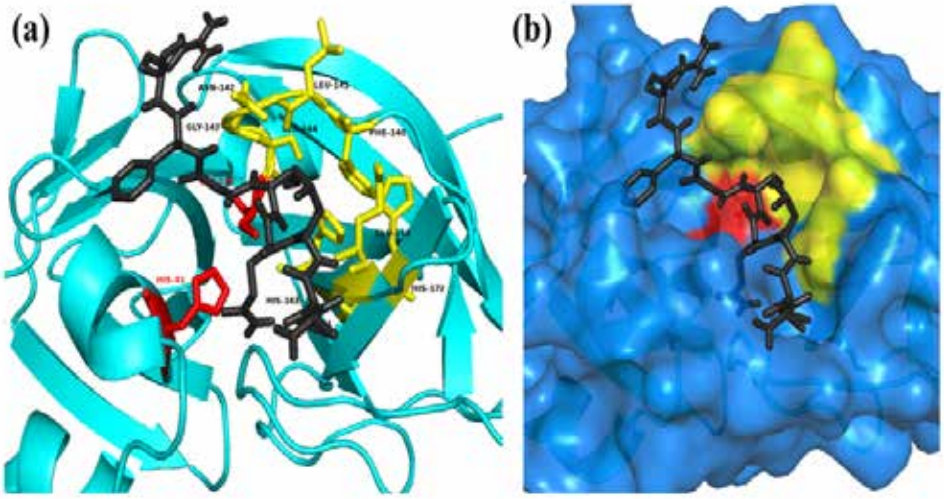


Fig. 6.5: Molecular docking interactions and orientations of peptides (Pep1) with binding pocket of Mpro. (a) Ribbon diagram, (b) Surface structure.

As a preliminary work, investigators preformed in silico work by high-throughput virtual screening approach to examine the binding affinity of FDA approved drugs targeting the viral protease Mpro. Figure 6.5 shows the three-dimensional structure focusing on the Mpro active site. The substrate peptide (black colour) is shown to bound at the active site. Using structure-based approach for drug repurposing, this study is expected to pave way for identifying the molecules that binds to Mpro active site and their potential can be used as antiviral molecules against COVID-19.

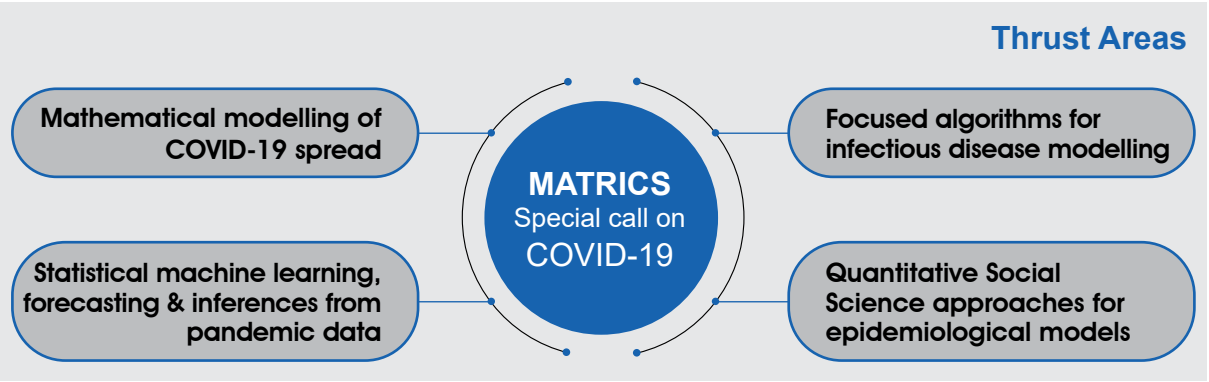
6.1.3 MATRICS Short-term special call on COVID-19

As R&D units of the country were striving to come up with antivirals and vaccines to eliminate coronavirus, it was also imperative to develop mathematical models to study the rate of spread of COVID-19 among the population. Similarly, data driven inference was also critical for forecasting of coronavirus infections. In this context, SERB announced a special call for short-term projects in the areas of mathematical modelling of COVID-19 spread, statistical forecasting, focused algorithms for infectious disease modelling and quantitative social science approaches for epidemiological models.

Under this special call, 624 proposals were received, and 38 proposals were supported for one year.

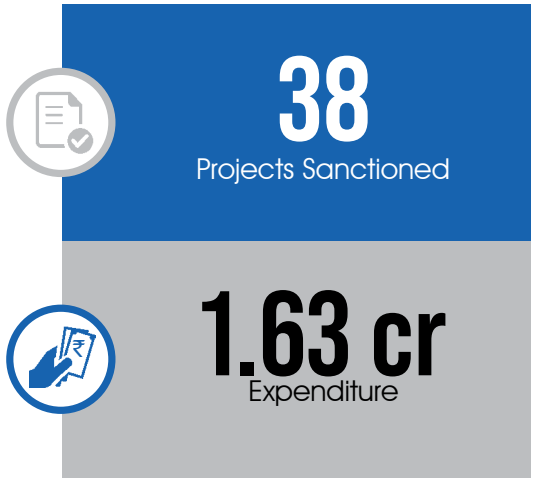
FEATURES

- **Special call under MATRICS Scheme for COVID-19 related research**
- **Rapid/short-term MATRICS projects in identified thrust areas**
- **Project duration of one year with a fixed grant of Rs.5 lakh plus overheads**



Highlights of one of the proposals supported is given below:

Modeling the spread of novel coronavirus (SARS-CoV-2) in host tissue and its potential epidemiological implications for COVID-19: In this project a general collation of scaling relation between virus particle dimension and genome size and explored its role in viral life history was obtained. A wide range of genome and particle sizes was seen in the 381 viruses on which the study was performed (Fig. 6.6). A clear scaling relation of the form for bacteriophages and giant NCLDVs has been observed. However, genome size and capsid volume did not appear to scale proportionally in case of RNA viruses when compared to the DNA viruses. Capsid volume variation of RNA viruses was about three orders of magnitude, while their genome size varied by about an order of magnitude. This variation in the physical parameters appears to be intricately linked to the life history traits of viruses (multiplication rate, viability and mode of transmission/entry into host cell) that are ultimately related to their life cycle. In most RNA viruses, the inherent error-prone replication without proof-reading imposes a constraint on the genome size.



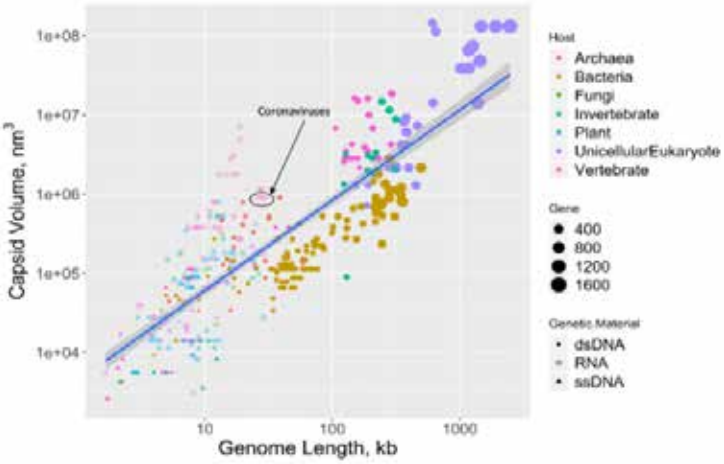


Fig.6.6: Scaling relation between capsid volume and genome length for all class of viruses

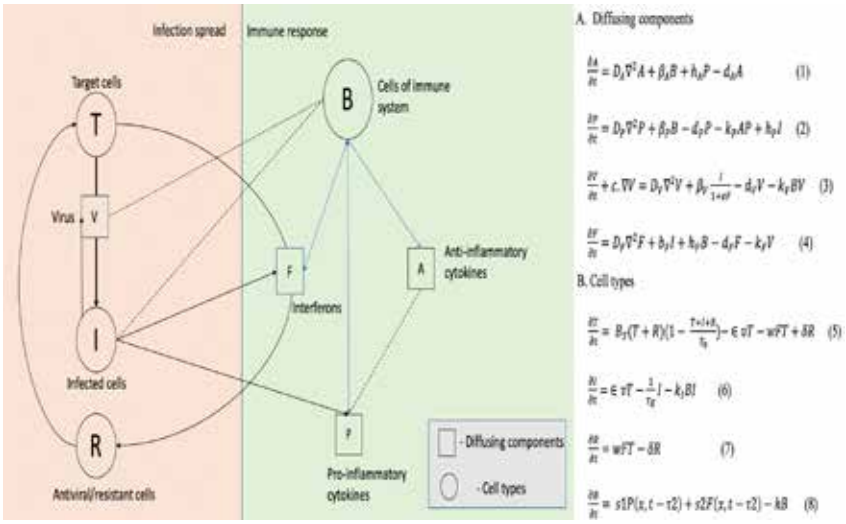


Fig. 6.7: The dynamical equations for infection dynamics

Also, in RNA viruses, genome packaging and capsid assembly occur simultaneously, so the secondary or tertiary structure of the RNA genome has an impact on the capsid size of a virus. While the largest RNA virus has a genome size of 33.5 kb (Nidovirus), the average size appears to be about 10 kb. Corona viruses, which come under the Nidoviridae family, have some of the largest genome and particle dimensions most likely because of their proof-reading machinery and nucleocapsid.

With this broad picture in the background regarding virus size and life-history, a continuum framework to understand the spatiotemporal dynamics of viral spread in the host has been developed.

The actual details of viral infection and immune response are expectedly complicated, and a clearer picture is yet to emerge. However, significant efforts have been put to come up with a bare-bones picture of disease progression for COVID-19 and then come up with a minimal set of parameters and equations (Fig. 6.7) to exhibit these experimental and clinical observations in a simple mathematical framework.

The work is in progress at Indian Institute of Technology, Bombay.

6.2 COVID-19 INDIA NATIONAL SUPER MODEL

SERB coordinated the efforts of COVID-19 India National Supermodel committee constituted by DST to bring out mathematical correlations and a comprehensive model concerning the spread of COVID-19 pandemic and spatiotemporal progression of the viral disease through the country. The supermodel is a variation of SAIR model which divides the population into four groups: Susceptible (those who are not yet infected), Asymptomatic (infected, but with no or little symptoms), Infected (infected with significant symptoms), and Removed (were infected, now recovered or deceased). The COVID-19 pandemic is unique due to (i) a large number of people in group A, who do not require any medical intervention (barring rare exceptions) yet can infect others, and (ii) a small number of people in group I may require significant medical intervention. It is assumed that the transition of a person from S to A or I depend on the physiology of the person.

The model has four parameters: epsilon, beta, gamma, and eta. Parameter epsilon denotes the fraction of population that, if infected, transitions to I. Parameter beta denotes the probability of a person coming in contact with an infected person and catching the infection. Parameter gamma denotes the probability of an infected person recovering on a specific day. The parameter is effected by the medical support provided. Parameter eta denotes the probability of an infected person dying on a specific day. This parameter is also effected by the medical support provided. All the four parameters change with time as a function of level of lockdown and medical facilities available. Figure 6.8 shows the active symptomatic infections for India, as predicted by the model.

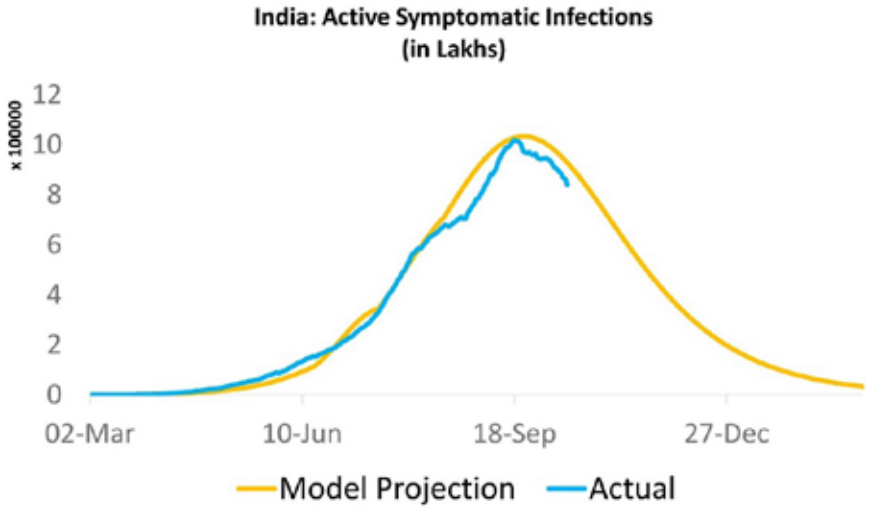


Fig. 6.8: Model projection of active symptomatic infections for India

The model thus developed will help to monitor the future transmission of infection and aid in decision making involving health system preparedness and other mitigation measures.

