



वार्षिक प्रतिवेदन
**ANNUAL
REPORT
2024-2025**

अनुसंधान एवं
विकास रिपोर्ट
**RESEARCH &
DEVELOPMENT
REPORT**

सीएसआईआर-केंद्रीय विद्युतरसायन अनुसंधान संस्थान
CSIR-Central Electrochemical Research Institute
वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद
Council of Scientific and Industrial Research
कारैकुडी-630 003, तमिलनाडु, भारत
Karaikudi-630 003, Tamil Nadu, India

Development of plasma-sprayed thermal barrier coatings for nozzle guide vanes of small gas turbines and development of highly adherent erosion and corrosion resistant alloy/ceramic ultra-thin multi-layered coatings for aircraft components

HCP-36

Division(s): Corrosion & Materials Protection

PI: Dr. C. Arunchandran

Co-PI(s): Dr. G. Sreedhar

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 09.02.2021 to 31.03.2025

Budget (Rs. in Lakh): 29.72

Objectives

- To develop highly adherent erosion and corrosion-resistant alloy/ceramic ultra-thin multi-layered coatings for aircraft components.

Highlights

- Developed a nano-multilayered TiCr/TiCrN

coating with a thickness of approximately 8.5 μm and a bi-layer thickness of 7.5 nm using an in-house designed unbalanced magnetron sputtering system.

- Subjected the pristine and erosion-tested samples at 30° and 90° impinging angles to potentiodynamic polarisation tests in 3.5 wt% NaCl solution.
- The erosion test's impingement angle and temperature affected the corrosion behaviour of the substrate and the coating.
- The coating demonstrated approximately 93 times greater erosion resistance than the bare Ti6Al4V substrate at an erodent speed of 30 m/s and 400 °C.

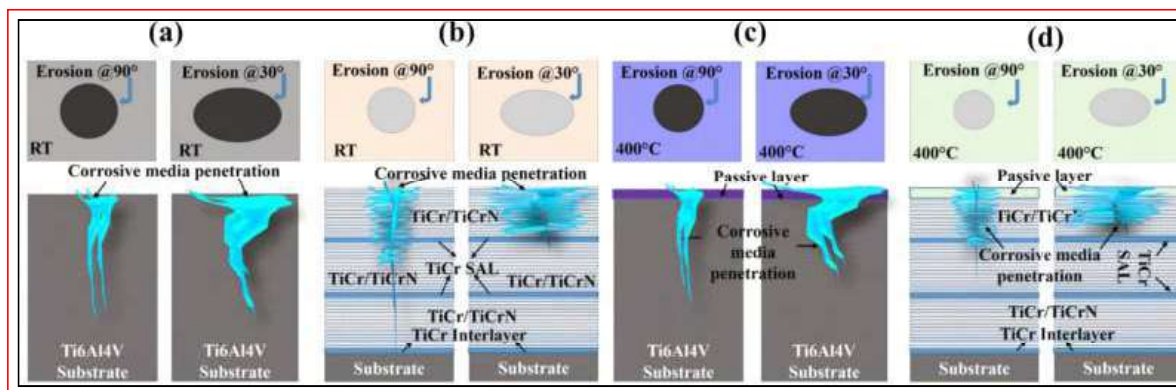


Figure 1. Corrosion mechanism after erosion (a) Ti6Al4V at RT, (b) TiCr/TiCrN at RT, © Ti6Al4V at 400 °C, (d) TiCr/TiCrN at 400 °C.

CSIR - JIGYASA 2.0 with Virtual Lab integration project

HCP-0101

Division(s): All the Divisions

PI: Dr. S. Angappan

Co-PI(s): Dr. J. Mathiyarasu and Dr. R. Sindhuja (VL)

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2025

Budget (Rs. in Lakh): 37.96

Objectives

- To popularize STEM (Science, Technology, Engineering and Mathematics) learning and innovation.
- To inculcate scientific temper among school students and reignite the minds of teachers.
- To encourage experimentation and innovation in education and emergence of new student entrepreneurs in our country.
- To develop a virtual learning platform for electrochemical science and technology
- To adopt and promote student – scientist connect schemes through adoption of schools by NITI Aayog's ATL schools.
- To develop and demonstrate Do It Yourself (DIY) kit or devices will be distributed to the students and schools.



Futuristic Fridays (12.04.2024)



Installation and activation of global climate clock (22.04.2024)



10th International Yoga Day (21.06.2024)



10th International Yoga Day (21.06.2024)



Summer Internship Programme for school students (08th to 12th, July 2024)



One day scientist program (03.10.2024)



State level workshop on "Green Hydrogen Technologies"



Onsite Experiment for IX-XII Standard students of KV, Karaikudi



Lab @ School Programme during 23.10.2024 to 09.12.2024

CSIR mission mode project on AI-enabled technologies & systems (AITS)

HCP-00042

Division(s): Electrochemical Power Sources
PI: Dr. R. Sindhuja
Co-PI(s): Dr. P. Murugan
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 23.05.2022 to 31.03.2025
Budget (Rs. in Lakh): 60.93

Objectives

- Data generation and collection for drive pattern, usage pattern, road conditions, and operating conditions of electric two-wheeler in India.
- Analysis of complex and varied parameters affecting the energy system in the vehicle using

machine learning tools in order to predict performance and range of the battery.

- Use the data-driven models and ML tools for optimizing the size and performance of the battery for the e-mobility application.
- Prediction of remaining useful life of the battery and develop predictive maintenance plan based on developed deep learning AI tool.

Highlights

- Developed a model and implemented in hardware for SOH prediction with the accuracy range of 93-99 %.
- The model developed was implemented in hardware for range prediction.



Fig.1. Standalone hardware used for model implementation

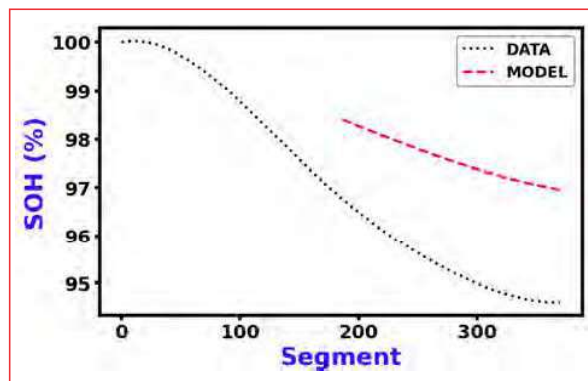


Fig.2. State of health prediction vs actual data for an EV

Development of next-generation water electrolyzer to generate green hydrogen (H2T Mission)

HCP-00044MI

Division(s): Electrochemical Process Engineering and Electroplating & Electrometallurgy
PI: Dr. S. Vengatesan
Co-PI(s): Dr. R. Malini and Dr. C. Jeyabharathi
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2022 to 31.03.2025
Budget (Rs. in Lakh): 1012.64

Objectives

- Improvement in electrocatalytic activity of existing noble-metal catalysts.
- Design and fabrication of efficient electrodes with low noble-metal loading.
- Membrane-electrode-assembly (MEA) fabrication with improved electrode-electrolyte interface.

- Electrolyser stack assembly, performance, and stability testing.
- Integration of electrolyzer stack with Solar energy.

Highlights

- Prepared a low-loading iridium-based mixed metal oxide anode electrocatalyst using two strategies: (i) surfactant-assisted method; (ii) molten-salt method.
- Developed a 30 kW electrolyser stack using MEA and electrolyser components and assessed its performance.
- Developed pressurized PEM electrolyser stack.

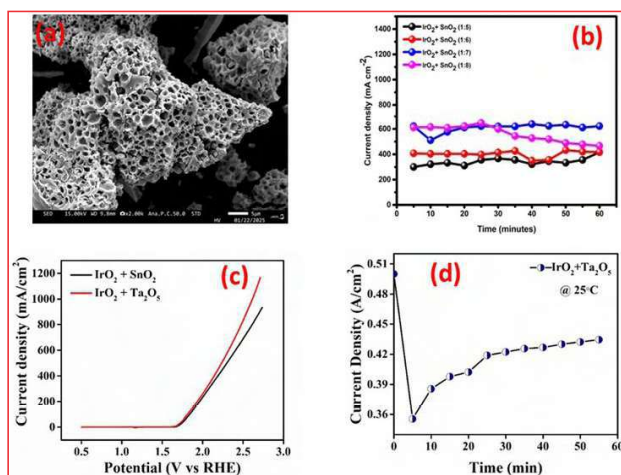


Figure 1. (a) SEM image of the $\text{IrO}_2\text{-SnO}_2$ catalyst (b) Chronoamperometry curves for $\text{IrO}_2\text{-SnO}_2$ (1:5 to 1:8) at cell voltage of 2 V and at 25 °C (c) LSV curves for OER on $\text{IrO}_2\text{-SnO}_2$ and $\text{IrO}_2\text{-Ta}_2\text{O}_5$ at 10 mV/s (d) Chronoamperometry curve for $\text{IrO}_2\text{-SnO}_2$ and $\text{IrO}_2\text{-Ta}_2\text{O}_5$ at cell voltage of 2 V and at 25 °C.



Figure 2. (a) 30 kW stack (b) 30 kW stack integrated with testing unit.

Indigenous proton exchange membrane for polymer electrolyte fuel cells

HCP-00044FBR1

Division(s): CSIR-CECRI Chennai Unit
PI: Dr. Santoshkumar D. Bhat
Co-PI(s): Dr. Harshal Agarwal and Dr. Vishal M. Dhavale
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2023 to 31.03.2025
Budget (Rs. in Lakh): 101.320

Objectives

- Development of short-chain reinforced composite membranes for polymer electrolyte fuel cells.
- Development of sPEEK-based composite membranes for polymer electrolyte fuel cells.

Highlights

- At an operating voltage of 0.6 V, the short side chain membrane (AQP) exhibited current densities of 1.19 A/cm², 0.78 A/cm², and 0.53 A/cm² at 100%, 30%, and dry gas conditions, respectively. In contrast, the composite (AQPC) membrane (p-styrenesulfonate (PSS) on graphitic carbon nitride (CN) incorporated in AQP) demonstrated improved performance, with current densities of 1.5 A/cm², 1.12 A/cm², and 0.93 A/cm² under the same operating conditions.
- The Aq-f-CeO₂ based membrane electrode assembly (MEA) achieves a maximum current density of 2 A cm² at a cell voltage of 0.6 V and a peak power density of 1.55 W/cm², surpassing that of pristine SSC-PFSA membrane (1.2 W/cm²) in the H₂-O₂ configuration.
- Significantly, a 2 Wt.% concentration of sPSEBS within the sPEEK polymer matrix achieved a current density of 0.942 A/cm² when tested at 60 °C and 100% relative humidity (RH).

- SSC PFSA/PABS-f-SWCNT displayed remarkable cell performance of 2.1 A/cm² at 0.6 V, 60 °C and 100 % RH.

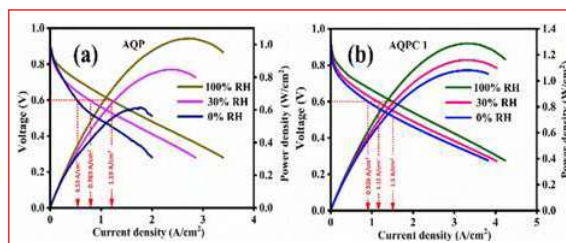


Figure 1. Polarization and power density curves showing the effect of varying humidity on fuel cell performance of (a) AQP and (b) AQPC 1 membranes

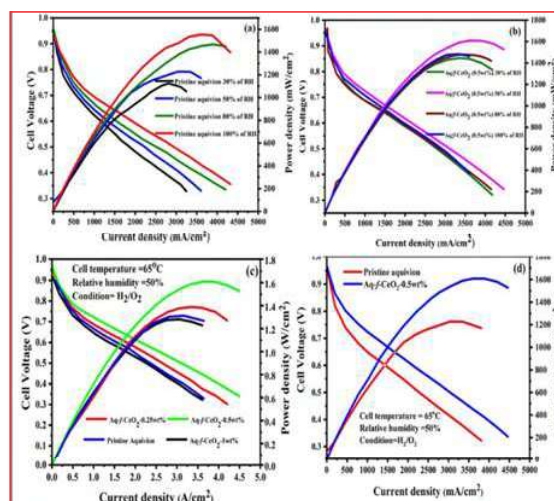


Figure 2. (a, b) Fuel cell performance of (a) SSC-PFSA and (b) SSC-PFSA-f-CeO₂ membranes at different RH% (c) Cell performance of pristine SSC-PFSA and various ratios of Aq-f-CeO₂-x wt.% (x = 0.25, 0.5, and 1 at 65 °C (H₂/O₂) under 50% RH. (d) Comparison of SSC-PFSA and 0.5 wt.% f-CeO₂-based SSC-PFSA at 65 °C under 50% RH.

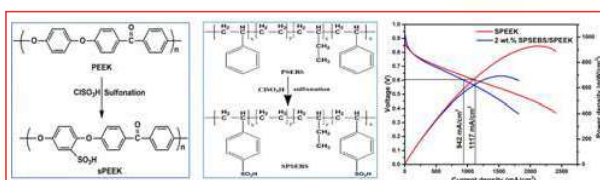


Figure 3. Mechanism of sulfonation of PEEK and PSEBS and cell performance of prepared electrolyte membranes.

Demonstration and validation of indigenously developed electrocatalyst for polymer electrolyte fuel cells

HCP-00044FBR2

Division(s): CSIR-CECRI Chennai Unit
PI: Dr. Vishal M. Dhavale
Co-PI(s): Dr. G.V.M. Kiruthika
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2022 to 31.03.2025
Budget (Rs. in Lakh): 206.12

Objectives

- Development of alternate and active Pt-based electrocatalyst (Indi. Pt/C) in comparison to state-of-the-art Pt/C.
- Development of a cost-effective synthesis method and scale-up of an alternate Pt-based catalyst.
- Integration of MEA with the indigenously developed catalyst.
- Target fuel cell performance is 0.7-0.9 A/cm² @ cell voltage of 0.6 V in a hydrogen-air atmosphere

Highlights

- Synthesized Pt nano-crystallites supported on functionalized carbon with different compositions viz. 40 and 50 Wt.% by the polyol process at elevated temperature.
- Reproducibility for 40 Wt.% Pt/C is nearly 100% at the scale of 1 and 5 g.
- Indigenous Pt/C catalyst with 40 wt.% composition showed an improved ORR performance in comparison to the commercial Pt/C catalyst.
- 40 Wt.% Pt/C catalyst showed enhanced electrochemical surface area of $\sim 90 \pm 5 \text{ m}^2 \text{ g}^{-1}$.
- MEA fabricated with Indi. Pt/C displayed a current density of 1.6 A/cm² @ cell voltage of 0.6 V in H₂-Air.

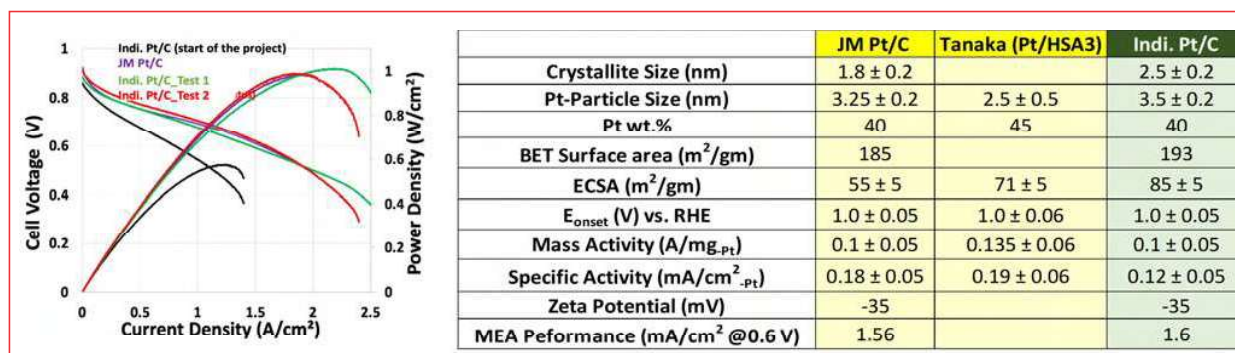


Figure 1. (left) Comparative polarisation curve of Indi. Pt/C with JM Pt/C based MEA, and (right) Comparative table of properties of Indi. Pt/C with standard JM and Tanaka Pt/C.

Phenome India – CSIR Health Cohort Knowledgebase (PI-CHeCK)

HCP-47

Division(s): Electronics & Electrocatalysis
PI: Dr. V. Ganesh
Co-PI(s): Dr. V. Murugan
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 25.11.2022 to 31.03.2027
Budget (Rs. in Lakh): 26.75

Objectives

- To develop a prospective longitudinal cohort of CSIR employees and their family.
- To develop clinically useful personalized risk prediction score for complex metabolic disorders.
- To create data-rich biorepository.
- To increase the predictive accuracy of diagnosis and prognosis of complex disorders like cardio-metabolic diseases.

Highlights

- Carried out the first phase of blood sampling

under PI-CHeCK, a national mission from CSIR in Healthcare theme in March, 2024 at CSIR-CECRI, Karaikudi.

- About 380 participants including CECRI Staff, Pensioners and their spouse were participated in the sampling and assessed their health status.
- Conducted several tests including body composition analysis, blood metabolite analysis, ECG, Spirometry, Fibro scan and Microbiome analysis to assess the health status of an individual and their impact on societal composition. (Figure 1)
- Analysis of the test results revealed interesting features connected with food habits, regional weather conditions and personal habits of an individual.
- Performed these tests and collected the samples with the help of volunteers from CSIR – CECRI, Karaikudi (Research scholars & Project assistants) and across other CSIR laboratories through enthusiastic participation. (Figure 2).

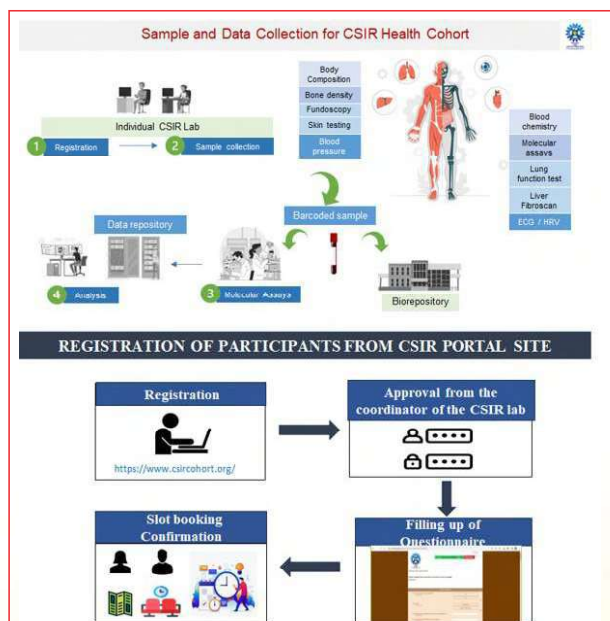


Figure 1. Pictorial representation of the various tests carried out during PI-CHeCK sampling held at CECRI Health Center for first phase of the blood sampling.



Figure 2. Photograph of the volunteers from CSIR – CECRI, Karaikudi and across other CSIR laboratories helped during the first phase of blood sampling.

Synthesis and screening of a benchmark adsorbent for CO₂ capture under flue gas conditions

HCP-48M1

Division(s): Electrochemical Process Engineering
PI: Dr. V. Ravi Babu
Co-PI(s): Dr. A. Sivashanmugam and Dr. S. Vasudevan
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 10.05.2023 to 31.03.2026
Budget (Rs. in Lakh): 951.00

Objectives

- Optimization of process parameters involved in the synthesis of bulk-scale production of adsorbent (10 kg/batch).



Figure 1. Installation and commissioning of pilot plant (10 kg/batch) at CECRI site.

- Continuous bulk scale production of CSIR-CECRI's adsorbent 10 kg/ batch.

Highlights

- Installed the pilot plant for bulk-scale production of adsorbent (10 kg/ batch) and produced 70 kg of adsorbent.
- Evaluated the cyclic stability of the adsorbent under synthetic flue gas.
- The adsorbent retained a similar CO₂ adsorption capacity of ~2.5 mmol/g for 50 cycles.



Figure 2. Adsorbent produced using existing facility.



Figure 3. 25 kg Dual tower gas adsorption unit.

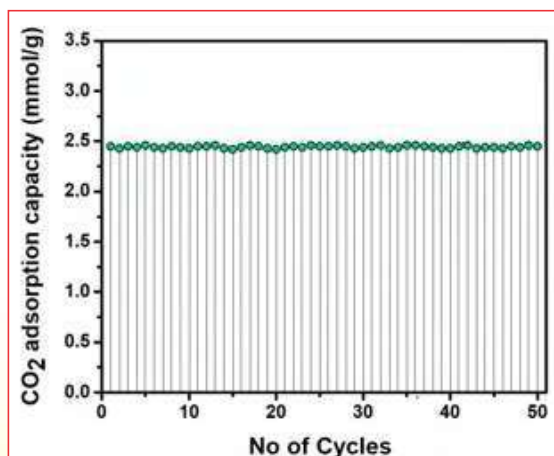


Figure 4. Multicycle stability of adsorbent under synthetic flue gas conditions

Development of carbonated bricks and aggregates for utilization of captured CO₂

HCP-48M2

Division(s): Corrosion & Materials Protection

PI: Dr. M. Ashok

Co-PI(s): Dr. J. Daniel Ronald Joseph

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 15.05.2023 to 31.03.2026

Budget (Rs. in Lakh): 31.50

Highlights

- Carried out exfoliation of expandable graphite at different temperature ranging from 200 to 1000 °C under inert temperatures. The crucible containing expandable graphite was inserted in a muffle furnace which was already set at a desired temperature for 3 min. in order to exfoliate graphite sample (EXG 200 -1000 °C). Graphene (GR) is dispersed in methanol by ultra-sonication. Pure PEEK granules are added into graphene solution and stirred. The solution is heated so as the methanol gets evaporated and the PEEK granules are coated with GR.

Objectives

- To develop laboratory scale industrial by-products incorporated carbonated bricks and aggregate using CO₂ curing technique.



Figure 1. Produced (a) Class C fly ash-based aggregates and (b) Carbonated porous concrete bricks.

Album



Celebration of Birth Anniversary of Dr. B.R. Ambedkar [April 14, 2024].

Direct air capture of CO₂ using phase-change amines and adsorption

HCP-48FBR

Division(s): Electrochemical Process Engineering

PI: Dr. V. Ravi Babu

Co-PI(s): Dr. A. Sivashanmugam and Dr. S. Vasudevan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 10.05.2023 to 31.03.2026

Budget (Rs. in Lakh): 80.60

- Tested the formulated adsorbent under different temperature and pressure conditions (Figure 2).
- The optimized adsorbent (TA-P600-4) captured CO₂ for 14 h at ambient conditions (400–450 ppm CO₂) with a CO₂ capacity of about 1.2 mmol/g (Figure 3).

Objectives

- Synthesis and modification of novel adsorption for direct air capture.
- Design and fabrication of a bench-scale adsorption unit for direct air capture.
- Testing and evaluation of CO₂ capture from direct air.

Highlights

- Installation and commissioning of direct air capture is in progress (Figure 1).



Figure 1. Direct air capture unit installed at CECRI.

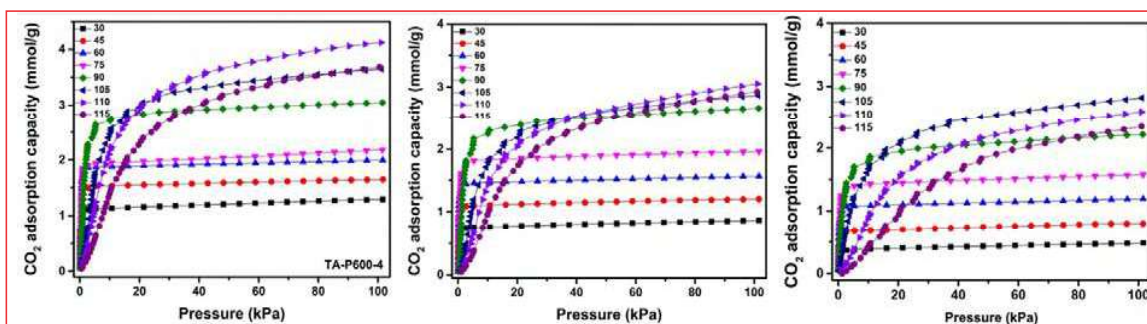


Figure 2. CO₂ adsorption capacity for PEI/silica composites at different temperatures.

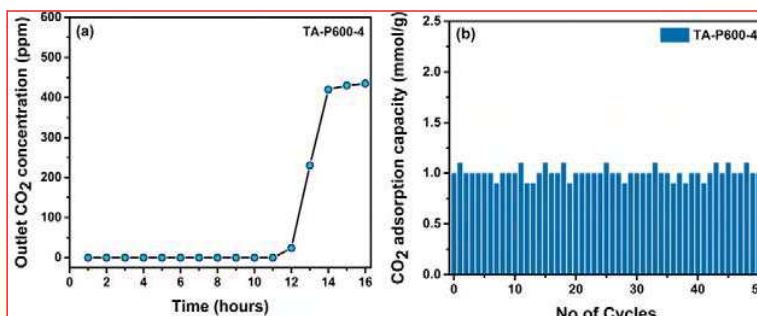


Figure 3. CO₂ adsorption under direct air conditions and multicyle stability.

Redox flow battery (RFB)

HCP-53

Division(s): Electrochemical Power Sources

PI: Dr. P. Ragupathy

Co-PI(s): Dr. A. Sivashanmugam

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 07.07.2023 to 31.03.2025

Budget (Rs. in Lakh): 157.99

Objectives

- Investigation of highly efficient and stable electrocatalyst for the effective electro-conversion of $2\text{Br}^-/\text{Br}_2$ and I^-/I^{3-} redox couples to boost the performance of metal-halide hybrid redox flow batteries.
- Exploration of an effective electrolyte formulation for metal-metal redox flow batteries (Zn/Mn, Zn/V, Zn/Ce systems).
- Exploration of robust, low cost and highly conductive ion exchange membrane for proposed redox flow batteries.
- The custom-made single cell (9 cm^2 or 25 cm^2) will

be assembled and the performance of metal-halide and metal-metal hybrid redox flow batteries will be evaluated along with the postmortem analysis.

- Demonstration of 5 kW ($2.5\text{ kW} + 2.5\text{ kW}$) Metal-Halide (Zn/Br_2) / Metal-Metal (Zn/V, Mn and Ce) hybrid redox flow battery.

Highlights

- Designed a multi-purpose single moulded gasket for electrolyte flow and sealing solution in the AVRFB system.
- β -cyclodextrin (β -CD) as a carrier in the catholyte improved electrochemical performance by stabilizing and releasing 4-hydroxy TEMPO (4-HT) radicals, speeding up electron transfer.
- The Zn/4-HT flow battery had coulombic, voltaic, and energy efficiencies of 85%, 82%, and 70%, respectively.
- Developed and demonstrated kW level of AVRFB stack as shown in Figure 1.



Figure 1. Single moulded gasket for electrolyte flow with sealing solution and AVRFB stacks (12 & 20 cells).

Rare earth recovery from waste magnet (NdFeB): Waste scrap to metal/oxide/salt product

HCP-00054M1

Division(s): Electroplating & Electrometallurgy

PI: Dr. M. Jayakumar

Co-PI(s): Dr. G. Sreedhar and Dr. C. Jeyabharathi

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.09.2023 to 31.03.2026

Budget (Rs. in Lakh): 174.50

Objectives

- Studying the voltammetric redox behaviour of RE^{3+} and $TM^{m+}-RE^{3-}$ in oxide and chloride molten salt eutectics using electrochemical techniques such as cyclic voltammetry.
- Molten salt electrolysis of rare earth metals and alloys from oxide-fluoride and chloride-based

eutectics up to 100 A, along with process optimisation.

- Simulated composition using commercial salts and RE salts recovered from spent magnets.
- Scale up of a more efficient process to 300 A/cm² on a 1 kg scale for RE alloy.

Highlights

- Fabricated a high-temperature electrochemical cell with custom-designed furnace (Figure 1a).
- RE products obtained with simulated composition mimic the spent magnets as displayed in Figure 1b.
- Electrowinning using the actual RE mixture from spent magnets.



Figure 1. (a) High temperature electrochemical cell (b) RE products from mixture simulating spent magnet composition.

Improvement of bio-methanation and enrichment of biogas (Bio-CNG) in the Himalayan region

HCP-00054M2

Division(s): Electrochemical Process Engineering

PI: Dr. V. Ravi Babu

Co-PI(s): Dr. A. Sivashanmugam and Dr. S. Vasudevan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 04.09.2023 to 31.03.2026

Budget (Rs. in Lakh): 236.00

Objectives

- Optimization of synthesis parameters of the adsorbent and test its potential for biogas enrichment.
- Investigation on the dynamics of CH_4 , CO_2 , H_2S and moisture removal under biogas conditions in a lab-scale with high selectivity towards CO_2 .
- Design and production of material for biogas enrichment.

- Enrichment of biogas to bio-CNG from 1 ton of biomass.

Highlights

- Demonstrated the adsorption capacity for a synthetic biogas mixture (40 % CO_2 and 60 % CH_4) at the SWMS biogas plant and near-zero emission of CO_2 for the first 27 minutes (Figure 1a).
- Demonstrated the excellent CO_2/CH_4 selectivity of the adsorbent, making it highly suitable for biogas upgrading applications (Figure 2b).
- Demonstrated the excellent cyclic stability and regeneration efficiency of the adsorbent for over 50 cycles (Figure 3).

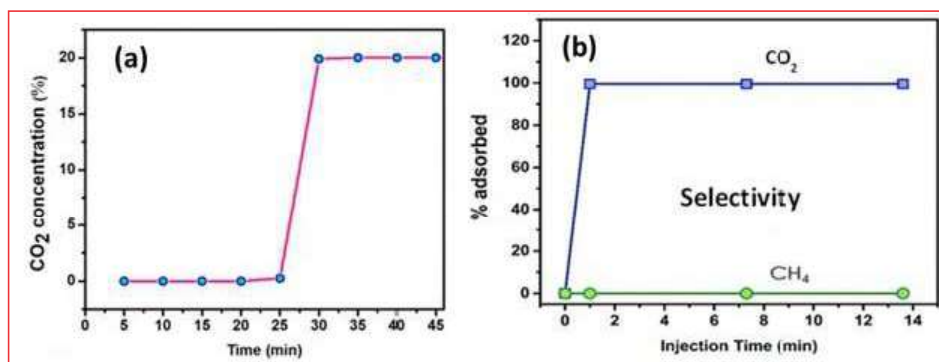


Figure 1. (a) CO_2 Breakthrough curve for 60% CH_4 and 40% CO_2 ; (b) Selectivity of adsorbent towards CO_2 .

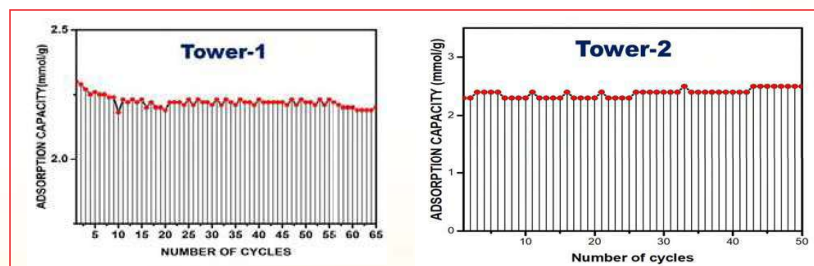


Figure 2. Multicycle stability of the adsorbent under synthetic flue gas conditions.

Valorisation of biotic & industrial wastes for energy storage application in lithium-ion battery and supercapacitor

HCP-00054M3

Division(s): Electrochemical Power Sources

PI: Dr. M. Sathish

Co-PI(s): Dr. S. Sudhakar and Dr. S.T. Nishanthi

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 12.09.2023 to 11.09.2026

Budget (Rs. in Lakh): 93.60

Objectives

- Design & development of process for biomass (Water hyacinth) derived carbon for Li-ion battery and supercapacitor application (Partner Lab).
- Multi-functional active carbon from textile industrial waste derived biochar and application in Lithium-ion batteries/supercapacitor application (Partner Lab).
- Development and demonstration of process

technology for the preparation of porous activated carbon for energy storage applications (Partner Lab).

- Fabrication of LiB (18650) and SC (100F) cells by using the waste derived carbon thus developed and testing of cell performance (CSIR-CECRI).
- Process scales up and large batch preparation for making waste derived carbon for application in LiB/SC (Industry partner).

Highlights

- Fabricated Li-ion cells with increased LFP content in the cathode and tested at different C-rates (Figure 1) and further optimization of fabrication process condition is under progress.
- Fabricated cylindrical supercapacitor device with bio-derived activated carbon, and the specific capacitance and voltage optimization via electrolyte modification is under progress.

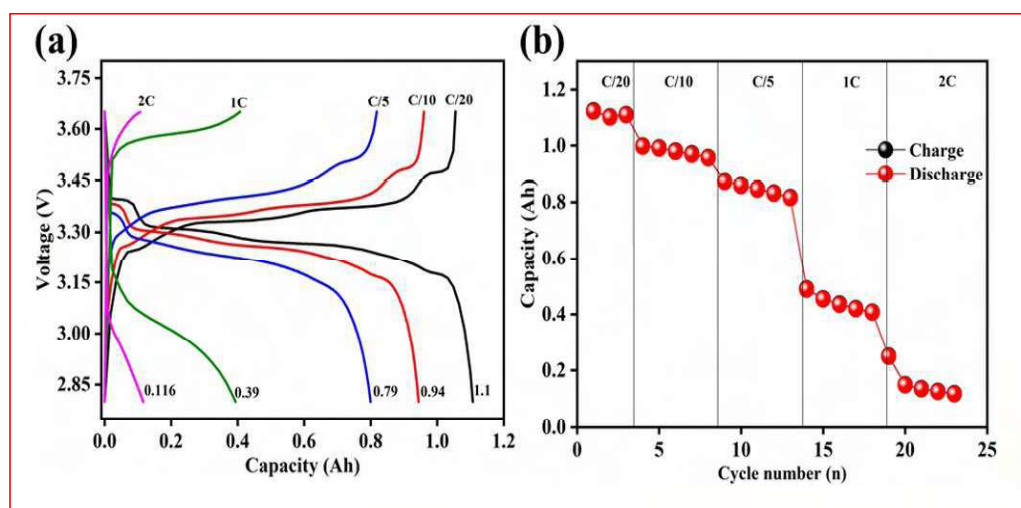


Figure 1. (a) Galvanostatic charge-discharge (b) Rate capability curves of MCMB/LFP Li-ion cells at various C-rates.

Recovery of lithium from potential Indian primary resources for battery applications

HCP-00056

Division(s): Electrochemical Power Sources and Electroplating & Electrometallurgy

PI: Dr. S.T. Nishanthi

Co-PI(s): Dr. C. Naveen Kumar

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 31.08.2023 to 31.03.2025

Budget (Rs. in Lakh): 150.880

- 18650 cylindrical cell fabrication with in-house developed LFP cathode.

Highlights

- Synthesized LiFePO_4 cathode material using Lithium carbonate from Indian primary ore.
- Powder X-ray diffraction (XRD) analysis confirmed the formation of LiFePO_4 without any other impurity phases.
- Carried out electrochemical testing in coin cell format and rate capability studies are under progress.

Objectives

- Synthesize LiFePO_4 (LFP) based cathode material from the Li_2CO_3 or LiNO_3 extracted from primary lithium sources.
- Material validation through CR2032 coin cells (half-cell studies).

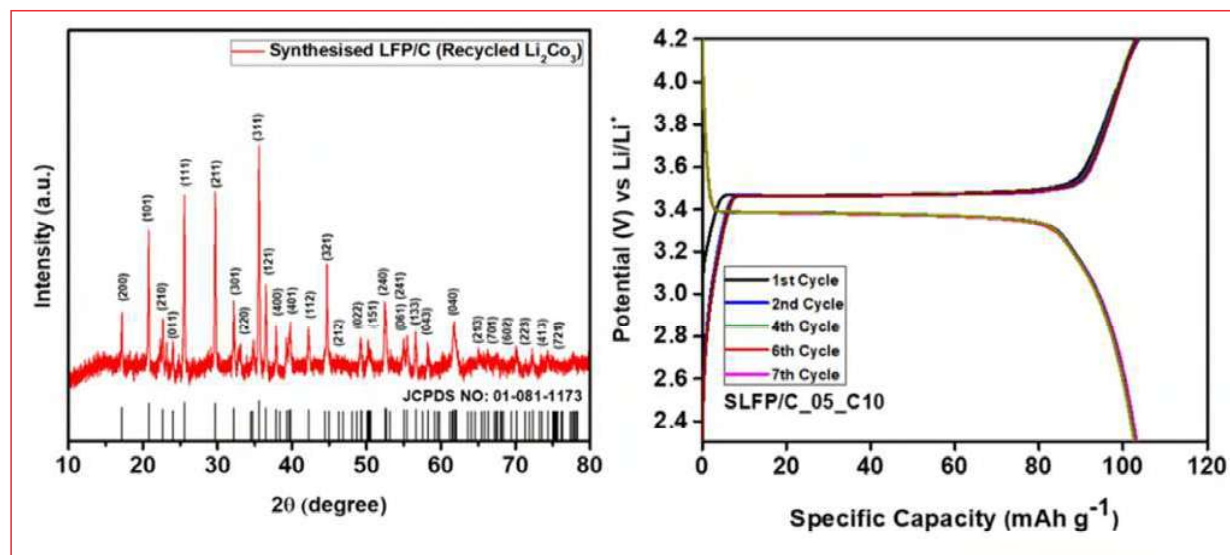


Figure 1. XRD pattern and galvanostatic charge/ discharge profile at 0.1 C of regenerated LFP cathode material

Development of eco-efficient synthetic lightweight aggregates (EESLAs) using coal refuse mixed with industrial by-products

MLP-0401

Division(s): Corrosion & Materials Protection

PI: Dr. M. Ashok

Co-PI(s): Dr. J. Daniel Ronald Joseph

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 13.09.2022 to 12.09.2024

Budget (Rs. in Lakh): 24.04

Objectives

- Development of eco-efficient synthetic lightweight aggregate for the production of concrete, bricks and paver blocks using coal refuse mixed with industrial by-products.

Highlights

- Developed synthetic aggregated using the

pelletization technique.

- Sustainable paver blocks were cast using industrial by-products such as copper slag and fly ash in varying mix proportions.
- To assess the durability and field performance of the developed paver blocks, a demonstration pedestrian pathway—measuring approximately 150 feet in length and 3.5 feet in width—was constructed at CSIR–Central Electrochemical Research Institute, Karaikudi.
- This pilot installation facilitates monitoring of real-time weathering, surface wear, and the long-term structural integrity of the blocks under actual pedestrian usage.



Figure 1. Produced synthetic aggregates based on (a) fly ash, (b) coal refuse, and (c) copper slag.



Figure 2. Paver blocks using industrial by-products.



Figure 3. Demo pedestrian pathway using sustainable paver blocks.

Development of hard chromium plating process using sulphate based electrolyte as a replacement of existing hazardous process

MLP-0402

Division(s): Electroplating & Electrometallurgy
PI: Dr. N. Rajasekaran
Co-PI(s): Dr. C. Naveen Kumar
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 23.09.2022 to 30.09.2024
Budget (Rs. in Lakh): 125.00

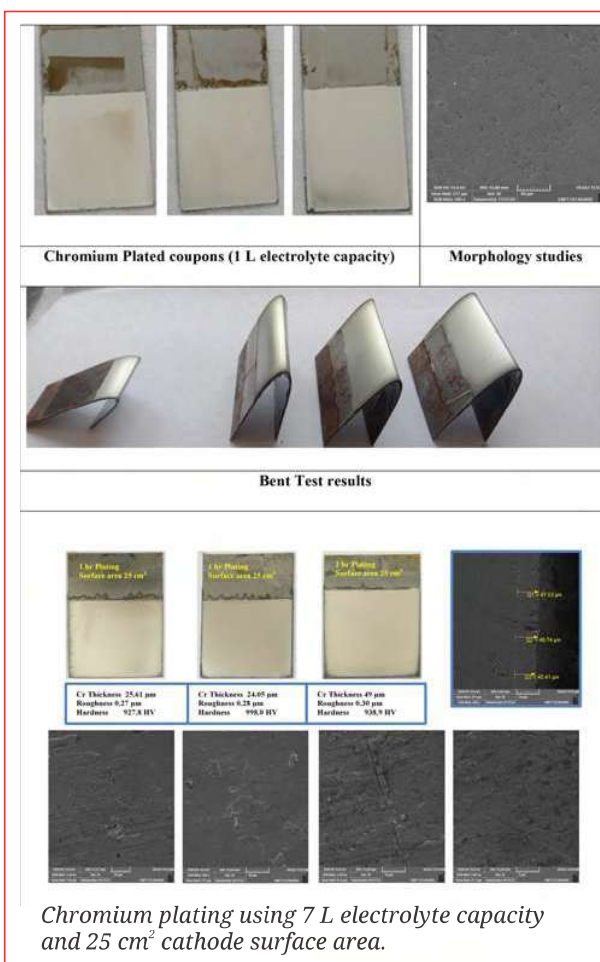
Objectives

- To develop eco-friendly sulphate based electrolytes for hard chromium plating process.
- To optimize the composition, concentration and stability of the electrolyte.
- To optimize the plating parameters like current density, electrolyte pH and temperature.
- To scale up the process up to 20 L electrolyte capacity.
- Chromium coating with >40 micron thickness.
- Coating with good corrosion resistance (~250 hrs NSS) and abrasion wear resistance (<20 mg per 10000 cycles).

Highlights

- The electrolyte composition and conditions were optimized in 7 L electrolyte capacity.
- The micro hardness and thickness of the deposits were observed. The maximum microhardness observed is 998 HV and also the 49 μm coating thickness was achieved.

- Surface morphology and bent test confirms the better quality of chromium deposits with good adhesion properties.



Alternate fluoride and sulphide based cathode materials for thermal batteries

MLP-0404

Division(s): Electroplating & Electrometallurgy and Electrochemical Power Sources

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: DRDO-Research Centre Imarat (RCI)

Duration: 25.04.2023 to 31.03.2025

Budget (Rs. in Lakh): 208.81

Highlights

- Synthesized MoS_2 , CoS_2 , FeF_3 and Cu_2O at a scale of 100 g per batch via hydrothermal/one-pot method in an indigenously developed pressure reactor.
- Manufactured thermal batteries at Hyderabad Batteries Limited with the assistance of DRDO-RCI, using CoS_2 , FeF_3 , and Cu_2O based materials and their performance was compared with that of commercial CoS_2 and FeS_2 .
- Materials were sent to DRDO-RCI and Hyderabad Batteries Limited for testing as cathodes in thermal batteries versus LiSi alloy; results are shown in Figure 1.

Objectives

- Produce electrically conducting (Fe-Co-Zr-Ni) trifluorides, CoS_2 and MoS_2 , CuO materials as cathodes for thermal batteries at a scale of 500 g per day.
- Analyze their suitability (targeted properties: thermal stability, stable voltage plateau, good discharge potential) as cathode materials in thermal batteries.

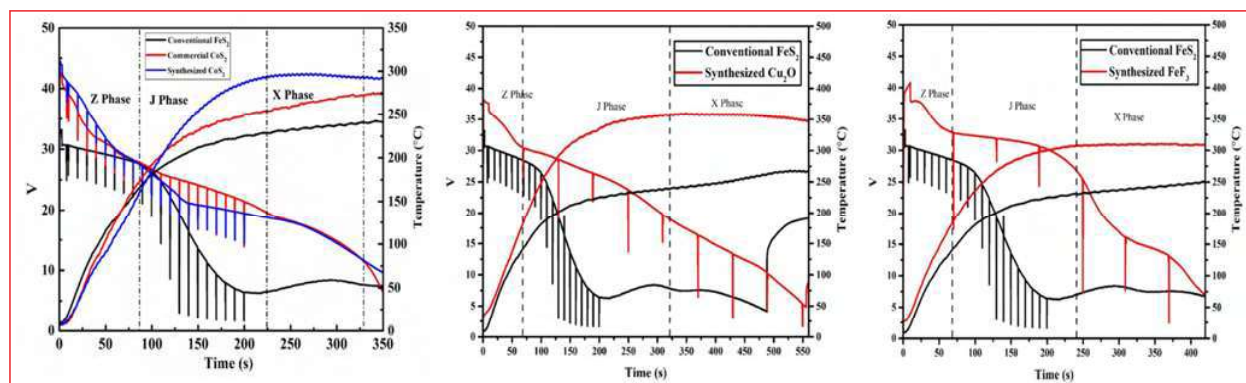


Figure1. Discharge Performance of 17 Cells Series Connected LiSi- FeS_2 and LiSi- CoS_2 , LiSi- FeF_3 and LiSi- Cu_2O ; Battery Modules with Load Current of 5A (Continuous) & 19.9A (Pulsed).

Development of electrically rechargeable zinc air batteries

MLP-0405

Division(s): Electrochemical Power Sources and Electroplating & Electrometallurgy

PI: Dr. S.T. Nishanthi

Co-PI(s): Dr. Aiswarya Bhaskar

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2023 to 31.03.2025

Budget (Rs. in Lakh): 135.00

Objectives

- Gram scale synthesis of carbon-based bifunctional oxygen catalyst (both OER & ORR) with minimum potential gap.
- Fabrication and optimization of advanced air cathode ($10 \times 10 \text{ cm}^2$).

- Development of reversible zinc based anodes to increase the efficiency (>50%).
- Optimal cell designing and tested towards zinc air batteries ($10 \times 10 \text{ cm}^2$) with cycle life of >1000 cycles (50 % DODzn).

Highlights

- Synthesized various bifunctional oxygen catalysts including carbon-based catalysts and studied their electrochemical performances.
- Synthesized reversible zinc anode through electrochemical deposition and its parameter optimization was carried out.
- Designed ERZAB cell with a size of $10 \times 10 \text{ cm}^2$ and tested at 10 mA/cm^2 .

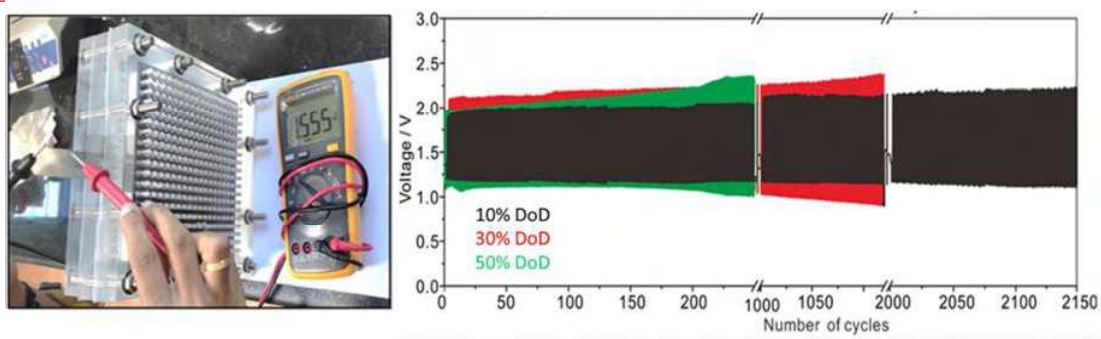


Figure 1. Photograph of 100 cm^2 in-house assembled zinc-air battery with ZIF-67@Pt/CB catalyst and Galvanostatic charge/discharge profile at 10 mA/cm^2 .

Cobalt-free and low cobalt, high-capacity cathodes for lithium-ion batteries

MLP-0406

Division(s): Electrochemical Power Sources

PI: Dr. Aiswarya Bhaskar

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2023 to 31.03.2025

Budget (Rs. in Lakh): 125.999

Objectives

- To develop Cobalt-free or less cobalt high-capacity positive electrode material for next generation lithium-ion batteries (LIBs).
- To carry out investigations on structure, morphology and electrochemical performances of synthesized material.

Highlights

- Synthesized cobalt-free, iron-containing layered-spinel composite positive electrode materials by employing the co-precipitation method for applications in lithium-ion batteries.
- The XRD analysis of layered spinel integrated materials with nominal compositions $0.6[\text{LiNi}_{0.4}\text{Mn}_{0.4}\text{Fe}_{0.2}\text{O}_2]-0.4[\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4]$ and $0.6[\text{LiNi}_{0.5}\text{Mn}_{0.3}\text{Fe}_{0.2}\text{O}_2]-0.4[\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4]$ revealed a set of reflections corresponding to the layered

phase which could be assigned to the space group $R\bar{3}m$ and another set of reflections corresponding to the spinel phase with space group $Fd3m$. Additional reflections were observed indicating the impurity phase Fe_3O_4 .

- The initial charge capacity delivered by LS64-NMF442-CP and LS64-NMF532-CP was 135 mAh g^{-1} and 143 mAh g^{-1} , respectively. The LS64-NMF442-CP and LS64-NMF532-CP offered initial discharge capacity of 148 mAh g^{-1} and 132 mAh g^{-1} , respectively (Figure 1). The initial coulombic efficiency exhibited by LS64-NMF442-CP and LS64-NMF532-CP was $>100\%$ and 93% , respectively.
- The low initial charge capacity and high coulombic efficiency of LS64-NMF442-CP in the first cycle could be attributed to the absence of electrochemical activity of Mn ($\text{Mn}^{3+} \rightarrow \text{Mn}^{4+}$) from the spinel component during the first charge. The coulombic efficiency values obtained for cells assembled with both samples were $>97\%$ after 7 cycles. The materials, LS64-NMF442-CP and LS64-NMF532-CP delivered a capacity retention of 89% and 71% (calculated w.r.t. 8th cycle) after 100 cycles.

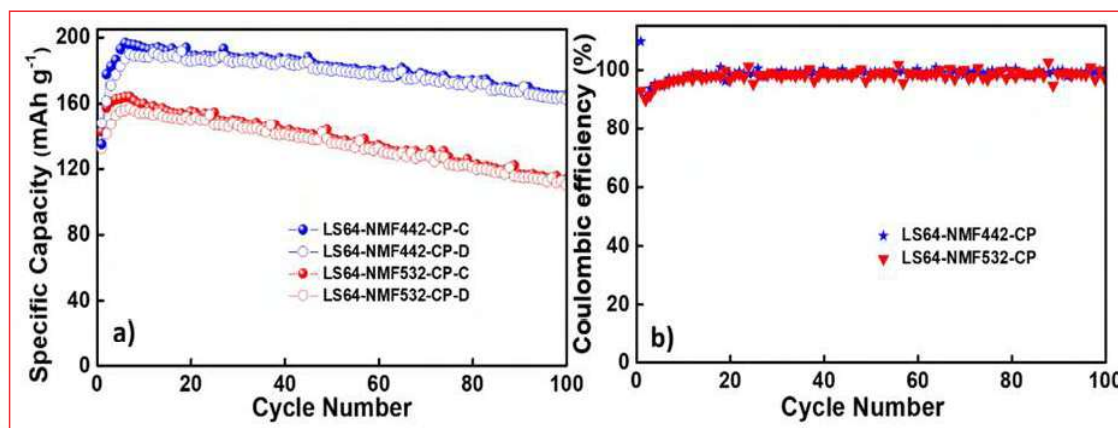


Figure 1. a) Cycling stability studies of LS64-NMF samples in the voltage range of 2.00-4.95 V vs. Li^+/Li at a C-rate of C/10, where "C" depicts charge and "D" depicts discharge and b) corresponding coulombic efficiency plot.

Indigenous development of processes and materials for highly efficient and stable perovskite solar cell technology

MLP-0407

Division(s): Electroplating & Electrometallurgy
PI: Dr. Subhendhu Kumar Panda
Co-PI(s): Dr. A. Pandikumar
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2023 to 31.03.2025
Budget (Rs. in Lakh): 158.40

Objectives

- Strengthening CSIR's capabilities to tackle challenges in the development, fabrication, characterization, and scaling up of highly efficient perovskite solar cells.
- Optimizing processes and device structures to achieve reproducible power conversion efficiencies (PCE) between 20-23% in small-area devices (active area of 0.1-0.2 cm²) using standard materials and architectures, with stability tested at 5000 h.
- Development and refinement of scale-up methodologies for perovskite mini-modules (5 × 5 cm²) targeting power conversion efficiencies of 15-17%, as well as larger-area modules, utilizing the established scale-up infrastructure at CSIR-NIIST, with demonstrated stabilities of 3000 h for mini-modules and 1000 h for full-sized modules.
- Development and synthesis of advanced materials aimed at achieving high-efficiency and stable perovskite solar cells, including 2D, 3D, and 2D-3D hybrid perovskites, as well as organic and inorganic hole and electron transport materials (HTMs and ETMs), and their paint-based formulations.
- To function as the nodal laboratory for supporting and facilitating the screening of perovskite and related materials/molecules within CSIR, with a focus on technology development and commercialization.

Highlights

- Formulated a highly conductive carbon ink exhibiting excellent stability, hydrophobicity

and resistivity of 30-60 Ω.cm that is suitable for perovskite solar cells and a provisional Indian patent was filed on the formulation.

- Stabilized FAPI layer by using P-QDs under ambient conditions and characterized.
- Optimized the TiO₂ electron transport layer (ETL) paint formulation (50 ml per batch).
- Coated the ETL paint onto large scale substrates and observed uniform pin-hole free coating with improved stability, high optical transmittance and improved wettability.
- Prepared Pb-free perovskite inks such as MA₃Sb₂I₉ and MABiI₃ for studying their opto-electronic properties and application in solar cell.

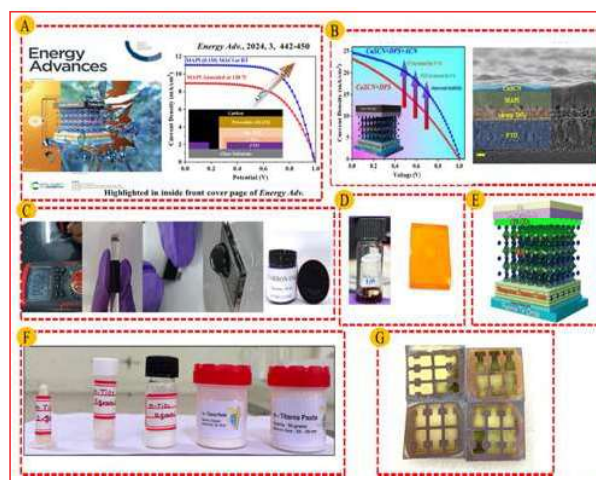


Figure 1. A) MACl stabilized MAPi for highly efficient Perovskite solar cell was highlighted in Energy Advances by RSC Publications. (B) CuSCN for improved hole transport material for enhanced PSC application. (C) Carbon Paint as a Counter electrode. (D) Optimized Pb-free Perovskite Solar cells. (E) Schematic representation of the PSC Architecture for P-QDS. (F) Different Formulations of TiO₂ as Electron Transport layer. (G) Fabricated MAPi based Perovskite solar cell.

Upscaling of neodymium metal/ Nd-Pr production along with other rare earth metals (La, Ce) and their alloys by molten salt electrolysis

MLP-000088

Division(s): Electroplating & Electrometallurgy

PI: Dr. M. Jayakumar

Co-PI(s): Dr. G. Sreedhar and Dr. C. Jeyabharathi

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.09.2023 to 31.03.2026

Budget (Rs. in Lakh): 470.66

- Upscaling the chlorides-based molten salt electrowinning process of Rare Earth metal/alloy (La, Ce, Nd) & (NdPrFex, NdFex, NdPrx, LaNiy) up to 1000 A capacity (Phase-II).
- Evaluation of Nd product for permanent magnet application and physico-chemical characterization of Nd product and technology demonstration (Phase I & II).

Objectives

- Development and optimization of molten salt electrowinning conditions for Rare Earth metal/alloy (La, Ce, Nd) & (NdPrFex, NdFex, NdPrx, LaNiy) at 300 A capacity through the chloride route (Phase I).
- Development and optimization of molten salt electrowinning conditions for Rare Earth Borides, REB₆ (RE: La, Ce, Nd, Sm, Eu) at 100 A (Phase I).

Highlights

- Achieved the electrowinning of RE metals with purity (La: > 90 %, Ce > 70 %), RE alloys (La-Ni: > 95 %, Nd-Pr: > 70 %) and RE Borides, REB₆ (La, Sm, Ce :> 99 %) (Figure 1).
- Establishment of a controlled atmosphere facility is in progress.



Figure 1. Electrowon RE products through molten salt electrowinning.

Electrochemical-based eco-friendly recovery of bioactive compounds and polymers from seaweeds

FTT-020511

Division(s): Electrodeics & Electrocatalysis

PI: Dr. V. Murugan

Co-PI(s): Dr. S. Senthilkumar

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 77.76

Objectives

- To develop optimal electrode substrate(s) for in situ depolymerization of seaweed powder.
- To establish optimal electrolyte, pH, surfactant and potential to achieve gram scale synthesis of dimeric and monomeric saccharides.
- To establish harvesting protocol for other phycocolloids in anode/cathode surface and bulk electrolyte.
- Determination of composition and purity of seaweed extracts.
- Comparison of the quality of the phycocolloids with those produced by conventional methods.

Highlights

- Carried out the experimentation of 500-2000 mL capacity reactor for electrohydrolysis of marine

algal biomass to derivatize κ -carrageenan and sodium alginate.

- Explored the optimal potential, electrode surface, electrolyte composition for isolation of κ -carrageenan & other phycocolloids from *Kappaphycus alvarezii*.
- Studied the optimal choice of anode/cathode for leachant-free isolation of bioactive compounds from *S. wightii*.



Figure 1. Representative product image isolated from *Kappaphycus alvarezii* via electrochemical method. (a) -Carrageenan (yield 41-59 %), (b) cellulose (yield 1.47 %) and (c) polyphenol (yield 1.7-10%).

Table 1: Key parameters for electrochemically-isolated κ -Carrageenan compared with standard samples.

Commercial grade parameters for κ -Carrageenan (KC)	Commercial standard from SRL Chemicals Pvt. Ltd., India	CECRI KC	Indian Standard 16147:2014 for food grade
Avg. viscosity (cP)	41.42	32.28	>5 cP
Ash content (%)	19.35	16.30	15 – 40
pH	5	9.56	8-11

Propylene carbonate from carbon dioxide

FTT-030501

Division(s): Electroplating & Electrometallurgy and Electro-organic & Materials Electrochemistry

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. M. Kathiresan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 163.54

Highlights

- **Sustainable Approach:** A facile strategy to synthesize propylene carbonate from CO₂ and propylene oxide using ionic resins, promoting carbon utilization.
- **Efficient Catalyst:** Ionic resin catalyst exhibits high stability, reusability and minimizing the need for regeneration or replacement.
- **Mild Reaction Conditions:** The process operates under low pressure and moderate temperatures, significantly reducing energy consumption compared to conventional methods.
- **High-Purity Product:** Produced high-purity propylene carbonate without solvent-based purification or energy-intensive post-processing, streamlining industrial application.
- **Eco-Friendly Process:** Eliminates solvent usage and minimizes waste, aligning with stringent regulatory and sustainability goals (SDG: 7 Affordable and clean energy).

Objectives

- A sustainable approach for the synthesis of propylene carbonate from CO₂ and propylene oxide.
- Production of High-Purity Propylene Carbonate (>99%) Industrial and Commercial Applications.
- Design and Development of flow reactor for Synthesis of Propylene Carbonate from propylene oxide and Carbon dioxide at a scale of 5 kg per day.
- Optimization of Parameters Suitable for pilot scale demonstration.
- Technology Demonstration.

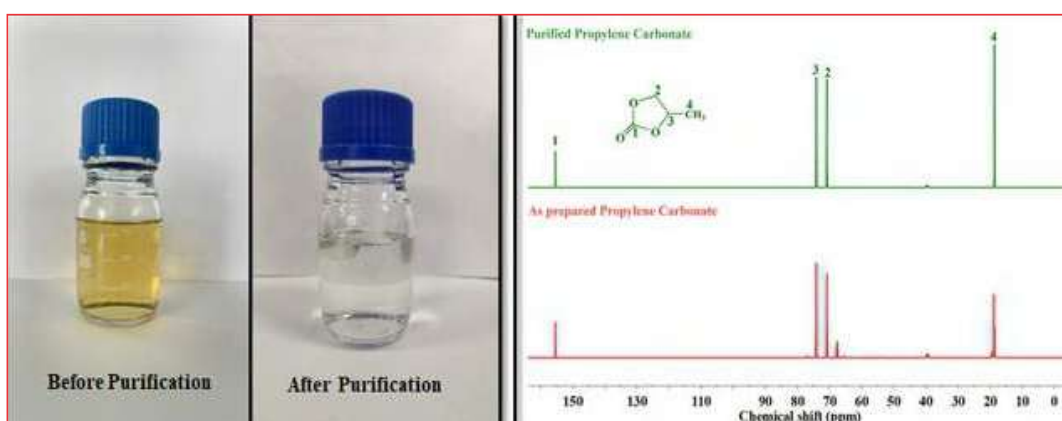


Figure 1. Synthesized Propylene Carbonate using Brominated Anionic Resin.

Development of efficient scale-up strategies for indigenous alkaline anion exchange membranes (AAEMs) for water electrolyzers

FTT-060502

Division(s): Electrochemical Process Engineering and Electroplating & Electrometallurgy
PI: Dr. S. Vengatesan
Co-PI(s): Dr. R. Malini and Dr. C. Jeyabharathi
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2024 to 31.03.2026
Budget (Rs. in Lakh): 196.40

Objectives

- Design and synthesis of novel aromatic hydrocarbon anion exchange polymers.
- Strategies for scale-up of polymer synthesis protocols (~50 g).
- Strategies for scale-up of large area membrane (25 x 20 cm²) fabrication by solution casting (sheet type) and hot melt extrusion (roll type) processes.

- Physico-chemical and mechanical characterization of the membrane.
- Application of the membrane in a water electrolyser for making a 0.5 kW system.

Highlights

- Developed anion exchange membranes with high conductivity using styrene (backbone monomer) and 4-vinyl pyridine (functional monomer) via radical co-polymerization method.
- Performed the co-polymerization reaction by varying co-monomer ratios using three methods: (i) dispersion co-polymerization (radical), (ii) bulk co-polymerization (controlled radical), and (iii) TEMPO-mediated co-polymerization (controlled radical) (Figure 1).
- Set up a reactor unit for scaling-up of anion exchange polymer synthesis (Figure 2).

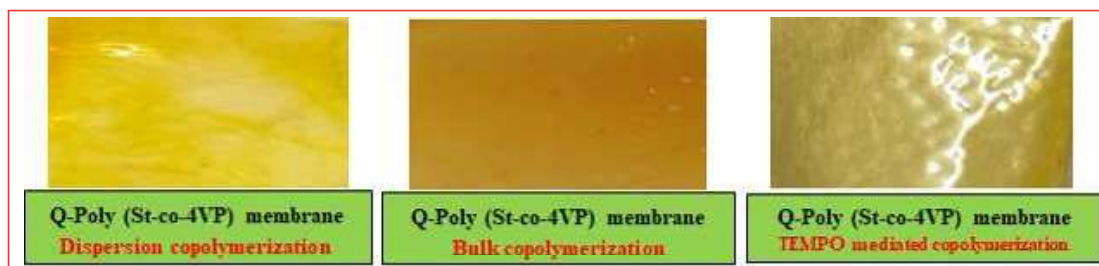


Figure 1. Anion exchange membranes prepared by various polymerisation methods.



Figure 2. Synthesis reactor unit for scale-up synthesis of polymer.

Scale up of short side chain PFSA composite membrane for low humidity polymer electrolyte fuel cells

FTT-060503

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. Santoshkumar D. Bhat

Co-PI(s): Dr. Harshal Agarwal and Dr. Vishal M. Dhavale

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

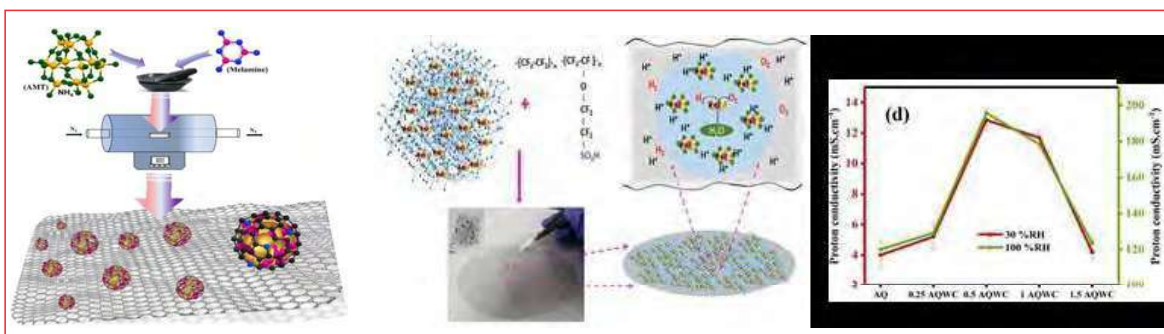
Budget (Rs. in Lakh): 159.40

Highlights

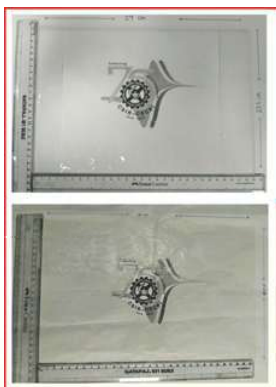
- Synthesized $W_2C@NC$ via isothermal temperature programmed carburization with controlled gas flow and optimum carbon source.
- Fabricated membrane with uniform thickness with ionic conductivity of 150 mS cm^{-1} at 100 % RH and scaled-up to 700 cm^2 with thickness within $20 \mu\text{m}$
- SSC PFSA and SSC-PFSA/ $W_2C@NC$, composite membranes displayed ionic conductivity of 170 and 190 mS cm^{-1} respectively at 100 % RH.
- SSC-PFSA membrane displayed single cell performance of the range of $1\text{-}1.5 \text{ A/cm}^2$ at 0.6 V , 60°C and 100% RH. The comparison confirms the scaled up membranes provide on -par performance compared to the lab version of the membranes.

Objectives

- Preparation of short-side chain composite membranes comprising SSC-PFSA and tungsten semi-carbide/PABS-f-SWCNT.
- Scale up of the composite membranes with solvent casting in Elcometer film applicator and melt cavity casting with area up to 600 cm^2 .



Scheme1. (a) Synthetic procedure and morphology of $W_2C@NC$ (b) Preparation of SSC-PFSA/ $W_2C@NC$ composite membrane and its ionic conductivity.



Scheme 2: Scaled up (a) SSC-PFSA and (b) SSC-PFSA/ $W_2C@NC$ composite membrane.

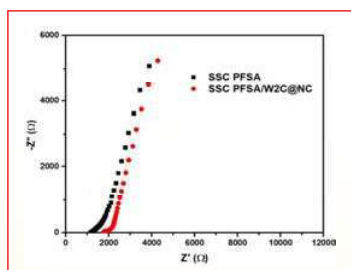


Figure 1: Nyquist plot of SSC-PFSA and SSC-PFSA/ $W_2C@NC$.

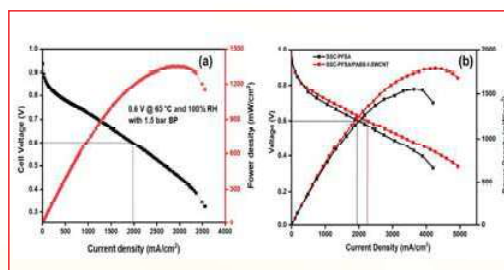


Figure 2. Polarization curves of (a) SSC-PFSA/ $W_2C@NC$ membranes (b) SSC-PFSA and SSC-PFSA/ PABS-f-SWCNT (0.5 Wt.%) composite membrane.

Fuel cell e-tractor: Development of drive train

FTT-060504

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. Harshal Agarwal

Co-PI(s): Dr. Vishal M. Dhavale

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 45.86

Objectives

- Conceptualization and design of Fuel Cell operated E-Tractor (11 hp).
- Design and development of PEM Hydrogen Fuel Cell Engine (HFCE) (Beta version) for electric tractor (Power Rating ~5 kW).
- Design and development of Fuel Cell management system (FCMS) (Beta version) for data analysis and health monitoring using AI and ML.
- Development of drive train for Fuel Cell operated E-Tractor (11 hp).

- Testing and performance analysis of the developed PEMHFCE based drive train using Trans-axle test bed.

Highlights

- Prepared the 3D CAD models of
- The essential components of tractor viz., transmission system, hydraulic assembly, seat assembly, steering assembly and front axle.
- The drive train components viz., battery pack, hybridization converter, electric motor.
- The PEMHFCE system viz., humidifier and recirculation pump.
- Finalized the design of indigenous 5 kWe stack and modelling is in progress.
- Fabricated the Anode Ejector (CFD assisted design).
- P&ID is finalized and testing plan is ready for individual components and lines.
- Fuel Cell ECU hardware is ready and software development of fuel cell electronic control unit (ECU) is under progress.

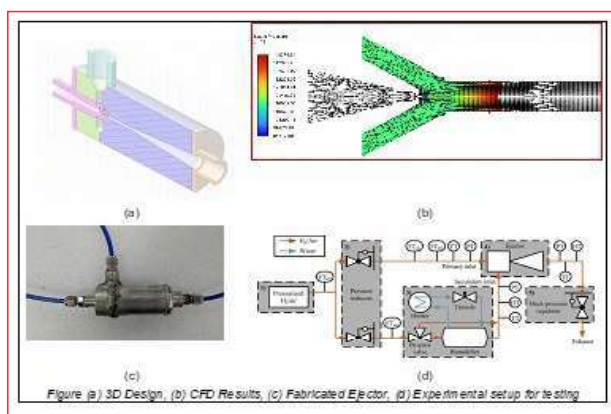


Figure 1. (a) 3D Design, (b) CFD Results, (c) Fabricated Ejector, (d) Experimental setup for testing.

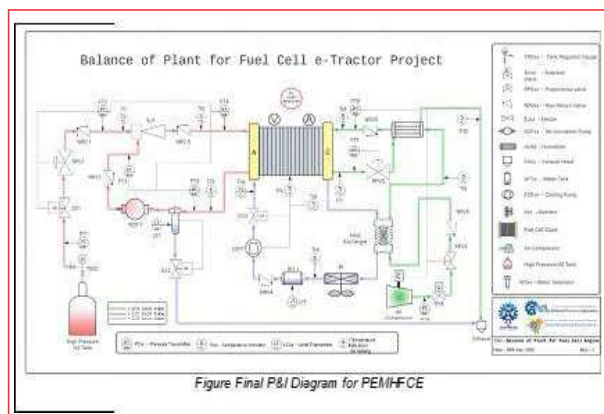


Figure 2. Final P&ID Diagram for PEMHFCE.

Development of light weight Mg based AP65 and AZ31 alloy for defence/ strategic energy applications

FTT-080503

Division(s): Electroplating & Electrometallurgy

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. N. Rajasekaran

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 172.00

Objectives

- Development of lightweight Mg AP65 alloy and AZ31 alloy as negative electrodes to operate with high power & short duration on seawater-activated batteries.
- Development of light weight Mg based AP65 alloy and AZ31 alloy with a large-scale dimension 265 mm (L) x 265 mm (W) x 0.33 mm (T) for sea water batteries to deliver discharge operating voltage higher than 1.2 V and cut-off voltage greater than 1.0 V at 350 mA cm⁻² high current density.
- The proposed novel Mg-based AP65 and AZ31 battery grade anode alloy can be patented, and efforts will be continued toward the technological transformation to real-time

industrial needs. Technology can be transferred to DRDO-NSTL.

Highlights

- Fabricated a graphite die with inner dimensions 300 mm × 250 mm × 25 mm to produce Mg alloy through casting.
- Mg AZ31 and Ap65 alloys were produced through casting and hot rolling processes.
- Elemental composition (through EDS, ICP-OES) and XRD patterns were found to match the commercial alloys.
- CECRI AZ31 showed superior corrosion resistance, making it ideal for low-power long-endurance seawater batteries, despite a slight reduction in discharge voltage.
- CECRI AP65 demonstrates enhanced charge transfer resistance and a higher discharge voltage, making it suitable for high-power, short-duration seawater-activated battery applications requiring high electrochemical stability and reactivity.

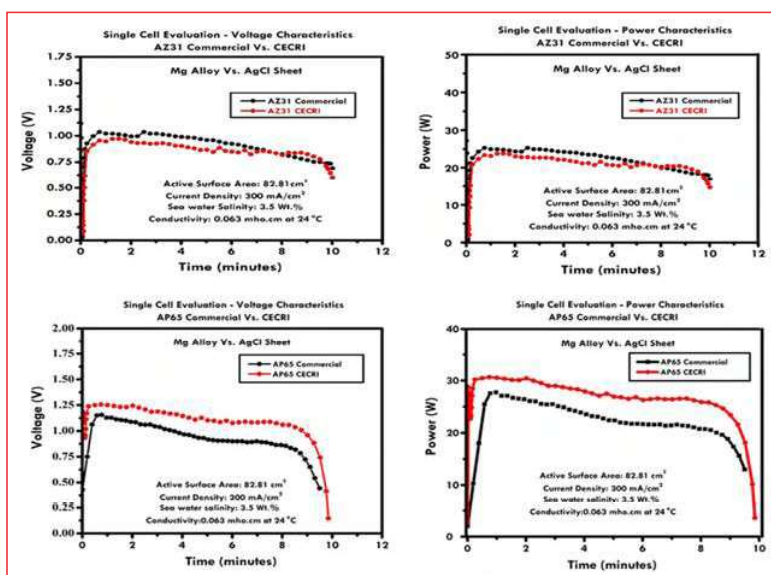


Figure 1. Electrochemical properties of the seawater battery using CECRI's electrode.

Light-weight automotive component from indigenously developed 6063 aluminium alloy powder by additive manufacturing

FTT-080504

Division(s): Electrochemical Process Engineering and Engineering & Technical Services
PI: Dr. Deepak Kumar Pattanayak
Co-PI(s): Er. Srinivasan Perumal
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2024 to 31.03.2026
Budget (Rs. in Lakh): 187.00

Objectives

- Development of indigenous AM-grade aluminum Al6063 alloy powder.
- Optimization of process parameters such as laser power, scan speed, hatch spacing, and volumetric energy density to achieve dense components using selective laser melting (SLM).
- Heat treatment and post-treatment optimization, such as solutionisation and artificial ageing of Al6063 alloy SLM component.
- Evaluation of microstructure, composition, phase, and mechanical properties (Hardness, Yield strength, Tensile strength, Elongation, and

Fatigue strength) of as-built and post-treated Al6063 alloy.

- Corrosion and wear resistance analysis of as-built and post-treated Al6063 alloy.
- Development of automotive components such as suspension components (like suspension knuckles) and battery pack parts with complex designs using SLM technology, along with evaluation of properties in collaboration with the industry partner NALCO, Odisha, and validation by the agency ARAI, Pune.

Highlights

- Developed an indigenous AM grade spherical Aluminium Al6063 powder of 15-45 microns by plasma-based spherulidisation technique as shown in Figure 1.
- Al6063 powder was microalloyed using Ti nano powder, as shown in Figure 2.
- Optimized the process parameters to obtain crack-free and highly dense samples (Figure 3).

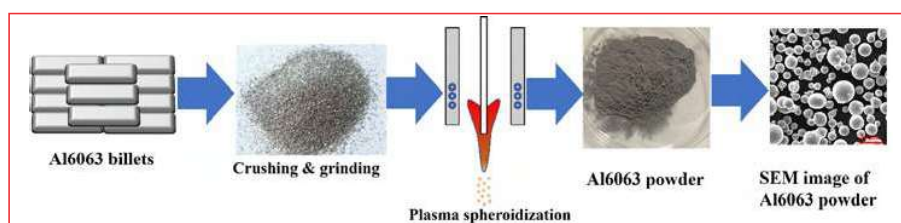


Figure 1. Schematic diagram of powder preparation process.



Figure 2. Schematic diagram for process optimization.



Figure 3. Optical micrographs of Al6063 specimens (a) prior to microalloying and after microalloying using b) 0.5 and c) 1 wt % Ti nano powder.

Decoupled water electrolyzer for independent hydrogen and oxygen production

FIR-060304

Division(s): Electro-organic & Materials Electrochemistry
PI: Dr. A. Pandikumar
Co-PI(s): Dr. S.M. Senthilkumar
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01. 04. 2024 to 31.03.2026
Budget (Rs. in Lakh): 85.58

Highlights

- Electrochemical studies of phosphomolybdic acid (PMA), phosphotungstic acid (PTA), and silicotungstic acid (STA) revealed their characteristic redox behaviour. PMA showed multiple redox peaks with a first reduction at +0.25 V vs. Ag/AgCl, while PTA and STA exhibited reduction peaks at -0.25 V vs. Ag/AgCl, corresponding to two- and multi-electron transfer processes, respectively.
- Studied the liquid redox-mediated water splitting in 0.1 M H_3PO_4 in both chambers, then with POM in one chamber and H_3PO_4 in the other. In this setup, POM reduction couples with OER, and POM re-oxidation couples with HER.
- Among the three POMs studied, PMA is stable in the ambient environment compared to PTA and STA, resulting in prolonged reoxidation, causing HER in another chamber.
- Assessed the purity of the gas using gas chromatography, and the gas was also quantified for the decoupling systems with three POMs. The highest hydrogen production rate was observed in the PMA-based decoupling system, followed by the PTA and STA-based systems.

Objectives

- To construct a decoupled electrolyzer with a liquid redox mediator and a suitable OER/HER electrocatalyst for the overall alkaline and acidic electrolysis of water.
- The effect of different polyoxometalates as liquid redox mediators is to be examined, in which decoupling of hydrogen and oxygen for hydrogen production is carried out.
- To construct a decoupled electrolyzer with a liquid redox mediator and suitable OER/HER electrocatalyst for the overall alkaline and acidic electrolysis of water.
- Stability of POMs in the decoupling system is demonstrated using the chronoamperometry technique, and the hydrogen produced is to be quantified using GC analysis.

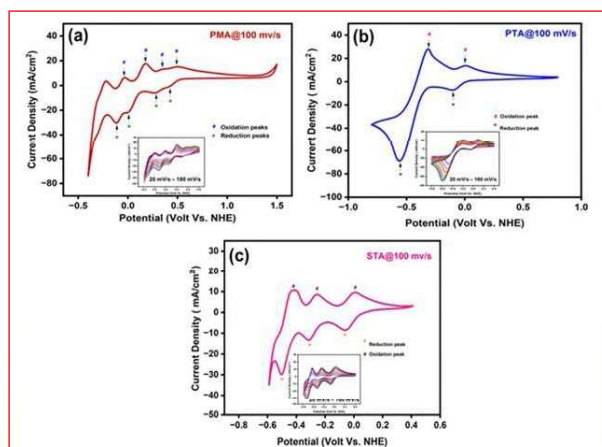


Figure 1. Cyclic voltammograms for (a) PMA, (b) PTA and (c) STA at 100 mV/s with 0.05 M concentration.

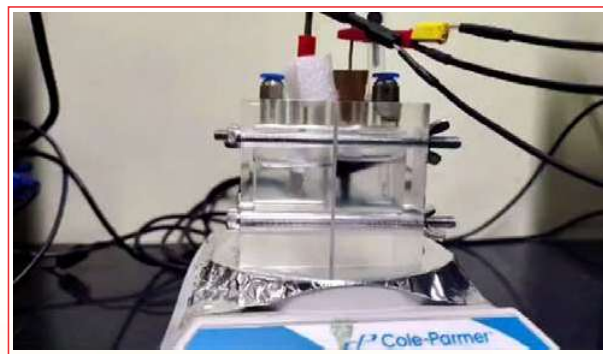


Figure 2. Digital photograph of decoupled electrochemical cell.

Understanding the site-specific activity and rational designing of non-noble metal oxide-supported single-atom catalysts: A time-resolved electrochemical tip-enhanced Raman spectroscopy study

FIR-060305

Division(s): Electrodics & Electrocatalysis and Electroplating & Electrometallurgy

PI: Dr. P. Tamilarasan

Co-PI(s): Dr. C. Jeyabharathi

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01. 04. 2024 to 31.03.2026

Budget (Rs. in Lakh): 84.00

Highlights

- Synthesized M_1/NMO SAC with Pt metal sites by electrochemically depositing metal oxide host followed by controlled physical vapour deposition of ultra sub-monolayer Pt atoms at high temperature using a modified DC sputtering system.
- Confirmed the Pt atoms in the host by the atomic number dependent contrast in the high resolution transmission electron micrograph.
- Used the indigenous TERS tip for spatial surface mapping of ultra-sub-monolayer of Nile Blue A on the SAC thin film. The redox reaction of NBA is monitored temporally and correlated with applied potential in time domain. The chemical changes during the redox reaction are in agreement with our previous report using SHINERS.
- Indigenously fabricated the ultrasharp gold tips due to unavailability of the TERS tips. The tips were loaded onto the tuning fork cantilever and tested successfully.

Objectives

- To develop M_1/NMO ($M = Pt, Pd$; $NMO = CeO_2, SnO_2, TiO_2$) single-atom thin film catalyst by physical vapour deposition and determine the electrocatalytic activity using a standard redox probe.
- To identify the target active sites by spatial mapping and determine the potential-dependent changes by temporal mapping using electrochemical tip-enhanced Raman Spectroscopy.
- To deploy the site-specific activity and stability information to optimize the synthesis conditions of M_1/NMO catalyst for high hydrogen evolution, oxygen evolution and oxygen reduction activities.

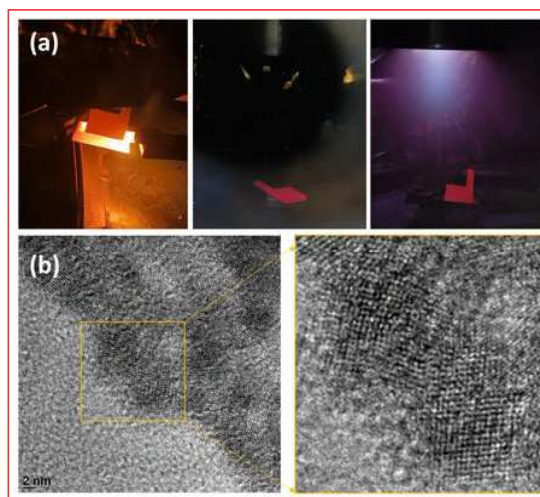


Figure 1. (a) Deposition of ultra-sub-monolayer Pt atoms at high temperature using a modified DC sputtering system. (b) High-resolution transmission electron micrograph of M_1/NMO SAC with Pt metal sites.

Exploring the lead-free and highly stable halide perovskites for ultra-sensitive UV photodetector applications

FIR-080304

Division(s): Electrodeposition and Electrocatalysis and Electroplating & Electrometallurgy

PI: Dr. Subhendu Kumar Panda

Co-PI(s): Er. S.P. Thipperudraswamy

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 25.07.2024 to 31.03.2026

Budget (Rs. in Lakh): 46.08

Photoresponsivity of the device should be in range of 2-60 mA/W with the quick response time of 10 ms - 100 s.

- Ultrafast spectroscopic measurements and carrier life time measurements to establish the phenomenon for new transient electronic states and electron hole charge separation.

Highlights

- Synthesized lead-free halide perovskites (e.g., Cs_3ZnCl_5 , $\text{Cs}_3\text{Cu}_2\text{I}_5$, $\text{MA}_3\text{Bi}_2\text{Cl}_9$, $\text{FA}_3\text{Bi}_2\text{Cl}_9$) via wet-chemical routes with wide band gap and tunable optical properties for Cs_3ZnCl_5 ~4.26 eV, $\text{Cs}_3\text{Cu}_2\text{I}_5$ ~4.09 eV, and $\text{FA}_3\text{Bi}_2\text{Cl}_9$ ~3.09 eV as shown in (Figure 1), which are suitable for UV photodetector applications.
- Substitution of $\text{MA}_3\text{Bi}_2\text{Cl}_9$ (Fig 1-c) with $\text{FA}_3\text{Bi}_2\text{Cl}_9$ (Figure 1-d) resulted in a spectral shift towards the UV region ($\text{MA}_3\text{Bi}_2\text{Cl}_9$ ~2.79 eV - $\text{FA}_3\text{Bi}_2\text{Cl}_9$ ~3.09 eV), suggesting enhanced potential for tuning optical properties in UV-responsive photodetector design.
- Established the structural-optical property correlations to guide material selection for device integration.

Objectives

- To produce a thin film of perovskite materials and tune the absorption of the perovskite materials by optimising suitable synthesis routes.
- Establishing the relation between the crystal structure and the optical properties of the synthesized double perovskites.
- To develop suitable and cost-effective photo detectors with new functionalities, emphasizing the use of hybrid perovskite materials.
- Optimising and enhancing the photo detector device parameters, photoresponsivity, response time, and specific detectivity.
- Fabrication of perovskite-based photodetector structures and studying the feasibility studies.

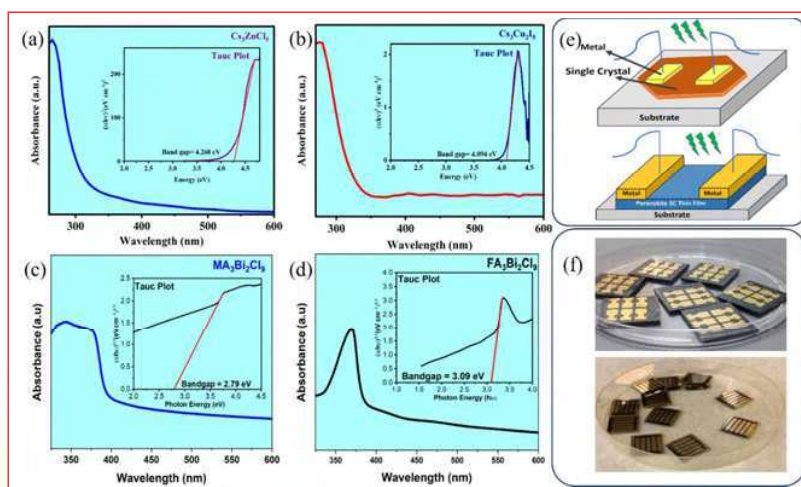


Figure 1. Absorption spectra and Tauc plots illustrating the band gaps of (a) Cs_3ZnCl_5 , (b) $\text{Cs}_3\text{Cu}_2\text{I}_5$, (c) $\text{MA}_3\text{Bi}_2\text{Cl}_9$, and (d) $\text{FA}_3\text{Bi}_2\text{Cl}_9$. (e) Schematic representations of single-crystal photodetector architectures. (f) Structures of perovskite devices with gold and aluminium electrodes.

Electrochemical synthesis of organic intermediates: synthesis of 3, 4, 5-trimethoxy benzaldehyde (TMBA), 4-tert-butylbenzaldehyde (TBBZA) from their corresponding toluenes and p-benzoquinone (p-BQ) and 1, 4-hydroquinone (HQ) from phenol

FBR-030301

Division(s): Electro-organic & Materials Electrochemistry

PI: Dr. V. Suryanarayanan

Co-PI(s): Dr. M. Kathiresan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 03.05.2024 to 31.03.2026

Budget (Rs. in Lakh): 69.00

Objectives

- Development of a suitable electrolyser to produce TBBZA and TMBA from their corresponding toluenes and 1,4-HQ and p-BQ from phenol.
- Optimization of different electrochemical parameters such as current density, concentration of precursor, electrolysis

temperature, separator, inter-electrode distance, and flow rate to obtain high current and yield efficiency.

Highlights

- Electrolysis of 4-tertiary butyl toluene (4-TBT) in 100 ml, 500 ml and 1 L batch cells in H_2SO_4 /methanol electrolyte medium at 50°C, was done, where NMR & GC-MS confirm the formation and purity of the product, namely 4-tertiary butyl benzaldehyde (TBBZA). Various electrochemical parameters were optimized.
- A yield efficiency of 64%, 73% and 80% of product in the batch cell, with current efficiency of 53% & 100% conversion were obtained. Energy consumption of approximately 26.4 for the batch cell was noted.

Album



Sapling plantation on the occasion of 54th Earth Day in CSIR-CECRI Campus [April 22, 2024].

Development of highly efficient visible light-driven photocatalyst: A thin film approach for solar hydrogen production

FBR-060301

Division(s): Electrochemical Power Sources and Electro-organic & Materials Electrochemistry
PI: Dr. M. Sathish
Co-PI(s): Dr. A. Pandikumar
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.07.2024 to 31.03.2026
Budget (Rs. in Lakh): 50.22

Objectives

- To understand the insight of photo-excited electron movements, optical properties, reactivity and life time measurement of photoexcitons of MnNb_2O_6 and MTa_2O_6 based nanocomposites for overall photocatalytic water splitting under visible light irradiation.
- To synthesis possible nanostructures such as either $\text{MnNb}_2\text{O}_6/\text{TiO}_2$ & $\text{MTa}_2\text{O}_6/\text{TiO}_2$ and nanocomposites of $\text{MnNb}_2\text{O}_6/\text{g-C}_3\text{N}_4$ & $\text{MTa}_2\text{O}_6/\text{g-C}_3\text{N}_4$ via hydrothermal or wet chemical reaction systems.

- To understand the interfacial charge-transfer resistance and photocurrent response through photoelectrochemical measurement.
- To fabricate thin film and optimization of film thickness to get desired system for enhanced light absorption and electron transfer.

Highlights

- The metal Niobates NiNb_2O_6 , CoNb_2O_6 and TiO_2 were synthesized by hydrothermal method and characterized using various analytic techniques.
- The $\text{NiNb}_2\text{O}_6/\text{TiO}_2$ and $\text{CoNb}_2\text{O}_6/\text{TiO}_2$ heterojunction was formed by impregnation method. Each catalyst shows remarkable photocatalytic properties with excellent visible-light response.
- CoNb_2O_6 , TiO_2 and $\text{CoNb}_2\text{O}_6/\text{TiO}_2$ photocatalysts showed 797, 1116 and 6371 $\mu\text{mol/h/g}_{\text{cat}}$ of hydrogen evolution, respectively (Figure 1).

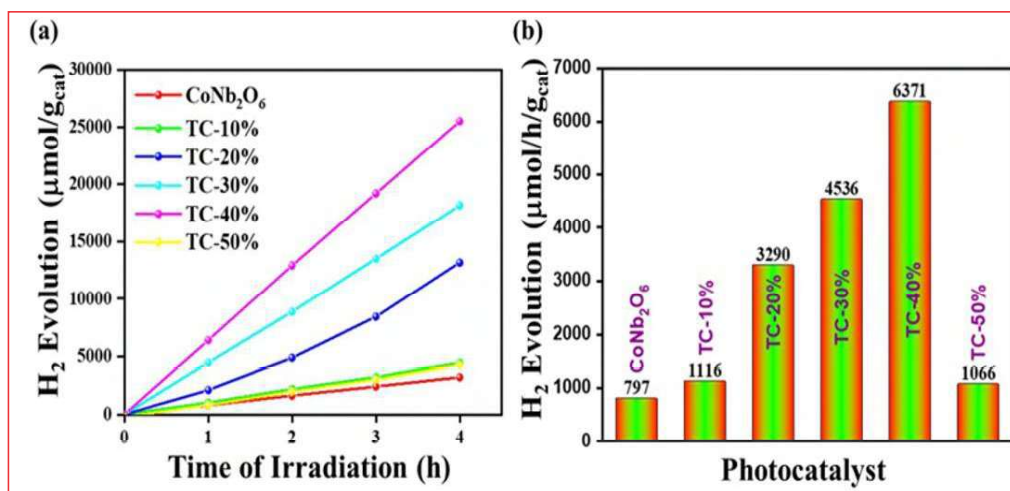


Figure 1. (a) H_2 evolution rate and (b) average rate of H_2 production of CoNb_2O_6 , TiO_2 , $\text{CoNb}_2\text{O}_6/\text{TiO}_2$.

State of health forecasting of battery using AI methods

FBR-060303

Division(s): Electrochemical Power Sources

PI: Dr. R. Sindhuja

Co-PI(s): Dr. P. Murugan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.07.2024 to 31.03.2026

Budget (Rs. in Lakh): 54.00

Objectives

- Develop a Machine Learning model (or ensemble of models) for State of Health (SOH) prediction for Battery.
- Devise an approach or strategy to capture the uncertainties and high variability of real world applications.
- Validate the model using carefully designed experiments that mimic a set of real-life scenarios.

Highlights

- Design of Experiments has been framed and data

collection is under progress with cylindrical cells at different load profiles.

- Preliminary model has been developed for SOH Estimation and NASA datasets were used for validating this model (Figure 1).

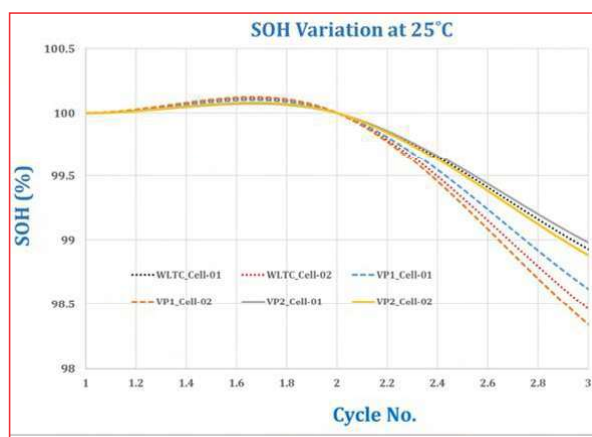


Figure 1. SOH degradation of cells subjected to different profiles as a function of cycle number cycled at 25°C.

Album



Dr. Chockkalingam Karuppaiah, Chief Technology Officer, Ohmium and Founder and Chairman of Vetri Labs, USA delivering a lecture on "Evolving Energy Landscape and Electrochemistry" [April 26, 2024].

Self-Powered Flexible Electrodes for Biosensor Applications and for Disease Analysis

FBR-070303

Division(s): Electrode and Electrocatalysis

PI: Dr. V. Ganesh

Co-PI(s): Dr. M. Pandiaraj

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 21.05.2024 to 31.03.2026

Budget (Rs. in Lakh): 65.00

Objectives

- To fabricate self-powered flexible electrodes using the concept of enzymatic bio-fuel cells (EBCs) for producing electrical voltage and power output from human body fluids, especially sweat.
- To develop efficient flexible electrodes (both anodes and cathodes) for producing sufficient voltage (1 V to 1.5 V) and power output (μ W to W) from EBCs.
- To alter the cell design and to employ redox mediators for enhancing the performance of EBCs.
- To utilize such EBCs for electrochemical bio-sensing applications especially for chiral distinction of amino acids and proteins, as a replacement for conventional electrochemical workstation.

- To employ EBCs for continuous monitoring of glucose for diabetic analysis as a proof of concept and state of art principle.

Highlights

- Fabricated the flexible bio-anode by immobilizing Glucose Oxidase (GOx) enzyme onto multi-walled carbon nanotubes (MWCNTs) through chemical functionalization (Figure 1).
- Optimized the conditions including enzyme loading, orientation of enzyme, pH and stability etc. to obtain the enhanced sensor performance of the bio-anode.
- Fabricated the flexible bio-cathode through immobilization of Bilirubin Oxidase (BOD) enzyme onto MWCNTs using chemical functionalization strategy (Figure 2).
- Optimized the conditions of flexible bio-cathode in terms of enzyme loading, pH, controlling the orientation of enzyme and stability etc. for obtaining the efficient oxygen reduction reaction performance.
- Assembled the flexible bio-anode and bio-cathode into an enzymatic bio-fuel cell (EBC) producing an open circuit voltage (OCV) of 0.5 V to 0.7 V and power output in the range of W.



Figure 1. Pictorial representation of the fabrication of bio-anode used for the electrocatalytic glucose oxidation.

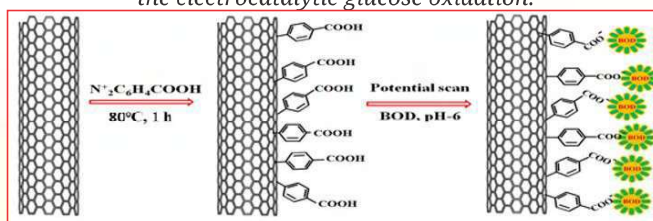


Figure 2. Schematic representation of the fabrication of bio-cathode used for the electrocatalytic oxygen reduction reaction.

Fabrication of vertically aligned graphene/ PPy on carbon fibre/fabric electrodes for flexible wearable supercapacitors

FBR-080302W1

Division(s): Electrodeics & Electrocatalysis

PI: Dr. C. Sivakumar

Co-PI(s): Dr. K. Giribabu

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 39.70

Objectives

- To establish the proof of concept, preparation of flexible active materials using vertically aligned graphene sheet/foam filled with nanofibrillar conducting polymer via tailored chemical/electrochemical route onto carbon fibre/fabric.
- To prepare redox active polymer gel electrolytes/room temperature ionic liquid electrolytes for flexible supercapacitor device

without separator.

- Assembling of prototype device (rectangle, square, cylindrical or wire shape and roll to roll), charge-discharge cycle tests, and validation for smart and wearable devices.

Highlights

- Prepared flexible PPy-coated carbon cloth (CC) electrodes (1×2 , 2×2 , 1×5 cm^2) attained by electrochemical polymerization of Py. The maximum loading of PPy polymer onto the CC electrode achieved using $[\text{Py}] = 0.1$ M.
- Obtained a maximum Areal Sp. Cap (CA) of 468 mF/cm^2 .
- Fabricated symmetric device (1×2 , 2×2 and 2×5 cm^2) and testing is in progress to determine scalability and feasibility for use in real-world applications enabling the next-generation energy storage devices.