6.3 WEBINARS ON COVID-19 RELATED RESEARCH

6.3.1 SERB COVID-19 Emerging Research (SERB-COVER)

SERB launched monthly webinar series called Webinars on COIVD-19 Emerging Research (SERB-COVER) on selected thematic areas starting from December 2020. In this webinar, selected project investigators supported under various SERB COVID-19 programmes presented their research progress. Eminent scientists, expert members and young scientists participated and deliberated on the recent developments on COVID-19.

1. SERB-Cover Webinar Series 1 titled "Antiviral materials and surface decontamination approaches for COVID-19" was conducted on 17th December 2020. Prof. Anil Mishra, Director, Institute of Nuclear Medicine & Allied Sciences, DRDO, New-Delhi chaired the session. Prof. Jayanta Halder from Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore in his presentation showed that quaternary small molecule (QSM) and a chitin/polyehtleneimine-based quaternary antimicrobial polymer (QAP) coated surfaces showed protective effect against the viral infections. Another presentation was on the study carried out by Dr. Nagma Parveen and her team from Indian Institute of Technology, Kanpur. The investigators, through virucidal assay have demonstrated that non-ionic and negatively charged surfactants show greater virucidal effect.

2. SERB-COVER Webinar Series 2 titled "Antiviral materials and surface decontamination approaches for COVID-19" was organized on 7th Jan 2021 and it was chaired by Prof. Dinesh Mahajan, Translational Health Science and Technology Institute, Faridabad. The webinar started with a presentation by Dr. Uttam Manna, Indian Institute of Technology, Guwahati. The investigators had developed highly tolerant superhydrophobic coating using Cu20 nanoparticles to achieve anti-viral property without affecting the super hydrophobicity of the fabric to be used for PPE kits. The PI conveyed that the added advantage of this bio-inspired coating was the extreme water repellent activity that would help in reducing the cytotoxicity of the prepared coating. The next presentation was by Dr. Suryasarathi Bose from Indian Institute of Science, Bangalore who illustrated in his presentation that 3-ply masks comprised of coating polycaprolactone, polyethylene imine with copper nanoparticles showed high filtration efficiency similar to N95. In continuation, Dr. B. S. Butola, Indian Institute of Technology, Delhi showed that the newly formulated decontamination spray consisting of salicylic acid, triclosan, benzalkonium chloride, chlorohexidine, ZnO, chloxylenol, L-pyroglutamic acid in water and ethanol are effective against microbial activity and it can be used on all types of garments. The investigator also conveyed that the added advantage of this spray is that it is UV protected, has long stability, and doesn't stain the fabric.

3. SERB-Cover Webinar series 3 titled "Drug repurposing – Clinical trials" was conducted on 4th March 2021. Prof. Ravindran, Institute of Life Science, Bhubaneswar and Prof. Amita Aggarwal, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow chaired the session. In the introduction chairperson opined that Ivermectin, an antiparasitic drug has been shown to inhibit the replication of SARS-CoV2 in cell culture model but there is limited evidence to support its clinical use in COVID-19 patients. He said that the basis for supporting randomized clinical trials of ivermectin was thus to understand its effectiveness in terms of combating the viral loads and recovery of COVID-19 patients. The study at All India Institute of Medical Science, New Delhi was led by Prof. Anant Mohan, and team, who in his presentation showed that administration of ivermectin-elixir did not exhibit any adverse effects at two different dosages and also showed modest decline of viral load on Day 5. In continuation, another clinical trial led by Dr. Biju George and team from Christian Medical College, Vellore in their presentation iterated that no side effects of the drug were observed in haemtological disorder patients recruited for the study. However, the plausible usage of ivermectin for COVID-19 will be known only when the trial is completed. In the final presentation, Dr. Naresh Kasouj, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram presented the possibilities of stem cell derived exosome-based therapy for clinical management of COVID-19 patients suffering from pneumonia caused by SARS-CoV2. He showed the successful isolation and culture of stem cell from Wharton's jelly of umbilical cord and further standardizing the protocol for exosome recovery from the cultured stem cells.

SERB-COVER Webinar Series Session No. 3
Drug repurposing – Clinical trials

Chairpersons	**Prof. B. Ravindran** Professor Emeritus, ILS, Bhubaneswar **Dr. Amita Aggarwal** Professor, SGPGI, Lucknow	February 2021
Welcome Chairpersons	**Dr. Neelima Mishra**, Scientist G, SERB Introduction	4.00-4.05 PM 4.05-4.15 PM
Prof. Anant Mohan & Dr. Tejas Suri AIIMS New Delhi	A randomized controlled trial of single-dose oral ivermectin in patients with COVID19 infection	4.15-4.30 PM
Prof. Biju George, CMC, Vellore	A Phase IIB open label randomized controlled trial to evaluate the efficacy and safety of Ivermectin in reducing viral loads	4.35-4.45 PM
Dr. Naresh Kasoju, SCTIMS&T, Trivandrum	Stem Cell Derived Exosome Therapy for Clinical Management of Lung Damage in Critically-ill Corona Viral Pneumonia Patients	4.50-5.00 PM
Chairpersons	Concluding Remarks	5.00-5.15 PM

Moderators: Dr. AV Balachandar and Dr. T. Thangaradjou

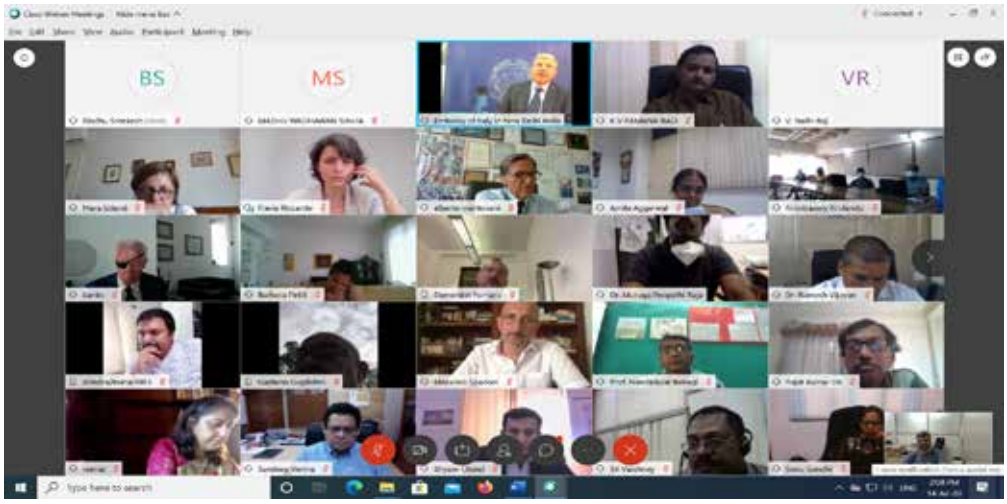
6.3.2 Scientific Webinar on Indo-Italian Cooperation for COVID-19: Activities and Perspectives

SERB along with DST organised the Scientific Webinar on Indo-Italian Cooperation for COVID 19: Activities and Perspectives, on 14th July 2020, in collaboration with Embassy of India in Rome and Embassy of Italy in India. The overall aim of the webinar was to develop strategic cooperation on COVID 19 related research activities and to explore the bilateral funding opportunities. Mr. Vincenzo de Luca, Ambassador of Italy to India, Indian Ambassador to Italy Mrs. Reenat Sandhu, Prof. Ashutosh Sharma, Secretary DST and Prof. Sandeep Verma, Secretary SERB, addressed the participants. In the webinar, discussions were held on various COVID-19 related R&D activities initiated by both countries under their National programmes on COVID-19, perspectives on Coronavirus disease research in both countries and funding opportunities for COVID-19 related research under the bilateral cooperation. The webinar focused on the following technical themes:

Session 1: Meeting the acute phase of the COVID-19 Pandemic (Sub areas: Drug repurposing and therapy, Diagnostics, Vaccines)

Session 2: Long term perspectives and future challenges (Sub areas: Genetics of disease outcome, Basic research for therapy and prevention, Artificial Intelligence for surveillance and prediction).

The presentations were delivered by lead speakers from both countries and the webinar was attended by more than hundred researchers and experts associated with COVID-19 research from both countries.



7

SUPPORT FOR SCIENCE AND TECHNOLOGY EVENTS

Dissemination and exchange of scientific knowledge are important aspects for the growth of researchers as well as for advancement of science. This requires productive opportunities for the research community to come together to discuss issues of common interest and foster new collaborations. Recognizing the significance, SERB supports Science and Technology events through its schemes, Assistance to Professional Bodies & Seminar / Symposia, International Travel Support (ITS), and Accelerate Vigyan.

7.1 ASSISTANCE TO PROFESSIONAL BODIES AND SEMINAR/SYMPOSIA

SERB extends partial financial support, on selective basis, for organizing technical meetings, seminars, conferences, and workshops events (National as well as International). Academic institutions, research laboratories, professional bodies, and other non-profit organizations engaged in promoting scientific research are eligible for financial support under the scheme. The support is mainly given to encourage participation of young scientists and research professionals in such events along with nominal support for pre-operative expenses like announcements brochures, etc.

FEATURES

- **Provides a platform to science professionals to have a dialogue on S&T issues of national and international importance**
- **The support is primarily to encourage participation of young scientists and researchers in such events**
- **Support is also provided to S&T professional bodies for publishing their work**

Website links
http://serb.gov.in/apbs.php
https://serbonline.in/SERB/seminar_symposia

The primary focus of the scheme is to support events having strong orientation towards scientific research in the areas of basic sciences, engineering, technology, agriculture and medicine. The scientific/technical contents of the events, thematic relevance, contextual impact, and extent and level of participation are key components for deciding the support worthiness and quantum of support for individual events.

Keeping in view the pandemic situation, due to COVID-19 outbreak across the globe, applications received under this scheme were not considered for financial support from 1st April, 2020. Only 299 seminar/symposia applications were considered for partial support in the financial year 2020-2021. In addition, partial financial support was extended to 18 applications for publication of Journals from Professional Bodies/Institutes/ Societies (Table 7.1)

Table 7.1: Support provided in 2020-21

S. No.	Items	Seminar/Symposia	Professional Bodies
1	Applications Received	299	18
2	Applications Sanctioned	25	01

7.2 INTERNATIONAL TRAVEL SUPPORT (ITS) SCHEME

International Travel Support (ITS) scheme provides financial assistance to Indian researchers for presenting a research paper in an international scientific event (conference, seminar, workshop etc.) held abroad. Support is also provided to young scientists (age limit below 35 years as on date of start of the event) for attending Training programmes, Short-term schools, and Workshops. For eminent scientists (more than 35 years), support is also provided to chair session or to deliver keynote address.

During the financial year 2020-21, COVID-19 pandemic took a toll all over the world and most of the international borders were sealed. Keeping in view of the COVID-19 situation, the consideration of applications under ITS scheme was temporarily ceased. Hence, support was not provided to any of the researchers under this scheme in the year 2020-21. However, claim of 67 participants were reimbursed in the reporting period who travelled in the financial year 2019-20 after their successful participation in the events.