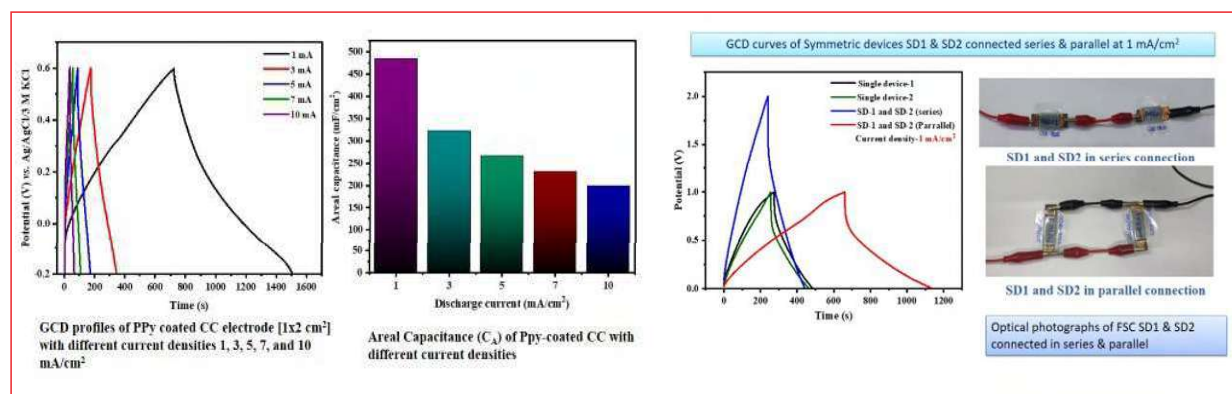


Figure 1. Illustration of the fabrication of flexible symmetric device (SD) and their GCD curves.

Cranio-maxillofacial devices decorated bioactive layer for enhanced osteointegration with antimicrobial properties

FBR-080302W2

Division(s): Electrochemical Process Engineering, Electroplating & Electrometallurgy and Electro-organic & Materials Electrochemistry
PI: Dr. Deepak Kumar Pattanayak
Co-PI(s): Dr. N. Lakshminarasimhan
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2024 to 31.03.2026
Budget (Rs. in Lakh): 39.70

Objectives

- Process parameter optimization of selective laser melting (SLM) technology for the construction of Ti metal cranio-maxillofacial implant mimicking the bone structure.
- Surface chemical and electrochemical modification of SLM Ti implant with the incorporation of bioactive and antimicrobial elements such as Mg / Ca / Sr and Zn / Ag / Ce into the nano-network structure.
- Mechanical and corrosion behaviour study of SLM Ti metal implant subjected to various surface functionalization in physiological body fluid conditions.
- In vitro bioactivity (apatite formation) evaluation of modified SLM Ti metal implants in

simulated body fluid (SBF) and antibacterial activity both in Gram-positive and Gram-negative bacteria.

- Evaluation of an in-vitro cell compatibility study in MG-63 osteosarcoma cells over surface-functionalized SLM Ti metal implant.
- Role of elemental incorporation, such as Mg / Ca / Sr & Zn / Ag / Ce, on gene expression changes promoting osteointegration and other phenomena.
- Design and development of a patient-specific SLM Ti-based cranio-maxillofacial implant with surface functionalisation for antibacterial, bioactive, and biocompatible properties, along with an in vivo study on its osteointegration ability in an animal model.

Highlights

- Optimized process parameter of Ti powder for 3D printing of porous scaffolds.
- Modified the surface chemistry of Ti metal using NaOH and $\text{Zn}(\text{NO}_3)_2/\text{Ca}(\text{NO}_3)_2$ solution to enhance the process feasibility.
- Developed porous scaffolds using 3D printing technology, and attempted successive surface modification.

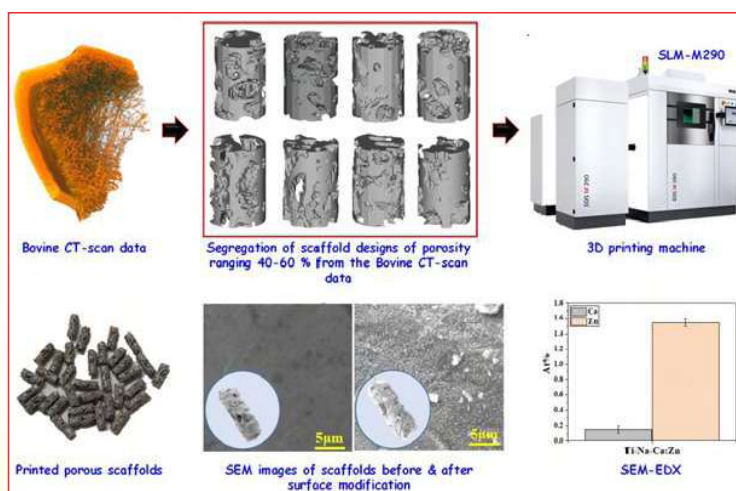


Figure 1. Various testing results of Ti metal cranio-maxillofacial implant.

Development of 12 V mechanically rechargeable zinc and aluminium-air batteries

IHP-002401

Division(s): Electrochemical Power Sources

PI: Dr. S.T. Nishanthi

Co-PI(s): Dr. Aiswarya Bhaskar

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 11.05.2024 to 31.03.2026

Budget (Rs. in Lakh): 25.00

- Fabrication and testing of 12 V/10 Ah mechanically rechargeable Aluminum-air battery stack.
- Testing of single cell and stack level with various current density and cycle life.

Highlights

- Scaled up the synthesis of oxygen reduction catalyst up to 50 g/batch and tested its performance.
- Assembled a 12 V mechanically rechargeable zinc air battery stack and tested its discharge performances.

Objectives

- Scaling up of oxygen reduction catalyst for air cathode fabrication 15 x 15 cm².
- Fabrication and testing of 12 V/10 Ah mechanically rechargeable zinc-air battery stack.

Album



Administering pledge on the observance of Swachhata Pakhwada [May 01, 2024].

Electrowinning of green Fe and Cr from their metal salts extracted from ferro-chrome slag

IHP-002402

Division(s): Electroplating & Electrometallurgy

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. N. Rajasekaran

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 01.04.2026

Budget (Rs. in Lakh): 25.00

Highlights

- Developed and validated a combined alkali fusion and hydrometallurgy process for the efficient extraction of $\text{Fe}(\text{OH})_3$ and $\text{Cr}(\text{OH})_3$ from Fe-Cr slag.
- Established a method for producing pure metallic iron from Fe^{2+} based acid-leached electrolytic solutions through an electro-deposition process.
- Developed a chemical reduction process for converting Cr^{6+} to Cr^{3+} , followed by electro-deposition to produce pure metallic chromium from Cr^{3+} -based electrolytic solutions.
- Achieved high extraction efficiencies of 97.62 % for chromium and 97.20 % for iron from Fe-Cr slag using the developed processes.
- Achieved a high current efficiency of 95 % for iron electro-winning from ferrochrome slag and 13 % current efficiency for chromium electro-winning.

Objectives

- To extract ferrous hydroxide and chromium hydroxide from ferro-chrome slag supplied by Tata Steel.
- To obtain ferrous sulphate and chromium sulphate from ferro-chrome slag supplied by Tata Steel with a purity of >99%.
- Electro winning of metallic Fe from ferrous sulphate and metallic Cr from chromium sulphate using electro winning with the help of an anion exchange membrane at each 1 kg capacity per day.

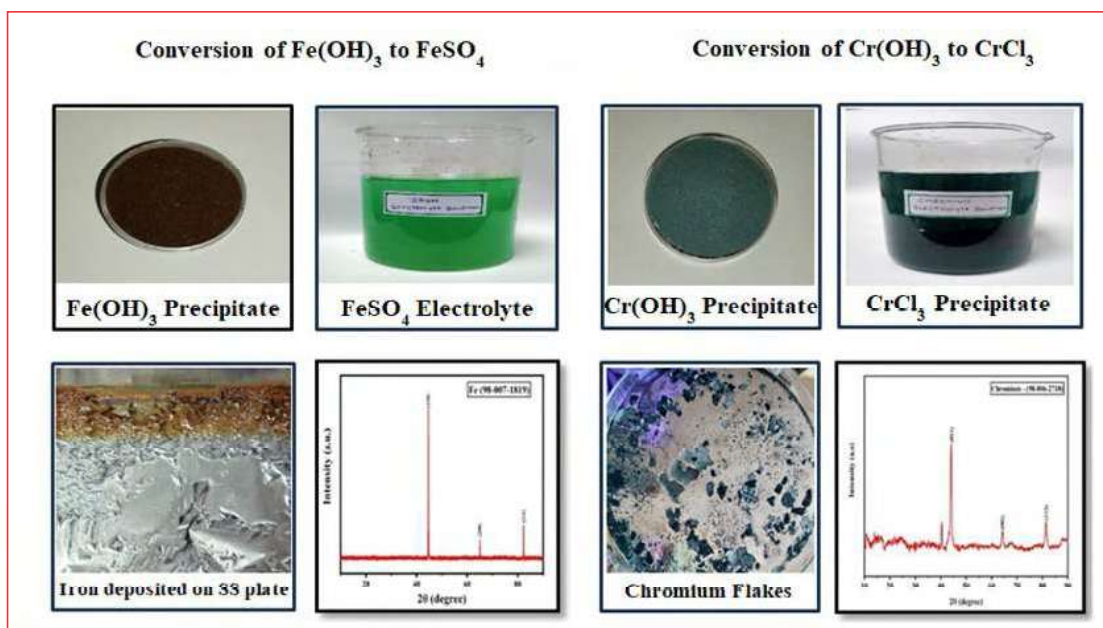


Figure 1. Photographs of products obtained at different stages of processing and XRD patterns of the final products Fe and Cr separated from Fe-Cr slag.

Process development for the paired electrosynthesis of phthalide 4-tertbutylbenzaldehyde and phthalide I tolyaldehyde dimethyl acetal

IHP-002403

Division(s): Electro-Organic and Materials Electrochemistry

PI: Dr. M. Kathiresan

Co-PI(s): Dr. V. Suryanarayanan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 01.04.2026

Budget (Rs. in Lakh): 25.00

- Scale-up synthesis of phthalide and 4-tert-butylbenzaldehyde to 10 g and 100 g levels.
- Optimization and development of electrode materials, cell design, and experimental parameters.
- Further scale-up of the process to 500 g and 1000 g batch sizes.

Highlights

- Carried out the electrochemical reaction using 0.1 M alkali fluoride as a weak base and neutral electrolyte, with graphite electrodes at room temperature for 4-7 hours and without membrane.
- Yields were 85% for anodic oxidation and 75% for cathodic reduction.
- Optimized the process parameters such as current density, temperature, pH, and electrolyte concentration to obtain maximum yield.

Objectives

- Simultaneous synthesis of phthalide and 4-tert-butylbenzaldehyde from phthalic acid and 4-tert-butyl toluene via cathodic reduction and anodic oxidation at 1 g and 10 g scales.
- Electrochemical trials with other substituted toluene for reaction scope exploration.
- Process parameter studies including current density, cell voltage, electrolyte type, concentration, and temperature.

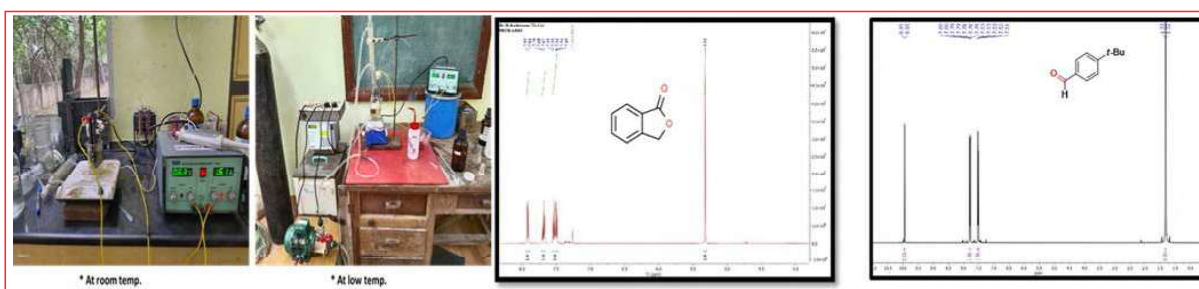


Figure 1. Photographs showing the electrochemical set up and the NMR spectra.

Imaging of functional interfaces: A scanning tunneling microscopic study

IHP-002404

Division(s): Corrosion & Materials Protection

PI: Dr. V. Saranyan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 25.00

Objectives

- Imaging metal surface with and without corrosion inhibitor to understand how inhibitors interact with the surface.
- Measure electronic impact of synthetic and non-synthetic (natural) corrosion inhibitors on metals.
- Imaging catalysts surface before and after electrochemical cycling to estimate the change in surface topography.
- Estimate the electronic bandgap of

electrocatalysts at the surface level using tunnelling spectroscopy.

- Mapping the surface changes in battery materials to determine the effect of charging and discharging.

Highlights

- Created highly ordered, pre-adsorbed 5,10,15,20-tetra(4-pyridyl) porphyrin (TPyP) adlayers onto Au (111) substrate in 0.1 M H_2SO_4 medium as a model system to probe the Nernst equation at the molecular level
- Self-assembled monolayers (SAMs) present a facile and versatile tool for surface modifications. Their ability to create tailored interfaces and control surface properties makes them invaluable in various scientific fields ranging from molecular electronics, biosensing, corrosion protection, lubrication, and nanofabrication. Explored the self-healing ability of SAMs using AFM nano-shaving technique.

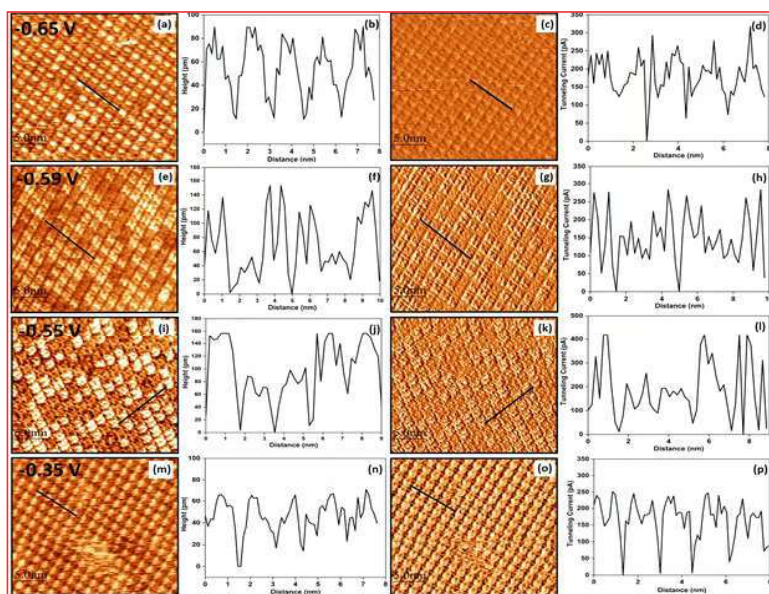


Figure 1. EC-STM images of TPyP at 4 different potentials $-0.65V_{pt}$, $-0.59V_{pt}$, $-0.55V_{pt}$ and $-0.35V_{pt}$ with the line topographical line profiles, tunneling current images and corresponding tunneling current line profiles at the same location.

Development of superhydrophobic nanocomposite coatings for leather

MMP-035201W1

Division(s): Corrosion & Materials Protection
PI: Dr. C. Arunchandran
Co-PI(s): Dr. V. Suryanarayanan
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.04.2024 to 31.03.2027
Budget (Rs. in Lakh): 62.50

Highlights

- Prepared a siloxane-based nanocomposite coating and applied on the leather surface using the spray coating method to achieve superhydrophobicity.
- The coating exhibited a water contact angle of 152° .
- The coated leather surface displayed excellent self-cleaning and anti-stain properties.

Objectives

- To develop a superhydrophobic nanocomposite coating with self-cleaning ability for leather.

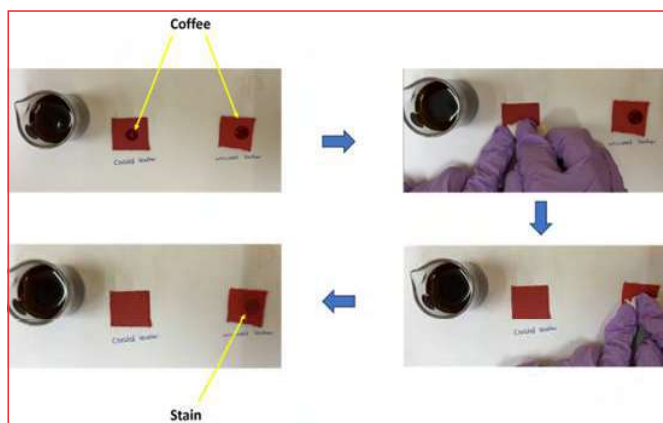


Figure 1. Comparison of uncoated and siloxane-based nanocomposite coated leather pieces under stain removal test.

Album



Shramdhan event at CECRI [May 02, 2024].

Thermoregulative and fire-retardant fabrics for industrial and military applications

MMP-035201W2

Division(s): Electro-organic & Materials Electrochemistry and Electroplating & Electrometallurgy

PI: Dr. M. Kathiresan

Co-PI(s): Dr. C. Naveen Kumar

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2027

Budget (Rs. in Lakh): 30.00

- Microencapsulated PCM is applied to leather, which will be used for upholstery and related areas.

Highlights

- Developed microencapsulated PCM with docosane (melting point of 43-46 °C) as the core, and SiO₂ as a shell material formed by interfacial polymerization.
- Developed PCM exhibited good compatibility with water-based binders and good dispersion stability, making it suitable for coating.
- Application of the prepared PCM onto leather through retanning or spray coating is in progress.

Objectives

- Development of microencapsulated Phase Changing Material (PCM) for heat insulation and thermoregulative property in leather application.
- Developing microencapsulated PCM with a greater enthalpy value during phase transition for improved thermoregulation.

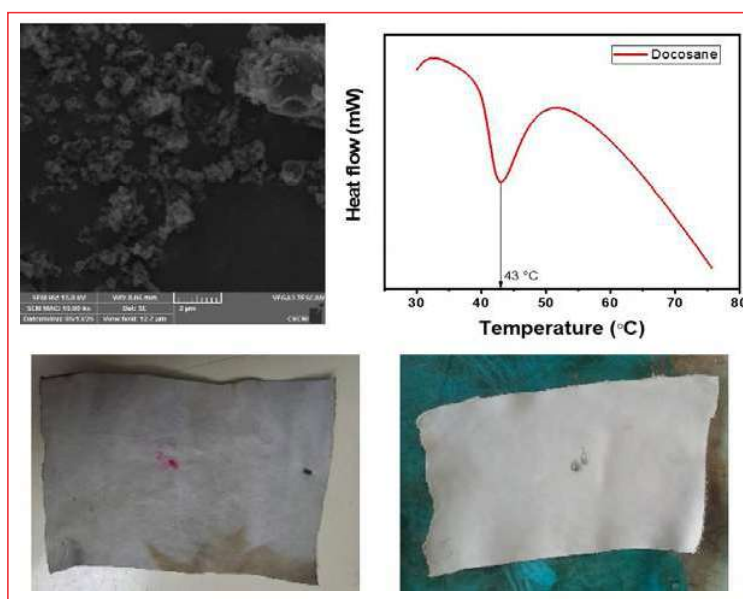


Figure 1. Scanning electron microscopic image and differential scanning calorimetric analysis of PCM, and photographs of leather containing PCM.

Doped-silicon carbide coatings on complex shapes using preceramic and their blends

MMP-035201W3

Division(s): Electrodics & Electrocatalysis

PI: Dr. P. Tamilarasan

Co-PI(s): Dr. K. Giribabu

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 30.03.2027

Budget (Rs. in Lakh): 76.92

Highlights

- Developed a stable preceramic formulation based on PDMS which gives better uniformity and adhesion. Optimized the bath composition for surface functionalization and preceramic curing
- Optimized the pre-pyrolysis, pyrolysis and post pyrolysis conditions. The molecular vibrational spectra confirmed the beta phase of the silicon carbide
- Determined the hardness, coefficient of friction and wear rate which are 1050 – 1250 Hv, 0.5 and 10^{-4} - 10^{-5} , respectively
- Achieved an uniform SiC coating on a tubular structure which are being expanded to industrial shapes

Objectives

- To develop process for doped inorganic polymer blend preceramic coatings on complex metallic shapes
- To optimize the pyrolysis conditions for doped silicon carbide coating with desired microstructure and crystallinity, ratios of Si:C, Si-C:Si-Si bonding and dopant

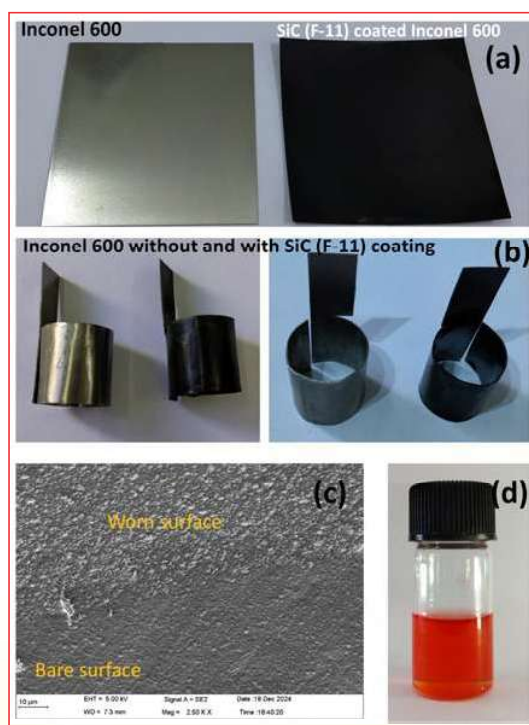


Figure 1. (a) Pristine and SiC coated Inconel 600 alloy plate, (b) Pristine and SiC coated Inconel 600 alloy complex structure, (c) electron micrograph of bare and worn surface of SiC coating and (d) digital image of one of the developed formulations.

The large scale production of SiC suitable for hard armour panels through carbothermal and magnesiothermic reduction techniques

MMP-035201W4

Division(s): Electroplating & Electrometallurgy and Electrodeposition & Electrocatalysis

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. Subhendu Kumar Panda and Dr. N. Rajasekaran

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2027

Budget (Rs. in Lakh): 50.08

Highlights

- Synthesised silicon carbide powder from iminosilane resorcinol (ISR) composite at 25 g per batch by the carbothermal reduction method.
- Resorcinol-formalin was used as a greener precursor, circumventing activated carbon sources.
- Efficient and Scalable Synthesis: Utilises carbothermal and magnesiothermic reduction techniques for the large-scale production of silicon carbide (SiC) optimised for hard armour applications.
- Sustainable Raw Material Utilization: Leverages (SiO₂) from rice straw ash and carbon from graphite, promoting eco-friendly and cost-effective production practices.
- Optimized Production Scale: achieved a production scale of 100 g / batch, demonstrating feasibility for industrial-scale implementation.
- Sustainable and Energy-Efficient Process: large-scale manufacturing while minimizing energy consumption and material waste, aligning with environmentally conscious industrial practices.

Objectives

- To develop a process for doped inorganic polymer blend preceramic coatings on complex metallic shapes.
- To optimize the pyrolysis conditions for doped silicon carbide coating with desired microstructure and crystallinity, ratios of Si:C, Si-C: Si-Si bonding and dopant.
- To produce SiC (500 g - 1 kg per batch) through High temperature reduction process by conformally coating SiO₂ with carbon yielding low-cost polymers suitable for hard armour panels.



Figure 1. Photographs showing the SiC product obtained from different sources of SiO₂ and Carbon.

Process development for extraction of magnesium chloride (MgCl_2) from sea water bitterns and convert it into magnesium (Mg) metal

MMP-035201W5

Division(s): Electroplating & Electrometallurgy

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. N. Rajasekaran

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 20.03.2024 to 31.03.2027

Budget (Rs. in Lakh): 81.78

Highlights

- Indigenously produced Mg (99.82%) at a scale of 1 kg per day with a current efficiency of 62.5% using commercial anhydrous MgCl_2 containing 25 Wt.% Mg through molten salt electrolysis process.
- Produced Mg (99.5%) with a 60% current efficiency at a production scale of 1 kg per day using sea bittern containing 13.5 Wt.% Mg through molten salt electrolysis method.
- Designed a pilot module molten salt reactor with a capacity of 10 kg per day.

Objectives

- To extract MgCl_2 from sea bittern and subsequently convert to Mg metal, 5 -10 kg per day using molten salt electrolysis.

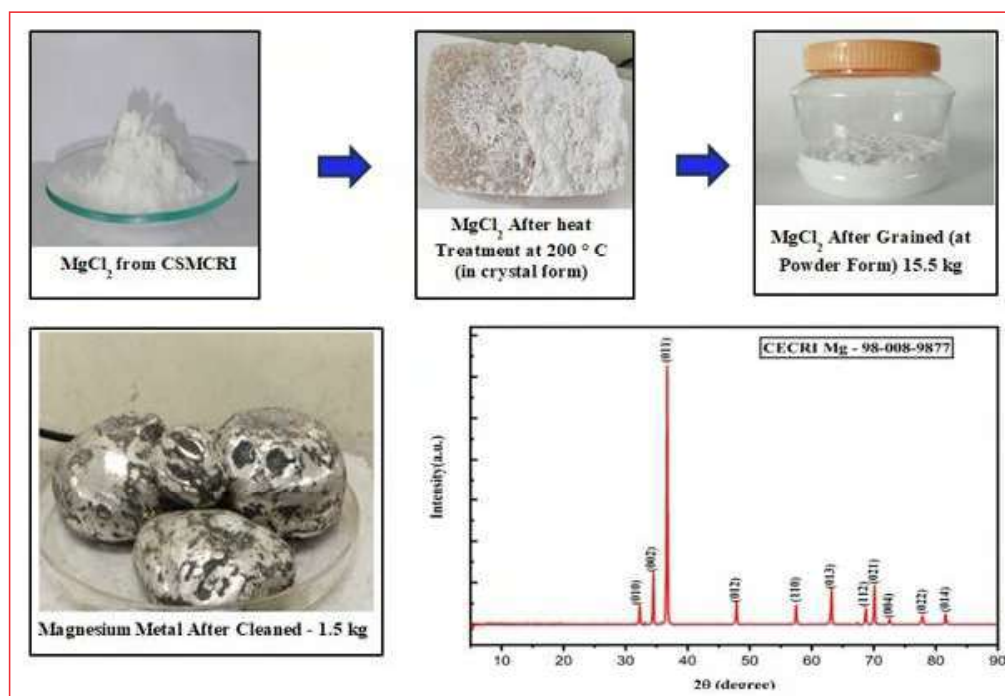


Figure 1. Conversion of MgCl_2 into Magnesium (Mg) Metal: (1.5 kg scale).

Fabrication of engineered reusable adsorbents for Sr from brine sources

MMP-035201(WP3)W6

Division(s): Electrodics & Electrocatalysis

PI: Dr. K. Giribabu

Co-PI(s): Dr. C. Suresh and Dr. M. Pandiaraj

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2027

Budget (Rs. in Lakh): 51.61

Objectives

- To develop an adsorbent for Sr adsorption at ambient conditions using a cellulose-based polymer matrix.
- Incorporation of inorganic materials into the polymer matrix to enhance the adsorption efficiency of Sr.

- Design of adsorption experiments will utilize response surface methodology to optimize various parameters for enhancing adsorption efficiencies.

Highlights

- Demonstrated the selectivity of cellulose-supported Ba-Alginate for Sr in seawater.
- The selectivity of the cellulose-supported Ba alginate matrix arises from Ba exchange and alginate binding with SrBa forms extensive cross-linking with alginate, creating ion-exchange columns that efficiently enrich Sr (II) from seawater.

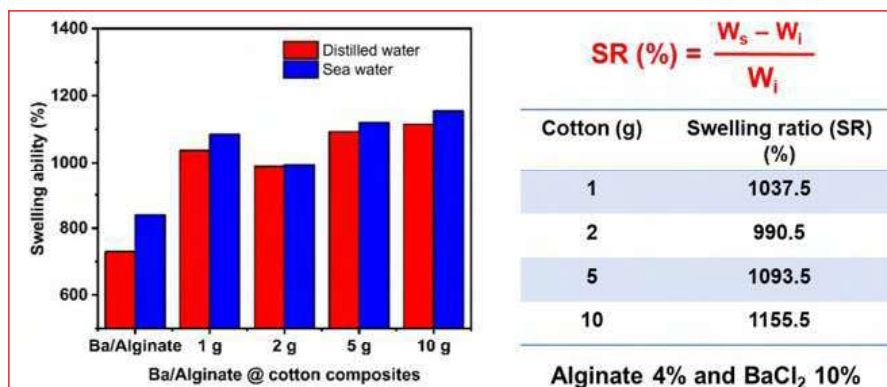


Figure 1. Swelling ability of synthesised Ba-Alginate @ cotton composite.

Table 1. ICP-OES analysis of Sr adsorption using Ba-Alginate@cotton column.

S.No	Name of the sample	Mg (ppm)	Ca (ppm)	Sr (ppm)
1	Seawater	134	381	5
2	Seawater+120ppm Sr	139	383	109
3	Ba-alg @ cotton (4%)	134	386	48
4	Ba-alg @ cotton (6%)	133	367	43
5	Ba-alg @ cotton (10%)	128	365	71
6	Ba-alg @ cotton (5g)	142	390	89

A novel composite coating system for high temperature corrosion resistance applications

MMP-035201W7

Division(s): Corrosion & Materials Protection

PI: Dr. S.M. Ganesan

Co-PI(s): Dr. Shekhar Hansda

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2027

Budget (Rs. in Lakh): 65.50

Objectives

- Development of reduced graphene oxide (rGO) and boron carbide (B_4C) based high performance corrosion resistance composite (HPCRC) coating system on 304SS substrate by fiber laser deposition method.
- Evaluation of HPCRC coating system's performance at high high-temperature environment.
- Successful demonstration and transfer of the coating system to industrial partner(s).

Highlights

- A novel composite coating system for coating

critical components in thermal and nuclear power plants.

- The proposed coating system has high-temperature (up to 400 - 500 °C) corrosion and erosion protection properties.
- The coating system is effective at absorbing gamma and neutron radiation in nuclear power components.

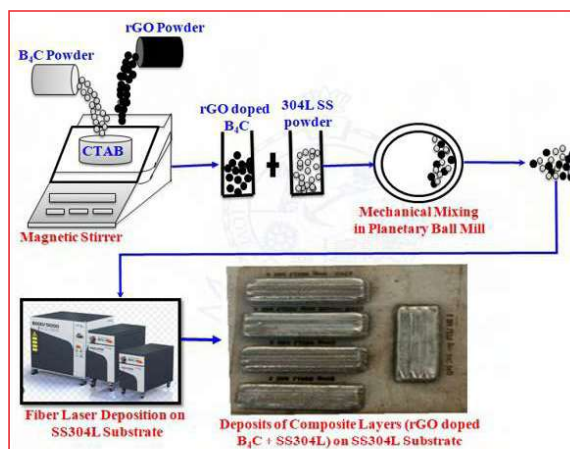


Figure 1. Steps in HPCRC coating development.

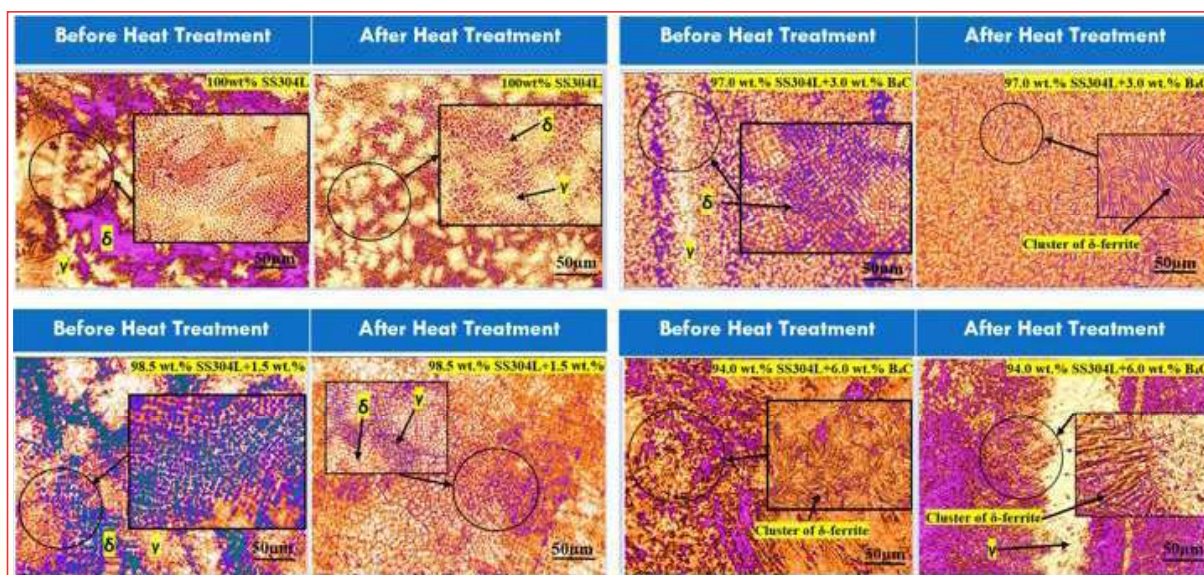


Figure 2. Optical micrographs of the laser cladded surfaces before and after heat treatment.

Development of two-coat system with active corrosion protection and improved weathering stability as a replacement for three - coat system for C4 and C5 corrosivity categories

MMP-035201W8

Division(s): Corrosion & Materials Protection

PI: Dr. C. Arunchandran

Co-PI(s): Dr. S. Muralidharan

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2027

Budget (Rs. in Lakh): 62.50

Objectives

- To develop a self-healing Zn-rich primer by optimising the amount of self-healing agent added into the primer for maximum corrosion protection.
- To develop an epoxy-siloxane topcoat with exceptional weathering stability as a safer alternative to isocyanate or urethane-based topcoats.

Highlights

- Synthesized conductive polymer polyaniline (PANI) hollow micro-nano capsules via oxidative polymerization.
- The as-prepared PANI- β NSA had a dark green colour, typical of conducting polyaniline particles, and the shape was a hollow rod structure.
- Optimized the Zn-rich epoxy with PANI pigments showed superior corrosion resistance with no red rust after prolonged exposure.
- Formulated epoxy-siloxane topcoat with various pigments to enhance UV stability, gloss, and hydrophobicity.

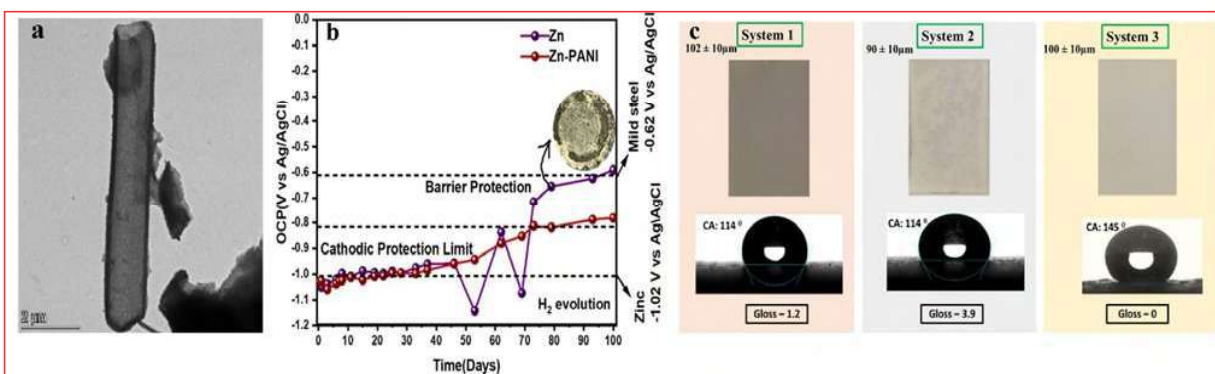


Figure 1. (a) HRTEM image of as-prepared PANI- β NSA, (b) Evolution of OCP for Zn-rich epoxy and PANI-based Zn-rich epoxy coatings for 100 days while immersed in 3.5 st. % NaCl solution and (c) The obtained finish, hydrophobicity, and gloss for various epoxy-siloxane formulations.

High temperature gradient aerogel based thermal insulation coatings for helicopter components

MMP-035201W9

Division(s): Electroplating & Electrometallurgy

PI: Dr. G. Sreedhar

Co-PI(s): Dr. B. Subramanian and Dr. Subhendu Kumar Panda

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2027

Budget (Rs. in Lakh): 69.00

thermal insulation coating and Lab scale test including thermal gradient analysis ($\Delta T > 100^\circ\text{C}$).

- Development of aerogel based thermal insulation coatings on main rotor blades and CEMILAC certification with patent filing in India.

Highlights

- Prepared the aerogel-based thermal insulation coatings and developed at the coupon level.
- Successfully demonstrated the required thermal gradient ($\Delta T > 100^\circ\text{C}$) to the CEMILAC team for aerospace certification.

Objectives

- Synthesis and preparation of aerogel based thermal insulation coating.
- Synthesis and preparation of aerogel based

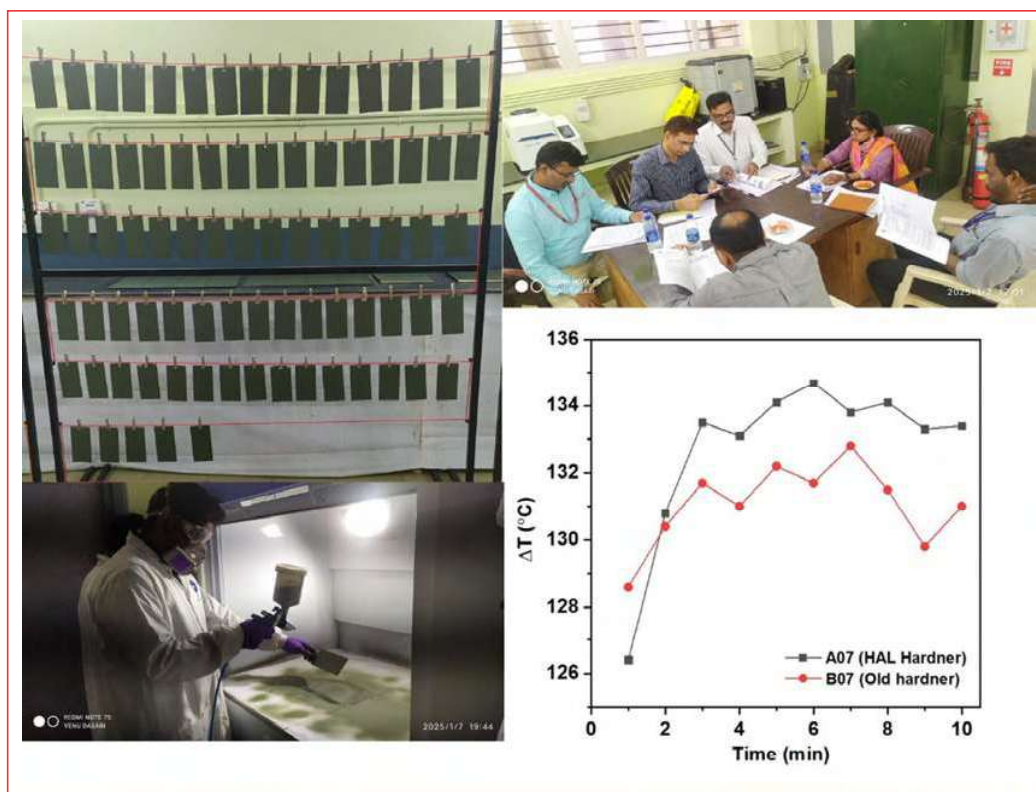


Figure 1. Photographs of the coating process and the results of the developed coatings are shown.

Battery to battery: Recovery of metal values from spent lithium-ion batteries and fabrication of new lithium-ion batteries - A circular economy approach

MMP-085201

Division(s): Electroplating & Electrometallurgy and Electrochemical Power Sources

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. Kuldeep Singh

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 02.07.2024 to 31.03.2027

Budget (Rs. in Lakh): 1867.69

Objectives

- Purification of the metal salts from approx. 90 to > 99% purity (25 kg scale), (CECRI).
- Synthesis of fresh NMC (532 or 333) from recovered lithium and metal salts (CECRI).
- Evaluation of NMC-532 or NMC-333 as cathode material in Li-ion battery (in the form of half-cell

studies in coin cells and pouch cells) and performance comparison with commercially available material (CECRI).

- Fabrication of 18650 cylindrical cells from the recycled salts (CECRI).
- A process flow diagram featuring material balance (metal/solid/water), heat balance, process conditions, consumption norms, utilities requirements, effluent (solid/liquid) generation and mitigation plan, operating costs, and a techno-economic evaluation of the combined recycling and re-cooking process (CECRI, IMMT, and NML).

Highlights

- Extracted Li with a purity of 99.9 % from commercial black mass (extraction efficiency was 77 %).
- Extracted Co, Mn, and Ni as their oxides with extraction efficiencies of 95 %, 85 %, and 89 %.
- The commercial NMC 333-based coin cell delivered an average specific capacity of 140 mAh/g while the CECRI B2B NMC 333 delivered 130 mAh/g after the 10th cycle from 140 mAh/g.

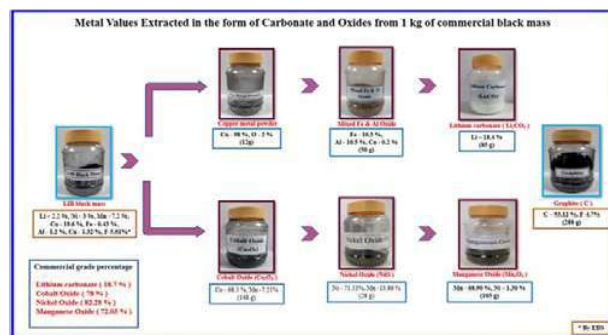


Figure 1. Photographs of the products extracted from 1 kg of black mass.

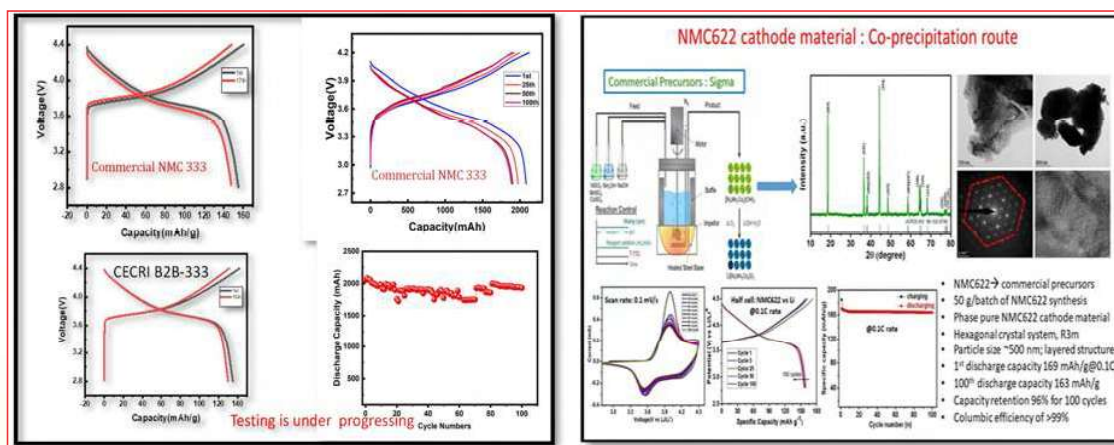


Figure 2. 18650 Cylindrical cell fabrications and testing results.

Mapping and tapping of critical metals/minerals (MapTapCrM) rare earth valorization through molten salt electrometallurgy

MMP-085202WP1

Division(s): Electroplating & Electrometallurgy

PI: Dr. M. Jayakumar

Co-PI(s): Dr. G. Sreedhar and Dr. C. Jeyabharathi

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 23.07.2024 to 31.03.2027

Budget (Rs. in Lakh): 100.00

- Recycling metal values from spent waste neodymium iron boron (NdFeB) magnets through molten salt electrometallurgy.

Highlights

- Synthesized Sm-Co products using the chloride route molten salt electrolysis (MSE) with varying atomic percentages of Sm and Co.
- Fabrication of the high-temperature voltammetry cell with the desired dimensions and design is in progress.

Objectives

- Producing samarium-cobalt (Sm-Co) alloy through molten salt electrowinning.



Figure 1. Photographs showing molten salt electrowinning set-up and the obtained SmCo product.

Album



Health Centre organized a blood donation camp in collaboration with the Govt. Hospital Head Quarter, Karaikudi [May 04, 2024].

Mapping and tapping of critical metals & minerals (MapTapCrm)

MMP-085202WP2

Division(s): Electroplating & Electrometallurgy
PI: Dr. C. Naveen Kumar
Co-PI(s): Dr. N. Rajasekaran
Funding Agency: Council of Scientific & Industrial Research, New Delhi
Duration: 01.08.2024 to 31.03.2027
Budget (Rs. in Lakh): 200.00

Objectives

- Extraction of Gallium and Magnesium from the identified primary and secondary sources (provided by CSIR-IMMT) followed by conversion to their oxide (in the case of Mg) and metal (in the case of Ga).
- Recovery of MgO from primary (Dolomite, magnesite rocks) and secondary sources (Steel Slag).

- Electron-won metallic Gallium from Gallium hydroxide extracted from Bayer Liquor or red mud.

Highlights

- Synthesized and characterized two types of Poly (hydroxamic) acid (PHA) resins.
- Type 1 PHA resin showed extraction efficiencies of Ga – 69 %, V – 11 %, and Al – 29 % from Bayer solution.
- Type 2 PHA resin exhibited extraction efficiencies of Ga – 43 %, V – 18 %, and Al – 1.9 %.
- Extracted high-purity MgO (99 %) from ferrochrome slag using a combined pyro- and hydro-metallurgical approach with 70 % extraction efficiency.



Figure 1. Photographs of synthesized PHA based resin and extracted Gallium with 99.90 % purity.

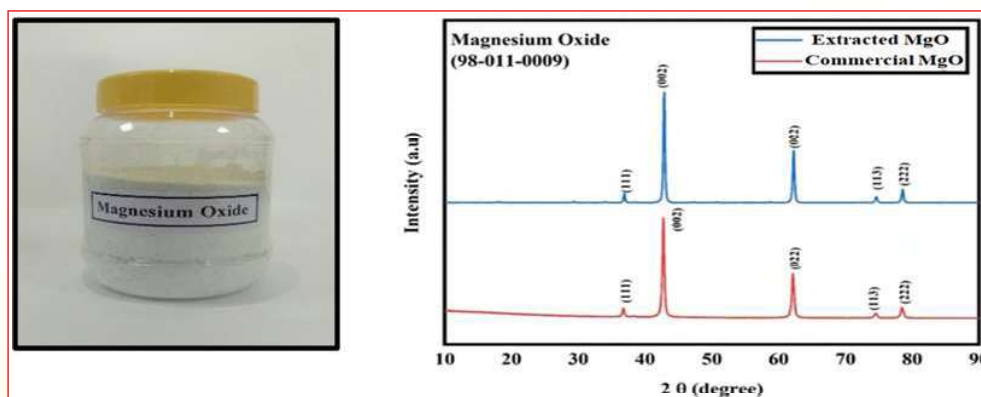


Figure 2. Prepared MgO and its XRD pattern comparison with commercially obtained MgO.

CSIR-Innovation centre for next generation energy storage solutions – Ver. 2.0 (ICeNGESS Ver 2.0)

MMP-065201

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. A. S. Prakash

Co-PI(s): Er. A. Balasubramanian

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 18.09.2024 to 31.03.2027

Budget (Rs. in Lakh): 8988.82

Objectives

- Establish the CSIR-Innovation Centre for Next Generation Batteries.
- To create an integrated battery innovation centre focused on shaping tomorrow's solutions, from the raw materials to the development of final products, driving advancements in next-generation battery technology.
- Establishing a new fully-fledged cathode production facility for SIBs.

- Scaling up the Technology Readiness Level (TRL) of Sodium-ion/Solid-state/Metal-air batteries.
- Implement a pilot production facility capable of accommodating various form factors (including prismatic, pouch, cylindrical 21700/32140 cells) to fulfil industry demands while adhering to global market standards.

Highlights

- Signing of MoU between CSIR-CECRI and CPWD for the ICeNGESS Ver.2.0 building.
- Developed novel electrolytes for Li-ion batteries and assessed for better performance and safety.
- Scaled up the production of sodium-ion battery cathode material to 1 kg.
- Explored new solid electrolytes based on NASICON, perovskite, and rock salt structures, achieving an ionic conductivity of approximately 10^{-4} S/cm.

Album



Director, CSIR-CECRI congratulating the K V Karaikudi for the best performance in the academic year 2023-2024 [May 15, 2024].

Ultra-low platinum alloy catalyst for polymer electrolyte membrane fuel cells

NCP-060302

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. M.U. Sreekuttan

Co-PI(s): Dr. Vishal M. Dhavale and Dr. Santoshkumar D. Bhat

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 01.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 77.00

Objectives

- An electrocatalyst with ultra-low Pt loading by dispersing Pt atoms on surface modified carbon alloy with improved scalability.
- Identification of active reaction centre.
- Detailed ORR mechanism and validation of electrocatalyst in PEFC with area 4-25 cm² using indigenously developed polymer membrane.

Highlights

- Synthesized electrocatalytically active Co-N_x and Co/Ni-N_x doped carbon substrate through two different approaches.
- The ORR activity of Co-N_x substrate is superior over Co/Ni-N_x in alkaline condition.