FEATURES

- **Provides opportunity to emerging and eminent scientists to present their research findings in international scientific events held abroad**
- **Economy class airfare by shortest route, airport-tax and visa fees are provided under the scheme**
- **Registration fee as per actual or Rs. 50,000 whichever is less is provided to young scientists**

Website links
http://serb.gov.in/its.php
https://serbonline.in/SERB/its

7.3 ACCELERATE VIGYAN (AV)

Accelerate Vigyan (AV) scheme aims to expand the research base, with three broad goals, (i) consolidation/aggregation of all national scientific training programmes, (ii) initiating high-end orientation workshops and (iii) creating opportunities for research internships.

SAMOOHAN aims to encourage, aggregate, and consolidate all scientific interactions in the country under one common roof. This programme encourages the event organizers supported by government agencies to register with Accelerate Vigyan online portal for aggregation of capacity building activities.

ABHYAAS is an attempt to boost Research & Development in the country by enabling and grooming potential PG/Ph.D. level students by developing dedicated research skills in selected areas/disciplines/fields through high-end workshops and training and skill internship. This is especially important for those researchers who have limited opportunities to access such learning capacities / facilities / infrastructure.

Website links
www.acceleratevigyan.gov.in

During the reporting period, total of 894 applications were received for High End Workshop and Training and Skill Internship. Among them, 72 and 64 applications were recommended for support for High End Workshop and Training and Skill Internship, respectively.

8

PATENTS AND PUBLICATIONS

8.1 PATENT FILED / GRANTED

Patents resulting from research & supported by SERB (Patents filed/granted during 01 April 2020 to 31 March 2021).

Scheme	Number of Patents filed
Core Research Grant	91
Early Career Research Award	71
Empowerment and Equity Opportunities for Excellence in Science	19
Impacting Research Innovation and Technology (IMPRINT-2)	20
J C Bose Fellowship	3
National Post-Doctoral Fellowship (N-PDF)	9
SERB Science and Technology Award for Research (SERB-STAR)	1
Short-term special call on COVID-19	2
Start-up Research Grant	3
Teachers Associateship for Research Excellence (TARE)	5
Young Scientists Scheme	15

8.2 PUBLICATIONS

Publications resulting from SERB funded projects/fellowships (Papers published during 01 April 2020 to 31 March 2021).

Scheme	SCI	Non-SCI	Total
Core Research Grant	3209	692	3901
Distinguished Investigator Award (DIA) Scheme	22	3	25
Early Career Research Award	1569	614	2183
Empowerment and Equity Opportunities for Excellence in Science	468	187	655
High Risk High Reward	3	-	3
Impacting Research Innovation and Technology (IMPRINT-2)	107	83	190
Intensification of Research in High Priority Areas (IRHPA)	11	2	13
J C Bose Fellowship	400	-	400
MATRICS	297	97	394
MATRICS Short-term special call on COVID-19	11	5	16
National Post-Doctoral Fellowship (N-PDF)	429	90	519
Ramanujan Fellowship	230	-	230
SERB Science and Technology Award for Research (SERB-STAR)	10	-	10
Short-term special call on COVID-19 (CRG)	18	1	19
Start-up Research Grant	175	74	249
Teachers Associateship for Research Excellence (TARE)	82	36	118
Women Excellence Award	5	-	5
Young Scientist Scheme	269	49	318

8.3 HUMAN RESOURCES DEVELOPMENT

Manpower sanctioned under different schemes / programmes during the year 2020-21

Scheme	JRF / SRF	Manpower other than JRF / SRF	Total
Ayurvedic Biology Program	1	1	2
Core Research Grant	654	249	903
Empowerment and Equity Opportunities for Excellence in Science	94	15	109
Intensification of Research in High Priority Areas (IRHPA)	37	16	53
Scientific and Useful Profound Research Advancement (SUPRA)	22	16	38
SERB-POWER Grant	19	5	24
Short-term special call on COVID-19 (CRG)	20	19	39
Start-up Research Grant	281	51	332

9

ADMINISTRATION

The Administration of any organisation plays a vital role in meeting its objectives. All efforts are made to ensure that SERB gets the institutionalised environment for producing results and targets. SERB provides motivation to the work force and makes them conceive their goals.

9.1 ADMINISTRATION AND RECRUITMENT

Action to fill up three vacant posts of Scientist-G (level 14) was initiated in the year 2019-20. Two posts were filled up on deputation basis, out of which one Scientist-G was repatriated to his parent organization in November, 2020. Consequently, another Scientist-G joined the post on 18.12.2020. Hence, out of 20 scientific sanctioned posts, 19 posts are already filled up and action for filling up of one post of Scientist-G is in progress. Action to fill up two vacant posts of Section Officer (level-6) was initiated in July, 2020 by giving a brief advertisement in Employment News and leading national dailies. The action to fill up these two posts is in progress.

9.2 IMPLEMENTATION OF OFFICIAL LANGUAGE

The Science and Engineering Research Board (SERB), since its inception has been implementing the guidelines issued by the Department of Official Language, Ministry of Home Affairs. Hindi Week was celebrated in SERB from 14th to 21st September, 2020. For the promotion of Official Language, various activities were organized for the staff/officers both Hindi and non-Hindi speaking. Cash prizes and certificates were distributed to the winners to motivate the officers and staff of SERB to adopt and promote usage of Hindi in official work.

In order to enhance the working knowledge of the officers/staff in Hindi, two Hindi Workshops were organized on 12.06.2020 and 24.12.2020. The experts shared their experience, expertise, knowledge and appraised about the rules, regulations and guidelines of official language. Large number of officers and staff participated in the said Workshops.

Quarterly meetings of Official Language Implementation Committee were held on 16.06.2020, 10.09.2020 and 3.12.2020 to review the progress of use of Hindi language in SERB and

the Quarterly Reports were sent to Department of Science and Technology (DST) on time. Inspection by the Parliamentary Committee on Official Language was conducted on 18.11.2020 to review the progressive use of Hindi language and follow up of instructions issued by the Department of Official Language.

Town Official Language Implementation Committee (NARAKAS) meeting was held on 26.11.2020 at Indian Institute of Mass Communication, New Delhi. SERB, being one of the members of the committee participated in the said meeting.

9.3 RIGHT TO INFORMATION ACT, 2005 (RTI)

The provisions of RTI Act, 2005 are being followed and requisite information is provided to the applicants under the RTI Act. A total of 61 applications were received during the financial year 2020-21. Out of which, 13 were received as transfer from other public authorities u/s 6(3).

Eleven appeals were also received during the year and disposed of by the Appellate Authority. A total fee of Rs.150/- was received by SERB for providing information under the RTI Act, 2005 during the year 2020-21.

9.4 VIGILANCE AWARENESS

Vigilance Awareness Week was observed by SERB from 27th October, 2020 to 2nd November, 2020. The theme of the week was "Satark Bharat, Samriddh Bharat". All officers/staff of SERB took integrity pledge to abide by the principles of honesty and integrity to fight against corruption on 27th October, 2020.

9.5 INTERNAL COMPLAINTS COMMITTEE (ICC) – WOMEN

Internal Complaints Committee (ICC) – Women, has been functioning in SERB since 2017. The Committee meets regularly and discussion on relevant issues are held. Composition of the committee, complaint procedures and the related information are available on the website of SERB.

9.6 AUDITED ANNUAL STATEMENT OF ACCOUNTS

As per the provisions laid down in Section 13 of the Science and Engineering Research Board (SERB) Act, 2008, the Annual Accounts of the Board are required to be prepared in the prescribed format and audited by the Comptroller and Auditor General of India (C&AG) or by their appointed auditors annually. Accordingly, the annual accounts for the financial year 2020-21 have been prepared and audited by a team of auditors from C&AG. The duly audited financial statement and annual accounts for the financial year 2020-21 form a part of the Annual Report.

ANNUAL STATEMENT OF AUDITED ACCOUNTS FOR THE YEAR 2020-21

Amount in Rs.

Balance Sheet as at 31.03.2021

	Schedule	Current Year	Previous Year
CORPUS / CAPITAL FUND AND LIABILITIES			
Corpus / Capital Fund	Schedule 1	37,48,47,492.89	2,00,72,13,799.90
Reserves and Surplus	Schedule 2	-	-
Earmarked / Endowment Funds	Schedule 3A, 3B, 3C, 3D & 3E	16,06,98,603.59	17,10,14,301.00
Secured Loans and Borrowings	Schedule 4	-	-
Unsecurred Loans and Borrowings	Schedule 5	-	-
Deferred Credit Liabilites	Schedule 6	-	-
Current Liabilites and Provisions	Schedule 7	9,56,90,664.18	15,08,99,872.00
Total		**63,12,36,760.66**	**2,32,91,27,972.90**
ASSETS			
Fixed Assets (Net)	Schedule 8	9,38,21,609.00	7,67,26,842.00
Investments-From Earmarked / Endowment Funds	Schedule 9	-	-
Investments-Others	Schedule 10	-	-
Current Assets, Loans, Advances etc.	Schedule 11	53,74,15,151.66	2,25,24,01,130.90
Miscellaneous Expenditure			
(to the extent not written off or adjusted)			
Total		**63,12,36,760.66**	**2,32,91,27,972.90**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

VPCA AND ASSOCIATES ★ Chartered Accountants ★ DELHI

CA Priya Wadhwa Chawla
(Partner)
M. No. 516631
Date : 26.06.2021
Place : New Delhi

For Science and Engineering Research Board

Secretary
SERB
Date :
Place : New Delhi

Director-Finance
SERB

Amount in Rs.

Income & Expenditure Account for the Year Ended on 31.03.2021

	Schedule	Current Year	Previous Year
Income			
Income from Sales / Services	Schedule 12	-	-
Grants / Subsidies *	Schedule 13	7,38,61,24,868.00	9,53,83,83,417.00
Fees / Subscriptions	Schedule 14	-	-
Income from Investments	Schedule 15	-	-
Income from Royalty, Publication etc	Schedule 16	-	-
Interest Earned	Scheduel 17	-	1,56,27,219.25
Other Income	Schedule 18	85,73,214.00	1,03,56,447.00
Increased/(Decrease) in stock of Finished Goods and Works-in-Progress	Schedule 19	-	-
Total (A)		**7,39,46,98,082.00**	**9,56,43,67,083.25**
Expenditure			
Establishment Expenses	Schedule 20	11,62,11,902.00	9,80,91,424.00
Other Administrative Expenses	Schedule 21	10,74,38,334.39	10,69,39,722.68
Expenditure on Grant, Subsidies etc	Schedule 22	8,70,78,09,946.00	8,35,66,64,114.46
Interest	Schedule 23	-	-
Depreciation (Net Total at the Year end)	Schedule 8	85,73,064.00	1,03,56,053.00
Total (B)		**8,94,00,33,246.39**	**8,57,20,51,314.14**
Excess of Income over Expenditure (A-B) (Before PPI & PPE)		**-**	99,23,15,769.11
Excess of Expenditure over Income (A-B) (Before PPI & PPE)		**(1,54,53,35,164.39)**	**-**
Prior Period Income	Schedule 24	30,44,36,648.63	25,78,45,083.82
Prior period Expenditure	Schedule 25	39,29,35,339.00	12,28,020.68
Excess of Income over Expenditure (A-B) (After PPI & PPE)		**-**	1,24,89,32,832.25
Excess of Expenditure over Income (A-B) (After PPI & PPE)		**(1,63,38,33,854.76)**	**-**
Transfer to Special Reserve (Specity each)		**-**	**-**
Transfer to / from General Reserve		**-**	**-**
Balance Being Surplus (Deficit) carried to Corpus/Capital Fund		**(1,63,38,33,854.76)**	**1,24,89,32,832.25**
Significant Accounting Policies	Schedule 26		
Contingent Liabilities and Notes to Accounts	Schedule 27		

* CY- This amount reflect total grant received by SERB of Rs. 7,41,17,92,699/- less Fixed Assets purchased of Rs. 2,56,67,831/- (transferred to Corpus Fixed Assets Sch. 1)

* PY- This amount reflect total grant received by SERB of Rs. 9,56,57,00,000/- less Fixed Assets purchased of Rs. 2,73,16,583/- (transferred to Corpus Fixed Assets Sch. 1)

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

VPCA AND ASSOCIATES * Chartered Accountants * DELHI

CA Priya Wadhwa Chawla
(Partner)
M. No. 516631
Date : 26.06.2021
Place : New Delhi

For Science and Engineering Research Board

Secretary
SERB
Date :
Place : New Delhi

Director-Finance
SERB

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 1 - Corpus / Capital Fund

Particulars	Current Year	Previous Year
Corpus Balance at the beginning of the year	1,93,04,86,957.90	82,57,71,496.65
Add: Sale/Exchange of Fixed Assets (Laptop & Printer)	-	5,002.00
Less: Interest earned on refunds during FY 2019-20 transferred to GOI, Consolidated Fund	(1,56,27,219.25)	-
Less: Interest earned during FY 2017-18 & FY 2018-19 transferred to GOI, Consolidated Fund	-	(14,42,22,373.00)
Add/(Deduct) : Balance of net income/(Expenditure) transferred from the Income & Expenditure Account	(1,63,38,33,854.76)	1,24,89,32,832.25
Corpus Balance at the end of the year (A)	**28,10,25,883.89**	**1,93,04,86,957.90**
Corpus (Fixed Assets) Balance at the beginning of the year	7,67,26,842.00	5,97,71,314.00
Add: Contributions towards Corpus/Capital Fund (Fixed Assets)		
FY 2019-20	-	2,73,16,583.00
FY 2020-21	2,56,67,831.00	-
Sale/Exchange of Fixed Assets (Laptop & Printer)	-	(5,002.00)
Deferred Revenue Grant for FY 2019-20*	-	(1,03,56,053.00)
Deferred Revenue Grant for FY 2020-21*	(85,73,064.00)	-
Corpus (Fixed Assets) Balance at the end of the year (B)	**9,38,21,609.00**	**7,67,26,842.00**
Total of Corpus & Corpus (Fixed Assets) (A) + (B)	**37,48,47,492.89**	**2,00,72,13,799.90**
Refer Point No. 12 In Schedule 26 Significant Accounting Policies		

Schedule 2 - Reserve and Surplus

Particulars	Current Year		Previous Year	
1. Capital Reserves :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
2. Revaluation Reserves :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
3. Special Reserve :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
4. General Reserve :				
As Per Last Account	-		-	
Addition during the year	-		-	
Less : Deductions during the year	-	-	-	-
Total		**-**		**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 3A - Earmarked/Endowment Funds MFPI

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**1,50,88,947.00**	**3,25,77,350.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (MFPI)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest from SERB on Saving Balance	6,98,812.00	6,98,812.00
Interest on MFPI Refund	-	2,12,291.00
Refund from previous year Grant FY 2013-14 (Ann. 1 & 1A)	-	7,200.00
Refund from previous year Grant FY 2014-15 (Ann. 2 & 2A)	-	43.00
Refund from previous year Grant FY 2015-16 (Ann. 3 & 3A)	-	6,94,559.00
Refund from previous year Grant FY 2016-17 (Ann. 4 & 4A)	89,783.00	9,13,925.00
Refund from previous year Grant FY 2017-18 (Ann. 5 & 5A)	-	3,05,640.00
Refund from previous year Grant FY 2018-19 (Ann. 6 & 6A)	-	2,57,623.00
Total (a+b)	**1,58,77,542.00**	**3,56,67,443.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (MFPI- Capital) (Ann. 7 & 7A)	3,58,775.00	77,349.00
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (MFPI- General) (Ann. 8 & 8A)	15,32,588.00	5,01,147.00
Total c)	**18,91,363.00**	**5,78,496.00**
d) Less: Amount given back to Ministry of Food Processing	**-**	**2,00,00,000.00**
Net Balance as at the year end (a+b-c-d)	**1,39,86,179.00**	**1,50,88,947.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 3B - Earmarked/Endowment Funds S & T Programme

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**1,81,32,642.00**	**1,60,46,676.00**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (S & T Programme - Schedule Castes)	-	-
Grant in Aid (S & T Programme - Schedule Tribe)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
S & T SC-Interest from SERB on Saving Balance	8,31,001.00	4,85,275.00
S & T ST-Interest from SERB on Saving Balance	5,124.00	4,067.00
S & T SC- Refund from previous year Grant FY 2013-14 (Ann. 9 & 9A)	2,29,546.00	9,32,581.00
S & T SC- Refund from previous year Grant FY 2015-16 (Ann. 10 & 10A)	3,22,633.00	1,13,852.00
S & T SC- Refund from previous year Grant FY 2016-17 (Ann. 11 & 11A)	-	56,412.00
S & T SC- Refund from previous year Grant FY 2018-19 (Ann. 12 & 12A)	4,36,685.59	3,59,909.00
S & T - Interest on Refund -SC	-	1,33,870.00
Total (a+b)	**1,99,57,631.59**	**1,81,32,642.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (S & T- Schedule Castes - Capital)	-	-
Grant-in-aid (S & T- Schedule Tribe - Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (S & T- Schedule Castes - General)	-	-
Grant-in-aid (S & T- Schedule Tribe - General)	-	-
Total c)	**-**	**-**
Net Balance as at the year end (a+b-c)	**1,99,57,631.59**	**1,81,32,642.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 3C - Earmarked/Endowment Funds ICPS

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**1,04,09,284.00**	**-**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid- ICPS	-	1,22,70,00,000.00
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (ICPS: 349902010049636)	2,87,611.00	1,04,09,284.00
Total (a+b)	**1,06,96,895.00**	**1,23,74,09,284.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	27,77,720.00	-
Other Additions	-	-
Grant-in-aid (ICPS- Capital) (Ann. 13 & 13A)	-	32,70,00,000.00
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure- Bank Charges	-	-
Grant-in-aid (ICPS- General) (Ann. 14 & 14A)	-	90,00,00,000.00
Total c)	**27,77,720.00**	**1,22,70,00,000.00**
Net Balance as at the year end (a+b-c)	**79,19,175.00**	**1,04,09,284.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 3D - Earmarked/Endowment Funds DOT

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**76,95,864.00**	**74,40,993.50**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (DOT- General)	-	-
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest from SERB on Saving Balance	84,257.00	4,01,115.00
Total (a+b)	**77,80,121.00**	**78,42,108.50**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (DOT- Capital)	-	-
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (DOT- General) (Ann. 15 & 15A)	-	1,46,244.50
Total c)	**-**	**1,46,244.50**
Net Balance as at the year end (a+b-c)	**77,80,121.00**	**76,95,864.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 3E - Earmarked/Endowment Funds IMPRINT-II -MHRD

Particulars	Current Year	Previous Year
a) Opeing Balance of the Funds	**11,96,87,564.00**	**-**
b) Additions to the funds		
i) Donations / Grants	-	-
Grant in Aid (IMPRINT-II)	-	27,20,00,000.00
ii) Income from Investments made on account of Funds	-	-
iii) Other Additions	-	-
Interest earned on Saving Balance (IMPRINT-II: 349902010049001)	33,22,988.00	23,15,077.00
Refund from previous year Grant FY 2018-19 (Ann. 16 & 16A)	58,976.00	-
Interest on IMPRINT-II Refund	85,969.00	24,997.00
Total (a+b)	**12,31,55,497.00**	**27,43,40,074.00**
c) Utilization / Expenditure towards objectives of funds		
i) Capital Expenditure	-	-
Fixed Assets	-	-
Other Additions	-	-
Grant-in-aid (IMPRINT-II- Capital) (Ann. 17 & 17A)	-	8,73,62,736.00
ii) Revenue Expenditure		
Salary, Wages and allowance etc	-	-
Rent	-	-
Other Administrative Expenditure		
Grant-in-aid (IMPRINT-II- General) (Ann. 18 & 18A)	1,21,00,000.00	6,72,89,774.00
Total c)	**1,21,00,000.00**	**15,46,52,510.00**
Net Balance as at the year end (a+b-c)	**11,10,55,497.00**	**11,96,87,564.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 4 - Secured Loans and Borrowings

Particulars	Current Year		Previous Year	
1. Central Government		-		-
2. State Government		-		-
3. Financial Institutions				
a) Term Loans	-		-	
b) Interest accrued and dues	-	-	-	-
4. Banks :				
a) Term Loans	-		-	
Interest accrued and due	-		-	
b) Other Loans	-		-	
Interest accrued and due	-	-	-	-
5. Other Institutions and Agencies		-		-
6. Debentures and Bonds		-		-
7. Others		-		-
Total		**-**		**-**

Schedule 5 - Unsecured Loans and Borrowings

Particulars	Current Year		Previous Year	
1. Central Government		-		-
2. State Government		-		-
3. Financial Institutions				
4. Banks :				
a) Term Loans	-		-	
b) Other Loans	-	-	-	-
5. Other Institutions and Agencies		-		-
6. Debentures and Bonds		-		-
7. Fixed Deposites		-		-
8. Others		-		-
Total		**-**		**-**

Schedule 6 - Deferred Credit Liabilites

Particulars	Current Year	Previous Year
a) Acceptances secured by Hypothecation of Capital Equipment & other assets	-	-
b) Others	-	-
Total	**-**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
A) Current Liabilities				
1. Acceptances		-		-
2. Sundry Creditors				
a) For Goods		-		-
b) Others:				
Shree Bhagatrams, New Delhi	-		6,510.00	
Uneecode Inc., Delhi (RSM Enterprises, New Delhi)	-		14,150.00	
Suresh Malik & Co. (VPCA and Associates)	12,85,020.00		9,66,420.00	
National Mission on Bamboo Application	-		10,80,145.00	
FDS Management Services Private Limited	3,53,686.00		4,127.00	
Mansarover Industrial Corporation, New Delhi	-		2,350.00	
S. N Solutions, Delhi	1,66,853.00		-	
Suncity Projects Private Limited, New Delhi	1,58,579.00		85,120.00	
Balmer Lawrie & Co. Ltd., New Delhi	-		14,77,844.00	
Dinesh Singh Tomer, New Delhi	1,966.00		1,242.00	
Darsheel Enterprises, New Delhi	-		8,700.00	
Shalu Tour And Travels, New Delhi	3,04,950.00		1,84,091.00	
R S Travels Solution Private Limited	-		1,45,033.00	
Sonpal	18,300.00		11,970.00	
Sr. Post Master Sarojini Nagar, H.P.O.	3,009.00		1,493.00	
Deldsl-Digital NTC	74,100.00		74,100.00	
Digital NTC-New Delhi	30,680.00		29,770.00	
Airtel	33,941.52		33,942.00	
K B Enterprises, New Delhi	22,442.00		22,128.00	
MV Infotech India, New Delhi	-		29,972.00	
Nandini Flower Decoration, New Delhi	7,800.00		5,000.00	
Uneecops Technologies Limited, New Delhi	-		25,189.00	
Gung HO Marketing Services Private Limited, New Delhi	1,78,200.00		-	
J W Marriott, New Delhi	9,180.00		-	
Adeptech Solutions Private Limited, New Delhi	-		2,835.00	
NSDL E Governanace Infrastructure Limited	766.00		743.00	
Net Creative Mind Solutions Private Limited	-	26,49,472.52	53,100.00	42,65,974.00
3. Advances Received		-		-
4. Interest accrued but not due on :				
a) Secured Loans / Borrowings		-		-
b) UnSecured Loans / Borrowings		-		-
5. Statutory Liabilities				
a) Over Due		-		-
b) Others : TDS - Section 194C	17,038.00		9,419.00	
TDS - Section 194J	19,500.00		-	
TDS - Section 194I	900.00		-	
TDS - Section 192	8,97,393.00		8,00,561.00	
GST -TDS	2,98,724.00	12,33,555.00	1,81,082.00	9,91,062.00
Total (1)		**38,83,027.52**		**52,57,036.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 7 - Current Liabilities And Provisions