- Co-N_x based substrates synthesized through high temperature annealing of PANI showed an Eonset of 1.0 V and E_{1/2} of 0.83 V vs RHE in alkaline condition. ADT test showed only 16 mV reduction in E_{1/2} after 10000 potential cycles in between 0.6 and 1 V.
- Among different synthesis approach of ZIF, water and TEA mediated synthesis of ZIF showed high yield in less synthesis time.
- The Co-N_x derived carbon synthesized through ZIF-TEA approach, shows an Eonset of 1.0 V and E_{1/2} of 0.80 V vs RHE in alkaline condition. ADT test shows only 17 mV reduction in E_{1/2} after 10000 potential cycles in between 0.6 and 1 V.
- Low-Pt (2 Wt.%) alloy dispersion on Co-N_x and Co/Ni-N_x doped substrate was performed using simple thermal treatment method Initial ORR performance of Pt2%/Co-N_x shows Eonset of 1.05 V and E_{1/2} of 0.85 V vs RHE in 0.1 M HClO₄. ADT test shows only 24.4 mV reduction in E_{1/2} after 10000 potential cycles in between 0.6 and 1 V.

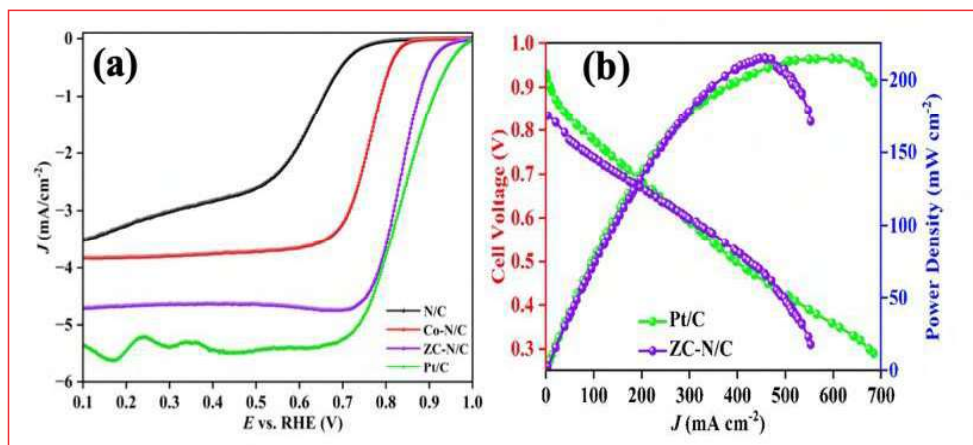


Figure 1. (a) Linear sweep voltammogram (LSV) of Co-N/C in oxygen saturated 0.1 M KOH with an electrode rotation of 1600 rpm and (b) Single cell fuel cell analysis of Co-N/C at 70 °C.

Pilot scale molten salt electrowinning of light metal and rare earths

PPP-240001

Division(s): Electroplating & Electrometallurgy and Corrosion & Materials Protection

PI: Dr. C. Naveen Kumar and Dr. M. Jayakumar

Co-PI(s): Dr. G. Sreedhar, Dr. C. Jeyabharathi and Dr. G. Anand Babu

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 06.05.2024 to 31.03.2026

Budget (Rs. in Lakh): 100.00

Highlights

- Produced Mg and Ca at a scale of 1-10 kg per day through molten salt electrolysis.
- Optimized and developed rare earth (La, Ce, Nd, Pr) alloys on a scale of 1 kg per day via an indigenous molten salt electrowinning method.

Objectives

- Demonstration of Mg/Ca metal at 10 kg/day and alloys of RE (La, Ce, Nd, Pr) at 1 kg/day through Molten Salt Electrolysis.



Figure 1. Photographs showing molten salt electrolysis set-up and the products Mg, NdFe_x and LaNi_y produced.



CSIR - Integrated skill initiative - Phase II

NWP-100

Division(s): Skill Development Group

PI: Dr. S.M. Rajendran

Co-PI(s): Dr. S. Angappan

Mentor: Director, CSIR-CECRI

Funding Agency: CSIR-Human Resource Development Centre, Ghaziabad

Duration: 22.10.2020 to 31.03.2025

Budget (Rs. in Lakh): 326.210

Objectives

- To conduct Govt. Sponsored Skill Training Programmes.
- To train the youth, jobless, deprived and economically weaker society to develop their skill according to match the requirements of industrial skill sets and also Up skilling the skilled one to meet the industrial standard available in their regulatory guidelines.
- It also aims to create opportunities for the development of talent within the country and improve the overall scope and space for underdeveloped sectors.
- Establish and enforce cross-sectoral, nationally and internationally acceptable standards for skill training in the country by creating a sound quality assurance framework for skilling, applicable to all Ministries, States and private training providers.
- They National Skill Development Mission are: (i) Institutional Training, (ii) Infrastructure, (iii) Convergence, (iv) Trainers, (v) Overseas Employment, (vi) Sustainable Livelihoods, (vii) Leveraging Public Infrastructure.
- Benefits of Technical Skill Development are (i) Enrich Skill Set, (ii) Get Better Job Opportunities, (iii) Become Eligible for Promotions, (iv) Save Time and Money, (v) Make Intelligent Purchase Decisions, (vi) Stay Relevant and Future-Ready, (vii) Open Up Alternate Income Avenues.

Highlights

- We have conducted 20 Skill Development Training Programmes. We have trained about 712 trainees out of all the above trainings. We have issued participation certificate also to every individual trainee with respect to their trainings in which they took part.
- Targets achieved by reaching closest figure of more than the 450 and above of candidates trained.
- Created required infrastructures for conducting all type of trainings and procured equipment for providing hands on trainings.
- Provided certificates with skill and CSIR logo to all the eligible trainees.
- Prepared brochures for Refresher courses, Faculty Development Programmes and Skill Development Training Programmes for every year.
- Conducted few numbers of Faculty Development Programme [FDP] also to faculties of different academic centers.
- MoU signed with Karpagam Academy of Higher Education, Coimbatore by CSIR- CECRI on 01.07.2024.
- Created number of Entrepreneurs, self-employment and more number jobs to the jobless persons.
- Developed ties with various organizations for conducting the trainings in a sustained way.
- Created infra facilities viz. Conference Halls, meeting rooms, Smart Class rooms, furniture's and skill training hostels with Bunker beds.

Materials for energy conservation and storage platform (MECSP)

(DST- IISc Energy storage platform on supercapacitors)

GAP-34/19

Division(s): Electrochemical Power Sources

PI: Dr. Aiswarya Bhaskar

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Department of Science & Technology, New Delhi

Duration: 19.05.2019 to 31.03.2025

Budget (Rs. in Lakh): 82.1

Objectives

- To develop efficient bifunctional oxygen electrocatalysts for Zinc-air batteries.
- To optimize the performance of Zinc-air batteries
- To develop Na-intercalation electrode materials for hybrid batteries.

Highlights

- Developed a MOF-derived CoFe material using a hydrothermal method followed by pyrolysis as bifunctional catalyst for electrically rechargeable Zn-air batteries.
- Investigated ORR and OER activities of the MOF-derived CoFe catalyst and achieved onset

potential and half-wave potential values of 0.97 V and 0.85 V vs RHE while those of OER were 1.55 V and 0.37 V vs. RHE, respectively.

- Fabricated Zn-air battery with air cathode using the MOF-derived CoFe which exhibited stable cycling for up to 1000 cycles (Figure 1).

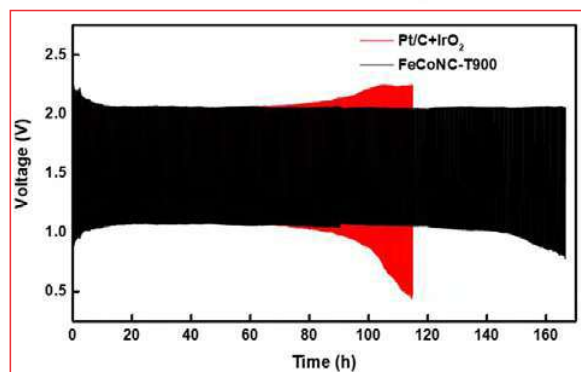


Figure 1. Cyclic galvanostatic charge-discharge profile of the cell with MOF-derived CoFe catalyst in comparison with Pt+IrO₂ catalysts at a 10 mA cm⁻² current density.

Album



Swachhata Pakhwada Plantation by the Members of Research Council, CSIR-CECRI [May 15, 2024].

Fabrication of pouch-type hybrid supercapacitor device with MXenes-based nanocomposite electrodes in redox additive electrolytes

GAP-18/21

Division(s): Electrochemical Power Sources

PI: Dr. M. Sathish

Co-PI(s): Dr. P. Murugan

Funding Agency: SERB-Department of Science & Technology , New Delhi

Duration: 13.12.2021 to 12.12.2024

Budget (Rs. in Lakh): 27.83

Objectives

- To explore the possibilities of MXenes-based nanocomposite electrodes for supercapacitor applications in redox additive electrolytes.
- To study the physicochemical and electrochemical characteristics of MXene and MXene-based nanocomposite electrodes using various analytical and electrochemical techniques.
- To study the electrochemical supercapacitor performance of MXenes-based nanocomposite in symmetric and asymmetric configuration in redox additives containing aqueous and non-aqueous electrolytes.

- To fabricate pouch-type hybrid supercapacitor device, optimization of electrode materials loading, concentration of redox additive to attain high cell voltage, specific capacitance and energy density.

Highlights

- Prepared MXene/carbon nanotube nanocomposite electrode by a one-step ultrasonication process.
- Achieved a high energy density of 41 Wh/kg with the supercapacitor comprising developed nanocomposite electrode and a redox-additive electrolyte, nearly doubling that of the conventional electrolyte.
- Fabricated a MXenes-based pouch-type hybrid supercapacitor and achieved 2.7 V operating voltage while the optimization of device parameters, such as capacitance, energy density, power density, is under progress.



Figure 1. Cyclical galvanostatic charge-discharge. Photographs of fabricated MXene-based hybrid pouch-type supercapacitor and powering an LED arrays by the MXene-based hybrid pouch.

Nanostructured MOFs as electrocatalysts for desulfurization of organic sulphides in fossil fuels

GAP-19/21

Division(s): Electroorganic & Materials Electrochemistry
PI: Dr. V. Suryanarayanan
Co-PI(s): Dr. T. Raju
Funding Agency: Department of Science & Technology, New Delhi
Duration: 20.12.2021 to 19.06.2025
Budget (Rs. in Lakh): 22.21

Objectives

- Fabrication of different nanostructured MOFs and their characterization.
- Application of the materials for desulfurization process.

Highlights

- Synthesized monometallic MOFs such as Co, Ni and Al using BTC and 4,4-bipyridine as linkers and carbonized, subsequently.
- Characterized the structure and morphology of the composite.
- Investigated the suitability of the MOF for electrooxidative desulfurization of benzothiophene (BT) using LSV, Tafel slopes and EIS (Figure 1).
- High electrochemical active surface area and enlarged pore volume leading to innumerable active sites, resulting in enhanced performance towards desulfurization.

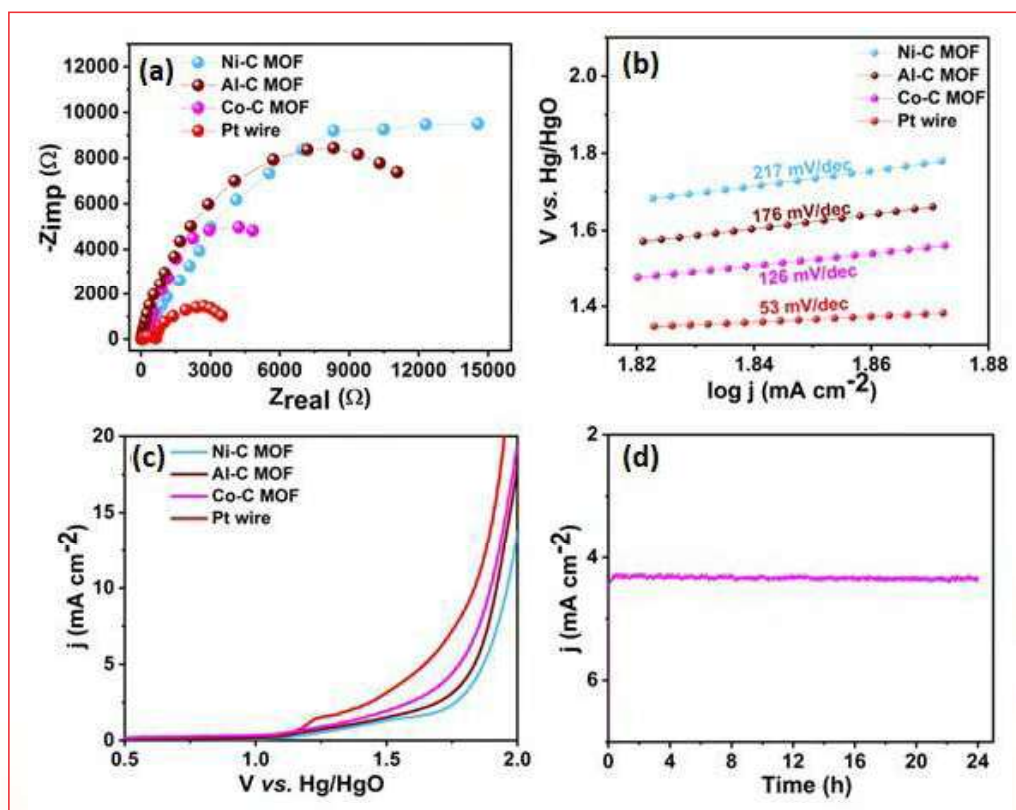


Figure 1. (a) LSV, (b) Tafel plot, (c) Nyquist plot of Al, Co and Ni-C MOF electrocatalysts in comparison with Pt wire, in 0.5 M H_2SO_4 with 2 mM BT at a scan rate of 50 $mV s^{-1}$ and (d) Stability study.

Pt-free and active sites enriched metal-carbon alloy electrocatalysts for polymer electrolyte fuel cells

GAP-21/21

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. Vishal M. Dhavale

Co-PI(s): Dr. Santoshkumar D. Bhat

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 20.12.2021 to 19.12.2024

Budget (Rs. in Lakh): 28.42

Objectives

- Porous 3-D Pt-free electrocatalyst for improved mass- and reactant-diffusion.
- Development of cost-effective reaction active sites enriched Pt-free electrocatalyst (replacement of costly Pt-based electrocatalyst).

Highlights

- Developed a durable electrocatalyst boasting a resilient knotted bamboo tube-like morphology, termed the “tip-in growth” using a single-step synergistic catalytic pyrolysis method which involves the diffusion of carbon atoms on CoNi-

alloy nanoparticles, resulting in nitrogen-doped bamboo-like carbon tubes encapsulating CoNi-alloy nanoparticles (CoNi@NC-T).

- Obtained the unique carbon-shielded corrosion-resistant morphology through intricate interplay of temperature, thermal polymerization of dicyandiamide and the catalytic role of CoNi-alloy nanoparticles.
- Observed an oxygen reduction reaction activity of CoNi@NC-T exhibits on par with the state-of-the-art Pt/C catalyst due to non-uniform distribution of local charges due to nitrogen doping, thereby enhancing conduction and polarization.
- Deployed CoNi@NC-T as a cathode catalyst in an anion exchange membrane fuel cell and achieved a peak power density of 170 mW cm^{-2} with a FUMASEP® FAA-3-30 membrane underscoring its potential for practical AEMFC application.

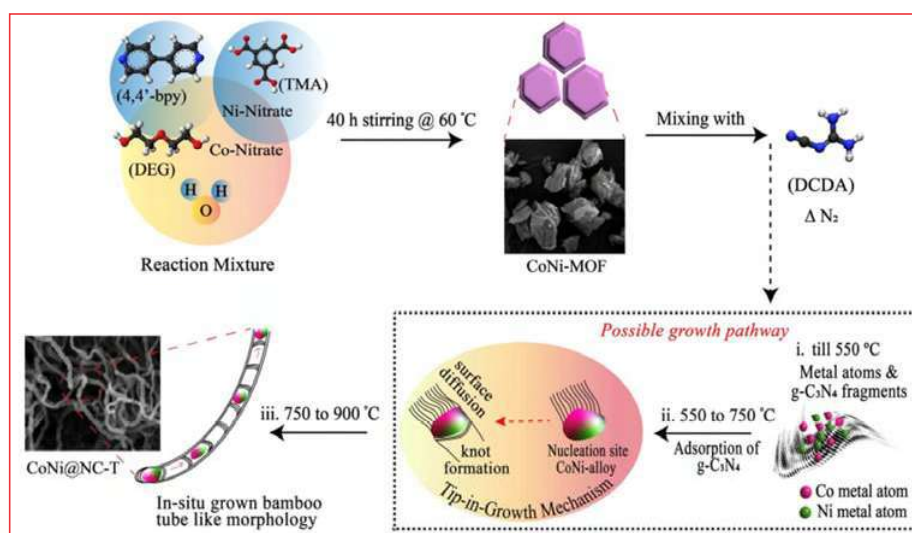


Figure 1. Schematic illustration for synthesis of CoNi@NC-T with bamboo tube-like morphology. [4,4'-bpy: 4,4'-bipyridine, TMA: trimesic acid, DEG: diethylene glycol, and DCDA: dicyandiamide].

Inducing internal vacancies in transition metal based ldhs via surface engineering as chalcogenides and ions modifications for water electrolysis

GAP-22/21

Division(s): Electrochemical Process Engineering
PI: Dr. Subrata Kundu
Co-PI(s): Dr. S. Vasudevan
Funding Agency: SERB-Department of Science & Technology, New Delhi
Duration: 21.01.2022 to 20.07.2025
Budget (Rs. in Lakh): 29.99

Objectives

- Synthesis of highly stable, active and modified layer double hydroxide and their various derivatives.
- Modification of LDH surfaces via different strategical procedure like foreign cation incorporation, anion exchange methods, deposition of LDH materials on various conductive substrates and the internal ion vacancy creation.
- Electrochemical studies of the synthesized defect rich LDH materials for electrocatalytic water

splitting in alkaline as well as in neutral and near-neutral electrolytes.

- Development of an alkaline water electrolyser of two electrode system using the synthesized high-performance and bi-functional water splitting modified LDH based materials.

Highlights

- Developed a novel S-doped CoV layer double hydroxide for the water oxidation and analyzed the detailed reaction kinetics and mechanism via in-situ EIS analysis, temperature-dependent studies, and pH-dependent studies.
- Developed W^{4+} ion doped NiCo-LDH for effective electrocatalytic OER where W-NiCo-LDH exhibits TOF value 31 times greater and activation energy value 3 times lesser as compared to bare NiCo-LDH.
- Incorporated Ir^{SA} and Ir^{NC}_{12} with NiMn-LDH supported on PAN nanofibers to enhance OER, HER, and TWS catalytic activity (Figure 1).

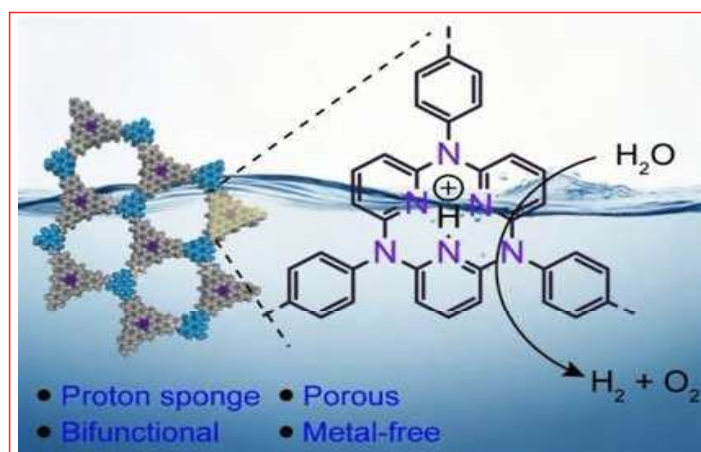


Figure 1. Schematic illustration of electrocatalytic water splitting on porous organic polymers (POP) based catalysts.

Development of heterostructured materials for an efficient photocatalytic and photoelectrochemical water splitting towards green energy harvesting

GAP-24/21

Division(s): Electrochemical Power Sources

PI: Dr. S. Arunmetha

Co-PI(s): Dr. M. Sathish

Funding Agency: SERB-TARE, New Delhi

Duration: 13.12.2021 to 12.12.2024

Budget (Rs. in Lakh): 10.05

Objectives

- To prepare the heterostructured materials derived from abundant minerals through facile inexpensive technology.
- To identify the promising photoactive materials that absorbs a significant portion of the solar spectrum.
- To estimate the stability and performance of the photoelectrode towards photoelectrochemical

activities and optimise the energy efficient hydrogen production.

- To design and develop an efficient PC and PEC water splitting (WS) hydrogen production system with optimised low cost stable photoanode material.

Highlights

- Synthesized $\alpha\text{-Fe}_2\text{O}_3/\text{TiO}_2/\text{g-C}_3\text{N}_4$ ternary nanocomposite through a hydrothermal process and achieved 8.829 mmol/g of hydrogen generation.
- Achieved 61% high photocurrent density $\sim 0.018 \text{ mA/cm}^2$ at $J1.23\text{V}$ for the $\text{Fe}_2\text{TiO}_5/\alpha\text{-Fe}_2\text{O}_3/\text{g-C}_3\text{N}_4$ ternary nanocomposite photocatalyst compared to the bare materials.
- Revealed a dual Z-scheme charge transfer mechanism by analyzing the band positions of the ternary nanocomposite.

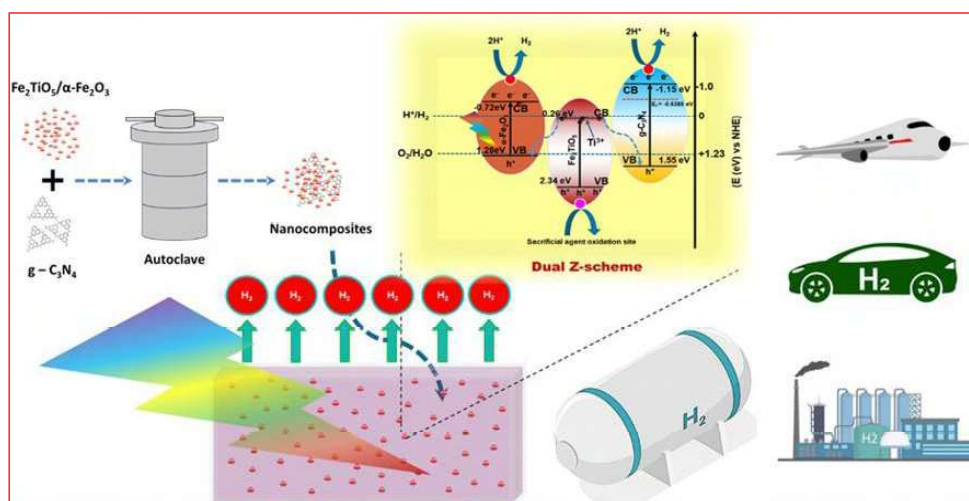


Figure 1. Schematic representation of $\text{Fe}_2\text{TiO}_5 / \alpha\text{-Fe}_2\text{O}_3 / \text{g-C}_3\text{N}_4$ ternary nanocomposite nanoarchitecture via hydrothermal synthesis for broadened visible-light absorption and efficient charge separation for sustainable hydrogen production.

Nanostructured materials for next generation energy conversion and storage devices

GAP-27/21

Division(s): CSIR-CECRI Chennai Unit
PI: Dr. A.S. Prakash
Co-PI(s): Dr. K. Ramesha
Funding Agency: Department of Science & Technology, New Delhi
Duration: 01.01.2022 to 31.12. 2026
Budget (Rs. in Lakh): 16.80

Objectives

- Synthesize cost-effective and eco-friendly electrocatalysts, including metal oxides and metal/oxide-carbon composites, using sustainable methods suitable for scale-up.
- Investigate materials with tunable electronic structures to enhance oxygen redox kinetics and improve overall catalytic efficiency.
- Develop catalysts capable of simultaneously driving ORR and OER, enabling efficient charge-discharge cycles in rechargeable metal-air batteries.
- Optimize catalyst morphology and composition to ensure long-term stability under harsh oxidative and reductive conditions in both aqueous and non-aqueous systems.
- Evaluate catalyst performance through advanced electrochemical techniques and correlate activity with structural features to guide rational design of next-generation materials.

Highlights

- Prepared Li_3N powder and compared its phase with commercial sample using powder XRD and the results showed that the prepared sample is identical to the commercial sample (Figure 1).
- The electrochemical performance of the prepared Li_3N powder was tested in a Swagelok cell
- Electrochemical impedance spectroscopic

results of the Li_3N cathode showed low charge-transfer resistance and efficient ion diffusion, indicating strong electrode-electrolyte interaction.

- Cyclic voltammetric analysis confirmed the redox activity of Li_3N within the voltage window of 2.0–4.5 V demonstrating its capability to support oxygen reduction and evolution reactions.
- The effect of type of carbon on discharge behaviour revealed that Vulcan carbon significantly lowers the over potential (~ 1.0 V), attributed to its high conductivity and porous structure that enhances oxygen accessibility and Li_2O_2 formation.
- Resting time optimization showed that extending the rest period before cycling improves discharge efficiency; a 24 h rest reduces the over potential to 0.58 V, likely due to better oxygen saturation and stabilization of intermediate species at the cathode surface.

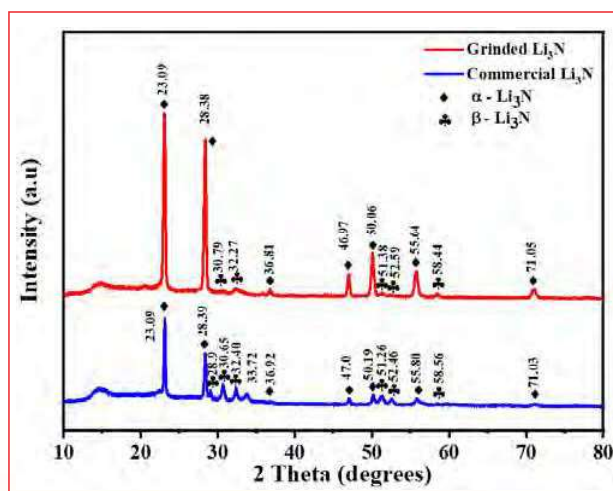


Figure 1. XRD patterns of the Li_3N sample prepared and commercial Li_3N samples.

Hand-held electrochemical platform for biomedical applications with particular emphasis on stress marker detection

GAP-28/21

Division(s): Electrode & Electrocatalysis

PI: Dr. A. Subbiah

Co-PI(s): Dr. M. Kathiresan and Dr. S. Senthilkumar

Funding Agency: Defence Research and Development Organization, New Delhi

Duration: 11.02.2022 to 10.02.2025

Budget (Rs. in Lakh): 45.00

Objectives

- MOFs, POPs synthesis and surface characterization.
- Incorporation of MOFs, POPs on to the electrodes.
- Electrochemical detection of analytes (Stress biomarkers) in clinical samples.
- Prototype device design and validation.

Highlights

- Designed bi-metallic metal organic frameworks (MOFs) based electrode and employed for the simultaneous electrochemical sensing of stress markers epinephrine and nor-epinephrine.
- Investigated the repeatability of the MOFs modified GCE by SWV and achieved retention of 95.3 and 94.5 % of its initial current for epinephrine and nor-epinephrine, respectively, after 30 continuous cycles.
- Achieved 95% recovery of the stress markers (EP and NE) in the spiked real samples blood and urine samples along with superior selectivity among interferents such as dopamine, ascorbic acid, uric acid, serotonin and KCl.

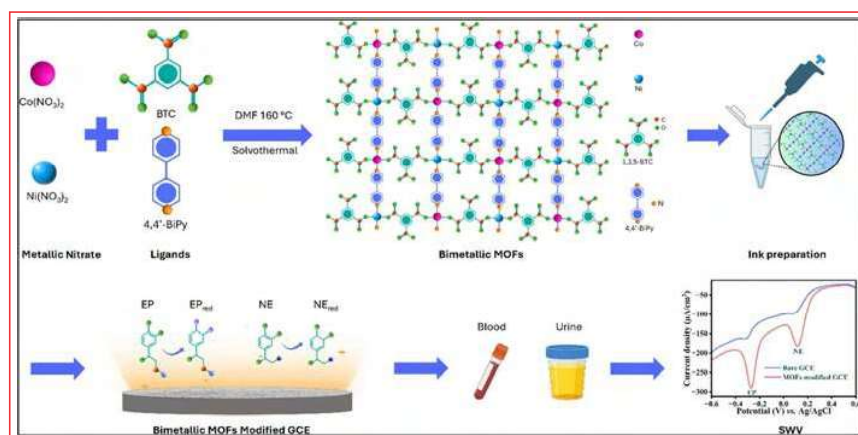


Figure 1. Schematic illustration of fabrication of bi-metallic MOFs based electrode and its application for the simultaneous electrochemical sensing of stress markers epinephrine and nor-epinephrine.

Electrochemical POC device for detection of vitamin B12 and vitamin A

GAP-30/21

Division(s): Electrode & Electrocatalysis

PI: Dr. C. Suresh

Co-PI(s): Dr. K. Giribabu

Funding Agency: Department of Science & Technology, New Delhi

Duration: 22.02.2022 to 21.08.2025

Budget (Rs. in Lakh): 40.5384

Objectives

- To develop stable and affordable sensing strategies for the quantification of vitamin B12 and vitamin A.
- To design and develop a miniaturized electrochemical POC amperometric device for sensing vitamins.
- To validate electrochemical POC devices with conventional methods such as chromatography

(HPLC or LC-MS) techniques for vitamin B12 and vitamin A.

- To demonstrate the applicability of the electrochemical POC device towards the analysis of vitamin B12 and vitamin A in patient samples (real analysis).

Highlights

- Achieved a very low limit of vitamin A detection of 72 nM using CoO modified GC electrode (Figure 1).
- Mitigated the interference effect and achieved excellent sensitivity towards vitamin A in the presence of other potentially interfering molecules.
- Developed CoO as an excellent matrix for determining very low concentrations of vitamin A having potential for practical applications.

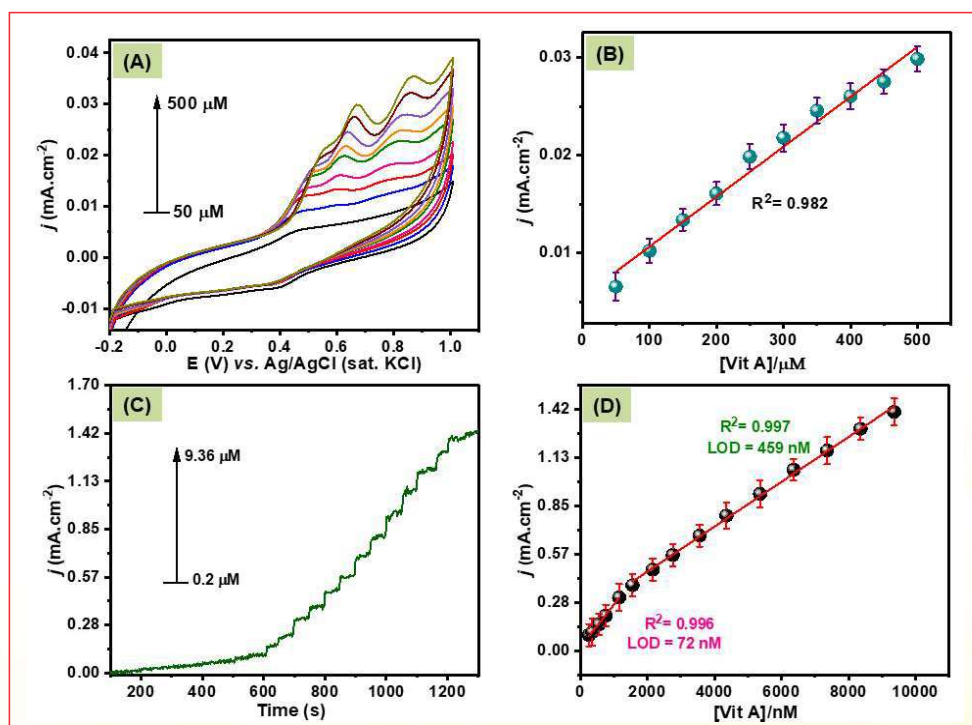


Figure 1. (A, B) Concentration effect and linear plot (C, D) Amperometric analysis of CoO/GCE with different concentrations of Vitamin A in 0.1 M acetate buffer (pH 3).

Automation and AI/ML-assisted development of solid-state battery

GAP-31/21

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. K. Ramesha

Co-PI(s): Dr. A.S. Prakash

Funding Agency: Department of Science & Technology, New Delhi

Duration: 14.02.2022 to 14.02.2026

Budget (Rs. in Lakh): 109.00

Objectives

- Developing Lithium garnet electrolyte of the general formula $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$. Obtaining cubic phase Lithium garnet with a conductivity of $\sim 10^{-3}$ - 10^{-4} S/cm.
- Improving the ionic conductivity of the garnet through doping of cations such as Sb, Ta, Al etc.
- Fabrication of composite electrolyte using the appropriate polymers as the host and the optimized composition of the Garnet-type material as the filler.
- Scaling up of the Lithium garnet electrolytes.

Highlights

- Synthesized doped Li garnet in bulk quantities of 10–20 g per batch (Figure 1) using the conventional solid-state method.



Figure 1. Sintered Sb-doped LLZO pellets.

- Confirmed the phase purity by XRD analysis (Figure 2), and the material exhibited ionic conductivity in the range of 10^{-4} S/cm at room temperature, as shown in the Nyquist plot.
- Prepared a composite solid polymer electrolyte (CSPE) using PVDF-HFP as the polymer host and as-synthesized Li-garnet as the ceramic filler and it exhibited ionic conductivity in the range of 10^{-4} S/cm.
- The CSPE demonstrated a high Li-ion transference number of 0.89, significantly higher than that of a conventional liquid electrolyte (0.31). This indicates suppressed anion mobility and enhanced cation transport, beneficial for minimizing concentration polarization.
- The electrolyte (CSPE) sustained stable Li stripping/plating for over 90 hours with minimal polarization (<100 mV), as evident, confirming strong interfacial compatibility and the ability to suppress dendritic growth.
- Half-cell test using LFP as the cathode revealed that the specific capacity was close to the theoretical capacity of 170 mAh/g. The reduced internal resistance confirmed effective ionic transport and interface stability of the CSPE system.

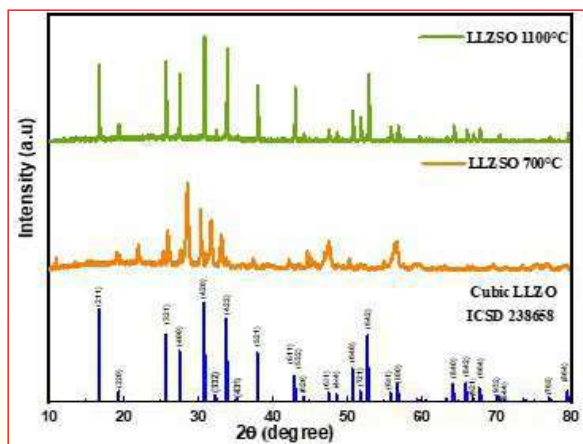


Figure 2. XRD analysis of $\text{Li}_{6.6}\text{La}_3\text{Zr}_{1.6}\text{Sb}_{0.4}\text{O}_{12}$.

Lithium salts as potential corrosion inhibitors and potential replacement for hexavalent chromium ion in hybrid sol-gel coating for active corrosion protection of Mg alloys

GAP-33/21

Division(s): Corrosion & Materials Protection
PI: Dr. C. Arunchandran
Co-PI(s): Dr. S. Sathiyarayanan
Funding Agency: SERB-Department of Science & Technology, New Delhi
Duration: 01.04.2022 to 31.03.2025
Budget (Rs. in Lakh): 27.5

healing property of the developed coating in real-time atmospheric conditions.

Highlights

- Deployed lithium carbonate (Li_2CO_3) to inhibit Mg AZ31 B corrosion by forming a magnesium carbonate (MgCO_3) protective film on the alloy surface.
- Incorporated Li_2CO_3 in the polysiloxane coating matrix to introduce a self-healing property to the coating for Mg AZ31 B and achieved high hydrophobicity with a water contact angle 132° .
- Found that the Li_2CO_3 polysiloxane coating exhibits self-healing by forming an MgCO_3 protective film on the exposed Mg AZ31 B surface when the artificially damaged coating is exposed to the marine environment.

Objectives

- To develop a lithium salt-based inhibitor for magnesium alloy AZ31 B to replace hexavalent chromium.
- To develop a simple and effective self-healing coating for Mg AZ31 B with lithium salts.
- To evaluate the corrosion resistance and self-

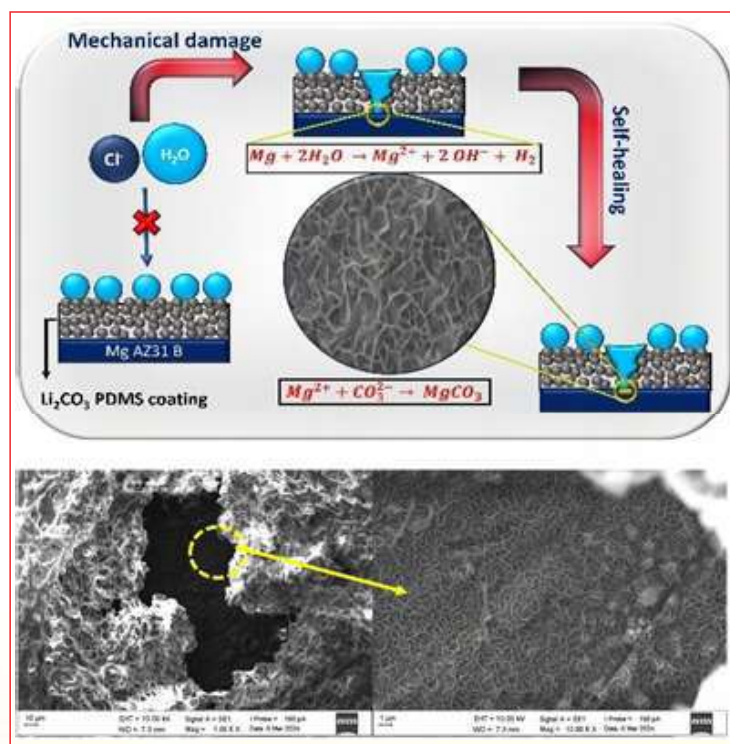


Figure 1. Schematic illustration of self-healing mechanism along with the SEM images.

Centre for rechargeable energy storage systems for augmenting transportation and electrification “(CREATE)”

GAP-03/22

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. A.S. Prakash

Co-PI(s): Dr. K. Ramesha

Funding Agency: Anusandhan National Research Foundation, New Delhi

Duration: 11.03.2022 to 10.03.2027

Budget (Rs. in Lakh): 142.04

Objectives

- Develop sustainable and low-cost electro catalysts for metal–air batteries using efficient synthesis methods.
- Enhance oxygen electro catalysis (ORR/OER) by engineering the electronic band structure and enabling Bifunctional catalytic activity.
- Develop high-loading sulfur cathode architectures (>70 wt% S) for lithium–sulfur (Li–S) batteries, employing advanced slurry casting, infiltration, or melt-diffusion techniques to maximize active material utilization.
- Optimize redox kinetics and sulfur conversion pathways through electrolyte formulation with high donor number solvents, lithium salts, and redox mediators, coupled with catalytic additives to promote reversible $S_8 \leftrightarrow Li_2S$ transformations.
- Demonstrate stable electrochemical performance of Li–S coin cells with a target specific capacity of $\geq 600 \text{ mAh} \cdot \text{g}^{-1}$ over 100 cycles,

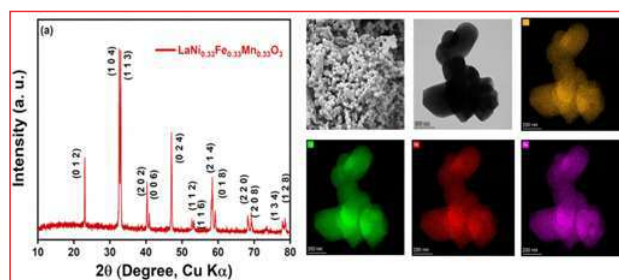


Figure 1. (a) Powder XRD patterns of the synthesized LNFC Perovskite oxides, (b) FESEM images showing particle distribution of LNFC catalyst with EDX mapping.

under lean electrolyte and high sulfur loading conditions.

- Advance Li–S battery technology by scaling up to pouch cell configurations, integrating optimized cathode, electrolyte, and separator systems to evaluate practical energy density and manufacturability.

Highlights

- Developed bifunctional electrocatalysts, particularly perovskite oxide LaNiO_3 (LNO) showing excellent conductivity and redox activity which on further co-doping with Co and Fe [$\text{LaNi}_{0.33}\text{Co}_{0.33}\text{Fe}_{0.33}\text{O}_3$ (LNFC)] enhances the eg orbital occupancy and Ni–O hybridization, improving OER performance.
- Synthesized LNFC via a low-temperature solution combustion route and characterized for phase formation and morphology (Figure 1).
- Studied the electrochemical activity by a rotating disk electrode (RDE) and assessed the OER capability of the catalyst by conducting LSV measurements in 1 M KOH solutions at 1600 rpm (Figure 2a).
- LNFC cathode exhibited a stable cycling performance up to 300 h with 2000 cycles.

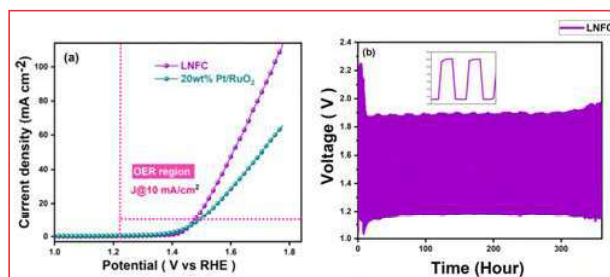


Figure 2. (a) OER activity-LSV curves of $\text{LaNi}_{0.33}\text{Co}_{0.33}\text{Fe}_{0.33}\text{O}_3$ (LNFC) and 20 Wt%Pt/RuO₂ catalyst at a sweep rate of 10 mV s^{-1} (b) Long-term cycle stability test of a Zn–air battery using the LNFC catalyst, conducted under 5-minute charge–discharge cycling intervals.

Design of genosensor system compatible biopolymer material ready for infectious diagnostic kit development

GAP-18/22

Division(s): Electrode & Electrocatalysis

PI: Dr. V. Murugan

Co-PI(s): Dr. C. Sivakumar

Funding Agency: SERB - ASEAN India Collaborative R&D Scheme, New Delhi

Duration: 22.09.2022 to 31.03.2025

Budget (Rs. in Lakh): 23.57

Objectives

- To develop Biopolymer derivative Functionalized with Redox-active species (BFR) convenient for multifunctional electrochemical diagnostic kit utility.
- Evaluate the physico-chemical properties of the BFR such as chemical structure, surface topography, ultrathin film characteristics and electrochemical properties essential for viral infection associated genosensing platform.
- Fabricate a prototype oligomeric biosensor platform based on BFR using carbon-screen

printed electrode, feasible for multi-variants SARS-CoV-2 assay diagnosis.

- Determination of genosensing parameters of BFR based oligomeric platform like linear range of analyte detection, current sensitivity, detection limit, specificity and selectivity.

Highlights

- Demonstrated a method for electrodeposition of biopolymer functionalized redox-species as transducer platform for peptide-based biosensor application.
- Developed immobilization protocol for shortest oligopeptide sequence associated to Fab region of SARS-CoV-2 neutralizing antibodies for electrochemical peptide-based biosensor construction has been studied (Figure 1).
- Constructed a positive/negative probe by bioaffinity layer-mediated immobilization over the EgGC electrode and explored the targeted sensing of spike proteins of SARS-CoV-2.

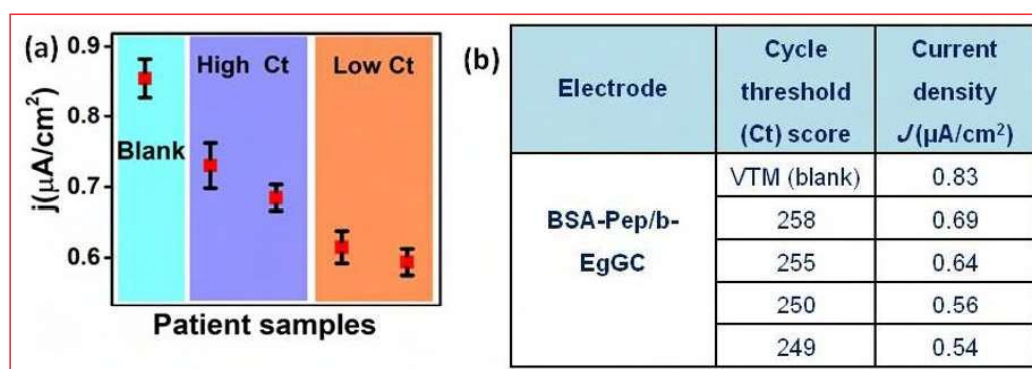


Figure 1. (a) Current response for the two different COVID-19 positive samples tested on the BSA-Pep/b-EgGC electrode. (b) Table represents the performance correlation of the prepared biosensor against the Ct score of validated clinical sample.

Refurbishing of lithium ion cathode material

GAP-21/22

Division(s): Electrochemical Power Sources and Electroplating & Electrometallurgy

PI: Dr. S.T. Nishanthi

Co-PI(s): Dr. C. Naveen Kumar

Funding Agency: Naval Science & Technological Laboratory, Visakhapatnam

Duration: 16.09.2022 to 15.09.2024

Budget (Rs. in Lakh): 50.13

- Reprocessing of cathode materials.
- Refurbishing of cathode materials and its performance evaluation.

Highlights

- Refurbished LFP cathode material successfully from spent lithium-ion batteries.
- Confirmed the formation of LiFePO_4 by X-ray diffraction (XRD) and no other impurity phases were found (Figure 1a).
- Carried out the electrochemical testing for specific discharge capacity in coin cell (full cell) assembled using the refurbished LFP (Figure 1b).

Objectives

- Collection of cathode materials from the dead/performance degraded lithium ion cells/batteries

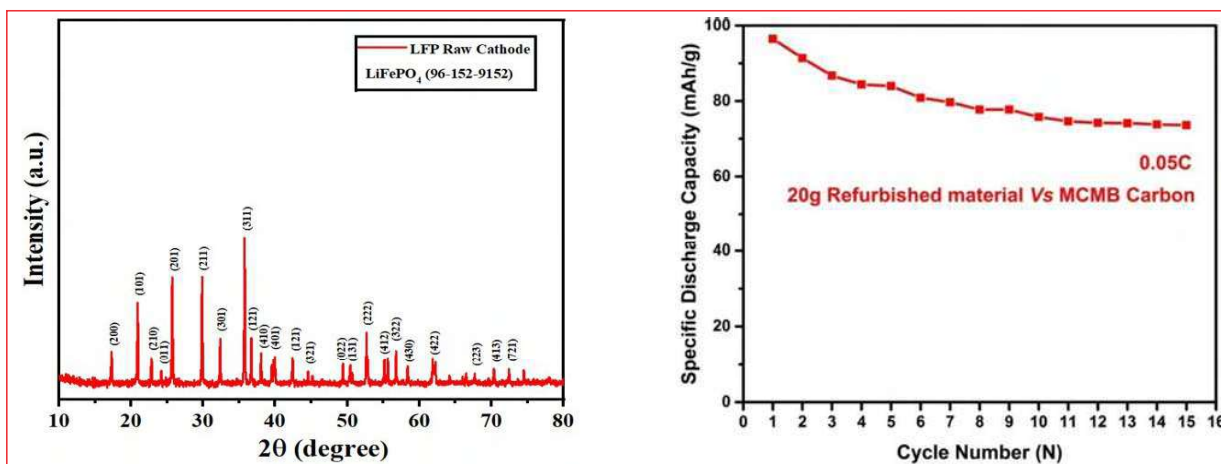


Figure 1. (a) XRD pattern of refurbished LFP cathode and (b) cycle number vs. capacity plot of full cell assembled using the refurbished LFP.

Understanding the transient potential oscillatory patterns of self-organized systems by time-resolved electrochemical plasmon-enhanced raman spectroscopy

GAP-24/22

Division(s): Electrode & Electrocatalysis

PI: Dr. P. Tamilarasan

Co-PI(s): Dr. C. Jeyabharathi

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 23.12.2022 to 22.12.2025

Budget (Rs. in Lakh): 30.42

Objectives

- To study the chemical changes in the electrodeposited cobalt, copper and nickel films (particularly, hydride and hydroxide formation) throughout potential oscillations using operando Shell-isolated Nanoparticle-enhanced Raman Spectroscopy (SHINERS).
- To find the associated chemical changes (protonation and deprotonation) in the organic additives, such as 1,4-Butynediol, 1,4-Butynediol ethoxylate and propargyl alcohol using operando SHINERS.
- To understand the lateral chemical distribution at various stages within a single potential

oscillation using quasi-operando tip-enhanced Raman spectroscopy (TERS) and correlating with the role of additives and evolution of surface morphology.

Highlights

- Observed an anomalous potential valley during the galvanostatic electrodeposition of copper, where the potential drop and self-recovery confirm the self-organization in the system.
- Revealed the mechanism using operando SHINERS where it is found that the dynamic interplay between electrode surface passivation, characterized by the formation of $\text{Cu}(\text{OH})_2$, and subsequent reduction by protons, elucidating the intricate electrochemical processes occurring during the deposition of Cu on the electrode surface.
- Understood that the strong proton accumulation on the electrode at deep in the valley reduces the $\text{Cu}(\text{OH})_2$ and CuO into Cu_2O and subsequently to metallic copper which helps the recovery process.

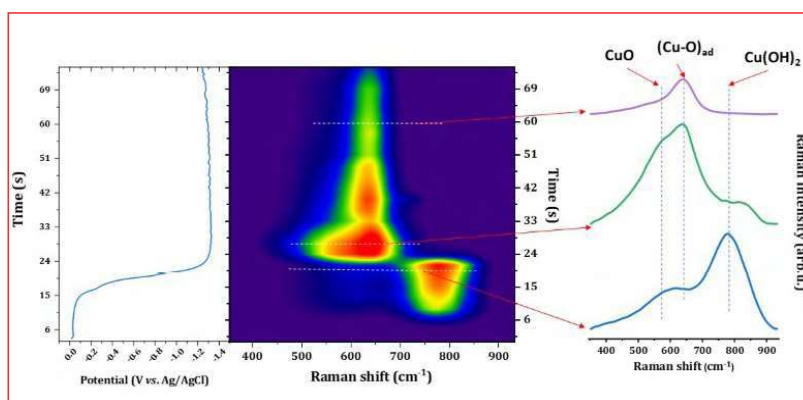


Figure 1. Spectroelectrochemical analysis of anomalous potential valley during Cu electrodeposition using operando SHINERS.

Development of self-powered wearable biosensors based on sweat actuated microfluidic biofuel cells for healthcare monitoring

GAP-26/22

Division(s): Electrodics & Electroanalysis

PI: Dr. A.M. Vinu Mohan

Co-PI(s): Dr. J. Mathiyarasu

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 07.10.2022 to 06.10.2024

Budget (Rs. in Lakh): 16.00

Objectives

- To develop sweat metabolite's based enzymatic biofuel cells with integrated microfluidic channels.
- To develop serpentine shaped stretchable electrochemical sensors for selectively detecting glucose, lactate, uric acid and hydration level from sweat samples.
- To develop a miniature printed circuit board for wireless data collection, and a DC-DC converter for boosting the voltage output of enzymatic biofuel cell.
- To develop fully integrated wearable biofuel cell based self-powered sensors for real-time sweat biomarker's monitoring via a smartphone device.

Highlights

- Developed a carbon-coated stainless steel thread (C-CT)-based self-powered biosensor embedded on a diaper substrate for glucose monitoring in urine samples from patients with urinary incontinence (Figure 1).
- The developed enzymatic biofuel cell (EBFC) comprise of a bioanode loaded with 1,4-Naphthoquinone (NQ) redox mediator and glucose oxidase (GOx) enzyme immobilized on gold nanowires (AuNWs) and oxygen-independent Ag/Ag₂O cathode (A, A') with agarose electrolyte gel was coated on both electrodes to avoid direct contact of the EBFC with the body.
- The EBFC enabled cell operation under small sample volumes < 10 μ L.
- Proposed the short-circuiting technique as an alternative measurement to avoid the need of using a potentiostat and glucose concentration was measured as a function of the current generated between the two electrodes while applying zero external voltage.

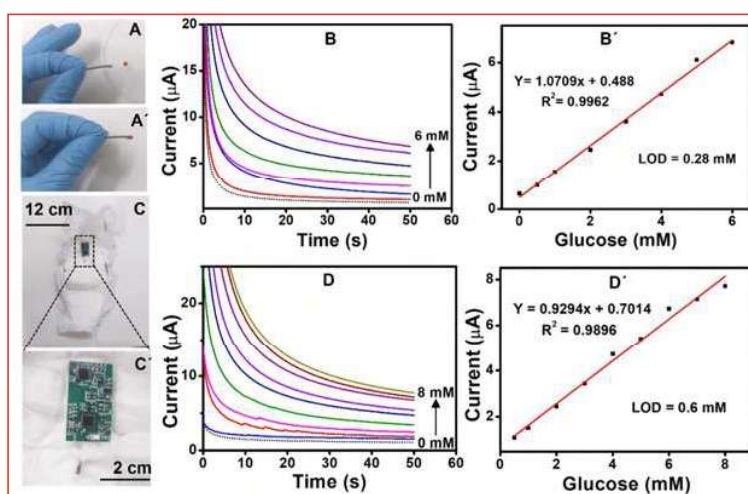


Figure 1. Photograph showing sampling of Agarose-coated EBFC with red dye (A, A'). Short-circuit measurements for glucose EBFC integrated with an Agarose gel electrolyte with glucose concentration varying from 0 mM to 6 mM (B, B'). Photograph showing diaper-embedded glucose EBFC connected to a Bluetooth-enabled PCB (C, C'). Diaper-embedded EBFC Sensor performances (D, D').

Design of novel luminophores for high spatiotemporal resolution of ECL imaging towards multiplexed bioassay

GAP-29/22

Division(s): Electrode & Electrocatalysis

PI: Dr. S. Senthilkumar

Co-PI(s): Dr. V. Murugan

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 01.02.2023 to 31.01.2026

Budget (Rs. in Lakh): 33.0

Objectives

- To develop potential-resolved SEM-ECL luminophores with multiple bioconjugate sites devised of organometallic (Ru/Ir) complex with semiconducting quantum dots/co-reactant(s) as single molecule to generate self-enhanced ECL signal through intramolecular interactions.
- To understand the optical, chemical structure, morphology, electrochemical and ECL properties of potentially-resolved SEM-ECL luminophores using comprehensive analytical tools.
- Exploration of potentially-resolved SEM-ECL luminophores as a solid-state multiplexed detection platform for the discrimination of

clinically important bio-thiols as biomarkers.

- To monitor the simultaneous yet real-time investigation of redox events in an in vitro and ex-vivo conditions using spatially resolved indigenous ECL microscopic technique.

Highlights

- Achieved ECL intensity enhancement on gold surface by selectively knocking out the Au active sites and the asperities by HO radicals that are generated either ex situ or in situ with Cu-Fenton reagent (Figure 1).
- Found that the ECL reaction mechanism switched from a direct route to a catalytic route when employing the standard ECL system composed of $[\text{Ru}(\text{bpy})_3]^{2+}$ and TPrA.
- Achieved a 2.6-times higher ECL intensity with a completely smoothened gold surface, reflecting 163 % of ECL efficiency compared to a roughened gold surface.
- Deployed technology for the detection of Cu^{2+} cations with a LOD value of $0.75 \mu\text{M}$ since the resulting ECL signal was stable for at least 60 s.

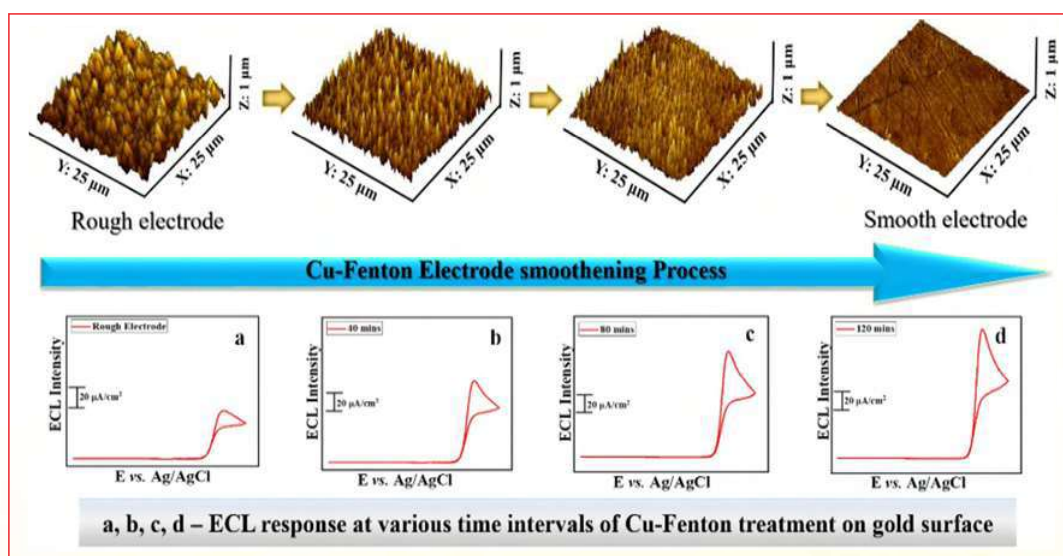


Figure 1. AFM topography of gold surface confirming surface smoothening (a,b,c,d) ECL response at various time interval of Cu-Fenton treatment of gold surface.

Ionic liquids for the electrodeposition of nickel and its alloys

GAP-30/22

Division(s): Electro-organic & Materials Electrochemistry

PI: Dr. V. Suryanarayanan

Co-PI(s): Dr. R. Sekar

Funding Agency: Defence Research and Development Organisation, New Delhi

Duration: 20.02.2023 to 19.12.2025

Budget (Rs. in Lakh): 22.39

Highlights

- Synthesized PIL, namely morpholinium glycolate (MMG) successfully which was used for electrodeposition of Ni-Cu on mild steel substrate.
- Revealed excellent cauliflower structure for Ni-Cu alloy deposition from SEM images, which is uniformly deposited throughout the substrate (Figure 1).
- Deployed choline chloride and aqueous bath for electrodeposition of Ni-Cu on mild steel for comparison which shows tiny fish-like structures, which are found to be uniform (Figure 2).
- Achieved maximum current efficiency of 89.69% with thickness of 22.16 $\mu\text{m/h}$ for ChCl containing bath.

Objectives

- Synthesis of novel protic ionic liquids (PILs) containing various tailor-made cations and anions and their physico-chemical characterization.
- Electrodeposition of Ni, as well as Ni-Cu alloys in PILs in few micrometers to nanometers and their characterization.

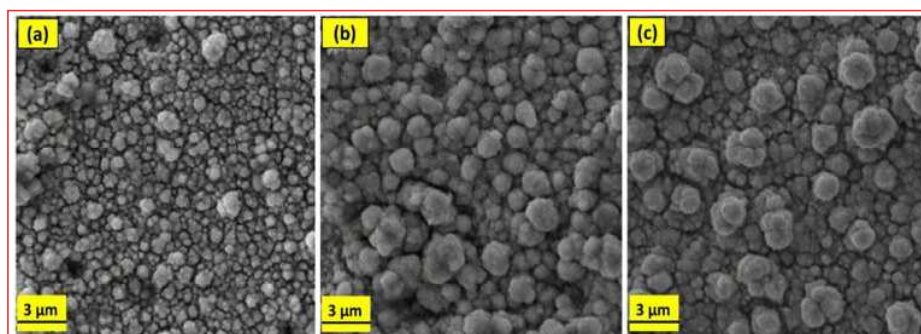


Figure. 1 SEM images obtained for Ni-Cu deposition on MS substrate (area 2 cm^2) from different baths of MMG. (a) Bath (Ni^{2+} : Cu^{2+} : 1.0: 0.05), (b) Bath (Ni^{2+} : Cu^{2+} : 1.0: 0.1) and (c) Bath (Ni^{2+} : Cu^{2+} : 1.0: 0.15) at a current density of 2 A/dm^2 at RT.

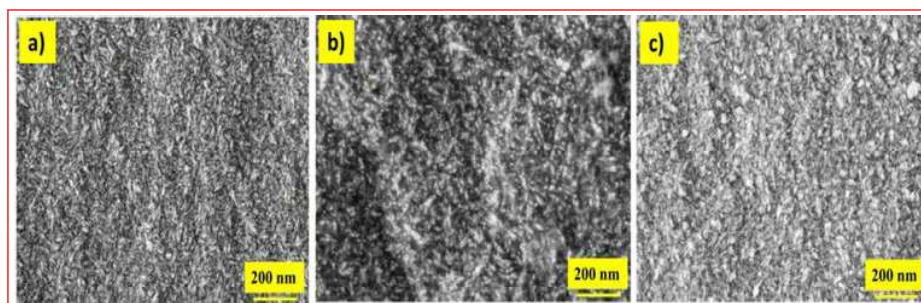


Figure. 2 SEM images obtained for Ni-Cu deposition on MS substrate (area 2 cm^2) from different baths of ChCl. (a) Bath (Ni^{2+} : Cu^{2+} : 1.0: 0.05), (b) Bath (Ni^{2+} : Cu^{2+} : 1.0: 0.1) and (c) Bath (Ni^{2+} : Cu^{2+} : 1.0: 0.15) at a current density of 2 A/dm^2 at RT.

Development of miniaturised single-electrode electrochemiluminescence platform for visual and high-throughput sensing of multiplex salivary biomarkers

GAP-31/22

Division(s): Electronics & Electrocatalysis

PI: Dr. S. Senthilkumar

Co-PI(s): Dr. V. Murugan

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 20.02.2023 to 19.01.2026

Budget (Rs. in Lakh): 31.85

Objectives

- To design novel self-enhanced ECL active biocompatible luminophores viz., (i) ruthenium (II), iridium (III)-chelates, (ii) luminal based nanocomposites and (iii) Quantum Dots.
- To understand the optical, chemical structure, morphology, electrochemical and ECL properties using spectroscopic, microscopic and electrochemical techniques.
- To utilize the ECL platform for an immunoassay of interleukin (IL)-8 mRNA and IL-8 protein in salivary samples.

Highlights

- Harnessed the transformative power of graphitic carbon nitride ($g-C_3N_4$) to develop an inspiring greener luminophore, poised to revolutionize electrochemiluminescence ECL applications.
- Adopted the ECL properties of $g-C_3N_4$ prettily by varying the thickness of the nanosheet.
- Achieved enhanced ECL emission from $g-C_3N_4$ NS (1:2) with unique attributes, including a band gap of 2.81 eV, crystalline size of 6 nm, layer thickness of 23 nm, surface area of 112.103 m^2/g , and pore volume of 0.196 cc/g (Figure 1).
- Developed a sensing methodology deploying the ECL probe for glutathione which has unparalleled sensitivity, rapid response times, and unmatched accuracy for the concentrations ranging from 1.0×10^{-6} to $5.0 \times 10^{-3} M$, culminating in a LOD of $43 \times 10^{-9} M$ in human urine sample with good recovery results.

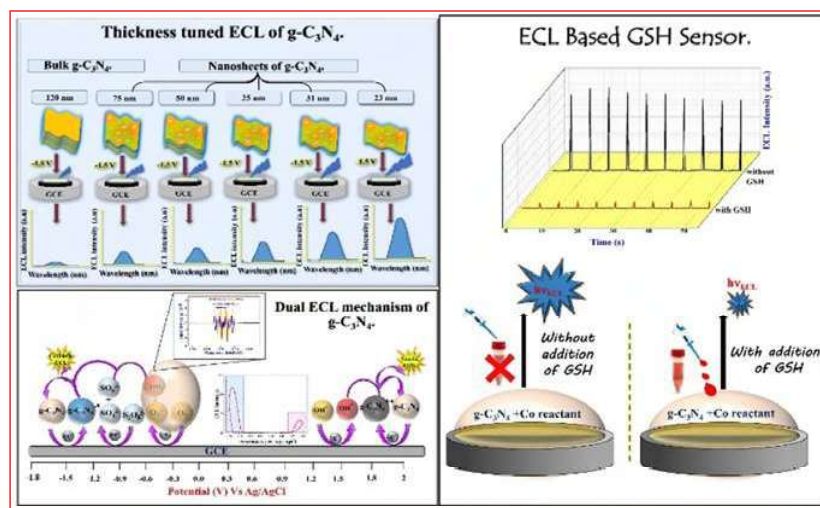


Figure 1. Schematic representation of ECL behaviour of $g-C_3N_4$, bulk and various ratio of $g-C_3N_4$, NS.

Indigenization of the HT-PEMFC technology at the raw materials and sub-component level by establishing pre-production scale manufacturing facilities

GAP-33/22

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. Vishal M. Dhavale

Co-PI(s): Dr. Harshal Agarwal

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 31.03.2023 to 30.03.2026

Budget (Rs. in Lakh): 144.32

Objectives

- Field geometry optimization trials for pre-defined anode gas compositions (reformate).
- Pt/C lab scale production optimization to reach production to the gm level.
- Flow-field optimization for pressure drop and uniform gas flow (single-cell level, 160 cm² area).
- First batch of indigenous MEAs with indigenous catalyst + indigenous membrane, tested in the single-cell level, active area of 160 cm².

Highlights

- Prepared Pt/C catalyst at lab-scale, using indigenous Pt-precursor (H₂PtCl₆) to support Make-in-India initiative, specific for the HT-PEMFC applications production of the prepared and displayed the reliable performance characteristics, which meet the benchmark values.
- Fabricated the MEAs with indigenous Pt/C catalyst with indigenous PBI membrane and achieved the current density of 0.481 A/cm² at a cell voltage of 0.6 V with stability > 32 hours at 70 A constant current.
- Recorded the I-V characteristics before and after the stability test which show the 8.5% drop in the current density, with an average cell voltage degradation rate of 0.67 mV/h (Figure 1).

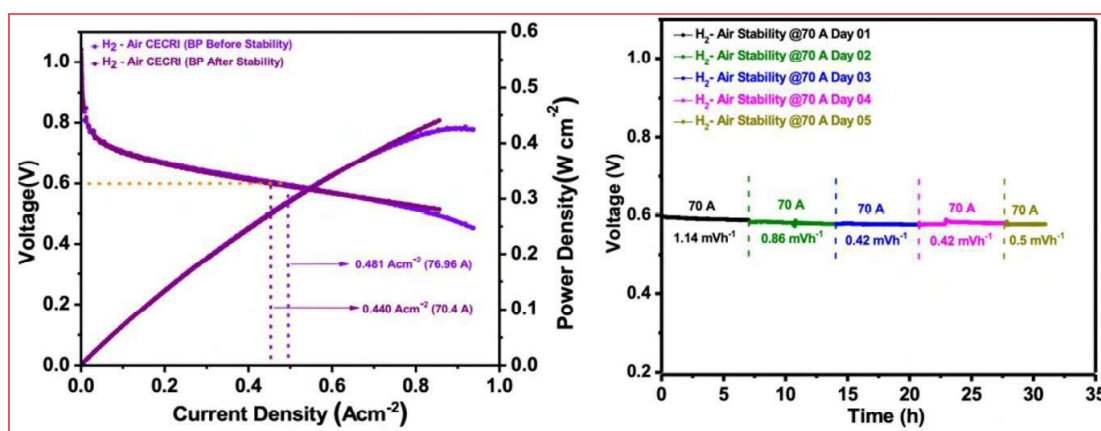


Figure 1: (Left) Polarization studies of HT-PEMFC fabricated with indigenous Pt/C and indigenous PBI membrane. (Right) Start-Up Shut-Down stability test conducted at constant current of 70 A.

Design and development of flow electrode capacitive deionization module for continuous water desalination

GAP-34/22

Division(s): Electrochemical Process Engineering
PI: Dr. R. Malini
Co-PI(s): Dr. S. Vasudevan
Funding Agency: Department of Science & Technology, New Delhi
Duration: 31.03.2023 to 31.03.2026
Budget (Rs. in Lakh): 23.91

Objectives

- To synthesize highly porous activated carbon from bio-waste and investigate the role of conductive additives in flow electrode and enhance the efficacy of flow electrode-based desalination.
- To investigate the significance of redox couple in the carbon slurry and identify the mechanism in the FCDI process through electrochemical characterization.
- To design and operate a continuous FCDI system with the treatment capacity of 6 L/hour.
- To compare the performance of prototype FCDI cell with reverse osmosis system in terms of energy requirements and water recovery.

Highlights

- The FCDI desalination performance at 2 V using the acquired palm shell activated carbon (5 Wt%)

along with graphite powder (1 Wt.%) in 0.5 M NaCl as flow electrode at a flow rate of 100 mL.min⁻¹ showed an average salt removal rate (ASRR) of ~13.08 µg.cm⁻².s⁻¹, salt removal efficiency (SRE) of ~32.35%, charge efficiency (CE) of ~8.78%, and average energy consumption (AEC) of ~0.59 kWh.mol⁻¹ for the feed water with a conductivity of 780 µS.cm⁻¹ at a flow rate of 2.5 mL.min⁻¹.

- Demonstrated a long-term operation of approximately 4 h with the tap water and 0.58 mg/L NaCl solution in recirculation mode.
- The membrane stacked FCDI cell with feed as tap water attained an average salt removal rate (ASRR) of 12 µg.cm⁻².min⁻¹, salt removal efficiency (SRE) of 51%, charge efficiency per cell pair (CE) of 42%, average energy consumption (AEC) of 0.043 kWh/mol, water recovery (WR) of 50%, and productivity (Pa) of 30 L/hm².
- Demonstrated the desalination of seawater in recirculation mode using the membrane stacked FCDI cell (active area 10 cm x 10 cm) with three cell pair architecture.
- This work enables the development of low-cost and energy-efficient flow electrode for continuous desalination, limiting pollution and reclaiming agro-waste.

Uniform coatings of doped silicon carbide on complex metallic shapes through electro-co-polymerisation route

GAP-01/23

Division(s): Electrode & Electrocatalysis

PI: Dr. P. Tamilarasan

Co-PI(s): Dr. C. Naveen Kumar

Funding Agency: Department of Science & Technology, New Delhi

Duration: 31.03.2023 to 30.03.2025

Budget (Rs. in Lakh): 46.68

Objectives

- To develop process for electropolymerization of metallocenes-doped or inorganic polymer blend polycarbosilanes coatings on complex metallic shapes.
- To optimize the pre-pyrolysis treatment and pyrolysis conditions for doped beta-silicon carbide coating formation with minimal mass loss, desired microstructure, crystallinity, ratios of Si:C, Si-C:Si-Si bonding and dopant.
- To test the scratch hardness and wear resistant

properties of the doped beta-SiC coated metallic structures according to the ASTM standards.

Highlights

- Electropolymerized polycarbosilanes (PCS), particularly Chloro(chloromethyl)dimethylsilane on metallic substrates where the conditions including counter electrode (Mg and Al), monomer concentration, supporting electrolyte concentration and current density have been systematically optimized (Figure 1).
- Found that thermal pre-treatment between 650 – 700 °C for 1 h under Ar atmosphere gives better crosslinking and adhesion where the subsequent pyrolysis at 1000 °C for 2 h under Ar atmosphere converts the PCS into SiC.
- Removed the secreted excess amorphous carbon by post-pyrolysis treatment at 600 °C in air for 2 – 2.5 h to obtain polycrystalline β -SiC film clearly showing TO and LO modes of SiC.

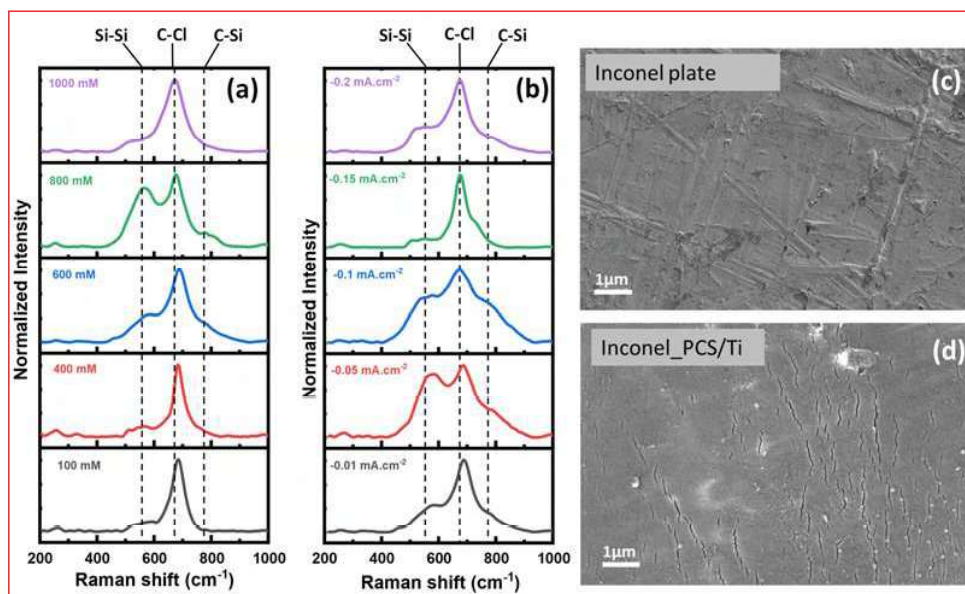


Figure 1. (a) Monomer concentration optimization, (b) current density optimization for galvanostatic electropolymerization of Chloro(chloromethyl)dimethylsilane. Electron micrograph of Inconel plate (c) before and (d) after the deposition of PCS.

Development of advanced thermal barrier coatings for high thrust rocket engines and components

GAP-02/23

Division(s): Electroplating & Electrometallurgy
PI: Dr. G. Sreedhar
Co-PI(s): Dr. B. Subramanian
Funding Agency: Indian Space Research Organisation, Mahendragiri
Duration: 31.03.2023 to 30.03.2025
Budget (Rs. in Lakh): 20.00

Objectives

- Synthesis of $\text{La}_2\text{Zr}_2\text{O}_7$ through the molten salt technique and Characterization.
- Modification of $\text{La}_2\text{Zr}_2\text{O}_7$ with primary and secondary additives.

- Development and optimization of coating parameters.
- Technology transfer to ISRO-IPRC.

Highlights

- Highly crystalline $\text{La}_2\text{Zr}_2\text{O}_7$ was synthesized through the molten salt technique as confirmed by powder XRD (Figure 1).
- Enhanced the properties of $\text{La}_2\text{Zr}_2\text{O}_7$ with the incorporation of additives such as Gd_2O_3 , TiO_2 , Ta_2O_5 , and Sc_2O_3 .
- Developed APS coatings at ISRO-IPRC and tested their performance.

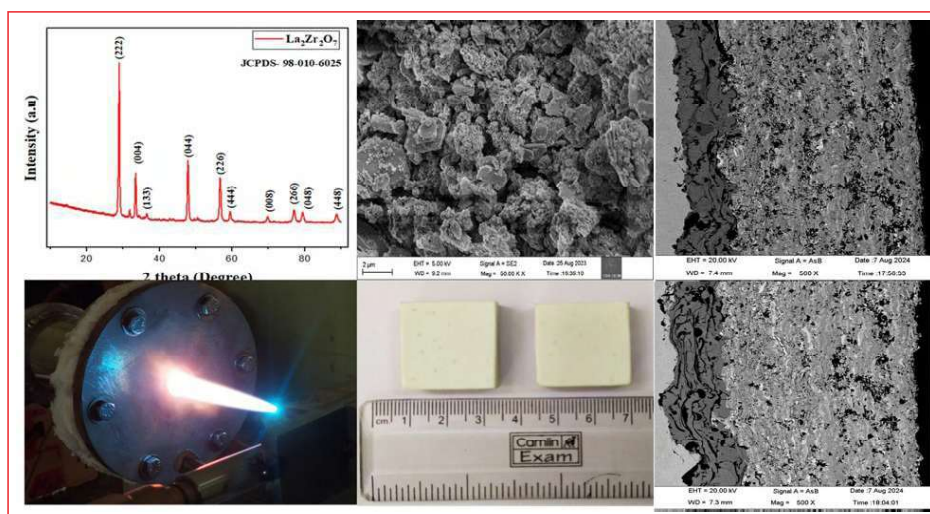


Figure 1. The powder XRD pattern, scanning electron micrographic images and photograph of sample are shown.

Electrochemical dating: A non-destructive and inexpensive analysis on metal and metal alloy artifacts

GAP-04/23

Division(s): Electroplating & Electrometallurgy

PI: Dr. C. Jeyabharathi

Co-PI(s): Dr. K. Giribabu

Funding Agency: Department of Science & Technology, New Delhi

Duration: 31.03.2023 to 30.03.2026

Budget (Rs. in Lakh): 39.50

Objectives

- Non-destructive sampling of the materials from metal-based ancient artifacts of known age, and also the unknown ancient archaeological materials.
- Electrochemical dating of Chola bronzes, metallic coins of the pre-colonial and colonial era.

- Electrochemistry of the sampled materials and developing an analysis library to correlate with archaeometry and electrochemical dating.

Highlights

- Collected Indian copper and copper alloy-based coins from different centuries.
- Prepared parafilm impregnated electrode (PIGE) and utilized for voltammetry of immobilized microparticles (VIMP) analysis (Figure 1a).
- Constructed a plot from the voltammetry analysis to identify the chronological information of the artefacts (Figure 1b).
- Attempted to identify the age of unknown age copper and copper-based alloy artifacts.

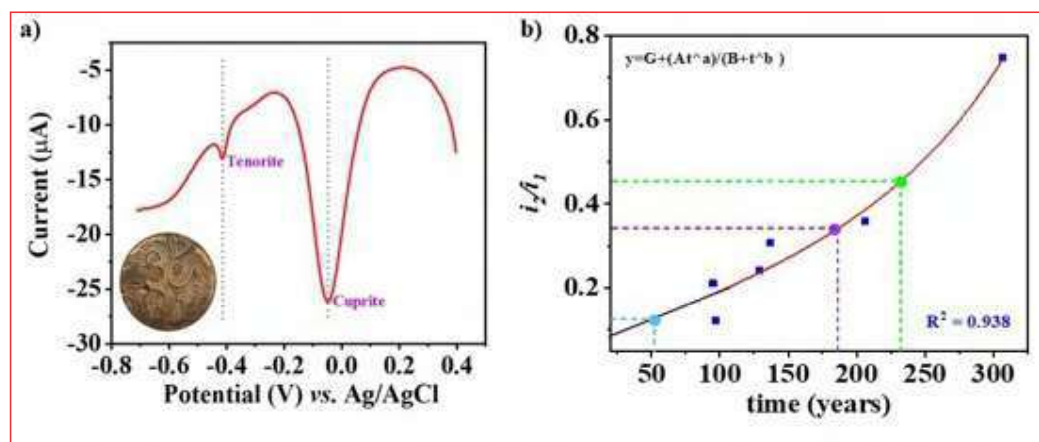


Figure 1. a) VIMP analysis of a cu-based coin using PIGE; b) Calibration plot from voltammetry analysis.

Concerted approach to diagnose and manage anemia through development of cost-effective point-of-care devices

GAP-11/23

Division(s): Electrodics and Electrocatalysis

PI: Dr. V. Ganesh

Co-PI(s): Dr. M. Kathiresan

Funding Agency: Department of Science and Technology, New Delhi

Duration: 28.06.2023 to 15.11.2024

Budget (Rs. in Lakh): 11.15

Objectives

- To develop materials and electrochemical detection methodologies for anemia through sensing the following analytes: (a) Vitamin A, (b) Folic acid and (c) Minerals Fe & Zn.
- To fabricate electrochemical sensing platforms using home-made screen-printed electrodes for the detection of proposed target analytes.
- Integration of electrochemical sensor with a portable electronic gadget for development of a hand-held device.
- Testing and evaluation of the developed electrochemical sensing platforms for clinical analysis as well as nutritional assessment of food items.
- Validation of the electrochemical sensing platform for anemia detection.

Highlights

- Developed electrochemical sensing platforms and methodologies for the selective and sensitive detection of Folic acid using amperometry and differential pulse voltammetry by employing chemically modified carbon-based screen-printed electrodes (Figure 1).
- Demonstrated the electrochemical detection of Zn using bismuth deposited gold electrode by employing adsorptive stripping voltammetry.
- Performed the real sample analysis to demonstrate the electrochemical detection of Folic acid and Zn using blood serum and food samples.
- Optimized the performance of developed electrochemical sensor in terms of pH, deposition time, loading of the active material and stripping characteristics etc. for Folic acid and Zn detection.
- Identified suitable indigenous sensor matrix and electrochemical methods for assessing anemia through the detection of Folic acid and Zn mineral.

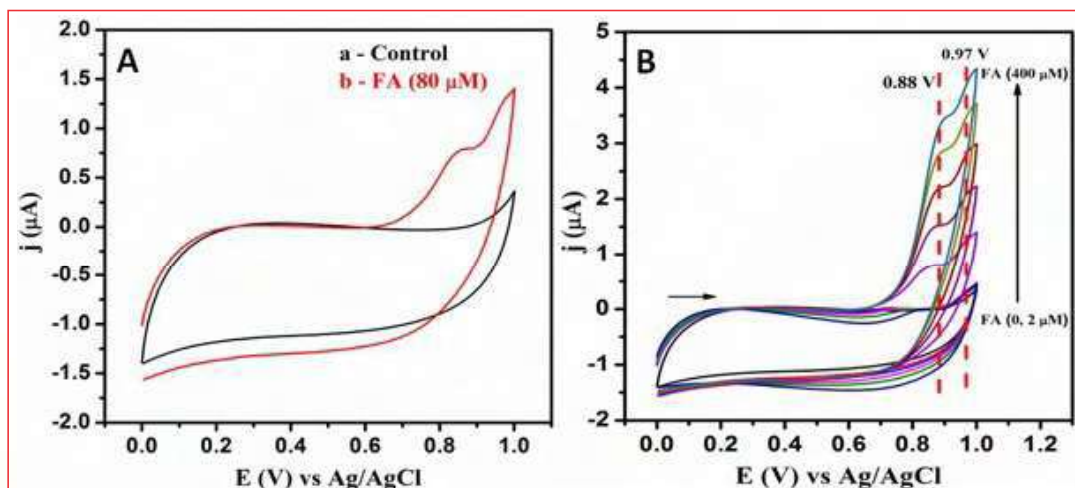


Figure 1. (A) CV curves recorded using SPE (carbon based) in absence and presence of folic acid at a scan rate of 25 mV/s in PBS (pH = 7); (B) CVs recorded for different concentrations of folic acid.

On-chip electrochemiluminescence based quantification of extracellular miRNA isolated from cancer spheroids

GAP- 14/23

Division(s): Electrodeics & Electrocatalysis

PI: Dr. M. Mohana

Mentor: Dr. S. Senthilkumar

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 13.10.2022 to 12.10.2025

Budget (Rs. in Lakh): 18.30

Objectives

- To construct lab-on-a-chip (LOC) for onco-screening of spheroidal extracellular miRNA.
- To develop and integrate electrochemiluminescence (ECL) as ultrasensitive detection platform for LOC set-up.
- To optimize the ECL-active luminophore(s) against the target miRNA specific to chemoresistance.
- Proof-of-concept evaluation of the efficacy of

chemotherapeutics on the regulation of miRNA expression.

Highlights

- Optimized the electrodeposited silver@poly-luminol nanocomposites on glassy carbon electrode (Ag@PL-GCE) for electrochemiluminescence (ECL) based miRNA detection.
- Associated a bio-affinity layer with Ag@Polymerized luminol for supporting the localization of target analyte (miRNA) and for a better tag of probe in GCE.
- Successful quenching of ECL signal upon hybridization of miRNA with its probe DNA (cDNA) (Figure 1).
- Constructed the microfluidic chip-based trapping of cancer spheroids to detect extracellular miRNA (Figure 2).

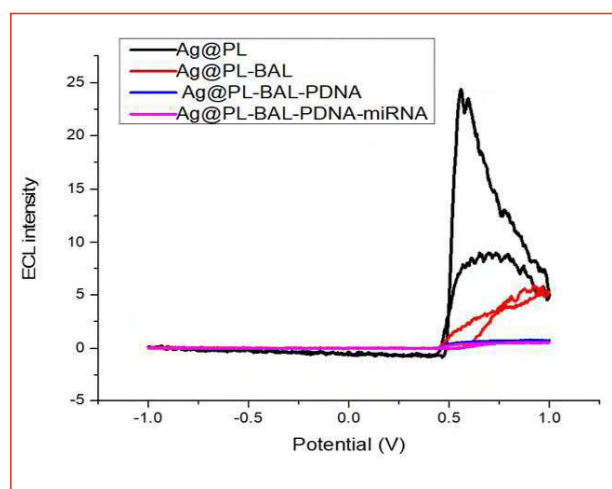


Figure 1. ECL quenching response against GCE functionalized with Ag@PL with bio-affinity layer, probe DNA and miRNA sequentially.

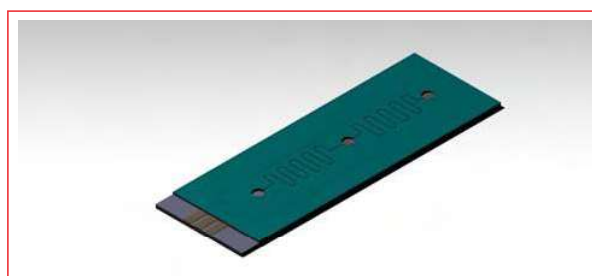


Figure 2. Microfluidic chip design for the trapping of cancer spheroids and simultaneous detection of extracellular microRNA.

Development of electro-catalysts and polymer membranes for hydrogen generation

GAP-17/23

Division(s): Electrochemical Process Engineering
PI: Dr. S. Vengatesan
Co-PI(s): Dr. S. Vasudevan and Dr. R. Malini
Funding Agency: BRNS-Department of Atomic Energy, India
Duration: 12.09.2023 to 11.09.2026
Budget (Rs. in Lakh): 37.311

Objectives

- Development of proton exchange polymer membranes.
- Development of noble-metal catalysts.
- Development of PEM electrolyser module.

Highlights

- Developed the aromatic hydrocarbon proton

exchange membrane, by cross linking poly (Sty-co-StyS), which showed conductivity as high as 1.57×10^{-2} S/cm.

- Developed Pt/C nanofibers using the electrospinning method where the FESEM images of the electrospun Pt/C nanofibers before and after calcination show clear fibrous morphology.
- Achieved good HER activity in the PEM electrolyser module comprising Pt/C electrocatalyst and developed membrane, showing a current density of ~ 100 mA/cm² (Figure 1).

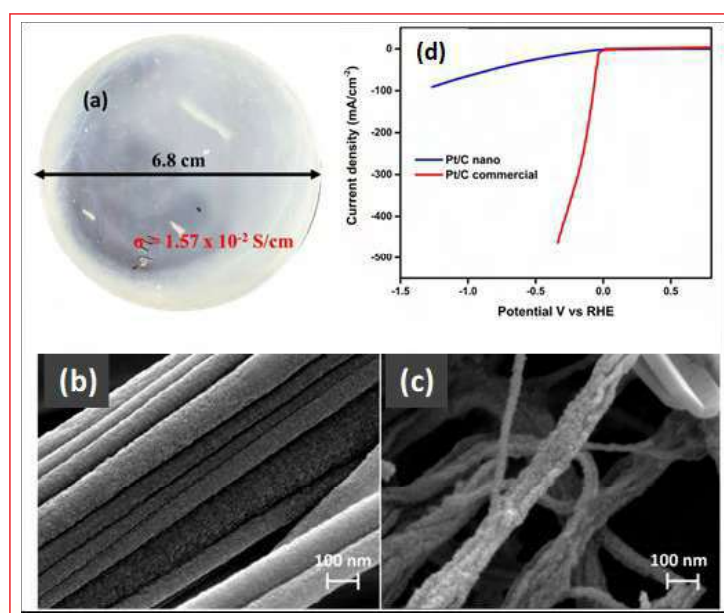


Figure 1. (a) Photograph and FESEM image of Pt/C nanofibers electrocatalyst (b) before and (c) after calcinations. (d) Comparison of LSV of Pt/C nanofiber catalyst and Pt/C commercial electrocatalyst.

Design and development of hetero-atom doped porous carbon/metal oxides composites as bi-functional (ORR/OER) oxygen electrocatalyst for energy conversion and storage applications

GAP-18/23

Division(s): Electro-organic & Materials Electrochemistry

PI: Dr. S.M. Senthil Kumar

Co-PI(s): Dr. R. Thangamuthu

Funding Agency: UGC-DAE Consortium for Scientific Research, Indore

Duration: 06.04.2023 to 05.04.2026

Budget (Rs. in Lakh): 19.52

Objectives

- To synthesize hetero atom doped porous carbons with tunable pore size and required quantity of hetero atoms by employing specific methods.
- Anchoring metal oxides, like, MnO_2 and Co_3O_4 with required morphology, crystallography and particle size over above prepared porous carbon surfaces.
- To characterize the catalysts material by using X-ray Photoelectron Spectroscopy and X-ray absorption spectroscopy at RRCAT BL-09.
- To evaluate their bi-functional activity by

employing linear sweep voltammograms at RDE, RRDE analysis of ORR and OER reactions.

- To design air cathodes and investigate their electrochemical performance in a metal-air battery configuration.

Highlights

- Prepared cobalt oxide integrated N, S dual-doped mesoporous hollow carbon spheres with high surface area, shell thickness, and mesoporosity, which act as an efficient catalyst for ORR and OER catalysts, by a single-step and eco-friendly method (Figure 1).
- Demonstrated superior current density, more positive onset potential, and lower Tafel slope values with less H_2O_2 production during ORR studies.
- Demonstrated multi-functionality of the catalyst with its superior OER activity with very less overpotential to reach 10 mA cm^{-2} current density.

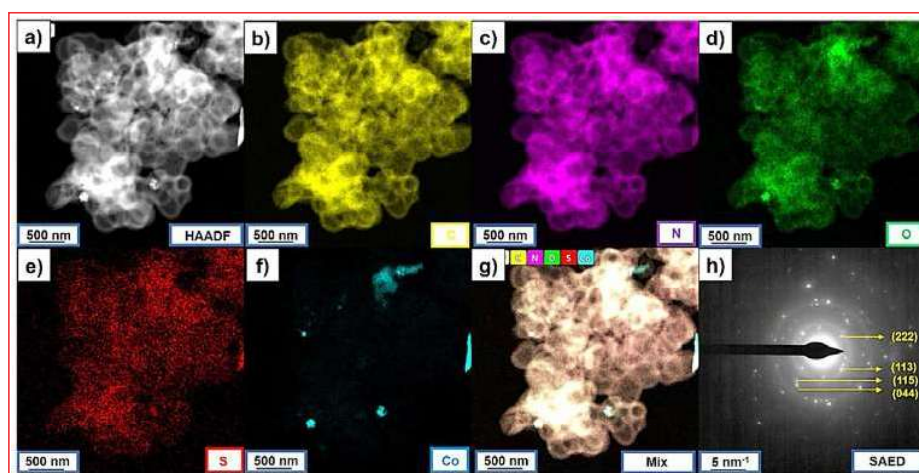


Figure 1. (a-g) Elemental mapping of cobalt oxide integrated N, S dual-doped mesoporous hollow carbon spheres, and (h) its corresponding SAED pattern.

Reinforcement perfluorosulfonic acid and short chain ionomer and sulfophenylated polyphenylenes with radical scavenger and expanded substrate via self-polymerization; its impact as composite membranes in polymer electrolyte fuel cell

GAP-28/23

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. Santoshkumar D. Bhat

Co-PI(s): Dr. Vishal M. Dhavale

Funding Agency: Anusandhan National Research Foundation, New Delhi

Duration: 30.01.2024 to 29.01.2027

Budget (Rs. in Lakh): 27.91

Objectives

- Reinforced composite membranes with short chain ionomers for higher ionic conductivity of 100 mS/cm.
- Reinforced composite membranes with hydrocarbon polymers for higher mechanical stability.
- Reinforced membranes with PTFE support for polymer electrolyte fuel cells for enhanced power density.

- Composite membranes with radical scavengers for higher chemical stability in polymer electrolyte fuel cells at low relative humidity.
- Maximum power density of 1 W/cm² with standard catalyst, and reinforced membranes in hydrogen/air configuration.

Highlights

- Evaluated the individual components of the reinforced membrane system to ensure optimal performance, including the mechanical properties and morphological features of pristine PFSA and PTFE membranes was conducted (Figure 1).
- Evaluated the PFSA and sulfophenylated polyphenylene (SPP) membranes were and compared under identical operating conditions.
- Fabricated reinforced membranes and incorporated poly(dopamine) to address delamination issue.

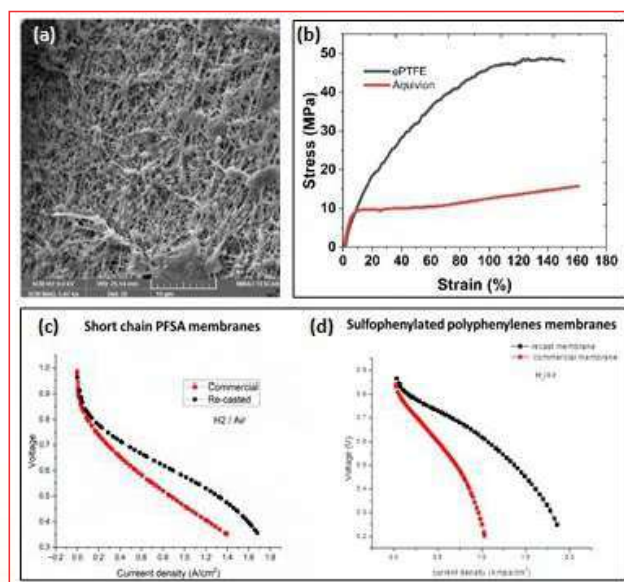


Figure 1. (a) SEM image of ePTFE, (b) mechanical properties of PFSA and ePTFE, (c & d) I-V characteristics of the SSC-PFSA and SPP membranes.

Design of electrified liquid-liquid and liquid-organogel interfaces: An active catalytic environment for CO₂ reduction

GAP-30/23

Division(s): Electrode & Electrocatalysis

PI: Dr. K. Giribabu

Co-PI(s): Dr. M. Pandiaraj

Funding Agency: Council of Scientific & Industrial Research, New Delhi

Duration: 15.02.2024 to 14.02.2027

Budget (Rs. in Lakh): 26.74

Objectives

- To study the electrocatalytic reduction of CO₂ at electrified liquid-liquid interfaces and liquid-organogel interfaces using two types of nano-/microscopic electrochemical cells viz. Liquid-liquid based electrochemical cell (both phases in liquid state) and gel based electrochemical cell (gelled organic phase).
- Integrating electrocatalyst (CuO_x and single atom catalyst [nickel functionalized carbon]) at the electrified interfaces through physisorption/applied Galvani potential individually and in tandem manner to evaluate the electrocatalytic reduction of CO₂.
- Assessment of electrochemical stability of the adsorbed electrocatalyst at the electrified liquid-liquid and liquid-organogel interfaces using in situ Raman spectroscopy and by optical imaging technique.

- The variation of electrolytes in both phases and change of organic phase solvent will be studied to understand the influence of surface polarity of the electrocatalyst towards the electrocatalytic reduction process.
- Mechanistic insights and formed products of the electrocatalytic reduction of CO₂ on electrocatalyst surface will be probed using scanning electrochemical microscopy, *in situ/ex situ*- electron paramagnetic resonance spectroscopy, nuclear magnetic resonance spectroscopy and differential electrochemical mass spectrometry.

Highlights

- Identified that the oxidation of the tetraphenyl borate anion present in the non-aqueous phase plays a crucial role in the bicarbonate reduction in the aqueous phase.
- Found that the oxidation of the anionic part of the electrolyte at the interface is electrode dependent, and the bicarbonate is reduced only in the presence of the electrified immiscible interface.
- Conducted isotope labelling experiments to substantiate the bicarbonate reduction at the electrified liquid-liquid interface.

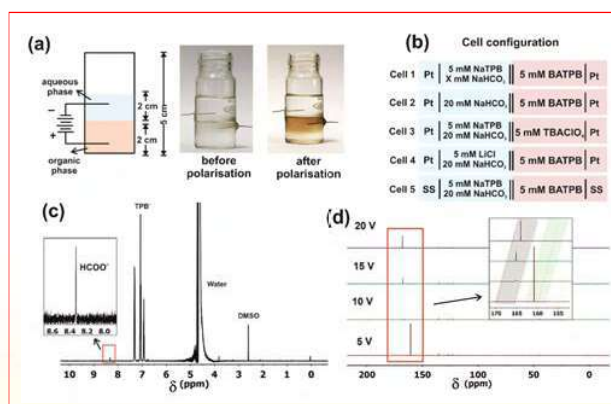


Figure 1. (a) Schematic illustration and photograph of electrochemical cell, (b) list of various cell configurations, (c) ¹H-NMR spectra of aqueous phase with cell 1 configuration (x=10 mM) at an applied bias of 10 V for 2 h, (d) ¹³C-NMR spectra of aqueous phase with cell 1 configuration (x=10 mM H¹³CO₃-labelled isotope) at an applied bias of 10 V for 2 h.