Particulars	Current Year		Previous Year	
6. Other Current Liabilities				
Expenses Payable				
Salary Payable	68,82,429.00		66,51,516.00	
Wages Payable	7,500.00		7,500.00	
EPF Payable Employee Contribution	1,69,200.00		1,63,800.00	
EPF Payable Employer Contribution	1,88,435.00		1,82,428.00	
NPS Contribution Payable	6,59,007.00		5,90,496.00	
Audit Fee Payable	7,79,500.00		6,54,500.00	
Telephone Expenses Payable (Reimbursement)	11,145.00		78,471.00	
Children Education Allowance Payable (Reimbursement)	2,43,000.00		3,24,000.00	
Medical Expenses Payable (Reimbursement)	-		3,131.00	
Newspaper Expenses Payable (Reimbursement)	-		41,700.00	
Travelling Expenses Payable (Domestic)	10,004.00		16,224.00	
Accomodation Expenses Payable	-		-	
Honorarium Expenses Payable (Non-Official)	43,000.00	89,93,220.00	-	87,13,766.00
Deductions Payable				
Secretary Deduction Payable (IIT Kanpur)	78,036.00		78,036.00	
Secretary Leave Salary & Pension Contribution Payable	8,10,514.00		2,01,987.00	
Other Employees Deduction Payable	1,03,165.00	9,91,715.00	2,68,039.00	5,48,062.00
Expenses (Current Liabilities Staff)				
Satish Marar	325.00		-	
Raja Ravi Verman	866.00		-	
Pradeep Kumar (IT Technician)	9,434.00		-	
Anima Johri	-		60,401.00	
Dr. G. Harish Kumar	-		751.00	
Praveen Kumar S	-	10,625.00	418.00	61,570.00
Time barred cheques taken back (FY 2011-12) (Ann. 19 & 19A)		-		3,44,235.00
Time barred cheques taken back (FY 2012-13) (Ann. 20 & 20A)		-		1,19,33,916.00
Time barred cheques taken back (FY 2013-14) (Ann. 21 & 21A)		-		1,62,51,065.00
Time barred cheques taken back (FY 2014-15) (Ann. 22 & 22A)		-		2,22,593.00
MINISTRY OF FOOD PROCESSING (PY's Meeting Refund)		5,54,552.00		5,54,552.00
GOVERNMENT OF INDIA, CONSOLIDATED FUND		6,46,99,786.66		9,95,59,578.00
Total (2)		**7,52,49,898.66**		**13,81,89,337.00**
Total (A) =(1) + (2)		**7,91,32,926.18**		**14,34,46,373.00**
B. Provision		-		-
1. For Taxation		-		-
2. Gratuity		88,57,000.00		16,97,320.00
3. Superannuation / Pension		-		-
4. Accumulated Leave Encashment		77,00,738.00		57,56,179.00
5. Trade Warranties / Claims		-		-
6. Others		-		-
Total (B)		**1,65,57,738.00**		**74,53,499.00**
Total (A+B)		**9,56,90,664.18**		**15,08,99,872.00**

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31.03.2021

SCHEDULE 8-FIXED ASSETS		GROSS BLOCK				DEPRECIATION					NET BLOCK	
(PURCHASED OUT OF GRANT-IN-AID RECEIVED FROM DST) DESCRIPTION	Rate of Depre-ciation	Cost / valution as at beginning of the year	Additions during the year	Deductions during the year	Cost / valuation at the year end	As at the beginning of the year	On Opening balance	On Additions during the year	On Deductions during the year	Total up to the year end	As at the current year end	As at the previous year end
A. FIXED ASSETS												
1. LAND												
a) Freehold		-	-	-	-	-	-	-	-	-	**-**	-
b) Leasehold		-	-	-	-	-	-	-	-	-	**-**	-
2. BUILDING												
a) On Freehold Land		-	-	-	-	-	-	-	-	-	**-**	-
b) On Leasehold Land		-	-	-	-	-	-	-	-	-	**-**	-
c) Ownership Flats/Premises		-	-	-	-	-	-	-	-	-	**-**	-
d) Interior work	10%	2,33,42,784.00	-	-	2,33,42,784.00	1,19,15,959.00	11,42,683.00	-	-	1,30,58,642.00	**1,02,84,142.00**	1,14,26,825.00
3. PLANT & MACHINERY	15%	15,72,908.00	-	-	15,72,908.00	6,77,694.00	1,34,282.00	-	-	8,11,976.00	**7,60,932.00**	8,95,214.00
4. VEHICLES		-	-	-	-	-	-	-	-	-	**-**	-
5. FURNITURE & FIXTURES	10%	1,51,60,259.00	58,764.00	-	1,52,19,023.00	60,57,687.00	9,10,257.00	5,876.00	-	69,73,820.00	**82,45,203.00**	91,02,572.00
6. OFFICE EQUIPMENT	15%	40,80,621.00	-	-	40,80,621.00	24,00,955.00	2,51,950.00	-	-	26,52,905.00	**14,27,716.00**	16,79,666.00
7. COMPUTER/PERIPERALS												
A) COMPUTER SOFTWARES	40%	5,88,55,802.00	-	-	5,88,55,802.00	5,07,35,496.00	32,48,123.00	-	-	5,39,83,619.00	**48,72,183.00**	81,20,306.00
B) PERIPHERALS	40%	14,06,835.00	1,75,749.00	-	15,82,584.00	10,31,461.00	1,50,149.00	57,365.00	-	12,38,975.00	**3,43,609.00**	3,75,374.00
C) PRINTERS/SCANNERS	40%	44,41,857.00	27,710.00	-	44,69,567.00	33,85,889.00	4,22,387.00	5,542.00	-	38,13,818.00	**6,55,749.00**	10,55,968.00
D) COMPUTERS	40%	1,09,41,133.00	9,09,780.00	-	1,18,50,913.00	92,28,743.00	6,84,956.00	1,81,956.00	-	1,00,95,655.00	**17,55,258.00**	17,12,390.00
8. ELECTRIC INSTALLATIONS	10%	24,24,085.00	1,26,300.00	-	25,50,385.00	12,36,368.00	1,18,772.00	1,26,300.00	-	14,81,440.00	**10,68,945.00**	11,87,717.00
9. LIBRARY BOOKS	40%	1,19,010.00	5,110.00	-	1,24,120.00	77,622.00	16,555.00	2,044.00	-	96,221.00	**27,899.00**	41,388.00
10. TUBEWELL & W. SUPPLY		-	-	-	-	-	-	-	-	-	**-**	-
11. INTANGIBLE ASSETS	25%	15,51,440.00	51,33,590.00	-	66,85,030.00	11,34,526.00	1,04,229.00	10,09,638.00	-	22,48,393.00	44,36,637.00	4,16,914.00
TOTAL OF CURRENT YEAR (A)		**12,38,96,734.00**	**64,37,003.00**	**-**	**13,03,33,737.00**	**8,78,82,400.00**	**71,84,343.00**	**13,88,721.00**	**-**	**9,64,55,464.00**	**3,38,78,273.00**	**3,60,14,334.00**
PREVIOUS YEAR		**12,12,94,045.00**	**27,33,289.00**	**1,30,600.00**	**12,38,96,734.00**	**7,76,51,945.00**	**97,34,910.00**	**6,21,143.00**	**1,25,598.00**	**8,78,82,400.00**	**3,60,14,334.00**	**4,36,42,100.00**
B. CAPITAL WORK IN PROGRESS		4,07,12,508.00	1,92,30,828.00	-	5,99,43,336.00	-	-	-	-	-	**5,99,43,336.00**	4,07,12,508.00
TOTAL (A+B)		**16,46,09,242.00**	**2,56,67,831.00**	**-**	**19,02,77,073.00**	**8,78,82,400.00**	**71,84,343.00**	**13,88,721.00**	**-**	**9,64,55,464.00**	**9,38,21,609.00**	**7,67,26,842.00**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 9 - Investments from Earmarked/Endowment Funds

Particulars	Current Year	Previous Year
1. In Government Securities	-	-
2. Other approved Securities	-	-
3. Shares	-	-
4. Debentures and Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others (to be Specified)	-	-
Total	**-**	**-**

Schedule 10 - Investments - Others

Particulars	Current Year	Previous Year
1. In Government Securities	-	-
2. Other approved Securities	-	-
3. Shares	-	-
4. Debentures and Bonds	-	-
5. Subsidiaries and Joint Ventures	-	-
6. Others	-	-
Total	**-**	**-**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
A) Current Assets				
1.Inventories :				
a) Stores and Spares (Stationery Stock)		12,07,561.00		9,33,172.00
b) Loose Tools		-		-
c) Stock-in-Trade				
Finished Goods		-		-
Work-in-Progress		-		-
Raw Material		-		-
2. Sundry Debtors :				
a) Debts outstanding for a period exceeding six months		-		-
b) others:		-		-
3. Cash Balances in Hand (including Cheques / Drafts and Imprest)				
Petty Cash Account		20,000.00		9,918.00
Imprest Cash		-		10,000.00
4. Bank Balances :				
a) With Scheduled Banks :				
On Current Accounts	-		-	
On Deposit Accounts	-		-	
On Savings Accounts - SERB (Union Bank of India)	40,03,80,278.40		1,71,41,67,284.90	
SERB EPFO Account (UBI)	1,688.26		531.00	
SERB RTI Account (UBI)	855.00		685.00	
SERB NM ICPS (UBI)	78,61,004.00		-	
IMPRINT-II Account (UBI)	11,00,71,396.00	51,83,15,221.66	11,85,11,462.00	1,83,26,79,962.90
b) With non-Scheduled Banks :				
On Current Accounts	-		-	
On Deposite Accounts	-		-	
On Savings Accounts	-	-	-	-
5. Post Office - Savings Accounts		-		-
Total (A)		**51,95,42,782.66**		**1,83,36,33,052.90**

Amount in Rs.

Schedules Forming Part of Balance Sheet as at 31.03.2021

Schedule 11 - Current Assets, Loans, Advances Etc

Particulars	Current Year		Previous Year	
B) Loans, Advancees and Other Assets :-				
1. Loans:				
a) Staff Loan		-		-
b) Other entities engaged in activities/objectives similar to that		-		-
c) Others		-		-
2. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account	-		-	
b) Prepayments				
Computer software expenses	3,72,525.00		2,33,798.00	
Video Conferencing License	8,07,896.00		8,27,516.00	
Vajra Website-Updation Expenses	1,20,263.00		1,19,934.00	
Membership Fee - India International Centre, New Delhi	91,450.00		73,160.00	
AMC Covid-19 Portal	98,206.00		-	
Lifesize Device Software Subscription-ICON 400	-		1,65,402.00	
Cyberoam Firewall - Licence Fee	-	14,90,340.00	36,108.00	14,55,918.00
c) Security Deposit				
Deldsl-Digital NTC (Security Deposit)	20,000.00		20,000.00	
Digital NTC (Security Deposit)	10,000.00	30,000.00	10,000.00	30,000.00
d) Others-				
Centre for Development of Advanced Computing, Noida	24,61,008.00		-	
Mahanagar Telephone Nigam Limited, New Delhi	45,61,880.00		-	
Red fox Hotel Aerocity, New Delhi	-		17,500.00	
Bureau of Outreach & Communication, New Delhi (DAVP)	1,80,082.00		10,00,000.00	
Deepak Krishna	-		5,000.00	
Dr. Rajwant	-		60,554.00	
Magesh Kumar - LTC Advance	14,000.00		-	
Pankja Kumar Rawat - LTC Advance	27,000.00		-	
Shiv Mohan Singh - LTC Advance	50,000.00		-	
Department of Science & Technology (IMPRINT-II Expenditure by SERB)	-		38,68,10,870.00	
Ministry of Human Resource Development	5,13,668.00	78,07,638.00	5,13,668.00	38,84,07,592.00
3. Income Accrued:				
a) On Investments from Earmarked/ Endowment Funds	-		-	
b) On Investment – Others	-		-	
c) On Loans and Advances	-		-	
d) Others (includes income due unrealized)	-		-	
Interest accrued on Saving A/c Balance - SERB UBI	76,72,061.00		1,73,14,179.00	
ICPS (UBI)	58,171.00		1,04,09,284.00	
IMPRINT-II (UBI)	8,14,159.00	85,44,391.00	11,51,105.00	2,88,74,568.00
4. Claim Receivable		-		-
Total = (B)		**1,78,72,369.00**		**41,87,68,078.00**
Total (A) + (B)		**53,74,15,151.66**		**2,25,24,01,130.90**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 12 - Income From Sales / Services