Development of non-precious metal based redox mediator for decoupled membrane-free electrolyzer for hydrogen production

GAP-32/23

Division(s): Electro-organic & Materials Electrochemistry
PI: Dr. A. Pandikumar
Co-PI(s): Dr. S.M. Senthil Kumar
Funding Agency: SERB-Department of Science & Technology, New Delhi
Duration: 04.03.2024 to 03.03.2027
Budget (Rs. in Lakh): 33.11

Objectives

- To design a facile method to synthesize and fabricate the transition metal based redox mediators of $M(OH)_2$ and non-precious transition metal based bifunctional catalyst.
- To correlate the redox mediator performance with the reversible transformation and charge/discharge capacities and the electrocatalytic performance of transition metal based binary and ternary bifunctional electrocatalysts.
- To construct a membrane free decoupled water electrolyzer with a solid redox mediator and a

bifunctional electrocatalyst for the overall alkaline electrolysis of water.

Highlights

- Developed India's first membrane-free decoupled water electrolysis for independent generation of H_2 and O_2 .
- Synthesized non-precious transition metal based hydroxides by hydrothermal and wet chemical routes as solid-state redox mediator and bifunctional electrocatalyst and fabricated a water electrolyzer, which is completely comprised of non-noble metal electrocatalysts.
- Demonstrated a proof-of-concept device for a membrane-free step-wise water electrolyzer for hydrogen and oxygen generation with a two-step decoupled cell potential of 1.91 V at 10 mA/cm².
- Decoupled H_2 and O_2 evolution spatiotemporally by reversing the current polarity and obtained 100% Faradaic efficiency for H_2 .

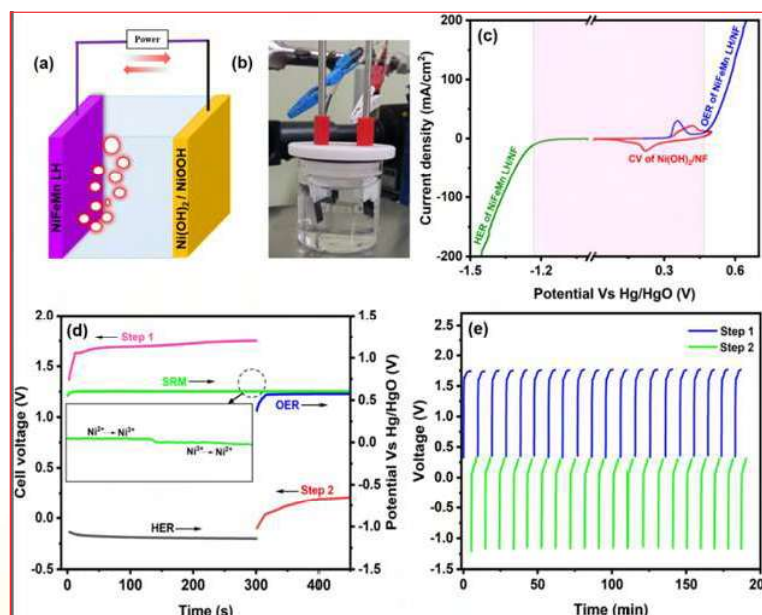


Figure 1: (a) Schematic illustration, (b) photograph of two electrode step-up, (c) Cyclic voltammogram, (d) Chronopotentiometry and (e) Stability plots of two-step water electrolysis.

Designing concealed defects enriched metal dichalcogenide decorated porous carbon nanostructures as sustainable electrocatalysts for green hydrogen generation

GAP-36/23

Division(s): Electro-organic & Materials Electrochemistry
PI: Dr. S.M. Senthil Kumar
Co-PI(s): Dr. P. Murugan
Funding Agency: SERB-Department of Science & Technology, New Delhi
Duration: 03.03.2024 to 03.03.2027
Budget (Rs. in Lakh): 27.35

Objectives

- To synthesize porous carbon nanostructures with controlled morphology, concealed defects and high surface area to serve as a robust support material for electrocatalysts.
- To introduce the metal dichalcogenide (MX_2) nanostructures (e.g., MoS_2 , WS_2) onto the porous carbon to enhance their intrinsic electrocatalytic activity towards the hydrogen evolution reaction (HER).
- To ensure uniform decoration of the porous carbon nanostructures with the maximum conductive phase of metal dichalcogenide nanoparticles using a scalable and cost-effective method.
- To comprehensively evaluate the electrocatalytic

performance of the synthesized hybrid nanostructures for green hydrogen generation in terms of overpotential, Tafel slope, exchange current density, and long-term stability in relevant electrochemical conditions.

- To investigate the chemistry behind the interface of the TMDs and the porous carbon support and the resulting electrocatalytic activity to gain fundamental insights for the rational design of high-performance and sustainable HER electrocatalysts.

Highlights

- Utilized molybdenum disulfide (MoS_2), produced by intercalation method, consisting mainly of 2H (semiconducting) and 1T (conductive) phases for HER (Figure 1).
- Overcome the inherent metastability and self-aggregation of 1T phase MoS_2 by integrating NH_4^+ ion intercalated 1T MoS_2 over N, S dual heteroatom doped hollow carbon spheres.
- Achieved exceptional electrocatalytic activity for the prepared catalyst (169 mV to reach 10 A/g current density, lower Tafel value of 74 mV/dec, and robust stability for 72 h in acidic medium).

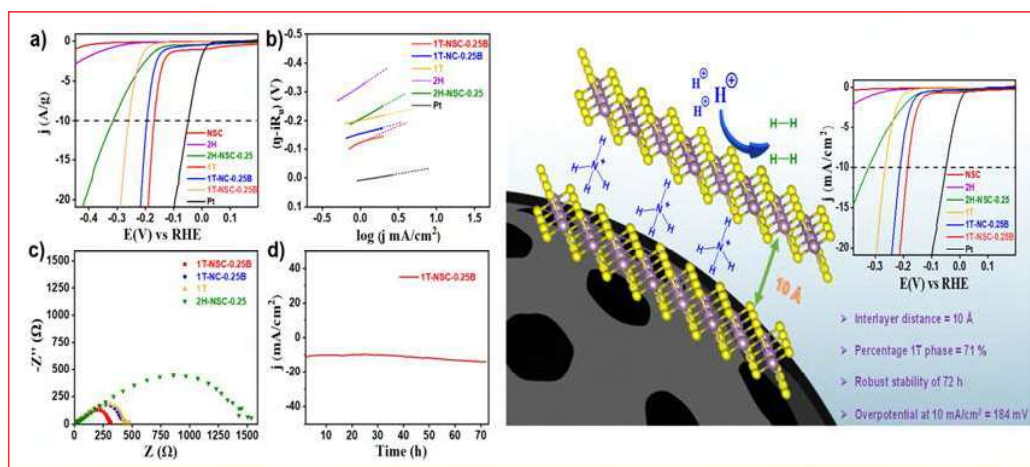


Figure 1. Left: (a) LSV (b) Tafel slope (c) EIS analysis of the prepared 2H-NSC and 1T-NSCs (d) CA evaluation of 1T-NSC-0.25B. Right: Schematic illustration of the HER process.

Design and development of AI-based smart battery management system for energy storage and e-mobility applications

GAP-35/23

Division(s): CSIR-CECRI Chennai Unit and Electrodeics & Electrocatalysis
PI: Dr. S. Hemavathi
Co-PI(s): Dr. Kuldeep Singh and Er. S.P. Thipperudraswamy
Funding Agency: Department of Science & Technology, New Delhi
Duration: 01.03.2024 to 31.03.2027
Budget (Rs. in Lakh): 120.00

Highlights

- Design and development of Unified Smart Battery Management System (BMS) for Li-ion batteries and advanced batteries tailored for Energy Storage and EV applications is under progress.

Objectives

- The main objective of this project is to design and develop Smart Battery Management system for managing the performance of lithium-based chemistry batteries such as LFP, NMC, LCO, NCA, and other advanced battery chemistries to ensure optimum performance and risk of damage to the battery to be prevented.
- The value-added feature of Artificial Intelligence includes an advanced intelligent algorithm to use for battery state estimation and health prediction to ensure accurate, high security, and energy management of Lithium-ion batteries remotely used in energy storage and e-mobility applications.

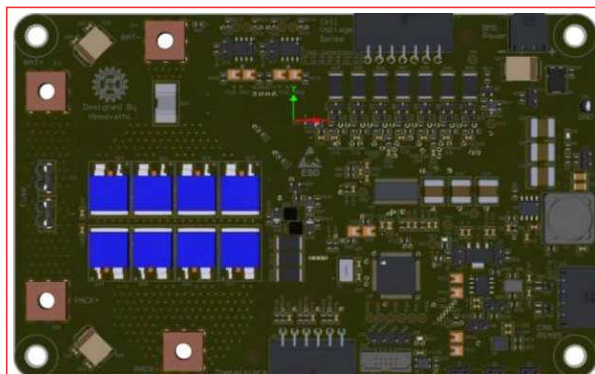


Figure 1. Protection Circuit Module of Proposed BMS.

Album



Dr. Kannan Srinivasan, Director, CSMCRI delivering expert talk organized by AcSIR Science Club [May 20, 2024].

Fabrication of flexible conductive fibres/fabric for wearable electronic textiles

GAP- 02/24

Division(s): Electrodics & Electrocatalysis

PI: Dr. C. Sivakumar

Co-PI(s): Dr. K. Giribabu

Funding Agency: National Textile Technical Mission, Ministry of Textiles, New Delhi

Duration: 05.04.2024 to 31.03.2026

Budget (Rs. in Lakh): 100.00

Objectives

- Preparation of flexible conductive fibres/fabrics by covalent linking of conducting polymer of PANI & its derivatives and % rGO onto the functionalized cotton surface, via *in-situ* polymerization/vapour phase polymerization route.
- Evaluation of critical parameters of conducting PANI and its derivative coated on cotton fabric (2 x 2 cm² 5 x 5 cm² & 1 ft x 1 ft) like conductivity (10-100 S/cm) values, mechanical properties (Tensile strength (12-40 Mpa), flexibility, laundry/water washing cycles (50-100), dry cleaning study and examine for the suitability of wearable electronic textiles.
- Fabrication of flexible conductive fibres/fabric,

assembly of flexible interconnects, testing and validation for wearable electronic textile for location monitoring in Military/Aviation.

Highlights

- Adopted a facile strategy to prepare rGO/PANI coated cotton fabric via dip and dry method followed by simple chemical oxidative route
- In situ chemical oxidative polymerization of ANI on rGO/cotton fabric (CF) using 50 mM in aqueous 1M HCl.
- Prepared poly(aniline) coated cotton cloth at various configurations of 1 x 1 cm², 2 x 2 cm² and carried out their physiochemical characterization of using FT-IR, Raman, FE-SEM analysis, and surface conductivity measurements.
- Prepared various Wt.% of GO loaded cotton cloth and formed PANI onto the cotton cloth. Confirmed the loading of GO through Raman analysis.
- Electrical conductivity of (1 x 1 cm², 2 x 2 cm²) cotton cloths were found in the range of 0.08 mS/cm to 620 mS/cm, based on the matrix of GO and PANI (Table 1).

Table 1. Electrical conductivity of Cotton Fabric with various loading of rGO, & PANI polymer.

Samples	% of loading	Conductivity (S/cm)
CF/PANI	+9.13	5.13 μ S/cm
CF/GO	+0.6	3.6 nS/cm
CF/GO/PANI	34.5	15.7 mS/cm
CF/rGO	-2.23	1.02 mS/cm
CF/rGO/PANI	+6.13	621.6 mS/cm

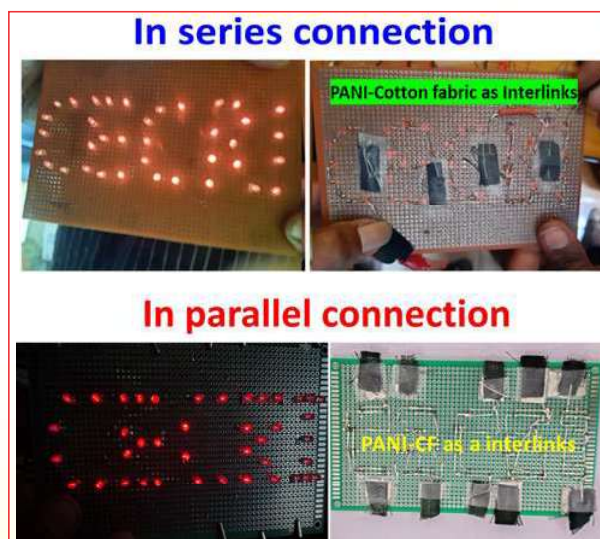


Figure 1. Digital photograph of LED lighted up (CECRI) by connecting with conductive cotton fabric.

Development of seaweed-derived cellulose and phytochemicals as cost-efficient additive composite for medical-grade textiles

GAP-04/24

Division(s): Electrodics & Electrocatalysis

PI: Dr. V. Murugan

Co-PI(s): Dr. S. Senthilkumar

Funding Agency: National Textile Technical Mission, Ministry of Textiles, New Delhi

Duration: 28.05.2024 to 27.05.2027

Budget (Rs. in Lakh): 51.48

Objectives

- To extract cellulose filaments from seaweed and study their physico-chemical properties.
- Study the mechanical strength of the cellulose fibres in conjugation with medical grade gauze.
- Isolation of residual bioactive substances other than cellulose from seaweed and process them with chitosan, toward hydrogel.

- To develop seaweed-chitosan hydrogel matrix on non-woven fabric and study the wound healing property in comparison with cellulose reinforced medical gauze.

Highlights

- Established protocol for isolation of cellulose from biomass of *Ulva compressa* and studied the optimal route for conversion of bulk cellulose into nanocrystals.
- Studied optimal experimental extraction procedures for polyphenols equivalent to gallic acid from *Ulva compressa*.
- Explored preliminary anti-bacterial function for the isolated polyphenols (gallic acid equivalent) both in crude and modified wound gauze dressing material form (Figure 1).

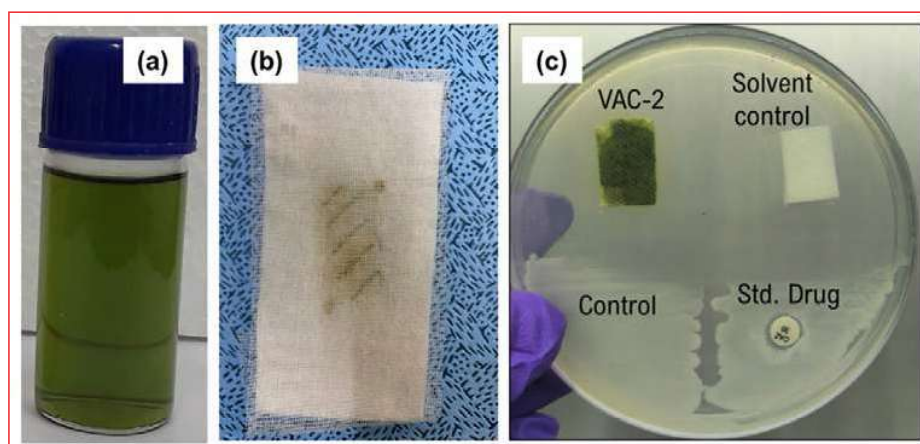


Figure 1. Representative image of (a) crude phytochemical extract in colloidal form, (b) cotton gauze modified with isolated polyphenol (gallic acid equivalent) and (c) zone of inhibition assay for selected VAC-2 (gallic acid equivalent) modified wound gauze studied against *Bacillus subtilis* in comparison with standard antibiotic and solvent.

Conductive yarns embroidered e-textile wearable systems for health and sports application

GAP-06/24

Division(s): Electrodics & Electrocatalysis

PI: Dr. M. Pandiaraj

Co-PI(s): Dr. N. Rajasekaran and Er. S.P. Thipperudraswamy

Funding Agency: Department of Biotechnology, New Delhi

Duration: 29.05.2024 to 28.05.2027

Budget (Rs. in Lakh): 78.42

Objectives

- Preparing sensor-integrated garments by direct digital printing/screen printing with conductive tracks and integrating metallic conductive yarns through computer controlled embroidering.
- Studying the effect of size, material and structure of the sensor-integrated electrodes on influencing skin impedance measurements.
- Investigating skin mimic phantom and sensor-

integrated garment interface as a testing platform for biosignal measurement.

- Integrating the sensor garments with low-power miniaturized microcontroller systems for wireless data transmission.

Highlights

- Embroidered silver and gold coated electrically conductive yarns to form sensor electrodes with various electrode structures using computerized embroidered assembly.
- Prepared conductive polymers and multiwalled carbon nanotubes deposited electrodes and integrated into various textile materials and wearable accessories.
- Evaluated the analytical applicability of the textile-based sensor for nitrite measurement in artificial urine samples and achieved a wide linear range (50 nM to 10 mM) during detection.

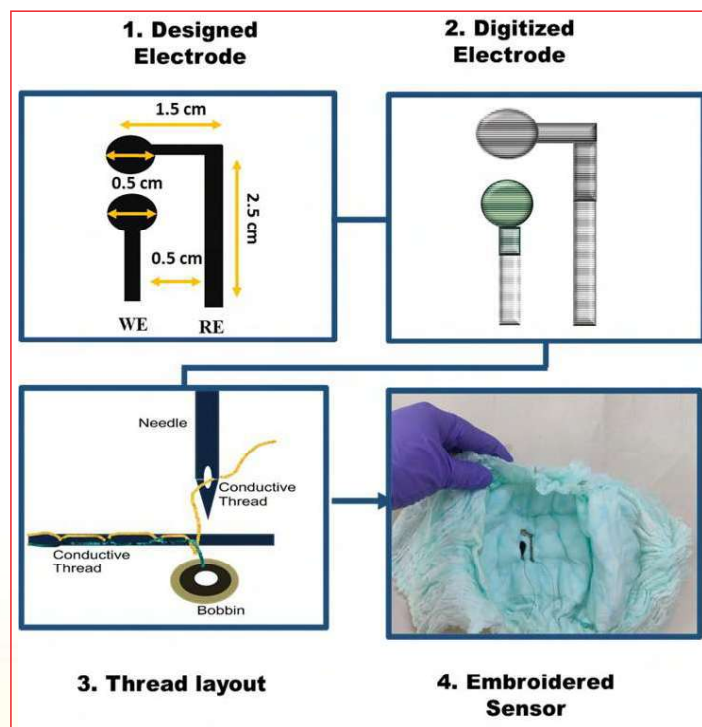


Figure 1. Electrode design, digitization and embroidering of textile electrodes on baby diaper.

Development of oxidation resistant iridium-rhenium (Ir-Re) coatings for satellite thrusters

GAP- 07/24

Division(s): Electroplating & Electrometallurgy

PI: Dr. G. Sreedhar

Co-PI(s): Dr. B. Subramanian

Funding Agency: SERB-Department of Science & Technology, New Delhi

Duration: 24.05.2024 to 23.05.2026

Budget (Rs. in Lakh): 42.00

- Optimization of CVD process parameters for the development of iridium-rhenium bi-layer CVD coatings on niobium alloy (C103).
- Fire test evaluation using steady and pulsing or dynamic modes at ISRO/Industry.

Highlights

- Established a low-temperature Chemical Vapour Deposition (CVD) setup to develop Ir/Re coatings on C103 alloy for the rocket thrusters (Figure 1).
- Completed trials to develop coatings on the coupon level.

Objectives

- Design of experiment on the development of iridium-rhenium CVD coatings.

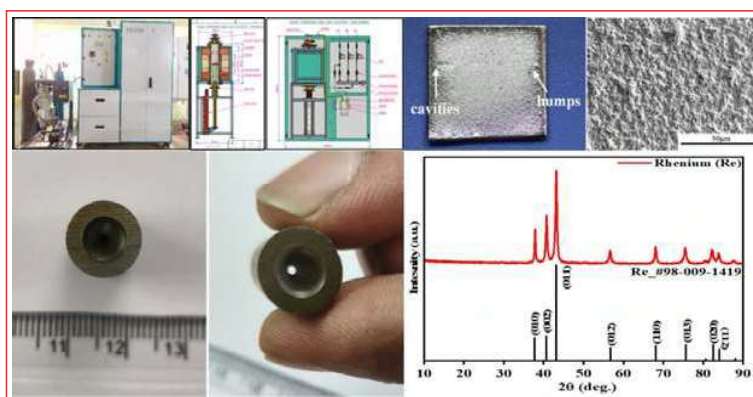


Figure 1. The photographs of the CVD setup and the coated sample along with the characterization results are shown.

Album



Dr. Deependra Singh, Chairman & MD, IREL (India) Limited, Prabhadevi, Mumbai delivering the National Technology Day Lecture [May 20, 2024].

Selective laser melted low modulus β -titanium alloy (Ti-Nb) bone implant with surface biofunctionalization

GAP-08/24

Division(s): Electrochemical Process Engineering
PI: Dr. Deepak Kumar Pattanayak
Co-PI(s): Dr. Rakesh C. Barik
Funding Agency: Anusandhan National Research Foundation, New Delhi
Duration: 27.05.2024 to 26.05.2027
Budget (Rs. in Lakh): 36.32

Objectives

- Optimization of process parameters for SLM based additive manufacturing of Ti-Nb alloy system.
- Development of biocompatible porous Ti-Nb alloy with antibacterial activity.
- Development of antibacterial bioactive glass powders and its subsequent coating over SLMed Ti-Nb implant via electrophoretic deposition.

- Cell material interaction over bioactive Ti-Nb alloy scaffold.
- Construction of Ti-Nb low modulus mandibular device with bioactivity, antimicrobial activity, and biocompatibility.
- In-vivo study of surface functionalized Ti-Nb alloy implant in animal model.

Highlights

- Developed additive manufacturing grade Ti-Nb alloy powder with particle size ranging between 15-50 μ m indigenously using plasma spheroidization method.
- Synthesized amorphous antibacterial bioactive glass powders using sol-gel method and evaluated its properties.
- Evaluated the antibacterial activity using both gram-positive and gram-negative bacterial strains *S. aureus* and *E. coli* respectively as shown in Figure 1.

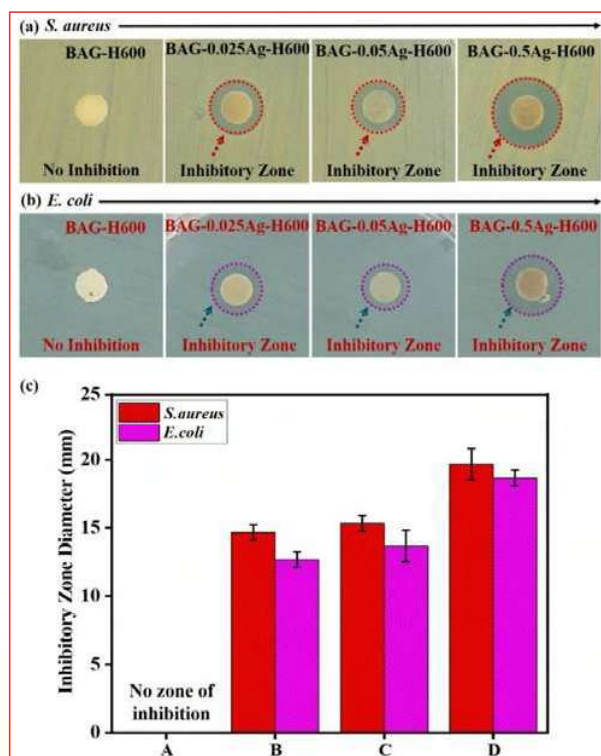


Figure 1. Antibacterial study of different silver incorporated bioactive glass powders against, (a) Gram-positive *S. aureus* and (b) Gram-negative *E. coli* bacterial strains, (c) bacterial inhibitory efficiency of different bioactive glass powders, (A) BAG-H600, (B) BAG-0.025Ag-H600, (C) BAG-0.05Ag-H600, and (D) BAG-0.5Ag-H600.

IoT based water and soil health monitoring systems with affordable indigenous sensors for intensive aquaculture

GAP-09/24

Division(s): Electrodics & Electrocatalysis

PI: Dr. J. Mathiyarasu

Co-PI(s): Dr. M. Pandiaraj

Funding Agency: Department of Biotechnology, New Delhi

Duration: 24.05.2024 to 23.05.2027

Budget (Rs. in Lakh): 78.42

- To develop control system for mobile monitoring system and its integration with processing unit of sensors for data-driven intelligence to materialize the automation of aerators and auto feeder.
- To test the efficiency of water and soil health monitoring systems and develop location specific advisories for farmers.

Highlights

- Developed electrochemical pH sensors on printed sensor platform using graphene and polyaniline-based ink formulations.
- Evaluated the working function of the pH sensor in both the small (50 μ L) and large (5 mL) volumes of pH solution.
- Developed a tiny electrochemical device for pH sensing and successfully interfaced with a smartphone and its performance was compared with the commercial portable potentiostat.

Objectives

- To design the indigenous cost-effective reliable sensors for measuring water and soil parameters in aquaculture ponds.
- To standardize and certification the accuracy of sensors in varying saline/non-saline waters and interferences.
- To develop IoT enabled sensor interface electronics for monitoring water and soil parameters in aquaculture ponds.

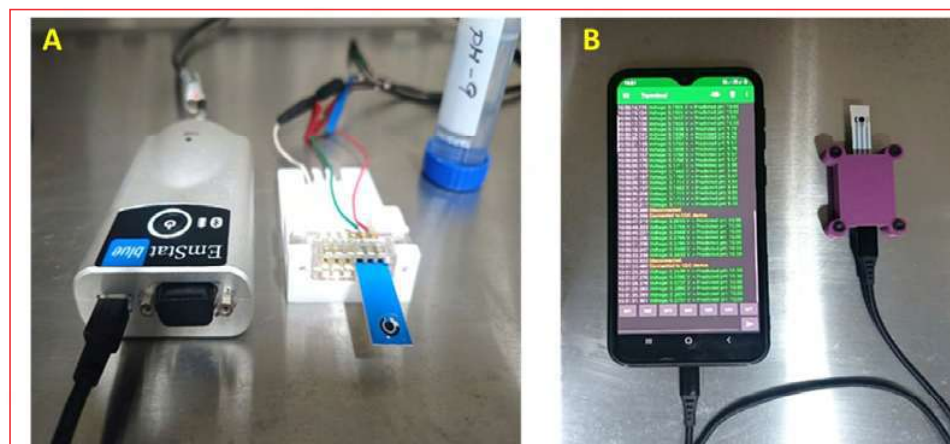


Figure 1. The pH sensor connected to (A) commercial potentiostat and (B) smartphone integrated miniaturized potentiostat.

Design and development of lithium-ion batteries and demonstration of 1.5 KWh battery pack for EV application

GAP-10/24

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. A.S. Prakash

Co-PI(s): -

Funding Agency: Department of Science & Technology, New Delhi

Duration: 21.04.2024 to 20.04.2027

Budget (Rs. in Lakh): 185.18

Objectives

- Develop 18650 Li-ion cells with NMC532/622/811 to achieve 230 Wh/kg energy density.
- Design Li-ion batteries suited for Indian geographic and socio-economic conditions.
- Develop and demonstrate a 1.5 kWh Li-ion battery pack.
- Fabricate and test 2.5 Ah cylindrical cells using NMC532/622/811 cathode and graphite anode.
- Optimize fabrication parameters such as slurry properties, coating thickness, and cell assembly.
- Evaluate electrochemical performance through charge-discharge cycling, rate capability, and impedance.

- Integrate cells into a 1.5 kWh battery pack with BMS and power electronics for protection and control.
- Test the developed components and battery systems at CECRI facilities.

Highlights

- Successfully developed a 18650 lithium-ion battery (LIB) with (NMC532) cathode, with 2.3 Ah capacity, reaching a nominal voltage of 3.6 V, marking a significant step in energy storage applications.
- Achieved an energy density of 192 Wh/kg (gravimetric) and 526 Wh/l (volumetric)-comparable to standard commercial cells.
- Battery design supports operation across a wide temperature range (10 °C to 60 °C), enhancing versatility for various applications.
- Preliminary tests suggest a competitive performance with commercial cells in terms of energy storage, efficiency, and lifecycle (Figure 1).

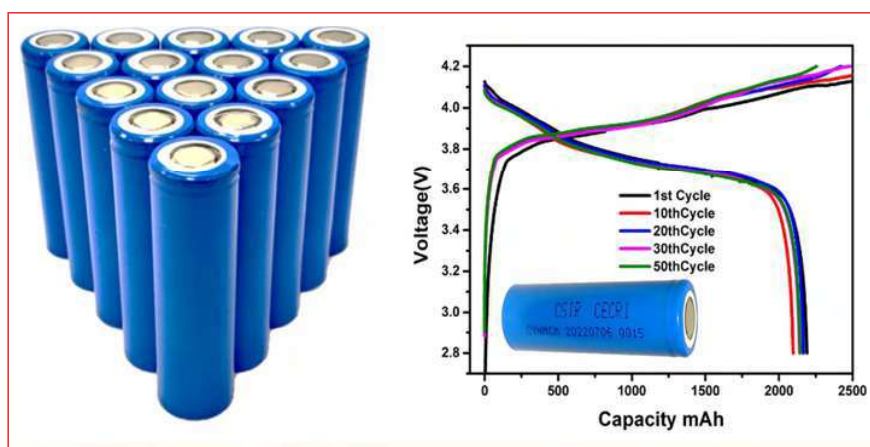


Figure 1. Photograph of fabricated Li-ion cells (18650 type) with NMC532 cathode and the cycling performance.

Development of non-cyanide autocatalytic silver-plating chemistry

GAP-14/24

Division(s): Electroplating & Electrometallurgy
PI: Dr. Subhendu Kumar Panda
Co-PI(s): Dr. N. Rajasekaran
Funding Agency: Indian Space Research Organisation, Bengaluru
Duration: 23.08.2024 to 22.08.2026
Budget (Rs. in Lakh): 19.88

Objectives

- To develop an eco-friendly, non-cyanide-based electrolyte for autocatalytic silver deposition on aluminium substrates.
- To optimize the pre-treatment (zincating) process for effective activation of Aluminium 6061 alloy, enabling uniform electroless nickel undercoating.
- To optimize the autocatalytic silver-plating process by adjusting the concentrations of reducing agents, stabilizers, and other additives to ensure bath stability.

- Design, fabrication and optimization of the flow bath reactor to coat the inner walls of the Al alloy waveguides.
- To achieve the $> 2 \mu\text{m}$ thickness of Ag deposition on the Al surfaces within two hours.
- To coat and demonstrate silver plating on RF multiplanar waveguides for space applications.

Highlights

- Optimized the pre-treatment zincating process, where the zinc layer provides a catalytic surface for the electroless nickel plating process.
- Achieved uniform electroless nickel deposition, measuring thickness approximately $2 \mu\text{m}$ for a 15-minutes.
- Confirmed the quality of nickel deposits and its adhesion properties using surface morphology and bend test, respectively (Figure 1).
- Observed successful silver deposition using a non-cyanide bath by an autocatalytic silver-plating process (Figure 2).

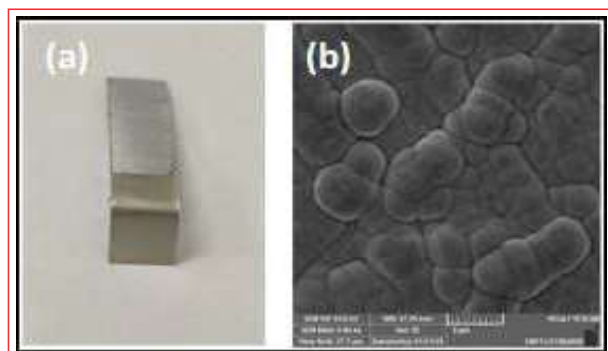


Figure 1. (a) Photograph and (b) electron micrograph of nickel electroless deposition on aluminium substrate.

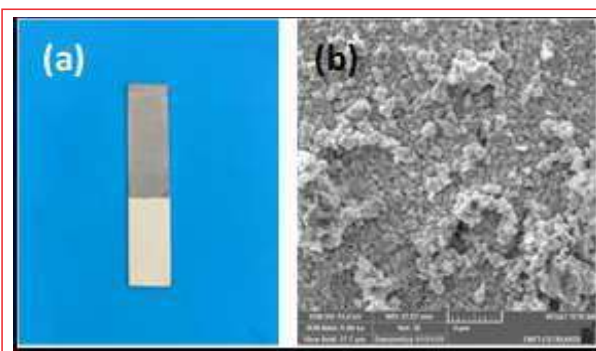


Figure 2. (a) Photograph and (b) electron micrograph of the autocatalytic silver-plating using a non-cyanide bath on aluminium substrate.

Development of polymer electrolyte membrane based air-cooled fuel cells for hydrogen mitigation during cold trap regeneration

GAP-16/24

Division(s): CSIR-CECRI Chennai Unit
PI: Dr. Akhila Kumar Sahu
Co-PI(s): Dr. Harshal Agarwal
Funding Agency: Board of Research in Nuclear Sciences, Mumbai
Duration: 16.11.2024 to 15.11.2027
Budget (Rs. in Lakh): 40.50

Objectives

- Development of OC-PEMFC stack with varying cross-section area which can be used for safe removal of hydrogen during cold trap regeneration and cleaning of sodium wetted.
- The proposed OC-PEMFC stack has a potential application for powering residential purposes, supplying energy to portable electronic devices etc.

- Development, demonstration and supply of one number of 500 W OC-PEMFC stack with in-house developed cathode flow-field design for removal of pure hydrogen.

Highlights

- Developing different flow field designs and fabrication for OC-PEMFC with varying cross-section area using computer aided designs (Figures 1 & 2).
- Carried out parameter studies such as pressure, temperature, air flow rate, parasitic power losses, water removal/retention, heat removal/accumulation, stability test.
- Work in progress for demonstration of 500 W OC-PEMFC stack with the current density in the range of 200–250 mA at 0.6 V of single cell voltage. Demonstration of OC-PEMFC with electronic load for the rated power of operation (Figure 3).

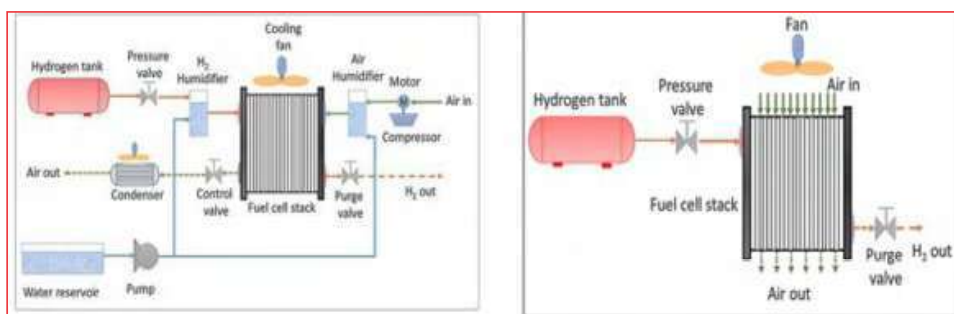


Figure 1. Schematics of closed cathode (left) and open cathode (right) fuel cell system.

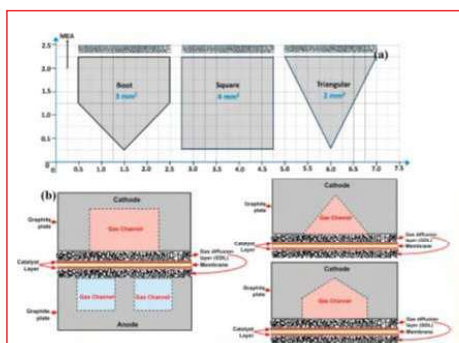


Figure 2. (a) Graphical representation of different cross-sectional designs (CSDs) such as boot, square, and triangular (dimensions are in mm); and (b) cross-sectional view of different CSDs which is in contact with the membrane electrode assembly.

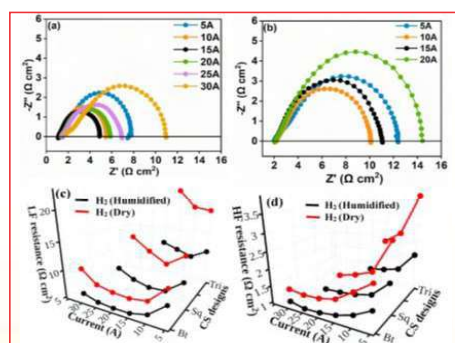


Figure 3. Nyquist plots for boot CSD measured at air flow rate (AFR) 1 m³/s (a) humidified and (b) dry H₂ condition, (c) low frequency resistance for different CSDs measured at AFR 3 m³/s; and (d) high frequency resistance for different CSDs measured at AFR 3 m³/s.

Functional textiles for flame retardant application: Use of non-halogenated organophosphorus and nitrogen composite

GAP-18/24

Division(s): Electronics & Electrocatalysis and Technology Transfer & Business Development
PI: Dr. A. Palaniappan
Co-PI(s): Dr. C. Sivakumar
Funding Agency: National Textile Technical Mission, Ministry of Textiles, New Delhi
Duration: 26.11.2024 to 25.02.2026
Budget (Rs. in Lakh): 49.9

Highlights

- Phytic acid, diamine and cotton cellulose composites ensure durable flame retardancy.
- Eco-friendly flame retardant with the use of non-halogenated, organophosphorus – nitrogen composite. The synergistic effects of phosphorus – nitrogen composites enhance char formation and thermal stability.
- Suitable for sustainable functional textiles in protective and home appliances.

Objectives

- To develop an eco-friendly flame retardant using phytic acid (Phosphorous rich molecule) and diamine or amide compounds (as a nitrogen source).
- To synthesize an organophosphorous and nitrogen composite that enhances flame retardancy through synergism.
- To investigate the flame retardancy using thermal and structural analysis (e.g., TGA, FE-SEM, FTIR, Vertical flammability test).

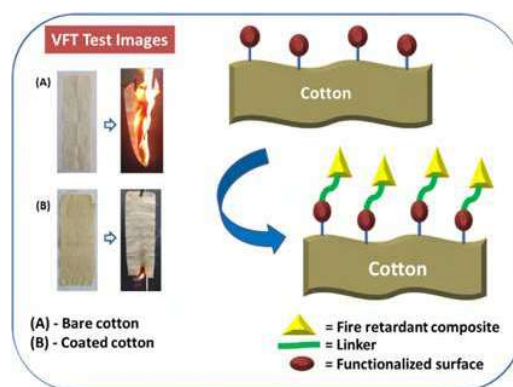


Figure 1. Digital images demonstrating fire retardant properties of the developed cotton cloth.

Album



Director, CSIR-CECRI administering pledge on the observance of World Blood Donor Day [June 14, 2024].

Soft-organic thermoelectrics: emerging green energy materials for body heat harvesting and temperature control

GAP-19/24

Division(s): Electro-organic & Materials Electrochemistry
PI: Dr. Dheepika Ramachandran
Co-PI(s): Dr. M. Kathiresan
Funding Agency: Department of Science & Technology, New Delhi
Duration: 10.06.2024 to 10.06.2029
Budget (Rs. in Lakh): 112.40

Objectives

- **Material Design:** Organic polymers with π -conjugation/MXenes will be combined with carbon fillers like carbon nanotubes and graphene to achieve high electrical conductivity and low thermal conductivity.
- **Processing & Characterization:** Composites will be prepared using optimized dry and wet

methods, with structural analysis to confirm successful formation.

- **Thermoelectric Evaluation:** The composites will be tested for electrical conductivity, Seebeck coefficient, and thermal conductivity to assess their performance.
- **Device Integration:** The materials will be made into flexible, lightweight thermoelectric modules for harvesting heat from surfaces and textiles, with real-life demonstrations to validate the technology.

Highlights

- Prepared the nanocomposite.
- Achieved the formation of flexible, free-standing thin films.
- Flexible device fabrication is in process.

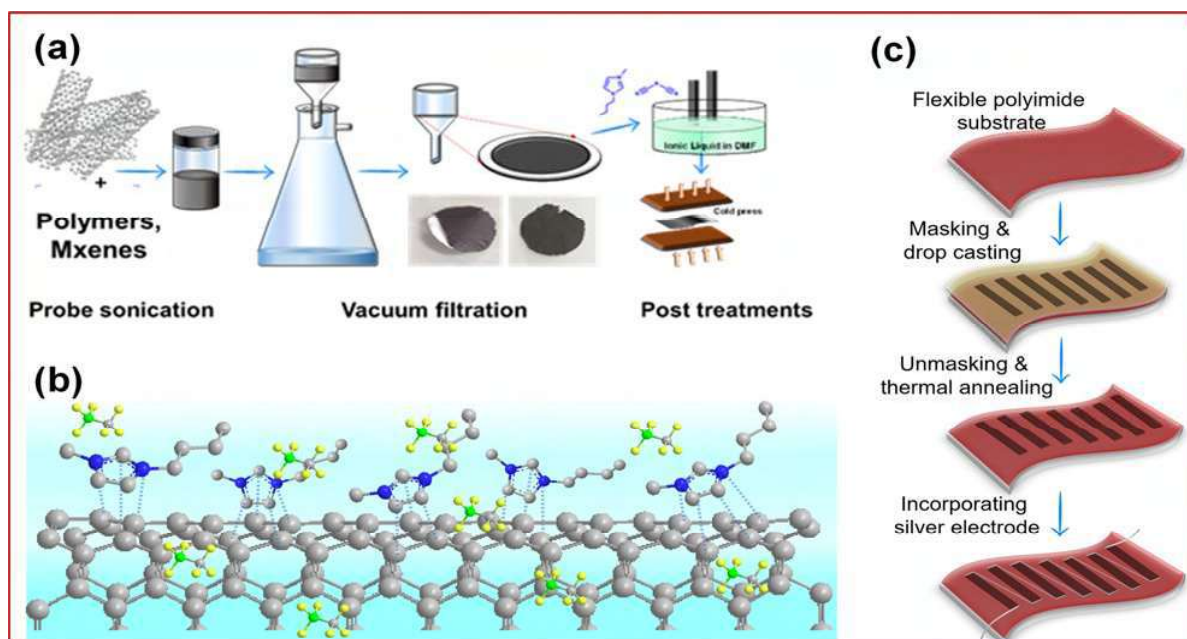


Figure 1. Schematic illustration of (a) flexible, free-standing film preparation, (b) Plausible molecular interaction between nanocarbon and molecules, and (c) Flexible thermoelectric device fabrication.

Development of TiN, TiCN, AlTiN and diamond-like carbon (DLC) coating over $\text{Ti}_6\text{Al}_4\text{V}$ substrate

GAP-30/24

Division(s): Electroplating & Electrometallurgy

PI: Dr B. Subramanian

Co-PI(s): Dr Subhendu Kumar Panda

Funding Agency: Indian Space Research Organisation, Bengaluru

Duration: 13.03.2025 to 12.03.2027

Budget (Rs. in Lakh): 20.28

compositional using XRD, FESEM, AFM, HRTEM Raman, XRF/XPS analyses.

- Evaluation of film thickness by cross-sectional FESEM / Profilometry and mechanical properties like nano hardness and abrasive resistance.
- Electrochemical corrosion analysis by potentiodynamic polarization and electrochemical impedance spectroscopy techniques.

Highlights

Objectives

- To develop transition metal nitride thin films such as TiN, TiAlN, TiCN, TiAlCuN, TiAlCuCN & TiO_2 and DLC onto $\text{Ti}_6\text{Al}_4\text{V}$ substrates by ion-assisted confocal planar DC magnetron Co-sputtering technique by optimizing the process parameters.
- Optimization and development of metal oxide TiO_2 and diamond-like carbon thin films onto $\text{Ti}_6\text{Al}_4\text{V}$ substrates by KrF based Pulsed Laser Deposition.
- Evaluation of structural, microstructural and

- Optimized AlN thin film deposition on Ti alloys, Si, and glass substrates using the ion-assisted confocal sputtering technique (Figure 1a).
- Revealed a compact, pore-free, and spherical surface morphology (Figure 1b) with a film thickness of $4.44\text{ }\mu\text{m}$ (Figure 1c) using SEM analysis.
- Confirmed the uniform morphology with an average surface roughness (R_a) of $\sim 16\text{ nm}$ (Figure 1d) using AFM analysis.

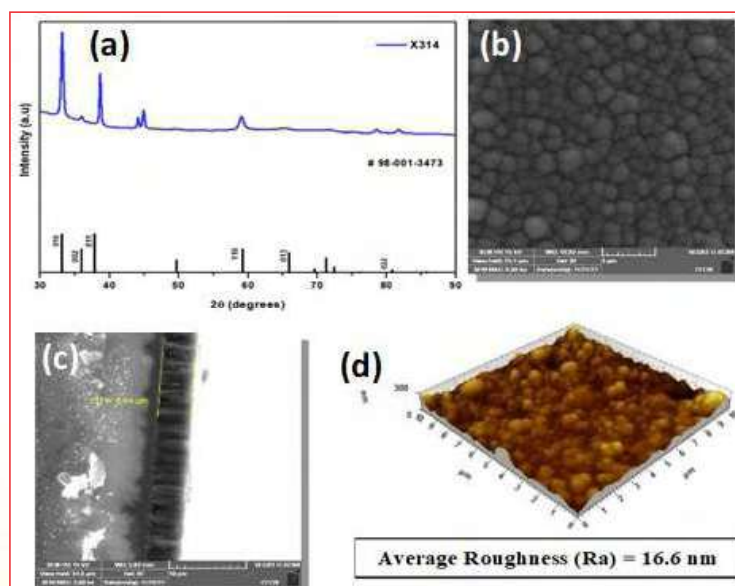


Figure 1. (a) XRD pattern, (b) SEM image, (c) Cross-sectional SEM image and (d) AFM analysis of the AlN thin film.

Polymer based coatings to improve the performance of ballistic materials

SSP-13/20

Division(s): Electroplating & Electrometallurgy and Electrochemical Process Engineering
PI: Dr. C. Naveen Kumar
Co-PI(s): Dr. S. Vengatesan
Funding Agency: Indian Ordnance Factories, Ordnance Clothing Factory (OCF), Chennai
Duration: 30.12.2020 to 29.12.2023
Budget (Rs. in Lakh): 45.51

Objectives

- To develop improvised ballistic material for light weight bullet resistant jacket/vest for better energy absorption, energy distribution and to reduce back face signature.
- To coat cross linked polymer on para aramid woven fabric.

- To coat graphene or graphene-based polymer composite coating on para aramid woven fabric.
- To coat nano carbon or graphene on ceramic plates.

Highlights

- Synthesized graphene oxide mixed cross linked polymers and coated on the surface of para aramid woven fabric (Figure 1).
- Demonstrated the coating process on aramid woven fabric to OCF officials.
- The ballistic evaluation of coated fabric has to be improved.
- A patent application for the coating of graphene oxide and polyurethane mixture on hard armor panels (Figure 2) is under process.

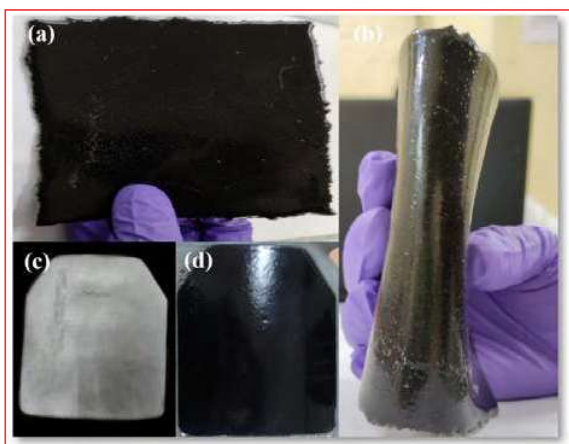


Figure 1. Photographs of (a) GO coated soft para aramid woven fabric, (b) flexible nature of GO coated para aramid woven fabric, (c) hard armor panel before GO coating, and (d) hard armor panel after GO coating.

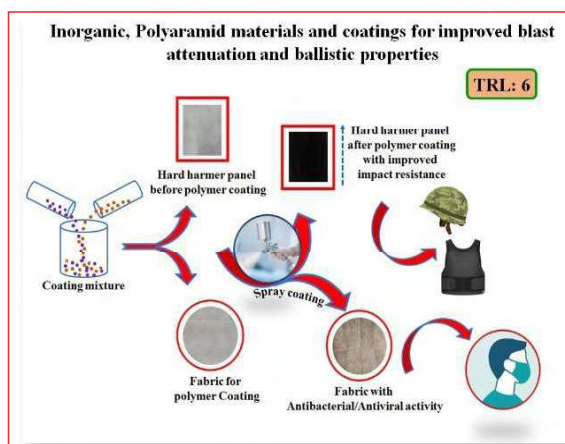


Figure 2. General scheme of polymer-based coatings for various application.

Development of thermal barrier coatings for casing material of box furnace

SSP-09/21

Division(s): Electroplating & Electrometallurgy
PI: Dr. G. Sreedhar
Co-PI(s): Dr. B. Subramanian
Funding Agency: GAIL (India) Limited, Noida
Duration: 12.04.2021 to 12.04.2026
Budget (Rs. in Lakh): 151.00

- To study the effect of thermal barrier coatings on the hot spot formation rate or time on mild steel box furnaces.
- Combined effect of TBC and filler materials on the formation of openings time and temperature drop of thermal insulation.

Highlights

- Performed the continuous testing of the thermal barrier coatings at 1250 °C and the coatings developed at CSIR-CECRI demonstrated adequate performance (Figure 1). These coatings can be used in the aerospace, oil, and gas sectors.

Objectives

- To study the root cause analysis on the formation time of openings in thermal insulation test blocks and identification of the nature of the problem.