Particulars	Current Year	Previous Year
1. Income from Sales		
a) Sale of finished Goods	-	-
b) Sale of Raw Material	-	-
c) Sale of Scraps	-	-
2. Income from Services		
a) Labour and Processing Charges	-	-
b) Professional / Consultancy Services	-	-
c) Agency Commissions and Brokerages	-	-
d) Maintenance Services (Equipment/Property)	-	-
e) Others	-	-
Total	**-**	**-**

Scheudel 13 - Grants / Subsidies

Particulars	Current Year		Previous Year	
1. From Central Government				
a) Grant in Aid (General)	4,07,14,91,498.00		6,68,72,00,000.00	
Transferred to Corpus/Fixed Assets (Schedule 1)	(2,56,67,831.00)	4,04,58,23,667.00	(2,73,16,583.00)	6,65,98,83,417.00
b) Grant in Aid (Capital)		2,81,99,52,390.00		2,10,00,00,000.00
c) Grant in Aid (Scheduled Castes - General)		30,72,67,379.00		30,85,00,000.00
d) Grant in Aid (Scheduled Castes - Capital)		6,98,85,194.00		22,00,00,000.00
e) Grant in Aid (Scheduled Tribe - General)		6,16,90,867.00		13,00,00,000.00
f) Grant in Aid (Scheduled Tribe - Capital)		3,44,36,107.00		7,00,00,000.00
g) Grant in Aid (Salaries)		4,70,69,264.00		5,00,00,000.00
2. State Government(s)		-		-
3. Government Agencies		-		-
4. Institutions Organisations		-		-
5. International Organisations		-		-
6. Other		-		-
Total		**7,38,61,24,868.00**		**9,53,83,83,417.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 14 - Fees / Subscriptions

Particulars	Current Year	Previous Year
1. Entrance Fees	-	-
2. Annual Fees / Subscriptions	-	-
3. Seminar / Program Fees	-	-
4. Consultancy Fee	-	-
5. Others	-	-
Total	-	-

Schedule 15 - Income From Investments (Income on Invest. From Earmarked/Endowment Funds transferred to Funds)

Particulars	Investment from Earmarked Funds		Investment -Others	
	Current Year	Previous Year	Current Year	Previous Year
1. Interest				
a) On Govt. Securities	-	-	-	-
b) Other Bonds/Debentures	-	-	-	-
2. Dividends				
a) On shares	-	-	-	-
b) On Mutual Fund Securities	-	-	-	-
3. Rents	-	-	-	-
4. Others : Interest on MFPI Balance in Saving Account	6,98,812.00	6,98,812.00	-	-
Interest on S & T SC Balance in Saving Account	8,31,001.00	4,85,275.00	-	-
Interest on S & T ST Balance in Saving Account	5,124.00	4,067.00	-	-
Interest on DOT Balance in Saving Account	84,257.00	4,01,115.00		
Total	**16,19,194.00**	**15,89,269.00**	-	-
Transferred to Earmarked/Endowment Funds	16,19,194.00	15,89,269.00		

Schedule 16 - Income from Royalty, Publication Etc.

Particulars	Current Year	Previous Year
1) Income from Royalty	-	-
2) Income from Publications	-	-
3) Other	-	-
Total	-	-

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 17 - Interest Earned

Particulars	Current Year		Previous Year	
1. On Term Deposits				
a) With Scheduled Banks	-		1,02,50,808.00	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	-	-	(1,02,50,808.00)	-
b)With Non-Scheduled Banks		-		-
c) With Institutions		-		-
d) Others		-		-
2. On Savings Accounts				
a) With Scheduled Banks	4,02,33,985.00		8,93,08,770.00	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	(4,02,33,985.00)	-	(8,93,08,770.00)	-
b) With Non-Scheduled Banks		-	-	
c) Post Office Savings Accounts		-	-	
d) Others		-	-	
3. On Loans :				
a) Employees / Staff		-		-
b) Others		-		-
4. Interest on Debtors and Other Receivables		-		-
5. Interest on Refund *	88,38,582.41		1,56,27,219.25	
Less: Transferred to GOI, Consolidated Fund under Current Liabilities	(88,38,582.41)	-	-	1,56,27,219.25
Total		**-**		**1,56,27,219.25**

*** Note: Interest on Refund earned during the FY 2019-20 has also been transferred to GOI, Consolidated Fund in Current FY (refer Schedule 1).**

Schedule 18 - Other Income

Particulars	Current Year	Previous Year
1. Profit on sale/disposal/exchange of Assets		
a) Owned assets	-	-
b) Assets acquired out of grants, or received free of cost	-	264.00
2. Export Incentives realized	-	-
3. Fees for Miscellaneous Services	-	-
4. Deferred Revenue Grant (AS-12)	85,73,064.00	1,03,56,053.00
5. Miscellaneous Income- Other Income RTI Receipts	150.00	130.00
Total	**85,73,214.00**	**1,03,56,447.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 19 - Increase / (Decrease) in stock of Finished Goods & Work in Progress

Particulars	Current Year	Previous Year
a) Closing Stock		
Finished Goods	-	-
Work-in-Progress	-	-
b) Less : Opening Stock		
Finished Goods	-	-
Work-in-Progress	-	-
Total	**-**	**-**

Schedule 20 - Establishment Expenses

Particulars	Current Year	Previous Year
a) Salaries and Wages	9,82,20,429.00	8,67,68,985.00
b) Allowances and Bonus	-	-
c) Contribution to Provident Fund- Employer	22,39,196.00	20,95,016.00
d) Contribution to Other Fund : NPS Employer Contribution	43,09,920.00	39,44,372.00
e) Staff Welfare Expenses	-	-
f) Expenses on Employee's Retirement & Terminal Benefits		
Leave Encashment Provision	20,31,880.00	-
Gratuity Expense	71,59,680.00	16,97,320.00
Secretary Leave Salary Contribution	2,97,000.00	2,91,225.00
Secretary Pension Contribution	6,48,172.00	5,01,013.00
g) Others		
Telephone Expenses Reimbursement	2,76,935.00	2,56,566.00
School Fee Reimbursement	2,43,000.00	3,24,000.00
Newspaper Reimbursement	64,963.00	92,201.00
Medical Reimbursement	3,30,323.00	4,60,849.00
Transfer Expenses Reimbursement	39,900.00	-
Leave Encashment	-	1,05,300.00
Leave Travel Concession	3,50,504.00	15,54,577.00
Total	**11,62,11,902.00**	**9,80,91,424.00**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 21 - Other Administrative Expenses

Particulars	Current Year	Previous Year
a) Bank Charges	71,382.13	92,608.68
b) Car Hire Charges	45,14,017.00	48,33,863.00
c) Professional Fees	63,71,410.00	27,25,823.00
d) Electricity Charges	17,76,692.00	18,95,347.00
e) Membership Fee	1,73,160.00	61,360.00
f) Meeting Expenses	30,05,359.00	81,97,536.00
g) Honorarium Expenses (Non- Official)	1,32,16,812.00	25,42,040.00
h) Hospitality Expenses	7,32,214.00	15,76,095.00
i) Printing & Stationery	40,02,122.00	44,89,156.00
j) Rent- Building	5,34,99,192.00	5,34,99,192.00
k) Advertisement/Publication	24,33,765.00	27,41,021.00
l) Courier Expenses	2,165.00	-
m) Conveyance Expenses	14,647.00	10,244.00
n) Housekeeping/Security Expenses	38,51,639.00	35,62,592.00
o) International Conference	-	7,62,138.00
p) Repair & Maintenance	7,45,242.00	8,73,359.00
q) Travelling Expenses (Domestic)	12,54,890.00	84,43,966.00
r) Travelling Expenses (International)	-	15,07,973.00
s) Audit Fee	4,49,500.00	4,49,500.00
t) Accommodation Expenses (Domestic)	33,388.00	9,19,509.00
u) Accommodation Expenses (International)	-	5,11,680.00
v) Computer Hardware & Software	14,32,252.00	13,44,588.00
w) Internet Charges	13,27,699.74	13,27,701.00
x) Newspaper & Periodicals	16,773.00	18,428.00
y) Postage Expenses	27,117.00	47,329.00
z) Telephone Expenses	3,68,160.00	3,68,160.00
aa) Festival Expenses	-	2,26,412.00
ab) NSDL E Governance Charges	3,154.00	3,272.00
ac) Training Exenses	10,000.00	5,000.00
ad) Conference Expenses	9,273.00	50,534.00
ae) AMC	55,88,151.00	17,21,111.00
af) Digitisation Cost	35,400.00	8,97,786.00
ag) Miscellaneous Expenses	24,72,758.52	12,34,399.00
Total	**10,74,38,334.39**	**10,69,39,722.68**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 22 - Expenditure on Grants, Subsidies Etc

Particulars	Current Year	Previous Year
Grants given to Institutions/Organisations		
a) Grants in Aid (Capital Assets) (Ann. 23 & 23A)	2,90,05,66,479.00	2,11,42,26,265.00
b) Grant in Aid (General) (Ann. 24 & 24A)	5,28,97,62,959.00	5,56,78,17,241.46
c) Grant in Aid (Scheduled Castes - Capital) (Ann. 25 & 25A)	10,37,62,970.00	15,00,57,474.00
d) Grant in Aid (Scheduled Castes - General) (Ann. 26 & 26A)	30,28,29,465.00	34,54,96,505.00
e) Grant in Aid (Scheduled Tribe - Capital) (Ann. 27 & 27A)	3,21,36,782.00	7,77,00,185.00
f) Grant in Aid (Scheduled Tribe - General) (Ann. 28 & 28A)	7,87,51,291.00	10,13,66,444.00
Total	**8,70,78,09,946.00**	**8,35,66,64,114.46**

Schedule 23 - Interest

Particulars	Current Year	Previous Year
a) On Fixed Loans (Including Bank Charges)	-	-
b) On Other Loans (Including Bank Charges)	-	-
c) Others	-	-
Total	**-**	**-**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 24 - Prior Period Income

Particulars	Current Year	Previous Year
A) Refund received against previous year grants		
a) Refund from Projects (Capital) FY 2011-12 (Ann. 29 & 29A)	-	1,36,923.00
b) Refund from Projects (General) FY 2011-12 (Ann. 30 & 30A)	1,24,470.00	3,43,817.00
c) Refund from Projects (Capital) FY 2012-13 (Ann. 31 & 31A)	15,92,470.44	7,85,337.00
d) Refund from Projects (General) FY 2012-13 (Ann. 32 & 32A)	2,03,933.00	2,94,831.00
e) Refund from Projects (Capital) FY 2013-14 (Ann. 33 & 33A)	4,74,306.00	22,78,137.03
f) Refund from Projects (General) FY 2013-14 (Ann. 34 & 34A)	3,30,573.00	13,60,308.79
g) Refund from Projects (SC-Capital) FY 2013-14 (Ann. 35 & 35A)	2,78,629.00	788.00
h) Refund from Projects (ST-Capital) FY 2013-14 (Ann. 36 & 36A)	-	21.00
i) Refund from Projects (Capital) FY 2014-15 (Ann. 37 & 37A)	24,35,740.00	47,51,389.15
j) Refund from Projects (General) FY 2014-15 (Ann. 38 & 38A)	28,41,712.60	33,57,169.90
k) Refund from Projects (SC-Capital) FY 2014-15 (Ann. 39 & 39A)	3,00,757.41	7,28,197.00
l) Refund from Projects (ST-Capital) FY 2014-15 (Ann. 40 & 40A)	-	9,288.00
m) Refund from Projects (ST-General) FY 2014-15 (Ann. 41 & 41A)	-	81,507.00
n) Refund from Projects (Capital) FY 2015-16 (Ann. 42 & 42A)	1,17,84,065.99	2,44,17,743.73
o) Refund from Projects (General) FY 2015-16 (Ann. 43 & 43A)	30,47,768.74	1,01,51,098.32
p) Refund from Projects (SC-Capital) FY 2015-16 (Ann. 44 & 44A)	11,98,097.00	1,42,370.00
q) Refund from Projects (SC-General) FY 2015-16 (Ann. 45 & 45A)	13,46,980.00	14,15,045.00
r) Refund from Projects (Capital) FY 2016-17 (Ann. 46 & 46A)	4,95,63,044.95	2,49,63,266.50
s) Refund from Projects (General) FY 2016-17 (Ann. 47 & 47A)	85,21,242.28	1,50,93,917.25
t) Refund from Projects (SC-Capital) FY 2016-17 (Ann. 48 & 48A)	16,16,413.00	24,00,382.00
u) Refund from Projects (SC-General) FY 2016-17 (Ann. 49 & 49A)	1,06,083.00	7,115.00
v) Refund from Projects (ST-Capital) FY 2016-17 (Ann. 50 & 50A)	8,07,971.00	8,30,982.00
w) Refund from Projects (Capital) FY 2017-18 (Ann. 51 & 51A)	1,88,87,742.81	1,38,01,860.05
x) Refund from Projects (General) FY 2017-18 (Ann. 52 & 52A)	1,24,00,508.22	3,43,05,010.77
y) Refund from Projects (SC-Capital) FY 2017-18 (Ann. 53 & 53A)	19,49,546.50	8,41,546.00
z) Refund from Projects (SC-General) FY 2017-18 (Ann. 54 & 54A)	9,34,819.00	23,30,590.88
aa) Refund from Projects (ST-Capital) FY 2017-18 (Ann. 55 & 55A)	33,028.00	-
ab) Refund from Projects (ST-General) FY 2017-18 (Ann. 56 & 56A)	-	2,01,359.00
ac) Refund from Projects (Capital) FY 2018-19 (Ann. 57 & 57A)	77,91,422.70	72,91,077.00
ad) Refund from Projects (General) FY 2018-19 (Ann. 58 & 58A)	4,65,45,353.03	10,36,18,895.45
ae) Refund from Projects (SC-Capital) FY 2018-19 (Ann. 59 & 59A)	4,20,047.00	-
af) Refund from Projects (SC-General) FY 2018-19 (Ann. 60 & 60A)	9,85,480.00	16,13,376.00
ag) Refund from Projects (ST-Capital) FY 2018-19 (Ann. 61 & 61A)	2,15,978.00	-
ah) Refund from Projects (ST-General) FY 2018-19 (Ann. 62 & 62A)	45,257.00	2,67,684.00
ai) Refund from Projects (Capital) FY 2019-20 (Ann. 63 & 63A)	26,09,509.00	-
aj) Refund from Projects (General) FY 2019-20 (Ann. 64 & 64A)	8,31,29,524.36	-
ak) Refund from Projects (SC-General) FY 2019-20 (Ann. 65 & 65A)	62,73,074.96	-
al) Refund from Projects (ST-Capital) FY 2019-20 (Ann. 66 & 66A)	1,07,200.00	
am) Refund from Projects (ST-General) FY 2019-20 (Ann. 67 & 67A)	5,10,759.00	-
an) Refund from Projects SERC (Ann. 68 & 68A)	2,76,037.00	-
ao) Refund from Projects PY (Ann. 69 & 69A)	59,92,945.64	24,051.00
B) Other income liabilities written back		
M/s Mansarover industrial Corporation, New Delhi	2,350.00	-
Grants Pending for Clearance (FY 2011-12 to FY 2014-15)	2,87,51,809.00	-
Total A) + B)	**30,44,36,648.63**	**25,78,45,083.82**

Amount in Rs.

Schedules Forming Part of Income & Expenditure for the year ended 31.03.2021

Schedule 25 - Prior Period Expenditure

Particulars	Current Year	Previous Year
a) Professional Fees	18,585.00	3,331.00
b) Accomodation Expenses	68,433.00	-
c) International Conference	-	1,51,598.00
d) Travelling Expenses (Domestic)	10,81,791.00	14,643.00
e) Advertisement Expenses	9,99,562.00	-
f) Grant-in-Aid (Capital)	-	-
g) Newspaper Reimbursement	(8,700.00)	37,881.00
h) Medical Expenses Reimbursement	50,705.00	1,38,965.00
i) Telephone Expenses Reimbursement	10,803.00	49,504.00
j) School Fee Reimbursement	-	27,000.00
k) Salary Arrear (Regular Employees)	(8,424.00)	-
l) Salary Arrear (Contract Employees)	-	25,790.00
m) AMC Computers & Printers	(29,972.00)	29,972.00
n) AMC Photocopier	4,735.00	4,735.00
o) AMC Biometric Attendance System	192.00	-
p) AMC MIS System (PRISM)	57,46,668.00	-
q) Newspaper & Periodicals	-	1,538.00
r) Bank Charges	-	(245.32)
s) Digitisation Cost	-	11,56,306.00
t) EPF Employer Contribution	-	523.00
u) Honorarium Expenses (Non-Official)	1,52,000.00	4,000.00
v) Leave Encashment	-	(4,17,520.00)
w) Depreciation A/c	9,81,170.00	-
x) Meeting Expenses	2,39,813.00	-
y) IMPRINT_II Expenses	38,36,27,978.00	-
Total	**39,29,35,339.00**	**12,28,020.68**

Amount in Rs.

Receipts & Payments for the Year Ended 31.03.2021

	Receipts	Current Year	Previous Year		Payments	Current Year	Previous Year
1	**Opening Balances**			1	**Expenses**		
a)	Cash in hand	19,918.00	20,000.00	a)	**Establishment Expenses (corresponding to Schedule 20)**	10,66,18,966.00	9,53,90,238.00
b)	Bank balances			b)	**Administrative Expenses (corresponding to Schedule 21)**	11,61,24,963.87	10,69,98,608.36
	i) In Current Accounts	-	-	2	**Payments made against funds for various projects**		
	ii) In Deposit Accounts	-	-		**Grants given to Institutions/Organisations**		
	iii) Savings Accounts : SERB UBI	1,71,41,67,284.90	62,67,42,669.47	a)	Grants in Aid (Capital Assets)	2,90,05,66,479.00	2,11,42,26,265.00
	: SERB RTI	685.00	294.68	b)	Grant in Aid (General)	5,28,97,62,959.00	5,56,78,17,241.46
	: SERB EPFO	531.00	112.00	c)	Grant in Aid (Scheduled Castes - Capital)	10,37,62,970.00	15,00,57,474.00
	: IMPRINT-II UBI	11,85,11,462.00	-	d)	Grant in Aid (Scheduled Castes - General)	30,28,29,465.00	34,54,96,505.00
2	**Grants Received**			e)	Grant in Aid (Scheduled Tribe - Capital)	3,21,36,782.00	7,77,00,185.00
a)	From Government of India			f)	Grant in Aid (Scheduled Tribe - General)	7,87,51,291.00	10,13,66,444.00
	Grant in Aid (General)	4,07,14,91,498.00	6,68,72,00,000.00	3	**Investments & Deposits made**		
	Grant in Aid (Capital)	2,81,99,52,390.00	2,10,00,00,000.00	a)	Out of Earmarked/Endowment Funds	-	-
	Grant in Aid (Scheduled Castes - General)	30,72,67,379.00	30,85,00,000.00	b)	Out of Own Funds (Investments-Others)	-	-
	Grant in Aid (Scheduled Castes - Capital)	6,98,85,194.00	22,00,00,000.00	4	**Expenditure on Fixed Assets & Capital Work-in**		
	Grant in Aid (Scheduled Tribe - General)	6,16,90,867.00	13,00,00,000.00	a)	Purchase of Fixed Assets	34,93,493.00	27,33,289.00
	Grant in Aid (Scheduled Tribe - Capital)	3,44,36,107.00	7,00,00,000.00	b)	Expenditure on Capital Work-in Progress	1,92,30,828.00	1,70,97,374.00
	Grant in Aid (Salaries)	4,70,69,264.00	5,00,00,000.00	5	**Refund of surplus money/loans**		
b)	From State Government	-	-	a)	To the Government of India	-	-
c)	From Other Sources (details)	-	-	b)	To the State Government	-	-
3	**Income on Investments from**			c)	To other providers of Funds	-	-
a)	Earmarked/Endowment Funds	-	-	6	**Finance Charges (Interest)**	-	-
b)	Own Funds		-	7	**Other Payments (Specify)**		
4	**Interest Received**			a)	MFPI Earmarked Payment	18,91,363.00	5,78,496.00
a)	On Bank Deposits	5,14,95,297.00	9,99,51,377.00	b)	Refund to Ministry of Food Processing	-	2,00,00,000.00
b)	Loans Advances	-	-	c)	ICPS Earmarked Payment	27,77,720.00	1,22,70,00,000.00
c)	Interest on Refund	88,38,582.41	1,56,27,219.25	d)	IMPRINT-II Earmarked Payment	1,21,00,000.00	15,46,52,510.00
5	**Other Income**	150.00	130.00	e)	DOT Earmarked Payment	-	1,46,244.50
6	**Amount Borrowed**	-	-	f)	IMPRINT-II Expenditure by SERB	-	11,10,87,177.00
7	**Any Other Receipts**			g)	Bureau of Outreach & Communication, New Delhi	1,80,082.00	10,00,000.00
a)	Refunds Received Against Previous Year Grant (SERB)	27,58,76,334.63	25,78,45,083.82	h)	Mahanagar Telephone Nigam Limited, Delhi	45,61,880.00	-
b)	MFPI Earmarked Receipt	89,783.00	23,91,281.00	i)	Centre for Development of Advanced Computing, Noida	24,61,008.00	-
c)	S & T Earmarked Receipt	9,88,864.59	15,96,624.00	j)	Government of India, Consolidated Fund	9,95,59,578.00	14,42,22,373.00
d)	ICPS Earmarked Receipt	1,06,38,724.00	1,22,70,00,000.00	k)	National Mission on Bamboo Application	10,80,145.00	
e)	IMPRINT-II Earmarked Receipt	38,04,879.00	27,31,88,969.00	l)	Deepak Krishna		5,000.00
f)	Receipt against MFPI Expenditure by SERB		7,59,796.00	m)	Dr. Rajwant	-	60,554.00
g)	Dr. P Sanjeeva Rao	-	-	n)	MHRD Expenditure by SERB	-	5,04,962.00
h)	Received from AISTDF	-	11,999.00	8	**Closing Balances**		
i)	Dr. Doyil T Vengayil	-	2,633.00	a)	Cash in hand	20,000.00	19,918.00
j)	Dr. Pravakar Mohanty	-	2,633.00	b)	Bank balances		
					i) In Current Accounts	-	-
					ii) In Deposit Accounts	-	-
					iii) Savings Accounts : SERB UBI	40,03,80,278.40	1,71,41,67,284.90
					: IMPRINT-II UBI	11,00,71,396.00	11,85,11,462.00
					: SERB RTI	855.00	685.00
					: SERB EPFO	1,688.26	531.00
					: SERB NM ICPS	78,61,004.00	-
	Total	**9,59,62,25,194.53**	**12,07,08,40,821.22**		**Total**	**9,59,62,25,194.53**	**12,07,08,40,821.22**

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

VPCA AND ASSOCIATES ★ Chartered Accountants ★ DELHI

CA Priya Wadhwa Gupta
(Partner)
M. No. 516631
Date : 26.06.2021
Place : New Delhi

For Science and Engineering Research Board

Secretary
SERB

Director-Finance
SERB

Date :
Place : New Delhi

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2021

SCHEDULE 26

SIGNIFICANT ACCOUNTING POLICIES

1. Basis of Preparation of Financial Statements

These financial statements have been prepared on the accrual basis of accounting, under historical cost convention, in accordance with the accounting principles generally accepted in India.

2. Fixed Assets

Fixed assets are stated at cost of acquisition less accumulated depreciation and impairment losses, if any. Cost of fixed assets comprises purchase price, duties, levies and other directly attributable costs of bringing the assets to its working conditions for the intended use.

3. Capital Work in Progress

Expenditure incurred on construction of assets which are not ready for their intended use are carried at cost less impairment (if any), under Capital work-in-progress.