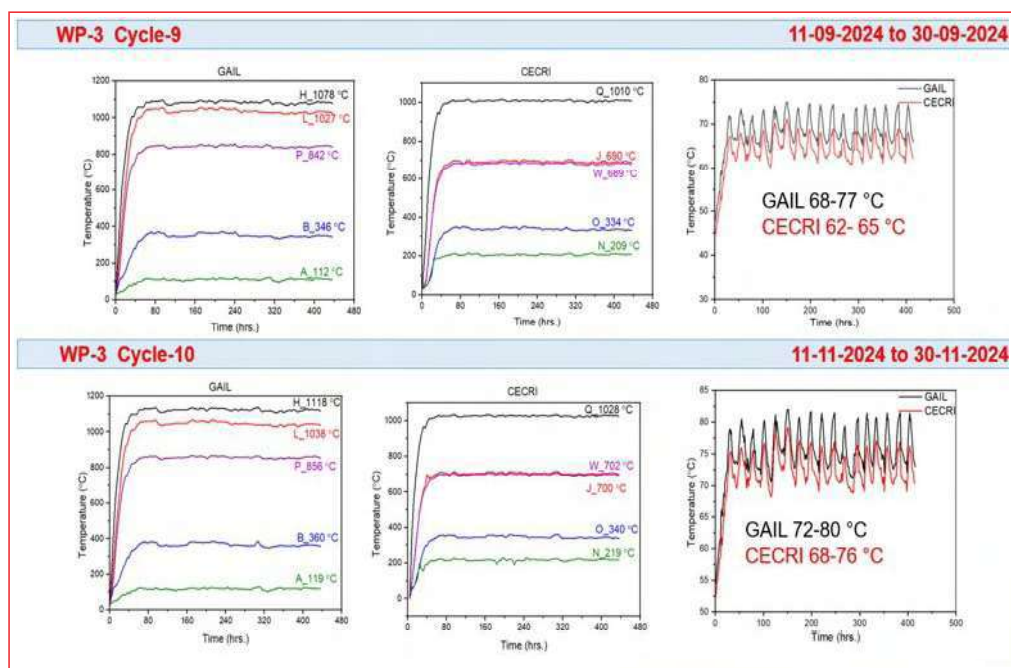


Figure 1. The comparison of test results of coating received from GAIL and CSIR-CECRI developed coating.

Sustainable process development for the synthesis of green ammonia from nitrogen

SSP-25/21

Division(s): CECRI Chennai Unit
PI: Dr. M.U. Sreekuttan
Co-PI(s): Dr. C. Naveen Kumar
Funding Agency: Ohmium International Inc., USA
Duration: 24.01.2022 to 24.07.2025
Budget (Rs. in Lakh): 247.00

- Validation of catalyst in 10 L capacity electrochemical flow reactor.

Highlights

- Performed the NRR studies in 0.1 M H_2SO_4 and observed a good Faradaic efficiency (> 40%) and ammonia yield (> $200 \mu\text{g h}^{-1} \text{mg}_{\text{cat}}^{-1}$) at -0.2 V vs RHE (Figure 1).
- Developed an electrochemical reactor with area 4 cm^2 and demonstrated the production of $0.125 \text{ mg h}^{-1} \text{cm}^{-2}$ of ammonia.

Objectives

- Development of nitrogen reduction reaction (NRR) electrocatalyst with Faradaic efficiency of > 25% and ammonia yield > $50 \mu\text{g h}^{-1} \text{mg}_{\text{cat}}^{-1}$.

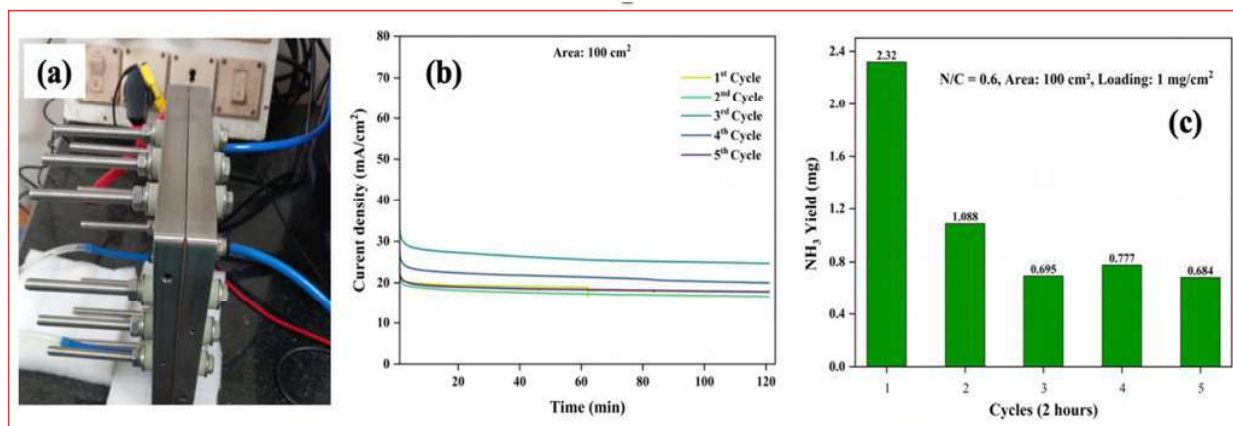


Figure 1. (a) Ammonia electrolyser reactor of 100 cm^2 (b) Chronoamperometric plot for the 100 cm^2 cell at a potential of 2 V and (c) Calculated ammonia yield.

Feasibility studies on the development of electrically rechargeable aluminium air batteries

SSP-29/21

Division(s): Electrochemical Power Sources and Electroplating & Electrometallurgy

PI: Dr. S.T. Nishanthi

Co-PI(s): Dr. M. Jayakumar

Funding Agency: National Aluminium Company Ltd., Bhubaneswar

Duration: 28.02.2022 to 28.06.2023

Budget (Rs. in Lakh): 121.56

Highlights

- Developed non-noble based bifunctional oxygen catalysts and tested its catalytic activity.
- Employed the optimized catalyst as an air cathode in the aluminium-air battery fabrication.
- In-house designed 25 cm² aluminium-air battery exhibited a cell voltage of ~1.5 V (Figure 1).

Objectives

- Development of bi-functional air cathodes and its characterization.
- Development of aluminium alloy anodes and its characterization.
- Optimization of electrolyte composition and Air-cathode fabrication.
- Feasibility studies at lab level, mechanism elucidation.



Figure 1. Photograph of in-house assembled aluminium air battery.

Album



10th International day of Yoga organized by AcSIR Science Club [June 21, 2024].

Development of piezoelectric dynamic pressure sensor

SSP-35/21

Division(s): Electroplating & Electrometallurgy
PI: Dr. G. Sreedhar
Co-PI(s): Dr. B. Subramanian
Funding Agency: Indian Space Research Organisation, Mahendragiri
Duration: 16.03.2022 to 14.06.2024
Budget (Rs. in Lakh): 42.00

Mahendragiri for ground-level testing and the results were satisfactory (Figure 1).

- Metallic 3D printer was used to make the dynamic pressure sensor housing assembly.
- Established the D33 and poling setup to test the newly fabricated sensing materials (Figure 1).

Objectives

- Design and fabrication of the dynamic pressure sensor for Indigenous development.
- Design of the sensing element and packaging of the sensor.
- Evaluation of the lab-scale prototype.
- Supply of 10 Numbers of dynamic pressure sensors in a phased manner.

Highlights

- Fabricated two numbers of dynamic pressure sensor prototypes and submitted to ISRO-IPRC,

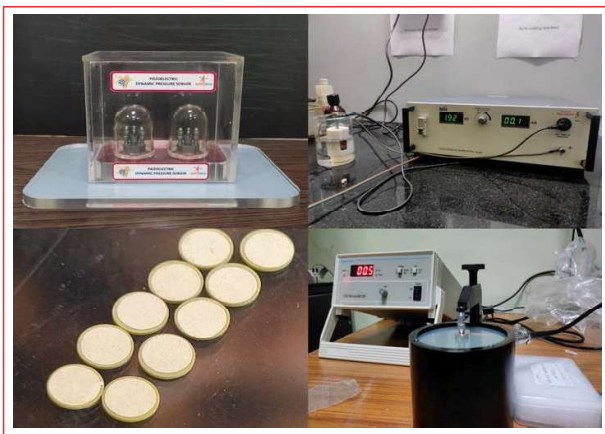


Figure 1. Photographs showing the fabricated dynamic pressure sensor prototypes, D33 and poling set up facility.

Album



10th International Yoga Day Lecture cum Demonstration by Dr.A. Selvaraj, Manavalakalai Mandram, Karaikudi [June 21, 2024].

Development of chromium coating using trivalent Cr bath electroplating process on inner bore of tubes and long cylindrical sections

SSP-02/22

Division(s): Electroplating & Electrometallurgy
PI: Dr. N. Rajasekaran
Co-PI(s): Dr. C. Naveen Kumar
Funding Agency: Defence Metallurgical Research Laboratory, Hyderabad
Duration: 29.03.2022 to 31.08.2025
Budget (Rs. in Lakh): 359.69

Objectives

- To electroplate nickel on inner surface of 4340 steel cylindrical tube.
- To electroplate Chromium over nickel plated inner surface of 4340 steel cylindrical tube.
- The plating sample is cylindrical tube with 120-130mm diameter and 6000/8000 mm length. Among 6000/8000mm length, the plating length is 2000 mm. This cylindrical tube will be provided by DMRL.



Figure 1. Trivalent hard chromium plating process assembly for 6 meter length gun barrel which was provided by DMRL.



Figure 2. The sectioned chromium plated inner surface of 2 meter tube.

- Thickness of Nickel Plating is 35-45 μm and thickness of chromium plating is 45-55 μm .

Highlights

- The electroplating of Ni on 2 and 6 meter gun barrel were demonstrated.
- The electroplating of trivalent Cr on 2 and 6 meter gun barrel were demonstrated.
- The scale up activity for 2 meter and 8 meter gun barrel plating process were completed.
- The plating facility like plant, and civil structures for 2 meter and 8 meter gun barrel were established.
- Micro hardness (>900 HV), Salt spray test (NSS >500 h), thickness (>50 μm) and wear resistance (weight loss < 6 mg after 10000 cycles) properties were achieved as per the requirements.



Figure 3. Electroplating plant established for chromium coating on inner bore of 6 meter gun barrel at CSIR-CECRI.

Point-of-care biosensors for stress biomarker detection

SSP-12/22

Division(s): Electrode & Electrocatalysis

PI: Dr. M. Pandiaraj

Co-PI(s): Dr. V. Murugan

Funding Agency: Defence Research and Development Organisation, New Delhi

Duration: 11.08.2022 to 10.08.2024

Budget (Rs. in Lakh): 45.61

Highlights

- A smartphone-assisted point-of-care (POC) electrochemical sensing approach was developed using screen-printed electrodes.
- Nitric oxide (NO) metabolite levels were measured in artificial saliva samples and laboratory standards to generate calibration data.
- Measuring NO metabolite levels in human saliva samples was achieved using a portable electrochemical sensor device attached to a smartphone.
- Spectroscopic studies were carried for validating the results of electrochemical sensor for monitoring NO metabolite levels in human saliva samples.

Objectives

- Developing enzymatic electrochemical sensing protocols for oxidative stress biomarkers detection.
- Developing enzyme mimic-based approaches for electrochemical detection of stress biomarkers. Integration of electrochemical detection protocol with screen printed electrode platform.
- Measurement of nitric oxide (NO) metabolites in biological samples (serum or sweat or saliva) using the developed sensors.

Album



A mass Rose plantation by the Children of Sishu Vidyalaya, CSIR-CECRI Campus on the occasion of 10th International Yoga Day [June 21, 2024].

Feasibility studies on extraction of $MgCl_2$ & other values from ferro-chrome slag and subsequent conversion of $MgCl_2$ to metallic Mg using molten salt electrolysis

SSP-03/23

Division(s): Electroplating & Electrometallurgy and Electrochemical Process Engineering

PI: Dr. C. Naveen Kumar

Co-PI(s): Dr. N. Rajasekaran

Funding Agency: Tata Steel, Jamshedpur

Duration: 17.04.2023 to 16.05.2024

Budget (Rs. in Lakh): 70.09

- To extract Mg from Fe-Cr slag at least above 70 % extraction efficiency is expected. Also, obtain other valuable elements such as Cr, Al, and Si from Fe-Cr slag.
- To obtain slag with Zero Cr_2O_3 for clean environment friendly and utilizable remnant slag.

Highlights

- The Fe-Cr slag was treated to extract Mg in the form of $MgCl_2$ with a purity of >95% and the remnant slag was completely devoid of Cr_6^{3+} .
- Converted the $MgCl_2$ extracted from Fe-Cr slag into Mg with a purity of ~98% through molten salt electrolysis.

Objectives

- To obtain magnesium chloride from Ferro-Chrome slag supplied by Tata Steel with a purity of >95%.
- To obtain Mg above 90 % purity from the obtained magnesium chloride.

Album



A mass Rose plantation by the Children of Sishu Vidyalaya, CSIR-CECRI Campus on the occasion of 10th International Yoga Day [June 21, 2024].

Investigations on the behavior of pre-cracked reinforced concrete structural elements with rebars supplied by Electrotherm India Pvt. Ltd. under actual coastal environment

SSP-13/23

Division(s): Corrosion & Materials Protection

PI: Dr. J. Daniel Ronald Joseph

Co-PI(s): Dr. M. Ashok

Funding Agency: Electrotherm (India) Ltd., Gujarat

Duration: 07.08.2023 to 06.08.2026

Budget (Rs. in Lakh): 35.32

rebars supplied by Electrotherm India Pvt Ltd. subjected to actual coastal environment.

Highlights

- Beams cast, cured and exposed to different environmental conditions.
- Flexural strength and behavior of beams reinforced with TMT, CRS and epoxy coated steel reinforcement was determined.
- Corrosion behavior of cracked concrete beams are being investigated.

Objectives

- Investigations on the behavior of pre-cracked reinforced concrete structural elements with

Album



Inauguration of CSIR-CECRI Industrial Conclave on Energy Conversion and Storage Devices at CSIR-CECRI Chennai Unit [June 27, 2024].

Atmospheric corrosion testing of hardware components – Phase I

SSP-15/23

Division(s): Corrosion & Materials Protection

PI: Dr. S.M. Ganesan

Co-PI(s): Er. G. Anand Babu

Funding Agency: Saint-Gobain Research India (P) Ltd., Chennai

Duration: 05.09.2023 to 05.12.2024

Budget (Rs. in Lakh): 21.05

Objectives

- Atmospheric and indoor corrosion testing of the hardware components.
- Evaluation of the corrosion rates of the hardware components for a total period of 1 year.

- Estimation of the atmospheric and indoor corrosion rates of each hardware component.
- Corrosion rate assessment and identification of appropriate corrosion mitigation measures.

Highlights

- Mirror and hardware samples were exposed both at indoor (i.e. within Stevenson chamber) as well as at outdoor seashore atmosphere at CECRI's outreach centre in Mandapam.
- The corrosion rates of the exposed items were evaluated every month which also included detailed microstructural characterizations like SEM, EDAX and XRD.

Album



Inauguration of Technical Exhibition in the Industrial Conclave on Energy Conversion and Storage Devices at CSIR-CECRI Chennai Unit [June 27, 2024].

Health assessment survey of ICCP system provided to repair and building docks of Cochin Shipyard Ltd.

SSP-16/23

Division(s): Corrosion & Materials Protection
PI: Er. M.S. Karthikeyan
Co-PI(s): Dr. S. Muralidharan
Funding Agency: Cochin Shipyard Ltd., Kochi
Duration: 20.09.2023 to 31.05.2024
Budget (Rs. in Lakh): 13.55

Objectives

- To assess the health status of the entire ICCP system in both the Repair & Building docks and suggest suitable remedial measures.

Highlights

- Option 1:** Repair, rehabilitation and

refurbishment of the existing ICCP components to achieve a design life of 10 years. This approach focuses on restoring the functional integrity of current infrastructure through targeted maintenance and component replacement.

- Option 2:** Deployment of new insoluble MMO anodes, engineered for a design life of 50 years. This long term solution offers superior durability, reduced maintenance and enhanced electrochemical performance.
- The current condition and health of the ICCP system were evaluated through a site survey conducted by the CECRI team. The key observations and findings are illustrated in Figure 1 to 4.

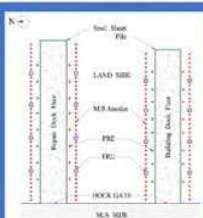


Fig. 1 Layout of the ICCP system in Repair and Building Dock of CSL



Fig. 2 Excavated mild steel anode



Fig. 3 Soil resistivity measurements

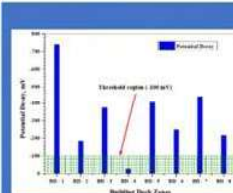
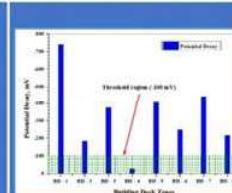


Fig. 4 Potential Decay of steel sheet piles in both docks from the instant ON / instant OFF measurements in CSL



Fabrication and testing of 18650 lithium ion cylindrical cells with Mesha processed activated carbon

SSP-19/23

Division(s): Electrochemical Power Sources

PI: Dr. M. Sathish

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Mesha Energy Solution Pvt. Ltd., Bengaluru

Duration: 28.11.2023 to 27.04.2024

Budget (Rs. in Lakh): 5.78

Objectives

- Fabrication of 15 Nos. of 18650 cylindrical cells using commercial LiFePO_4 as cathode and MCMB as anode material with Mesha PAC as additive in both anode and cathode (Required consumables like anode, cathode, conductive carbon and cell components, electrolyte, binder will be supplied by Mesha).
- Electrode fabrication with optimized composition from Phase-I project.
- Testing of assembled cells for different C-rates like 0.05C, 0.1C, 1C, 2C, 4C and 6C.

Highlights

- 15 Nos. of 18650 cylindrical cells were assembled

with LFP and MCMB with Mesha PAC carbon and without Mesha PAC carbon.

- Testing data at different C-rates has been provided to the client.
- Weekly/bi-monthly review, and regular interactions were conducted during the testing and evaluation of test data.
- Fifteen numbers of 18650 cylindrical cells were developed using electrode compositions (with and without Mesha PAC carbon additive) based on the optimized material ratios established from CR2032 coin cells in the Phase-I study.
- PAC-added cells showed enhanced discharge capacity compared to cells without PAC additive carbon with improved rate performance.
- Long-term cycling for 100 cycles demonstrated high-capacity retention with 99% coulombic efficiency.
- The obtained results confirm that the addition of PAC carbon significantly enhances the electrochemical performance and stability of 18650 LFP cells.

Album



Technical Exhibition in the Industrial Conclave on Energy Conversion and Storage Devices at CSIR-CECRI Chennai Unit [June 27, 2024].

Effect of radiation on the performance of lithium ion and lead acid batteries

SSP-20/23

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. K. Arumugasamy
Funding Agency: Naval Base, Visakhapatnam
Duration: 17.11.2023 to 26.07.2025
Budget (Rs. in Lakh): 33.00

Objectives

- The overall objective is to study electrical performance of the lead and lithium ion batteries under irradiation condition.

Highlights

- The gamma radiation was performed at the ICAR-IIHR Bangalore / Pondicherry university using a cobalt-60 (Co-60) isotope source with a dose rate of 3.5 k Gy/h. The key battery material / components (like electrolyte, separator,

conductive agent, additive) were put in glass bottles along with lead acid battery and given radiation treatments at doses of 5, 10, 20 and 50 kGy, respectively.

- List of components exposed to gamma radiation
 1. Battery electrolyte (Sulphuric acid, LiPF₆ in EC/DEC/EMC and vanadium electrolyte).
 2. Battery separator (PE, PP, Glass mat, solid polymer electrolyte).
 3. Battery additives (Super P, Carbon black, Lignin).
 4. 12 V / 2.5 Ah VRLA lead acid battery.
- The battery and its components are being evaluated using various characterization techniques (like XRD, FR-IR, UV-VIS, TGA, ESR) to explore the effect of gamma irradiation on Lithium & Lead battery and its components.

Album



Technical Exhibition in the Industrial Conclave on Energy Conversion and Storage Devices at CSIR-CECRI Chennai Unit [June 27, 2024].

Technical viability of electrocoagulation process as well as the development of electrode materials to treat textile effluent water

SSP-21/23

Division(s): Electrochemicals & Electrocatalysis

PI: Dr. S. Senthilkumar

Co-PI(s): Dr. J. Mathiyarasu

Funding Agency: WATSAN Envirotech Pvt. Ltd., Chennai

Duration: 26.12.2023 to 25.09.2024

Budget (Rs. in Lakh): 14.24

Objectives

- Identification of electrode materials based on easily and economically available and their combination with respect to the reduction of selected contaminants in effluent water.
- Assessing the efficiency of the developed material in lowering the chemical oxygen demand (COD), biological oxygen demand (BOD), colour and turbidity and TDS to some extent in the effluent water.
- Optimization of the electrocoagulation process with respect to critical operating parameters. This may be followed with electro-oxidation to get the optimised result.
- Lab-scale demonstration of the developed

process to reduce the contaminants of required level in 5 L scale of effluent water.

- After successful demonstration of 5 L scale to the client satisfaction, subsequent development of 100 & 1000 LPH plant will be executed by the client with the technical support of CSIR-CECRI.

Highlights

- BOD, COD, Colour and TDS were effectively removed without sludge formation using the developed methodology.
- The EAOPs was successfully used to degrade seven- different textile wastewater samples.
- The calculated average COD removal efficiency of 87% for 3 hours of electrolysis at 50 mA.cm^{-2} is achieved.
- Similarly, the developed electro-dialysis process was applied to the EAOP treated wastewater samples and the obtained TDS removal efficiency was 98.5 % within 2 hours with the current feed of 10 mA.cm^{-2} .
- The developed EAOPs and electro-dialysis processes are capable of bringing down the COD, BOD, TDS and etc.,



Before Electrochemical Treatment



After Electrochemical Treatment

Figure 1. EAOP for textile wastewater treatment.

Validation of M/s. Jotun protective coatings for durability under C5 high environment as per ISO 12944 – 6

SSP-22/23

Division(s): Corrosion & Materials Protection
PI: Dr. D. Sherwood
Co-PI(s): Dr. C. Arunchandran
Funding Agency: Jotun India Pvt. Ltd., Chennai
Duration: 14.12.2023 to 13.06.2024
Budget (Rs. in Lakh): 8.07

Objectives

- To validate the corrosion protection properties of Jotaprim mastic and Penguard Pro GF coatings for durability under C5 high corrosivity category as per ISO 12944-6.

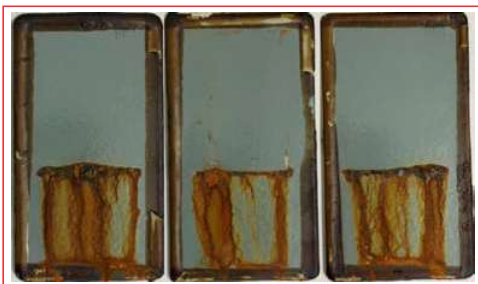


Figure 1. Photos of the coating system in triplicate after 60 days of neutral salt spray test.

Highlights

- Carried out the water condensation test for 720 hours as per the test regime I of ISO 12944-6 and the coatings passed the test without any blistering or chalking and other visible defects.
- The coatings passed 1440 hours of neutral salt spray test as per ASTM B117.
- The coatings showed very good adhesion properties.
- The tested coatings passed the test regime I of ISO 12944-6.

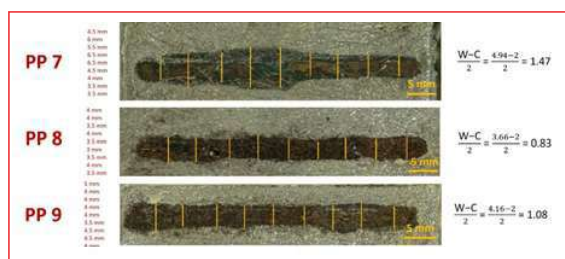


Figure 2. Photos of the scribed area after the removal of the coatings in triplicate within 8 hrs after the completion of the neutral salt spray test.

Album



A special training programme for Bharat Petroleum Corporation Limited (BPCL) Cochin on Cross Country Pipelines - Cathodic Protection and Survey Methods [July 01, 2024].

Evaluation of corrosion behaviour of steel rebar embedded in concrete containing ICRETE mineral additive

SSP-23/23

Division(s): Corrosion & Materials Protection
PI: Dr. M. Ashok
Co-PI(s): Dr. J. Daniel Ronald Joseph
Funding Agency: Navodaya Sciences Pvt. Ltd., Chennai
Duration: 04.01.2024 to 03.03.2025
Budget (Rs. in Lakh): 5.84

Grade) with and without ICRETE Mineral Additive.

Highlights

- Macro cell specimens were cast as per ASTM G109 for M25 grade concrete specimens (Figure 1).
- The inclusion of ICRETE mineral additive significantly reduced the macro cell potential and integrated current in both M25 and M50 grade concrete, indicating improved corrosion resistance.

Objectives

- To evaluate the corrosion behavior of steel rebar embedded in concrete (M25 and M50



Figure 1. Typical view of macrocell specimens under testing.

Album



Prize Distribution for the winners of sports organized by AcSIR Science Club [July 10, 2024].

Performance mapping and failure analysis of e-rickshaw & solar deep cycle batteries

SSP-24/23

Division(s): Electrochemical Power Sources

PI: Dr. Sundar Mayavan

Co-PI(s): Er. P. Seenichamy

Funding Agency: Regnant Energy Solutions, Uttar Pradesh

Duration: 25.01.2024 to 24.07.2024

Budget (Rs. in Lakh): 7.20

Objectives

- Performance mapping and failure analysis of e-Rickshaw & Solar deep cycle batteries.

Highlights

- Four e-Rickshaw batteries from four different

manufacturers has been subjected to life cycle test at 90 % DoD as per IEC 63193 Standard (i.e Lead-acid batteries for propulsion power of lightweight vehicles – General Requirements and methods of test).

- Two e-Bike batteries from two different manufacturers has been subjected to life cycle test at 90 % DoD as per IEC 63193 Standard (i.e Lead-acid batteries for propulsion power of lightweight vehicles – General Requirements and methods of test).
- Two deep cycle batteries has been subjected to cyclic endurance test as per IS 16270:2014 standard meant for Solar PV batteries.

Album



TOLIC Meeting - Hindi Section [July 16, 2024].

Investigating the corrosion problems due to the sweating of pipelines and suitable coating recommendations for Mahanagar Gas Limited, Navi Mumbai

SSP-26/23

Division(s): Corrosion & Materials Protection
PI: Dr. C. Arunchandran
Co-PI(s): Dr. Rakesh C. Barik
Funding Agency: Mahanagar Gas Limited, Navi Mumbai
Duration: 22-01- 2024 to 31-05- 2024
Budget (Rs. in Lakh): 12.40

Objectives

- To investigate corrosion problems due to sweating of gas pipelines and recommend a suitable coating system.

Highlights

- Conducted the coating condition survey for all

steel assets of the city gas terminals at Taloja, Ambernath, and Mahape.

- The major problem with the pipeline infrastructure of CNG terminals of MGL is due to the sweating of the pipelines, and the sweating of the pipeline is unavoidable due to operational requirements.
- Reviewed and updated the standard operating procedure (SOP) for painting for the steel assets of Mahanagar Gas Limited.
- Considering the severity and uniqueness of the corrosion problems due to sweating of the pipelines, suitable coating systems which are solvent-free and tolerant to rust and moisture were recommended.



Figure 1. Images of the coatings applied on CNG pipeline terminals at Taloja CGS terminals of MGL.

Corrosion assessment survey of the steel and concrete structural elements, equipments, piping at Tata Chemicals Ltd., Mithapur Plant at Gujarat and recommend its suitable mitigation methodologies

SSP-27/23

Division(s): Corrosion & Materials Protection
PI: Dr. Rakesh C. Barik
Co-PI(s): Dr. C. Arunchandran
Funding Agency: Tata Chemicals Ltd., Gujarat
Duration: 15.02.2024 to 14.08.2024
Budget (Rs. in Lakh): 10.15

Objectives

- The objective of this project is to assess the corrosion condition of steel and concrete structures, piping & equipment and suggest

suitable recommendation to mitigate the corrosion issues.

Highlights

- Recommended coating schemes for various structural steels in Tata Chemicals with special reference to C5 very high corrosion category.
- Recommended various strategies to enhance the durability of the concrete viz., coating to steel, coating to concrete, coatings to wet concrete surfaces, admixtures and conductive cement mortar with zinc anode.



Figure 1. Photograph of Tata Chemicals Ltd., Mithapur.

Evaluation and upgradation of existing nickel-plating process

SSP-29/23

Division(s): Electroplating & Electrometallurgy
PI: Dr. M. Jayakumar
Co-PI(s): Dr C. Jeyabharathi
Funding Agency: HBL Power Systems Ltd., Hyderabad
Duration: 20.02.2024 to 30.04.2025
Budget (Rs. in Lakh): 9.99

Objectives

- To evaluate and ascertain the existing nickel electroplating on perforated mild steel and different sized, shape components in terms of microstructure, thickness and electrochemical corrosion behavior and compare with the CECRI's data.
- To evaluate the effect of electrode geometry and

its alignment on the thickness homogeneity.

- To assess the impact of iron impurity in the existing electroplating solution on nickel plating on perforated mild steel.

Highlights

- Carried out the following studies:
 - Corrosion resistance and microstructure analysis of nickel-plated samples at HBL.
 - Corrosion and SEM analysis of nickel-plated substrates using HBL electrolyte at CECRI.
 - Corrosion and SEM analysis of HBL substrates plated at CECRI using in-house electrolyte.
 - Continuous plating of perforated strips of HBL substrates plated at CECRI using in house electrolyte.



Figure 1. Photograph of existing Nickel plating line.

Assessment of the epoxy painting of the conveyor structure at NCTPS – 1

SSP-31/23

Division(s): Corrosion & Materials Protection

PI: Er. R. Jeyaram

Co-PI(s): -

Funding Agency: Veeramuthu Enterprises, Chennai

Duration: 06.03.2024 to 05.06.2024

Budget (Rs. in Lakh): 1.01

Highlights

- Shot blasting and Euro Epoxy Zinc Phosphate Primer coat, Euro Epoxy High build MIO and PU top coat was completed.
- Dry film thickness (DFT) of the three-coat system consisting of Primer + Undercoat + Finish coat was measured and found to be in the range of 195 to 245 μ .
- The DFT measured is higher than the specified thickness of the system.
- Thickness of the coating system confirmed as per the specifications upto the topcoat.

Objectives

- To assess the surface Preparation by shot blasting.
- To assess the three-coat epoxy painting scheme.
- To measure the dry film thickness at site.



Figure 1. Field inspection at the site of M/s. Veeramuthu Enterprises, Chennai.

Study on the suitability of 12V/4Ah VRLA batteries for start-stop applications

SSP-33/23

Division(s): Electrochemical Power Sources

PI: Dr. Sundar Mayavan

Co-PI(s): Er. P. Seenichamy

Funding Agency: TVS Motors, Hosur

Duration: 08.03.2024 to 07.09.2024

Budget (Rs. in Lakh): 6.48

Highlights

- To Benchmark the performance of the batteries for Start-Stop / Micro-cycle applications. The batteries (12 V/4 Ah) of three different makes (Make 1, 2 & 3) will be subjected to testing under EN 50342-6 standard (Lead-acid starter batteries - Part 6: Batteries for Micro-cycle applications) to study their suitability and to understand the failure mechanism for start-stop / micro cycle applications.
- Make 1 battery showed much better performance and more suitable for start-Stop application as compared to other makes.

Objectives

- The overall objective is to study the suitability of 2-wheeler SLI lead acid batteries for start-Stop / Micro-cycle applications.

Album



Dr. V.K. Saraswat, Hon'ble Member, Niti Aayog, visiting labs at CSIR-CECRI on the occasion of its 77th Foundation Day Celebration [July 25, 2024].

Development of 400 prototype 18650 type cylindrical sodium-ion batteries using the sodium-ion cathode and anode materials provided by Tata Chemicals Ltd.

SSP-34/23

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. AS Prakash

Co-PI(s): Dr. A. Nagu

Funding Agency: Tata Chemicals Ltd., Mumbai

Duration: 18.03.2024 to 17.12.2024

Budget (Rs. in Lakh): 17.59

- Fabrication of 18650 Na-ion cells to Tata Chemicals along with their personnel and optimized processes.
- Scaling up the production to achieve bulk manufacturing of 18650 Na-ion cells and conducting electrochemical studies on the produced cells.

Highlights

- Electrochemical characterizations of the materials received from Tata Chemicals has been done in CECRI-Chennai Unit.
- With the cathode materials provided by Tata chemicals, half cells were fabricated and connected in Biologic VMP3 in the voltage range 2-4V. The first cycle discharge capacity has been found to be 120mAh/g as shown in Figure 1.
- The proposed objectives were achieved.

Objectives

- Comprehending and interpreting the methodologies and protocols for Na-ion battery fabrication supplied by Tata Chemicals, specifically focusing on Na-based cathode chemistry.
- Developing a standardized operating procedure (SOP) for the fabrication of 18650-type Na-ion batteries based on the guidelines provided by Tata Chemicals.

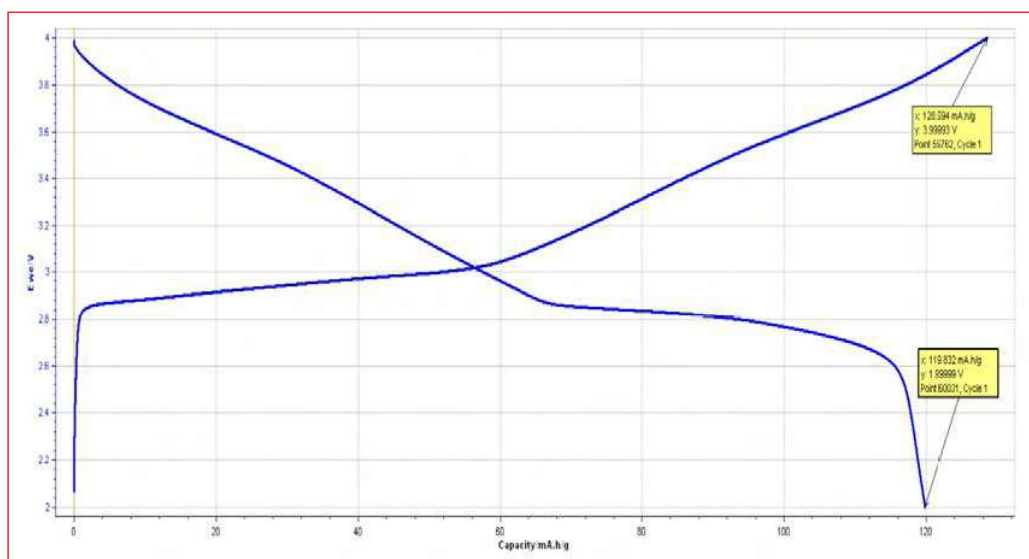


Figure 1. Charge-discharge curve of cathode material provided by Tata Chemicals.

Development of coating parameter and assisting in coating 100 meters electrode for NMC cells at CECRI facility

SSP-01/24

Division(s): CSIR-CECRI Chennai Unit and Electrochemical Power Sources

PI: Dr. Kuldeep Singh

Co-PI(s): Dr. S. Sudhakar

Funding Agency: Crimen Tech Pvt. Ltd. (Trydan Tech), Coimbatore.

Duration: 12.04.2024 to 11.04.2025

Budget (Rs. in Lakh): 12.78

- Fabrication of electrodes coating for 18650 cylindrical cells with NMC and graphite.

Highlights

- Optimized coating parameters for NMC material of the client at CSIR-CECRI's Li-ion battery fabrication facility.
- Fabricated 18650 cylindrical cells with the NMC cathode and graphite anode.

Objectives

- Development of NMC coating parameters and coating of 100 meter electrodes for NMC cells.

Album



Dr. V.K. Saraswat, Hon'ble Member, Niti Aayog, delivering the 77th Foundation Day Lecture of CSIR-CECRI [July 25, 2024].

Bipolar concrete penetrating corrosion inhibiting admixture for embedded steel against corrosion in concrete structures

SSP-03/24

Division(s): Corrosion & Materials Protection

PI: Dr. Rakesh C. Barik

Co-PI(s): Dr. S. Muralidharan

Funding Agency: CBS Chemicals Pvt. Ltd., Bengaluru

Duration: 14.05.2024 to 14.02.2025

Budget (Rs. in Lakh): 7.80

Objectives

- To carry out short-term test and long-term test as per RDSO Specification.

Highlights

- Short-Term Test Results (as per RDSO Requirements):
- Appearance: Clear liquid with a mild ammoniacal odor.
- Skin Irritation: No irritation observed.
- pH: 9.90.

- Specific Gravity: 1.02 – 1.04.
- Viscosity: 10.0 – 13.33 s.
- Corrosion Resistance: Negligible corrosion spots observed.
- Conclusion: CBS CGUARD 200 successfully met the RDSO requirements for short-term performance evaluation.
- Long-Term Test Results (as per RDSO Requirements).
- Corrosion Rate: Lower corrosion rate observed in both immersion and Tafel tests compared to the control sample.
- Effect on Concrete: No adverse impact on the compressive strength of concrete.
- Macro Cell Corrosion Test: Passed 9 cycles without failure.
- Conclusion: CBS CGUARD 200 demonstrated effective long-term corrosion inhibition performance and complied with all relevant RDSO standards.

Album



76th Management Council Meeting of CSIR-CECRI [July 29, 2024].

Physical, chemical and electrochemical testing of indigenously developed precursor materials for lithium ion cells

SSP-05/24

Division(s): CSIR-CECRI Chennai Unit and Electrochemical Power Sources

PI: Dr. Kuldeep Singh

Co-PI(s): Dr. S. Sudhakar

Funding Agency: Bridge Green Upcycle Pvt. Ltd., Chennai

Duration: 16.05.2024 to 15.05.2025

Budget (Rs. in Lakh): 11.98

- Precursor materials conversion to cathode active materials and electrochemical testing in coin cells.

Highlights

- Characterized indigenously developed precursor materials for Li-ion batteries (LIBs) for physico-chemical (Figures 1 & 2) and electrochemical properties.
- Evaluated the electrochemical performance through charge-discharge cycling, capacity, and stability.

Objectives

- Physical & chemical testing and suggesting modification in precursor chemicals for making cathodes.

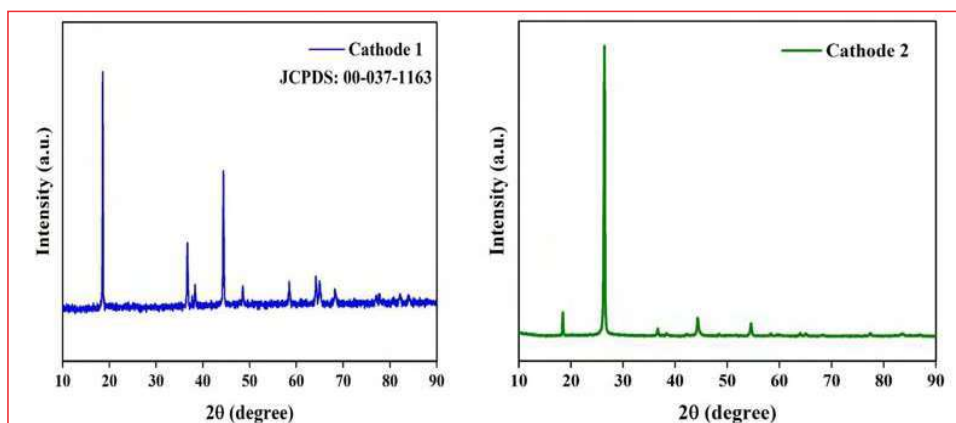


Figure 1. Powder XRD patterns of cathode active materials.

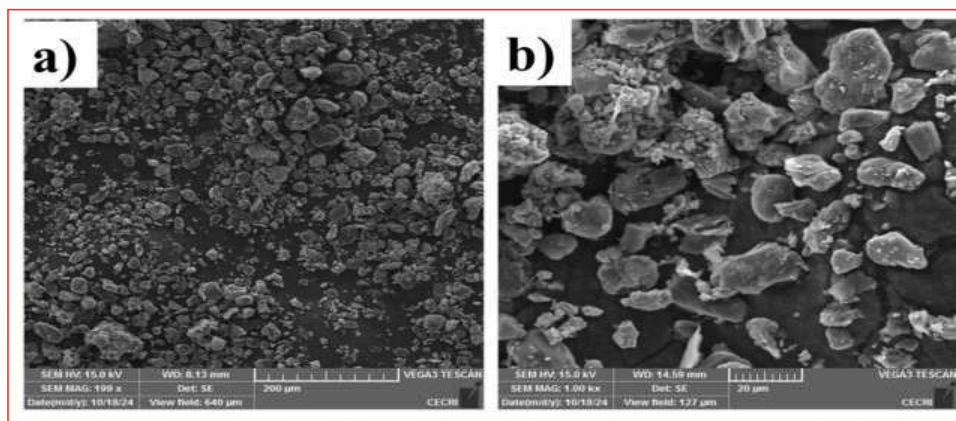


Figure 2. SEM images of cathode active materials.

Development of an electrocatalyst for anion exchange membrane water electrolyzers for large-scale hydrogen production

SSP-11/24

Division(s): Electrochemical Process Engineering
PI: Dr. Subrata Kundu
Co-PI(s): Dr. S. Vengatesan
Funding Agency: Ganganu Technologies Pvt. Ltd., Bengaluru
Duration: 12.07.2024 to 11.10.2025
Budget (Rs. in Lakh): 15.62

Objectives

- The purpose of this project is to develop an electrocatalyst with significantly lowering energy consumption and costs.
- Enhancing catalysts and electrodes to improve the efficiency of the hydrogen evolution process (HER) and oxygen evolution reaction (OER) in alkaline conditions.
- Designing specific synthetic route to design the suitable electrocatalyst.
- The modified electrocatalysts will be tested to assure durability, activity and ease of maintenance in industrial environments for AEM water electrolyzer.

- Overall, we will develop an efficient electrocatalyst for anion exchange membrane water electrolyzer that significantly lowers energy consumption and costs and preliminary testing in AEM electrolyser system.

Highlights

- Successfully synthesized VCoCO_x hydrothermally grown on Nickel foam, which gives low overpotential of 120.75 mV at -10 mA/cm^2 for HER which is much better compared to CoCO_3/NF (242.57 mV).
- Successfully synthesized NiMoFe-LDH hydrothermally grown on Nickel foam which gives low overpotential of 233.2 mV at 10 mA/cm^2 , which is lower compared to that of NiFe-LDH on Nickel foam (304.3 mV).
- In both the above, we achieved excellent durability ($>50 \text{ h}$) at 100 mA/cm^2 in alkaline electrolyte.
- Developed a scalable hydrothermal method for an OER and an HER catalysts.
- Electrolyzer testing initiated by industry partner.

Album



Director, CSIR-CECRI hoisting the National Flag on the occasion of 78th Independence Day Celebration [August 15, 2024].

Testing of PEM (membrane) supplied by M/s. GFCL Solar and Green Hydrogen Products Limited for water electrolyser

SSP-12/24

Division(s): Electrochemical Process Engineering
PI: Dr. S. Vengatesan
Co-PI(s): Dr. S. Vasudevan
Funding Agency: GFCL Solar and Green Hydrogen Products Limited, Gujarat
Duration: 18.07.2024 to 30.06.2025
Budget (Rs. in Lakh): 43.86

Objectives

- To investigate the physico-chemical properties of GFCL supplied PEM membranes.
- To explore the electrolyser polarization studies on the membranes by preparing membrane-electrode-assemblies (MEAs).

Highlights

- Proton exchange membrane (PEM) water electrolyzers have been well explored and made available in the market worldwide. State-of-art PEM electrolyzers mainly consist of anode, cathode and ion conducting membrane. The solid polymer is a thin semi-permeable membrane that conducts ions (cation or anion), and also acts as separator for anode and cathode compart-

ments. Nafion® Dupont, a proton conducting membrane, widely used in water electrolyzers and fuel cells due to its high chemical, mechanical and thermal stability along-with excellent proton conductivity. Here, the replacement of Nafion membranes would be a good import substitution process. In this direction, GFCL® Gujarat has been developing PEM membranes alternate to Nafion membranes for water electrolyser applications. These membranes are tested in CECRI for their suitability in electrolyzers.

- Herein, the physicochemical properties of 2 numbers of GFCL supplied PEM membranes were tested using standard testing protocols and compared with commercial Nafion 117 membrane. The properties include Ionic conductivity (IC), Ion-exchange capacity (IEC), Water uptake, Dimensional swelling, Tensile modulus, etc. Polarization studies on electrolyzer cell were performed by fabricating the membrane-electrode-assembly (MEA) using the GFCL-supplied PEM membranes, which was compared and benchmarked with standard MEA made using commercial Nafion 117 membrane.

Album



During the celebration of 78th Independence Day at Kendriya Vidyalaya, CSIR-CECRI Campus [August 15, 2024].

Enhancement of ORR activity of the carbon brush cathodes for Mg-air sea water battery and feasibility studies thereof (Phase I)

SSP-13/24

Division(s): Electrochemical Power Sources

PI: Dr. Aiswarya Bhaskar

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: High Energy Batteries (India) Ltd.

Duration: 07.08.2024 to 06.04.2025

Budget (Rs. in Lakh): 6.90

developed by CSIR-CECRI will undergo feasibility testing in HEB's laboratory version battery setup. The proto version battery will be tested for its feasibility in Phase I to generate (i) a voltage output of 1.4 V or higher at a current density of 1 mA cm^{-2} , (ii) Enhancing the cathode potential to +0.3 V (on load condition).

Highlights

Objectives

- Surface modification of carbon brush electrode supplied by High Energy Batteries (India) Ltd. (HEB) using conducting polymer.
- Implementing coating parameters and processes that are both repeatable and reproducible for consistent ORR performance.
- Coated carbon fibre based electrode should maintain its stability in seawater for a period of 3 months.
- The modified carbon based electrodes

- The supplied carbon fibres were subjected to heat treatment and the heat-treated fibres show improved ORR activity in sea water in comparison with original carbon fibre and heat-treated carbon brush supplied by HEB (India) Ltd.
- The metal modified carbon fibres showed better ORR activity than the carbon fibre and heat-treated brush supplied by HEB (India) Ltd.
- The metal modified carbon fibres showed better ORR activity than the conducting polymer coated carbon fibre.

Album



Invited Lecture by Prof. Thilagar P, IPC Department, IISc, Bengaluru [August 29, 2024].

Corrosion failure analysis and mitigation strategies for LPG cylinders: Enhancing durability and safety

SSP-15/24

Division(s): Corrosion & Materials Protection
PI: Er. G. Anand Babu
Co-PI(s): Dr. C. Arunchandran
Funding Agency: LPG Equipment Research Centre, Bengaluru
Duration: 23.10.2024 to 22.07.2025
Budget (Rs. in Lakh): 11.87

Objectives

- Investigate and identify the underlying causes of corrosion in LPG cylinders, specifically focusing on the corrosion observed at the bottom section.
- Recommend effective mitigation measures to prevent corrosion and enhance the durability and safety of LPG cylinders.

Highlights

- Investigated bottom-section corrosion in LPG cylinders used in domestic and commercial segments, identifying it as a critical safety and durability concern.
- Field & Lab Studies: Conducted site inspections, visual assessments, coating thickness measurements, metallographic and surface chemistry analyses (XPS), and corrosion simulation tests.
- Measurement Issues: Found duplex gauge readings for zinc coating thickness to be unreliable due to calibration errors, surface

roughness, and zinc hydroxide presence at the steel-zinc interface.

- Adhesion Deficiency: Measured zinc coating adhesion strength below the threshold limits, with XPS confirming high humidity during metallization as a root cause.
- Coating Performance: Simulated under-deposit (poultice) corrosion tests showed the existing duplex coating (zinc + primer + topcoat) provided satisfactory resistance in mud-retaining environments.
- Polarity Reversion Risk: Demonstrated that hot water immersion (~80 °C) reverses galvanic protection, causing steel corrosion, and this practice should be avoided.
- Wear-prone Areas: Identified cylinder bottom, foot ring, VP ring, and support frames as zones with severe coating wear due to mechanical handling.
- Recommended Upgrades: Appropriate counter measures with improved coating schemes were recommended.
- Quality Controls: Suggested to monitor environmental and process parameters during metallization and implement a cylinder marking system to track coating maintenance history.
- Impact: Expected improvements in LPG cylinder service life, reduced corrosion-related failures, better safety margins, and enhanced inspection reliability.



Figure 1. Photograph illustrating progressive corrosion in Domestic (A) and Commercial (B) gas Cylinders.

Performance evaluation and optimization of reliance graphene for Li-ion capacitor and Al-ion battery application

SSP-17/24

Division(s): Electrochemical Power Sources

PI: Dr. M. Sathish

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Reliance Industries, Maharashtra

Duration: 09.12.2024 to 08.12.2025

Budget (Rs. in Lakh): 40.32

Objectives

- Electrode fabrication and optimization of composition for Li-ion capacitor performance evaluation.
- To study the conventional three electrode and two electrode in non-aqueous Li-based electrolyte to understand the electrochemical behavior of the electrode material.
- To fabricate Li-ion capacitor in non-aqueous Li-based electrolyte and optimization of electrode

materials loading, coating thickness, potential window to optimize the electrochemical performance.