4. Depreciation

Depreciation on fixed assets is computed on the written down value (WDV) method at the rates and in the manner prescribed under the Provisions of Income Tax Act.

In respect of additions to/deductions from fixed assets during the year, depreciation is considered on pro-rata basis. Assets costing Rs.5,000/- each or less are fully provided.

5. Grant/ Subsidies Received

Grants, subsidies or similar assistance received for the general purposes and objectives of the Entity, on an irrevocable basis, be treated as income on receipt basis.

6. Expenditure on Grants, Subsidies etc.

Grants, subsidies or other similar assistance given to the Institutions/Organisations for general purposes and objectives of the Entity, on an irrevocable basis, be treated as expenditure when they are released.

7. Interest Income of SERB

Besides the grants-in-aid received from Central Government, SERB also generates income from: -

a. Interest on Short term FDs on the Grant-in Aid
b. Interest on the Saving A/c Balance; and
c. Interest on Refunds

As on 31st March, 2021, interest earned during the current FY 2020-21 has been transferred to Schedule 7 - Current Liabilities and Provisions and shown as payable to Government of India, Consolidated Fund.

8. Prior period Income/Expenditure

Income/expenditure relating to previous Financial Years has been booked as Prior Period Income/Expenditure in the Income and Expenditure Account.

9. Refund from beneficiaries:

a) Refund/repayment of grant/assistance received by SERB from the beneficiaries as per the conditions stipulated in the sanction document is accounted for on receipt basis.
b) Refund/repayment of grant/assistance given and received back in the same financial year has been netted off with Grant-in-Aid (expenditure) in the Income and Expenditure Account.
c) Refund/repayment of grant/assistance given in previous years and received back in later years (i.e. not in same financial year) has been shown as "Refund received against Previous Year Grant" in the Income and Expenditure Account under "Prior Period Income".
d) Refund/repayment of grant/assistance given in previous years and received back during the year through NEFT without any supporting documents or any communication from the grantee institutions and the details of which are not traceable till the finalization of Annual Accounts has been shown as "Refund from projects Previous Year" in the Income and Expenditure Account under "Prior Period Income".

10. Unspent balances of Grants received from DST:

The unspent balances of Grants received from DST are not to be refunded to DST as grants released by the Government are credited to Science and Engineering Research Board in terms of Section 10(1) of SERB Act, 2008.

11. Time barred cheques

All cheques issued by SERB during the FY 2020-21 have been encashed within its validity period of 3 months from the date of the issue of Cheque except 2 cheques for Honorarium expenses amounting to Rs. 4000/- and Rs. 12000/- which has been reversed on 31.03.2021.

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12. Government Grant for Fixed assets of SERB

In order to comply with AS-12 Accounting for Government Grants under direction of C&AG, amount equivalent to cost of acquisition of fixed assets out of Grants in Aid (General) has been shown as Corpus Fixed Assets. Depreciation for the year amounting Rs. 85,73,064/- is being credited to Income & Expenditure A/c as Deferred Revenue Grant as per para 8 of AS 12.

13. Retirement Benefits

SERB makes provision for liability towards encashment of leave lying to the credit of employees as on the last day of current financial year subject to the maximum period of leave allowable as per extant rules and retirement benefits shall be governed by the National Pension System (NPS) as applicable to the officers of equivalent rank of the Central Government as amended from time to time.

SERB makes provision for Gratuity as on the last day of the financial year subject to the maximum limit as per extant orders of retirement benefits as applicable to the officers of equivalent rank of the Central Government as amended from time to time.

14. Surplus/Deficit in Income & Expenditure A/c

Surplus/Deficit in Income & Expenditure Account at the year-end has been transferred to Corpus/Capital Account.

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

VPCA AND ASSOCIATES ★ Chartered Accountants ★ DELHI

CA Priya Wadhwa Chawla
M. No. 516631
(Partner)

Date: 26.06.2021
Place: New Delhi

For Science and Engineering Research Board

Secretary
SERB

Director-Finance
SERB

Date: …….
Place: New Delhi

SCHEDULE FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31.03.2021

SHCEDULE- 27 CONTINGENT LIABILITIES AND NOTES TO ACCOUNTS

1. CONTINGENT LIABILITIES

1.1 Claims against the Entity not acknowledge as debts **Rs. NIL** (Previous year **Rs. NIL**)

1.2 In respect of

- Bank Guarantees given by/on behalf of the Entity **Rs. NIL** (Previous year **Rs. NIL**)
- Letters of Credit opened by Bank on behalf of the Entity **Rs. NIL** (Previous year **Rs. NIL**)
- Bills discounted with banks **Rs. NIL** (Previous year **Rs. NIL**)

1.3 Disputed demands in respect of:

- Income tax **Rs. NIL** (Previous year **Rs. NIL**)
- Sales Tax **Rs. NIL** (Previous year **Rs. NIL**)
- Municipal Taxes **Rs. NIL** (Previous year **Rs. NIL**)
- In respect of claims from parties for non-execution of orders but contested by the Entity **Rs. NIL** (Previous year **Rs. NIL**)

1.4 Income Tax ***(Refer Para 6 below)***

- Current Year – Rs 12,12,88,862/- Previous year – Rs 12,12,88,862/-

	Current Year	Previous Year
FY 2011-12	Rs. 9,43,38,079/-	Rs. 9,43,38,079/-
FY 2012-13	Rs. 2,69,50,783/-	Rs. 2,69,50,783/-
FY 2013-14	Nil	Nil
FY 2014-15	Nil	Nil
FY 2015-16	Nil	Nil
FY 2016-17	Nil	Nil
FY 2017-18	Nil	Nil
FY 2018-19	Nil	Nil
FY 2019-20	Nil	Nil
FY 2020-21	Nil	Nil
Total	**Rs. 12,12,88,862/-**	**Rs. 12,12,88,862/-**

2. CAPITAL COMMITMENTS

- Estimated value of contracts remaining to be executed on capital account and not provided for (net of advances) **Rs. NIL** (Previous year **Rs. NIL**)

3. LEASE OBLIGATIONS

- Future obligations for rentals under finance lease arrangements for plant and machinery amount to **Rs. NIL** (Previous year **Rs. NIL**)

4. CURRENT ASSETS, LOANS AND ADVANCES

- In the opinion of the Management, the current assets, loans and advances have a value on realization in the ordinary course of business, at least equal to the amount at which they are stated in the Balance Sheet.

5. Net Loss in Current FY 2020-21

Total Income of Current FY 2020-21 is Rs. 7,39,46,98,082/- whereas Total Expenditure of Current FY is Rs. 8,94,00,33,246.39

In Income & Expenditure A/c excess of Expenditure over Income shows a difference of Rs. 1,54,53,35,164.39 as Gross Loss.

SERB is having Net Loss of Rs. 1,63,38,33,854.76 in FY 2020-21 after considering Prior Period Income of Rs. 30,44,36,648.63 and Prior Period Expenditure of Rs. 39,29,35,339/-.

6. TAXATION

SERB has got exemption u/s 10(46) of the Income Tax Act, 1961 for 5 financial years from FY 2013-14 to FY 2017-18 vide gazette notification no. 24/2017/F.No.196/15/2013-ITA-I published on 31st March, 2017.

Since our original application for exemption u/s 10(46) was from inception of SERB, the matter has been taken up again with CBDT to grant us exemption for FY 2011-12 and FY 2012-13 also.

Further we have applied for exemption u/s 10(46) of the Income Tax Act, 1961 to CBDT and Income Tax Department for FY 2018-19 and onwards.

In such a situation we have shown Contingent Liability for Income Tax at point 1.4.

SERB is registered as charitable organization u/s 12A of the Income Tax Act, 1961 from AY 2017-18 and eligible for exemption from Income Tax u/s 11 of the Income Tax Act, 1961.

7. FOREIGN CURRENCY TRANSACTIONS

(Amount Rs.)

7.1 Value of Imports Calculated on C.I.F. Basis:	**Current Year**	**Previous Year**
Purchase of finished Goods	Nil	Nil
Raw Materials & Components (Including in transit)	Nil	Nil
Capital Goods	Nil	Nil
Stores, Spares & Consumables		

7.2 Expenditure in foreign currency:

a)	Travel	Nil	Rs. 7,62,138/-
b)	Remittances and Interest Payment to Financial Institutions/ Banks in Foreign Currency	Nil	Nil
c)	Other expenditure:		
	- Commission on Sale	Nil	Nil
	- Legal and Professional Expenses	Nil	Nil
	- Miscellaneous Expenses	Nil	Nil
	- Grant-in-Aid (General)	Rs.7,97,20,044/-	Rs.10,76,30,893/-

7.3 Earning:

Value of Exports on FOB basis	Nil	Nil

7.4 Remuneration to Auditors:

- Auditors Fee (CAG)	Rs. 1,25,000/-	Rs. 1,25,000/-
- Auditors Fee (CA)	Rs. 3,24,500/-	Rs. 3,24,500/-
- Taxation matters	……..	……
- For management services	…….	……
- For certificate	…….	…….
- Others	……	……

Absorption of expenses incurred on IMPRIMT-II scheme from SERB Fund

SERB is funding various schemes since November 2011 as per the objectives stated in SERB Act, 2008. As a part of various scheme SERB has funded IMPRINT-I Scheme and released Rs. 19.56 crore till date. Now SERB has been made the nodal agency to implement IMPRINT-II Scheme to be funded by MHRD & DST jointly. During the FY 2018-19 and FY 2019-20 SERB has funded IMPRINT-II Schemes and released Rs. 27.56 crore and Rs. 11.12 crore respectively. The expenditure incurred by SERB on IMPRINT-II Scheme on behalf of DST was shown as recoverable in the Annual Accounts of SERB under the head "DST (IMPRINT-II) Expenditure by SERB" under Current Assets of respective years. Now as per the directions of Secretary, DST it has been conveyed that no separate grants would be released for IMPRINT-II by DST to SERB and that SERB would utilize the funds allocated during the year by DST to SERB for implementation of IMPRINT_II scheme also.

In line with above direction of Secretary, DST SERB has absorbed the expenditure incurred on IMPRINT-II Scheme during the FY 2018-19 and FY 2019-20 in the Current FY 2020-21 and also met the current year expenditure of Rs. 14.60 crore on IMPRINT-II scheme from its total fund allocation for FY 2020-21.

9. Long Outstanding Current Liabilities

Long outstanding liability with regard to 48-time barred cheques relating to previous FY 2011-12, FY 2012-13, FY 2013-14 and FY 2014-15 amounting to Rs 2,87,51,809/- has been written back in current FY 2020-21 on account of project closure, project not reconsidered in subsequent years and cheques reissued w.r.t time barred cheques. Another long outstanding payable liability of Rs. 2,350/- payable to M/s Mansarover Industrial Corporation, Delhi has also been written back on account of non-submission of bill/invoice even after 10 Years.

10. Previous Year figures have been regrouped /recast wherever found necessary.

11. Schedules 1 to 27 are annexed to and form an integral part of the Balance Sheet as at 31.03.2021 and the Income and Expenditure Account for the year ended on that date.

Compiled on the basis of data and information provided by the management of the SERB

For VPCA AND ASSOCIATES
Chartered Accountants

VPCA AND ASSOCIATES ★ Chartered Accountants ★ DELHI

CA Priya Wadhwa Chawla
M. No. 516631
(Partner)

Date: 26.06.2021
Place: New Delhi

For Science and Engineering Research Board

Secretary
SERB

Director-Finance
SERB

Date: ……..
Place: New Delhi

Notes

Notes

About SERB

Set up through an Act of Parliament, viz. the Science and Engineering Research Board Act, 2008, SERB serves as the national premier funding agency for planning, promoting and steering internationally competitive research in science and engineering. The mandate is to promote basic research in frontier areas of Science and Engineering and provide financial assistance to persons engaged in such research, academic institutions, research and development laboratories, and other agencies. This is achieved through various schemes like extramural research funding fellowships, grants, awards, scholarships and joint industrial relevant collaborations.

Science and Engineering Research Board

Submit R&D proposals online at: www.serbonline.in

3rd and 4th Floor, Block-II, Technology Bhawan, New Mehrauli Road,
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