- To study the electrochemical performance of Al-ion battery using different electrochemical techniques.

Highlights

- The samples provided by Reliance Industries were optimized for uniform coating on a carbon coated aluminum foil and optimization of coating thickness in under progress.
- Electrochemical performance testing using cyclic voltammetry, galvanostatic charge-discharge and electrochemical impedance spectroscopy is under progress for Li-ion capacitor and Al-ion battery applicationan the conducting polymer coated carbon fibre.

Album



Director, CSIR-CECRI felicitating the Rare Earth Elements (REEs) award 2024 winning team [September 02, 2024].

Correlation between pig residue composition and quantity with internal corrosion rate for natural gas / LPG pipelines

SSP-21/24

Division(s): Corrosion & Materials Protection

PI: Dr. S.M. Ganesan

Co-PI(s): Dr. J. Ravindran and Dr. Poonam Singh

Funding Agency: GAIL (India) Ltd., Noida

Duration: 04.10.2024 to 04.10.2027

Budget (Rs. in Lakh): 142.93

Objectives

- Correlation between the quantity of pigging residues and corrosion rates taking into consideration to the given surface areas of the pipelines.
- Correlation of corrosion rate findings with metal loss coupon data.

- Estimation of the corrosion related metal loss for a pipeline section over a period of three years.

Highlights

- Pigging residue samples were collected from the gas pipelines located at four different sites in India. The pigging residue samples were brought to CECRI for detailed analysis.
- Metallurgical, chemical and microbial analyses of the collected pigging residues were carried out.
- Indian standard IS-4032 (1985) was used for the chemical characterization of the constituents present in the pigging residues via wet chemical route.

Album



Dr. Gavin Towler, Corp Chief Scientist and Chief Sustainability Officer, Honeywell International, USA delivering a special lecture on "Sustainability Engineering" [September 03, 2024].

Corrosion protection performance evaluation of a thermoplastic coating system on galvanized steel for fencing applications

SSP-22/24

Division(s): Corrosion & Materials Protection

PI: Dr. C. Arunchandran

Co-PI(s): Er. R. Jeyaram

Funding Agency: Camwell Industries Pvt. Ltd., Uttar Pradesh

Duration: 02.12.2024 to 01.06.2025

Budget (Rs. in Lakh): 12.331

Highlights

- Evaluated the thermoplastic powder coated (Plascoat PPA 571, Axalta make) galvanized steel for its performance across various environmental and chemical conditions relevant to fencing applications.
- Salt Spray Resistance: Coating protects galvanized fencing in marine environments, passing 1440-hour neutral salt spray test.
- Weathering Resistance: Passed 1440-hour QUV test with minimal gloss loss, showing strong UV and moisture durability.
- Chemical Resistance: Effective in acidic, alkaline, neutral, and fertilizer-rich environments as the materials showed no surface degradation in such surroundings.
- Adhesion: Strong adhesion with ≥ 2.5 MPa pull-off strength and 0% adhesive failure under stress.
- Barrier Performance: Impedance of $10^{12} \Omega \cdot \text{cm}^2$ after 60 days in 3.5% NaCl shows excellent corrosion protection.

Objectives

- To assess the corrosion resistance of thermoplastic coatings (Plascoat PPA 571, Axalta make) applied to galvanized iron (GI) fencing components under C5-classified marine environments by testing through salt spray (fog) exposure, QUV-A accelerated weathering, pull-off adhesion strength, electrochemical impedance spectroscopy (EIS), and chemical immersion in various acidic, alkaline, neutral and fertilizer-based solutions.

Album



Director, CSIR-CECRI inaugurating the National Sports Day (FIT India) event for staff and students [September 04, 2024].

Evaluation of corrosion protection performance of a 3-coat system applied on hot dip galvanized steel for C5 high corrosivity category as per ISO 12944-6

SSP-23/24

Division(s): Corrosion & Materials Protection
PI: Dr. C. Arunchandran
Co-PI(s): Er. R. Jeyaram
Funding Agency: Rail Vikas Nigam Limited, Chennai
Duration: 10.01.2025 to 10.07.2025
Budget (Rs. in Lakh): 10.69

Objectives

- The primary objective is to investigate and validate the suitability of the coating system for C5-high corrosive environments, as per ISO 12944-6. This objective was met by carrying out the following tests on coated panels, which consist of primer, middle coat, and top coat:
 - Salt spray test for 1440-hour as per ISO 9227.
 - Pull-off adhesion test before and after accelerated corrosion tests as per ISO 4624.
 - Water condensation test for 720-hour as per ISO 6270-1.

- Electrochemical Impedance Spectroscopy (EIS) 1440-hour (This test is not a requirement as per ISO 12944-6).

Highlights

- Salt Spray Resistance:** Demonstrated good corrosion protection in marine conditions, successfully completing a 1440-hour neutral salt spray test (Figure 1).
- Moisture Resistance:** Did not meet the standard for the 720-hour water condensation test due to minor blistering observed.
- Adhesion:** Showed strong adhesion with pull-off strength ≥ 2.5 MPa and 0% adhesive failure under stress.
- Barrier Performance:** Achieved an impedance value of $109 \Omega \cdot \text{cm}^2$ after 60 days in 3.5% NaCl solution, indicating excellent corrosion barrier properties.

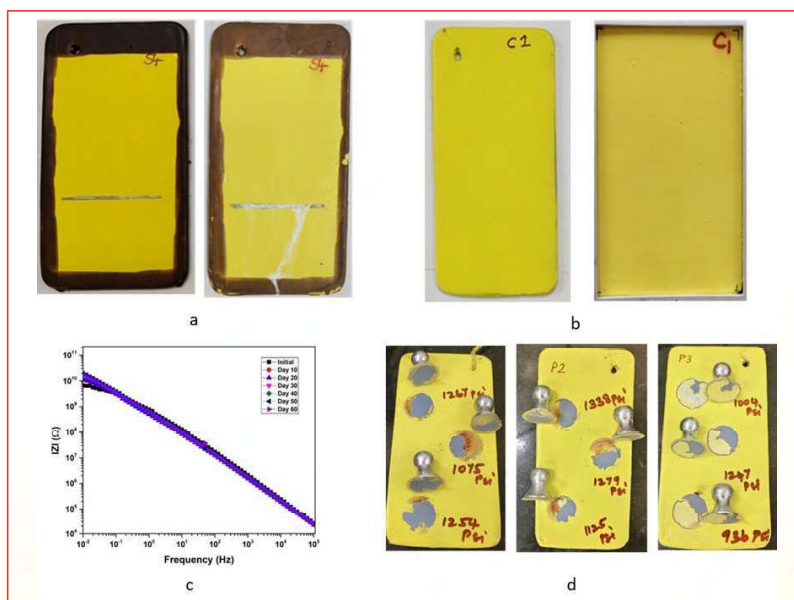


Figure 1. a) Photos of the coating system before and after 1440 h exposure to the neutral salt spray b) Photos of coating system prior to and following water condensation at 30 days c) EIS bode plot of the coating system exposed to 3.5 Wt.% NaCl solution d) Pull-off adhesion test results in triplicate.

Corrosion protection performance evaluation of a thermoplastic coating system on galvanized steel for fencing application

SSP-24/24

Division(s): Corrosion & Materials Protection
PI: Dr. C. Arunchandran
Co-PI(s): Dr. D. Sherwood
Funding Agency: MV Fence, Uttar Pradesh
Duration: 03.01.2025 to 01.07.2025
Budget (Rs. in Lakh): 12.331

Objectives

- To evaluate the corrosion resistance of thermoplastic coatings (Plascoat PPA 571 by Axalta) applied to galvanized iron (GI) fencing components in C5-classified marine environments using salt spray testing, QUV-A accelerated weathering, pull-off adhesion tests, electrochemical impedance spectroscopy (EIS), and chemical immersion in acidic, alkaline, neutral, and fertilizer-based solutions.

Highlights

- Assessed the thermoplastic powder-coated galvanized steel (Plascoat PPA 571, Axalta) for its durability under various environmental and

chemical conditions relevant to fencing applications.

- Salt Spray Resistance:** Demonstrated strong corrosion resistance in marine conditions by successfully completing a 1440-hour neutral salt spray test (Figure 1).
- Weathering Resistance:** Withstood 1440-hour of QUV exposure with minimal gloss loss, indicating high resistance to UV radiation and moisture.
- Chemical Resistance:** Maintained surface integrity in acidic, alkaline, neutral, and fertilizer-rich environments, showing no visible degradation.
- Adhesion:** Exhibited excellent adhesion with a minimum pull-off strength of 2.5 MPa and 0% adhesive failure under mechanical stress.
- Barrier Protection:** Achieved an impedance value of $10^{12} \Omega \cdot \text{cm}^2$ after 60 days in 3.5% NaCl solution, confirming strong corrosion barrier properties.
- The tested materials meet ISO 12944 Part 6 standards suitable for C5 High category corrosive environments (marine, industrial, and chemically aggressive).

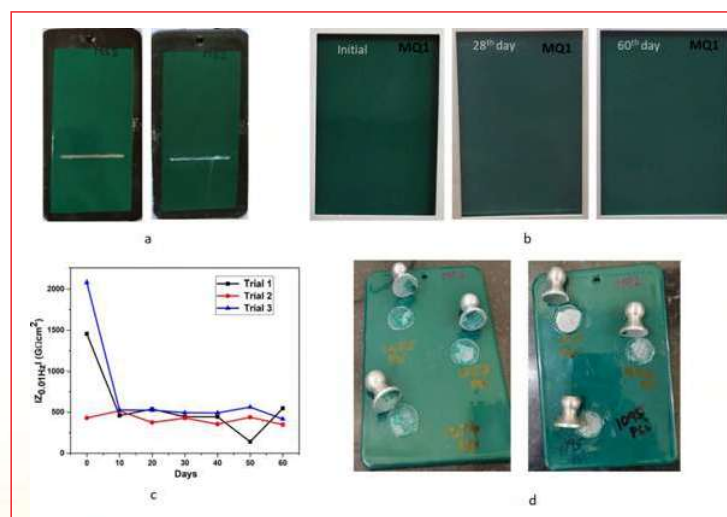


Figure 1. a) Photographs of the coating system before and after 1440 h exposure to the neutral salt spray b) Photographs of coating system prior to and following QUV exposure at 28- and 60-Days) Variation of $|Z_{0.01}|/H_z$ values in $G \Omega \text{ cm}^2$ with different times of exposure to 3.5 wt% NaCl solution for three trials d) Pull-off adhesion test results in duplicate.

Root cause analysis of crack in tubes near seal band and lifting lug welds

SSP-25/24

Division(s): Corrosion & Materials Protection
PI: Dr. S.M. Ganesan
Co-PI(s): Er. G. Anand Babu
Funding Agency: Bharat Heavy Electricals Ltd., Tiruchirappalli
Duration: 03.02.2025 to 03.08.2025
Budget (Rs. in Lakh): 15.01

Objectives

- Metallurgical analysis of the base materials, heat affected zone (HAZ) and weld.
- Detailed visual inspection and metallurgical characterization of the crack zone.
- Physical simulation of the welding and PWHT of

the weld at different temperature limits, if necessary.

- Analyzes of the cause(s) for the cracking issue and identification of appropriate mitigation methods.

Highlights

- Failure analysis of the weld is currently being carried out at identified critical areas of the boiler section.
- Metallurgical, thermal and mechanical analyses shall be carried out to identify the causes for the weld failure.
- Appropriate mitigation measures shall be recommended at the end of the project.

Album



Orientation Programme for the first year B. Tech., students 2024-25 [September 09, 2024].

Evaluation of anion exchange membrane supplied by “Naval Materials Research Laboratory” for water electrolyzers (CARS project)

SSP-26/24

Division(s): Electrochemical Process Engineering
PI: Dr. R. Malini
Co-PI(s): Dr. S. Vengatesan
Funding Agency: Naval Materials Research Laboratory, Ambarnath
Duration: 14.02.2025 to 13.08.2025
Budget (Rs. in Lakh): 9.81

Objectives

- The objectives of the current investigation are as follows:
 - I) Fabrication of MEA using NMRL supplied membranes (7 numbers) and commercial catalyst and electrolyser cell assembling, testing, performance evaluation and optimization studies
 - ii) Comparison and benchmarking the

performance of the NMRL supplied membranes with commercial anion exchange membrane

Highlights

- The catalyst coated membrane exhibited a maximum performance of 110 mA cm^{-2} at 2 V at 60°C for 1 M KOH electrolyte when Fumasep[®] FAA-3-PK-75 anion exchange membrane was employed.
- Tested the seven membranes developed at NMRL, DRDO using custom made AEM electrolyser cell and benchmarked with the commercial Fumasep[®] FAA-3-PK-75 anion exchange membrane.
- Among the tested membranes, membrane G exhibited 62 mA/cm^2 current density at 2 V at 60°C for 1 M KOH electrolyte.

Album



Director, CSIR-CECRI administering the Swachhata Hi Seva Pledge [September 23, 2024].

Evaluation of consumption rate and electrochemical efficiency of Ti-MMO (mixed metal oxide) anode for cathodic protection

SSP-27/24

Division(s): Corrosion & Materials Protection

PI: Dr. S. Muralidharan

Co-PI(s): Er. M.S. Karthikeyan

Funding Agency: Cormit Elect Projects Pvt. Ltd., Nagapattinam

Duration: 08.02.2025 to 21.05.2025

Budget (Rs. in Lakh): 4.85

Objectives

- Visual inspection of the MMO coating on the Ti substrate.
- Measurement of coating thickness using optical microscopy/scanning electron microscopy.
- Polarization testing of the Ti-MMO anode in distilled water.
- Millivolt drop testing in 3.5% NaCl solution at

high current density of 2000 A/m².

- Electrochemical consumption rate testing in NaCl medium at 600 A/m² for 15 days.

Highlights

- Electrochemical consumption rate test confirmed that the average weight loss was very negligible and the MMO coating remained intact throughout the test period with any signs of localized attack, loosening or discoloration.
- Millivolt drop test confirmed the no visible changes in the anodes appearance such as loss of catalyst, colour change, erosion or pitting (Figures 1 & 2).
- This iridium based MMO anodes are recommended for impressed current anodic protective system in different environments.

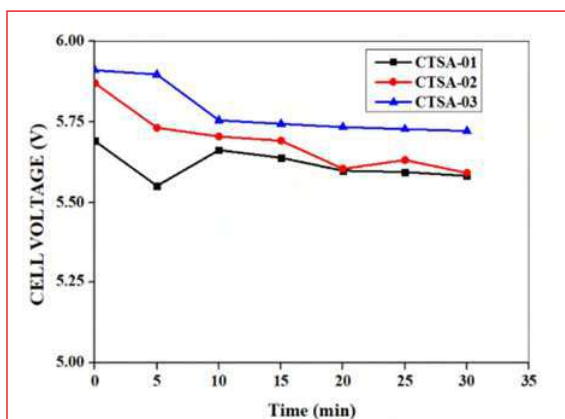


Figure 1. Cell voltage during the millivolt drop test.

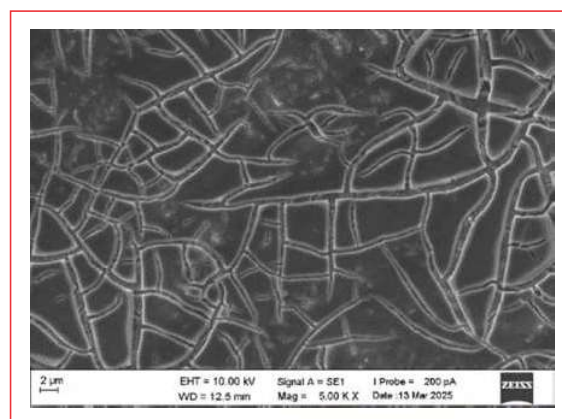


Figure 2. Surface morphology of MMO anode after millivolt drop test.

Determination and removal of moisture content in cathode materials provided by GFCL EV Products Ltd.

SSP-28/24

Division(s): CSIR-CECRI Chennai Unit

PI: Dr. A.S. Prakash

Co-PI(s): Dr. A. Nagu

Funding Agency: GFCL EV Products Ltd, Gujarat

Duration: 03.03.2025 to 04.05.2025

Budget (Rs. in Lakh): 7.10

Objectives

- Measure Initial Moisture Content: Accurately determine the moisture content present in the cathode material using Karl Fischer coulometric titration.
- Reduce Moisture Content: Achieve a moisture content of less than 300 ppm by subjecting the cathode material to controlled heating in a vacuum oven.
- Prevent Re-absorption: Immediately transfer the vacuum-dried material into aluminium foil pouches to prevent re-absorption of moisture.
- Controlled Environment: Perform all operations in a dry room to avoid exposure to moisture during sample handling.
- Final Moisture Measurement: Re-measure the

moisture content after vacuum drying using Karl Fischer coulometric titration to confirm that the desired moisture level <300 ppm.

- Batch Processing: Process approximately 8 batches of cathode material, with each batch consisting of sample sizes ranging from 100 to 500 grams.

Highlights

- Measured the initial moisture content using Karl Fischer coulometric titration.
- Reduced the moisture levels to below 300 ppm by controlled heating in a vacuum oven.
- Prevented re-absorption of moisture by immediately sealing vacuum-dried material in aluminium foil pouches.
- Maintained strict dry-room protocols throughout sample handling and processing.
- Verified final moisture content (<300 ppm) through re-measurement using Karl Fischer coulometric titration.
- Analyzed ~8 batches of cathode material (100–500 g/batch), with moisture levels confirmed below 300 ppm using Karl Fischer titration.

Album



Swachhata Hi Sewa sapling plantation by wards of staff [September 23, 2024].

Design and development of proof of concept (PoC) for rechargeable aluminium-ion batteries by developing CR2032 coin cells and cylindrical cells

SSP-32/24

Division(s): CSIR-CECRI Chennai Unit and Electrochemical Power Sources

PI: Dr. Kuldeep Singh

Co-PI(s): Dr. S. Sudhakar

Funding Agency: Aryo Green Tech Pvt. Ltd., Uttar Pradesh

Duration: 13.03.2025 to 12.03.2026

Budget (Rs. in Lakh): 29.75

Objectives

- Design and development of Proof of Concept (PoC) for Rechargeable Aluminium-ion batteries by developing CR2032 Coin Cells and Cylindrical Cells.

Highlights

- Aluminum-ion batteries (AIBs) represent a promising alternative to lithium-ion batteries due to aluminum's abundance, low cost, high theoretical capacity (2980 mAh/g), and enhanced safety profile.

- This proposal outlines a comprehensive research work to advance AIB technology through targeted tasks: electrolyte formulation and evaluation, cell design and fabrication, performance optimization, procurement of materials, and electrochemical characterization. The work will emphasize non-aqueous, ionic liquid-based electrolytes to improve ionic conductivity and safety. Prototype CR2032 coin cells will serve as the testing platform, with optimizations aimed at achieving superior specific capacity, rate capability, cycle life, and energy density.
- The project aligns with global efforts toward sustainable energy storage, leveraging inert atmosphere handling to ensure material integrity and safety.
- This research work will provide a structured pathway to advance aluminium-ion cell development, with a focus on innovation, safety, and practicality.

Album



Inauguration of Open Day on the occasion of 83rd Foundation Day of CSIR [September 26, 2024].

Type test of VRLA 1500 Ah cells as per IEC 60896 – 21 & 22

TSP-12/21

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. P. Seenichamy
Funding Agency: Exide Industries Ltd., Kolkata
Duration: 15.03.2022 to 14.09.2024
Budget (Rs. in Lakh): 20.00

Objectives

- Testing batteries as per IEC 60896 – 21 & 22 specification for Exide Industries.

Highlights

- Performed the following tests on 2V/1500 Ah batteries as per IEC 60896-21 & 22:
 - Valve operation: The test evaluates the battery's pressure relief valves to ensure they function safely and correctly under various

operational conditions, including overcharging, to prevent internal ignition or leakage.

- Service life at an operating temperature of 40 degree with medium exposure: The purpose of this requirement is to define the aggregate capacity and cycling behaviour of the battery undergoing very frequent or even daily discharges such as experienced in areas with irregular or insufficient main supply, and where recharge can be carried out only under float voltage settings conditions.
- Impact of stress temperature of 55/60 degree with medium exposure: The purpose of the requirement is to elicit information on how long units perform under elevated temperature stress conditions. These stress conditions degrade the performance of the units very rapidly as increased water loss and grid corrosion will result in increasing capacity losses.

Album



Students and public visiting the Open Day observed on the occasion of 83rd Foundation Day of CSIR [September 26, 2024].

Testing of 2V/80 Ah cells in PCCP container as per IRS 88/2004

TSP-13/21

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. P. Seenichamy
Funding Agency: United Leadoxide Products Pvt. Ltd.,
 Goa
Duration: 15.04.2022 to 14.04.2024
Budget (Rs. in Lakh): 5.75

■ Conducted the following tests as per IRS 88/2004 Standard on cells:

- * Capacity
- * Test for loss of capacity on storage
- * Endurance test
- * Ampere-hour and watt-hour efficiency test
- * Test for voltage during discharge
- * Life test
- * Sulfation test
- * Topping up test
- * Air pressure test

Objectives

- Testing batteries as per IRS 88/2004 specification for Indian Railways (RDSO).

Highlights

- Tested the 2V/80 Ah for use in railway signalling and telecommunication applications as per IRS 88/2004 standard: Low Maintenance Lead Acid Stationary Secondary Cells for S&T Installations.

Album



Students and public observing the scientific demonstration during the Open Day on the occasion of 83rd Foundation Day of CSIR [September 26, 2024].

Evaluation of battery performance for one year as per IS 15549:2005 and customer specification

TSP-02/22

Division(s): Electrochemical Power Sources

PI: Dr. Sundar Mayavan

Co-PI(s): Er. P. Seenichamy

Funding Agency: Exide Industries, Hosur

Duration: 09.05.2022 to 10.05.2024

Budget (Rs. in Lakh): 16.68

■ Conducted the following tests has been conducted as per IS 15549:2005 Standard:

- Test for C 10 capacity and voltage during discharge
- Test for C 1 capacity and voltage during discharge
- Ampere hour and watt hour efficiency test
- Test for retention of charge
- Acid retention capability test on separators
- Wicking test on separators
- Test on vent seal operation test for oxygen recombination efficiency
- Endurance life cycle test

Objectives

- Testing batteries as per IS 15549:2005 specification for Exide Industries.

Highlights

- Tested the 2V/600 Ah VRLA batteries for use in telecom as per IS 15549:2005: Stationary Valve Regulated Lead Acid Batteries-specification

Album



Dr. Anupam Agnihotri, Director, JNARDDC, Nagpur delivering the 83rd CSIR Foundation Day Lecture [September 26, 2024].

Testing of 2V/200 Ah cells in PCCP container as per IRS 88/2004

TSP-07/22

Division(s): Electrochemical Power Sources

PI: Dr. Sundar Mayavan

Co-PI(s): Er. P. Seenichamy

Funding Agency: United Leadoxide Products Pvt. Ltd.,
Goa

Duration: 27.10.2022 to 26.10.2024

Budget (Rs. in Lakh): 5.75

■ The following tests were conducted as per IRS 88/2004 Standard on cells:

- Capacity
- Test for loss of capacity on storage
- Endurance test
- Ampere-hour and watt-hour efficiency test
- Test for voltage during discharge
- Life test
- Sulfation test
- Topping up test
- Air pressure test

Objectives

- Testing batteries as per IRS 88/2004 specification for Indian Railways (RDSO).

Highlights

- Tested the 2V/200 Ah for use in railway signalling and telecommunication applications as per IRS 88/2004 standard: Low Maintenance Lead Acid Stationary Secondary Cells for S&T Installations.

Album



Swachhata Pakhwada - Shramdan Event organized on the observance of Gandhi Jayanthi [October 02, 2024].

Outdoor corrosion exposure of chromate free coating specimen for aircraft applications

TSP-09/22

Division(s): CSIR-CECRI Mandapam Unit
PI: Dr. S. Sivaprakash
Co-PI(s): --
Funding Agency: CSIR-National Aerospace Laboratories, Bengaluru
Duration: 29.11.2022 to 28.11.2024
Budget (Rs. in Lakh): 3.776

- Figure 1 represents exposed samples (one-year test cycle).



Figure 1. Batch IV samples after one year testing.

Objectives

- To extend outdoor atmospheric corrosion test facility for evaluation of chromate free coating.

Highlights

- Examined the samples of a chromium-free coating system for aircraft applications and exposed to atmospheric conditions for over a year.
- Periodic and systematic data collection was made every month, and communicated with the funding agency.

Album



Swachhata Pakhwada - Shramdan at the Karaikudi Railway Junction on the observance of Gandhi Jayanthi [October 02, 2024].

Testing for 2V/400 Ah & 2V/1000 Ah cells as per IS 16270:2014 specification.

TSP-03/23

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. K. Arumugasamy
Funding Agency: Exide Industries, Kolkata
Duration: 10.05.2023 to 09.05.2024
Budget (Rs. in Lakh): 8.35

Objectives

- Testing batteries as per IS 16270:2014 specification for Exide Industries.

Highlights

- Tested the 2V/400 Ah & 2V/1000 Ah VRLA

batteries for use in solar PV as per IS 16270:2014: Secondary Cells and Batteries for Solar Photovoltaic Application – General Requirements and Methods of Test.

- Conducted the following tests as per IS 16270:2014:
 - Rated capacity
 - Endurance
 - Charge retention
 - Cycling endurance in photovoltaic application (extreme conditions)
 - Recovery from sulphation test
 - Water loss on float charge

Album



Meeting with officials from HAL [October 09, 2024].

Analysis of cured positive & negative lead acid battery plates

TSP-08/23

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. K. Arumugasamy
Funding Agency: HBL Power Systems Ltd., Hyderabad
Duration: 24.11.2023 to 23.11.2024
Budget (Rs. in Lakh): 4.90

Highlights

- Analysis of cured positive & negative lead acid battery plates.
- Analysis of grid alloys using OES.
- Analysis of NAM and PAM of the lead acid battery plates.

Objectives

- Analysis of cured positive & negative lead acid battery plates.

Album



5th Workshop on Lab Safety Training [October 16, 2024].

Tailor-made physical training course on "Cross country pipelines-cathodic protection and survey methods" for Bharat Petroleum Corporation Limited (BPCL), Kochi

TSP-09/23

Division(s): Corrosion & Materials Protection

PI: Dr. Rakesh C. Barik

Co-PI(s): Dr. S. Muralidharan

Funding Agency: Bharat Petroleum Corporation Ltd., Kochi

Duration: 18.01.2024 to 17.04.2024

Budget (Rs. in Lakh): 5.40

Highlights

- 16 theory classes and 8 practical demonstrations in the context of corrosion and cathodic protection were delivered.
- Trained engineers and assessed the corrosion knowledge gained during the course.
- Issued the training certificate to the participants.

Objectives

- To impart training to the BPCL engineers on topics related to Oil and Gas Pipelines for a one week duration.



Group photo of the participants [February 02, 2024].

Strip down analysis of lead acid batteries

TSP-10/23

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. P. Seenichamy
Funding Agency: Schneider Electric, Bengaluru
Duration: 21.03.2023 to 20.03.2025
Budget (Rs. in Lakh): 19.44

Objectives

- Tear Down analysis of new/field failed VRLA batteries, which includes cut open analysis of the battery components like grid, NAM, PAM & Separator (using XRD/OES/CV/SEM if Necessary).

Highlights

- Tear Down analysis of 36 number of new VRLA

batteries used for UPS and data centers were completed.

- The main objective is to understand the design aspects of different makes of batteries used for UPS application which throws light on the following:

Battery dimension

Grid design

Active Material Design

Grid Alloy

PAM composition

NAM Composition

Morphology – PAM & NAM

Electrical Performance – Capacity

Album



Demonstration of fire safety equipments [October 16, 2024].



Industry oriented refresher training

TSP-01/24

Division(s): Skill Development Group

PI: Dr. S.M. Rajendran

Co-PI(s): All Concern Technical Coordinators

Mentor (if any): Director

Funding Agency: Public/Private Sector/Foreign Firm/Agency

Duration: 01.04.2024 to 31.03.2025

Budget (Rs. in Lakh): 17.7

Objectives

- To provide Industry Oriented Refresher Courses on the 12 identified fields which align to the mandate of the institute. They are (i) Fundamentals of corrosion and mechanisms (ii) Cathodic protection and pipeline corrosion (iii) Paint and coatings for corrosion protection (iv) Electrochemical power sources: Lead acid batteries (v) Electrochemical power sources: Lithium ion batteries (vi) Electroplating: Principles and practices (vii) Instrumental

methods of analysis (viii) Wastewater treatment technologies (ix) Surface Coatings for value added products (x) Metallurgy and materials protection for corrosion (xi) Solar Energy Materials-Fundamentals to device fabrication (xii) Metallurgy and materials protection for corrosion.

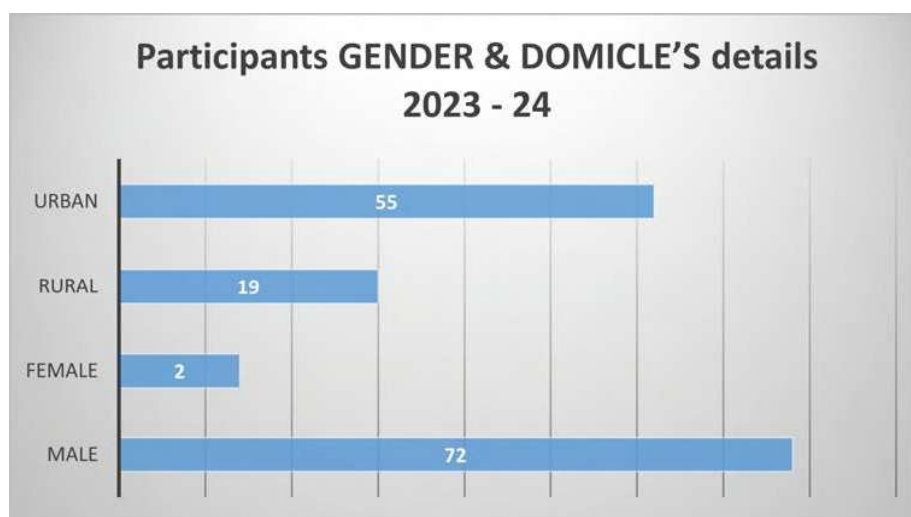
- To create self-employment and train budding entrepreneur and for industrial executives.
- To provide job related knowledge to the workers.
- To impart technical skills among the workers systematically so that they may learn quickly.
- To improve the individual's level of awareness.
- Increase an individual's skill in one or more areas of expertise.
- Increase an individual's motivation to perform their job well.

Highlights

- Programs Conducted (Table):

Sl.	Refresher Course Code	Name of the Course Conducted	Qualifications	Start Date	End Date	Participants
1	EMF 1	Industry Oriented Refresher Course on "Electroplating: Principles and Practices"	Academicians, Entrepreneurs, Executives	19.08.2024	23.08.2024	24
2	CSE 3	Industry Oriented Special Refresher Course on "Protective Coatings: Fundamentals, Inspection and Maintenance"	Executives from BHEL & IOCL	21.10.2024	25.10.2024	33
3	ECPS 1	Industry Oriented Refresher Course on "Electrochemical power systems-Lead-acid Battery: Care and Maintenance"	Academicians, Entrepreneurs, Executives	04.11.2024	08.11.2024	2
4	ECPD 2	Industry Oriented Refresher Course on "Solar Energy Materials: Fundamentals to device Fabrication"	Academicians, Entrepreneurs, Executives	16.12.2024	20.12.2024	2
5	ECPS 2	Industry Oriented Refresher Course on "Lithium-ion Battery: Materials to Manufacturing"	Academicians, Entrepreneurs, Executives	20.01.2025	24.01.2025	13

- Conducted 5 Industry-oriented Refresher Courses during 2024-2025.
- Trained a total of 74 participants (Academicians, Entrepreneurs, Executives and Faculty Members).



Testing of 2V/200, 80 & 500 Ah cells in PCCP container as per IRS 88/2004

TSP-02/24

Division(s): Electrochemical Power Sources
PI: Dr. Sundar Mayavan
Co-PI(s): Er. K. Arumugasamy
Funding Agency: Deepa Industries, Bengaluru
Duration: 13.04.2024 to 12.04.2026
Budget (Rs. in Lakh): 18.31

Objectives

- Testing batteries as per IRS 88/2004 specification for Indian Railways (RDSO).

Highlights

- Three models (2V/80 Ah, 200 Ah & 500 Ah) for use in railway signalling and telecommunication applications were tested as per IRS 88/2004

standard: Low Maintenance Lead Acid Stationary Secondary Cells for S&T Installations. Testing includes the following,

- The following tests will be conducted as per IRS 88/2004 Standard on three models of cells

1. Capacity
2. Test for loss of capacity on storage
3. Endurance test
4. Ampere-hour and watt-hour efficiency test
5. Test for voltage during discharge
6. Life test
7. Sulfation test
8. Topping up test
9. Air pressure test

Album



*FIT India Freedom Run 5.0 Swachhta and Swasthya
 [October 28, 2024].*

Extraction of magnesium metal from $MgCl_2$ by molten salt electrolysis

TSP-03/24

Division(s): Electroplating & Electrometallurgy
PI: Dr. C. Naveen Kumar
Co-PI(s): Dr. N. Rajasekaran
Funding Agency: Tuticorin Bio Energies, Tuticorin
Duration: 06.05.2024 to 05.07.2024
Budget (Rs. in Lakh): 1.21

- Energy Dispersive Spectroscopy (EDS) revealed the product composition as Mg: 97.82% and O: 2.18%.
- Conducted two electrolysis experiments at 0.2 and 0.4 A/cm² current densities for 8 h resulting in current efficiencies of 67.84% and 62.5%, respectively.
- Confirmed the feasibility of extracting high-purity magnesium metal from $MgCl_2$ via molten salt electrolysis.

Objectives

- To extract magnesium metal from anhydrous $MgCl_2$ using molten salt electrolysis.
- To evaluate the efficiency of magnesium extraction under different current densities.
- To characterize the purity and composition of the extracted magnesium metal.

Highlights

- Extracted magnesium metal ingot (Figure 1) from $MgCl_2$ supplied by Tuticorin Bio Energies.
- Inductively Coupled Plasma-OES analysis showed the product contained Mg: 99.90%, Fe: 0.025%, and Na: 0.028%.



Album



Training on patent filing by CSIR-URDIP and CSIR-IPU [November 08, 2024].

Special training course on cross country pipelines-cathodic protection and survey methods

TSP-04/24

Division(s): Corrosion & Materials Protection
PI: Dr. Rakesh C. Barik
Co-PI(s): Dr. S. Muralidharan
Funding Agency: Bharat Petroleum Corporation Ltd., Kochi
Duration: 26.06.2024 to 26.08.2024
Budget (Rs. in Lakh): 6.48

engineers, focusing on various aspects of corrosion problems in oil and gas pipelines.

Highlights

- A total of 16 theory classes and 8 practical demonstrations on corrosion and cathodic protection were conducted.
- Trained the participants and assessed their understanding of corrosion concepts during the course.

Objectives

- To impart a one-week training program to BPCL



Album



Sapling plantation by Dr. (Mrs.) N. Kalaiselvi, DG-CSIR & Secretary, DSIR, New Delhi [November 09, 2024].

Evaluation of Si nanocomposite as an anode material and fabrication of 150 prototype 18650 NMC/Si-graphite cells

TSP-05/24

Division(s): CSIR-CECRI Chennai Unit and Electrochemical Power Sources

PI: Dr. Kuldeep Singh

Co-PI(s): Dr. S. Sudhakar

Funding Agency: Cellark Power Tech Pvt. Ltd., Cuttack

Duration: 17.07.2024 to 15.05.2025

Budget (Rs. in Lakh): 15.85

Objectives

- Evaluation and testing of advance silicon as anode materials in NMC/Si-Graphite 18650 Cells.

Table 1. Comparison of electrochemical characteristics of Cellark's anode with conventional graphite anode

Parameter	Graphite Anode (Baseline)	Cellark Si Nanocomposite Anode
Specific Capacity	~372 mAh/g	>450 (8% silicon)
Energy Density Increase	-	30%
Cycle Life	500-1000 cycles	500+ cycles (stable)
Material Reduction	-	>50%
Volumetric Expansion	Minimal	Mitigated (<15% effective)

Table 2. Performance characteristics of fabricated 18650 NMC/Si-Graphite cells.

Materials Cathode: NMC622	specific capacity: 170mAh/g
Anode- Graphite + 8% Si (Cellark)	specific capacity: 450 mAh/g
Electrolyte	: DC:DMC: 1% VC+5% FEC
Projected Capacity & voltage	2.4-2.5 Ah/ 3.7 /V
Projected cycle life	1000 cycles

- To assess the electrochemical performance of Si nanocomposite anode materials.
- To develop a scalable fabrication process for 18650 NMC/Si-Graphite cells.
- To fabricate and test 150 prototype 18650 type cylindrical cells using Cellark Si composite.

Highlights

- Evaluated the electrochemical performance of Cellark's Porosil Si nanocomposite anode material and compared the performance with conventional graphite anode.
- Porosil delivered a specific capacity of > 450 mAh/g which is 30% higher than that of graphite anode (Table 1).
- Fabricated 150 proptotype 18650 cells integrating NMC/Si-Graphite cells using Cellark's graphite and the results are shown in Table 2.

Capacity test data@C/3:

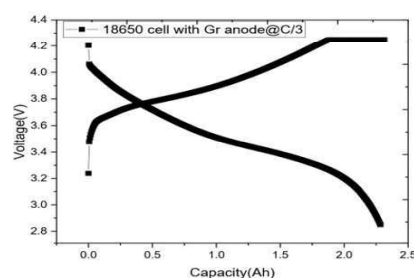


Fig. 1. Capacity(mAh/gm) vs. Voltage for Gr anode 18650 cell @C/3

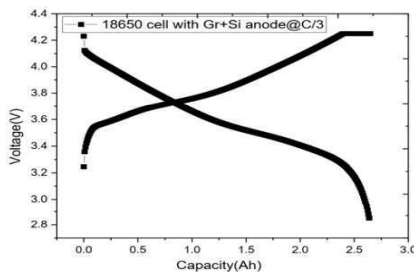


Fig. 2. Capacity(mAh/gm) vs. Voltage for Gr+Si anode 18650 cell @C/3

At C/3 current rate the cell capacity for Gr only anode is 2.31 Ah while for Gr+Si anode the cell capacity is 2.63Ah. The cell capacity in case of Gr+Si anode based cell is 11% higher than that of Gr only anode. The cathode was same for the cells.

Figures 1 & 2. Capacity vs. voltage profiles of convnentional graphite anode (Fig. 1) and Cellark's Graphite+Si anode (Fig. 2).

Operation management of under graduate program on Chemical & Electrochemical Engineering (C&ECE) for 2024-25

TSP-06/24

Division(s): Centre for Education
PI: Dr. B. Ramesh Babu
Co-PI(s): Dr. M. Raju
Funding Agency: -
Duration: 01.07.2024 to 30.06.2025
Budget (Rs. in Lakh): 113.60

Objectives

- Admission to B.Tech (Chemical and Electrochemical Engineering) programme in CECRI is being made through the single window system of Tamil Nadu Engineering Admissions (TNEA), Anna University, Chennai for 35 seats and 5 seats for other state quota through JEE (main) – All India Rank. Scientists of this institute are the faculty members of the course.
- Extension of Approval of our B.Tech Course by AICTE, New Delhi for the academic year 2024-2025.
- Renewal for Affiliation to Anna University for the academic year 2024-2025.
- The B.Tech programme is affiliated permanently to Anna University, Chennai since 2013.

Highlights

- Orientation program was conducted for 2024-2025 Batch on 09-09-2024.
- Five students joined through online counselling for B.Tech admission 2024-2025 (Other State quota) and thirty students have joined under Tamil Nadu Engineering Admissions (TNEA-2024). Four students have joined through Lateral Entry, total number of B.Tech students studying in this Academic year – 2024-2025 is 157.

B. TECH - TOTAL STUDENT -2024-25							
YEAR	HOSTEL STUDENT		TOTAL HOSTEL STUDENT	DAY SCHOLAR		TOTAL DAY SCHOLAR STUDENT	OVERALL TOTAL STUDENT
	BOYS	GIRLS		BOYS	GIRLS		
(FINAL YEAR) 2021-25	20	13	33	05	02	07	40
(THIRD YEAR) 2022-26	22	12	34	05	NIL	05	39
(SECOND YEAR) 2023-27	20	14	34	05	04	09	43
(FIRST YEAR) 2024-28	23	10	34	01	01	02	35
TOTAL STUDENT	85	50	135	16	07	23	157

- B Tech - Career Catalyst Workshop was conducted on 03-10-2024.



- CFE - Online meeting for AICTE approval to B.Tech. admission was conducted on 21-01-2025.



- A National Level Technical symposium INTERSECT – 2025 was organized on March 27 & 28, 2025.



- B.Tech NSS committee conducted a range of activities under the Anti-Drug Club program during the month of November and December 2024. The events were commenced by the Director of CSIR-CECRI.



Anna University Rank holder:

- **Ms. Vaishnavy S R** (2020-2024 Batch), secured **First Rank** in Anna University, Chennai.



- B.Tech students of Batch 2019-2023, **Mr. Balaji S**, secured **First Rank** in Anna University, Chennai with 9.26 CGPA and **Mr. Ananthan M**, secured **Second Rank** with 9.02 CGPA.



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OFFICE OF THE CONTROLLER OF EXAMINATIONS

Rank List April / May 2023 Examinations

Degree & Branch:	B.Tech. Chemical and Electrochemical Engineering	Total No of students Passed :	39	Rank Eligibility :	2
S.No	Reg Number	Student Name	Institute Name	CGPA	Class Rank
1	910218220005	BALAJI S	CENTRAL ELECTROCHEMICAL RESEARCH INSTITUTE (CSIR) KARAKUDI	9.26	FWD 1
2	910218220006	ANANTHAN M	CENTRAL ELECTROCHEMICAL RESEARCH INSTITUTE (CSIR) KARAKUDI	9.02	FWD 2



- B.Tech - Placement drive was conducted for Batch - 2020-2024. Nearly 90% students got placement including 30% of Higher studies.
- B.Tech - Placement drive was conducted for Batch - 2021-2025 (current Fourth year). Nearly 60% of students placed with annual package of 6 LPA – 9.10 LPA and 40% got higher studies.
- CSIR-CECRI B.Tech students won many prizes in Zone – XVI, Anna University, Chennai and Chief Minister Trophy.



- **Silver Medal** (Runner-up) – CSIR-CECRI B.Tech. Woman's team won Chess tournament held at Mohamed Sathak College of Engineering, Kilakarai, Ramanathapuram District on 18.09.2024.
- **Bronze Medal** – CSIR-CECRI B.Tech. Men's team won Chess tournament on 18.09.2024 held at Mohamed Sathak College of Engineering, Kilakarai, Ramanathapuram District.

Chief Minister Trophy:

- **Ms. Afrin Sulthana K**, B.Tech.–Third year student participated in the District Level competitions and won **Gold Medal** in Women's Table tennis (singles), in September conducted by Sports Development Authority of Tamil Nadu at Sivaganga.
- **Mr. Arunachalam B L**, B.Tech.–Fourth year student participated in the District Level competitions and won **Bronze Medal** in Carrom (Men's – singles), in September, 2024 conducted by Sports Development Authority of Tamil Nadu at Sivaganga. **Mr. Arunachalam B L**, B.Tech.–Fourth year student participated in the District Level competitions and won **Bronze Medal** in Carrom (Men's – singles), in September, 2024 conducted by Sports Development Authority of Tamil Nadu at Sivaganga.



Lithium ion cell analysis

TSP-07/24

Division(s): Electrochemical Power Sources

PI: Dr. R. Sindhuja

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Private Industry

Duration: 22.07.2024 to 21.09.2024

Budget (Rs. in Lakh): 3.54

Objectives

- Cut-open analysis of Lithium-ion 21700 Cylindrical cells
- Analytical, chemical and Morphological Characterization

Album



On the occasion of Curtain Raiser Event of India International Science Festival (IISF-2024) [November 09, 2024].

Fabrication of 50 prototype 18650 type cylindrical sodium-ion cells using the sodium-ion cathode and anode materials provided by Indi Energy

TSP-08/24

Division(s): CSIR-CECRI Chennai Unit
PI: Dr. A.S. Prakash
Co-PI(s): Er. A. Balasubramanian
Funding Agency: Indi Energy, Roorkee
Duration: 24.09.2024 to 01.02.2025
Budget (Rs. in Lakh): 9.44

Objectives

- Comprehending the methodologies and protocols for Na-ion battery fabrication, specifically focusing on layered material cathode chemistry.
- Developing a standardized operating procedure (SOP) for the fabrication of 18650-type Na-ion cells.
- Optimizing the processes involved in slurry preparation, coating, and calendaring of cathode and anode materials, including comprehensive quality assessments at each stage as per the requirements of fabrication equipment available at CSIR-CECRI facility.

- Fabrication of 50 prototype 18650 Na-ion cells within a dry room environment with less than 1% Relative Humidity (RH), adhering to the established SOP.
- Delivering 50 prototype 18650 cells with initial performance testing to Indi Energy produced through the outlined processes.

Highlights

- Characterized the cathode and anode materials supplied by Indi Energy systematically using XRD, SEM, and XPS techniques.
- Developed a standard operating procedure (SOP) for the fabrication of 18650-type sodium-ion cells.
- Optimized slurry preparation, electrode coating, and calendaring processes for both cathode and anode, incorporating rigorous quality control measures supported by the facilities at CSIR-CECRI.
- Successfully fabricated 50 prototype 18650 sodium-ion cells in a dry room environment (<1% RH).

Album



Lab visit of Dr. N. Kalaiselvi, DG, CSIR & Secretary, DSIR, Shri. S. Krishnan, IAS, Secretary, MeitY, GoI and Smt. Asha Ajit, IAS, Collector of Sivaganga District [November 09, 2024].

Lithium ion cell characterization

TSP-09/24

Division(s): Electrochemical Power Sources

PI: Dr. R. Sindhuja

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Private Industry

Duration: 29.10.2024 to 28.12.2024

Budget (Rs. in Lakh): 3.06

Objectives

- Cut-open analysis of Lithium-ion 21700 Cylindrical cells.
- Active material identification and design parameter identification.

Album



Dr. N. Kalaiselvi, DG, CSIR & Secretary, DSIR addressing on the occasion of Curtain Raiser Event of India International Science Festival (IISF-2024) [November 09, 2024].

Special training course on cross country pipelines-cathodic protection and survey methods

TSP-10/24

Division(s): Corrosion & Materials Protection
PI: Dr. Rakesh C. Barik
Co-PI(s): Dr. S. Muralidharan
Funding Agency: Bharat Petroleum Corporation Ltd., Kochi
Duration: 25.10.2024 to 25.12.2024
Budget (Rs. in Lakh): 6.48

Highlights

- A total of 16 theory classes and 8 practical demonstrations on corrosion and cathodic protection were conducted.
- Engineers were trained, and their understanding of corrosion concepts was assessed during the course.
- Training certificates were issued to all participants.

Objectives

- To impart a one-week training program to BPCL engineers, focusing on various aspects of corrosion problems in oil and gas pipelines.



Album



Shri. S. Krishnan, IAS, Secretary, MeitY, GoI addressing on the occasion of Curtain Raiser Event of India International Science Festival (IISF-2024) [November 09, 2024].

Lithium ion cell analysis

TSP-11/24

Division(s): Electrochemical Power Sources

PI: Dr. R. Sindhuja

Co-PI(s): Dr. S.T. Nishanthi

Funding Agency: Private Industry

Duration: 20.11.2024 to 19.01.2025

Budget (Rs. in Lakh): 1.31

Objectives

- Predict life of prismatic cells of LFP chemistry

Album



Ayurveda Innovation For Global Health 2024 - Ayurveda Medical Camp [November 11, 2024].

Heat and energy balance study for 2.4 kW air cooled stack via heat and energy balance

TSP-12/24

Division(s): CSIR-CECRI Chennai Unit
PI: Dr. Harshal Agarwal
Co-PI(s): Dr. Santoshkumar D. Bhat
Funding Agency: High Energy Batteries (India) Ltd., Maathur
Duration: 23.12.2024 to 23.06.2025
Budget (Rs. in Lakh): 10.92

Highlights

- Carried out the Mass & Heat Balance study through thermodynamic calculation with one dimensional (1D) approach.
- Made the recommendations of the blower for cooling the 2.4 kW stack and the reactions.
- Carried out the Material and Energy balance calculations for 2.4 kW stack.
- Recommended for selection of suitable BoP components for 2.4 kW Stack.
- Thermal and water management for all weather conditions for 2.4 kW stack.

Objectives

- The objective of the work is defined as “Mass & Heat Balance study through thermodynamic calculation with one dimensional (1D) and three dimensional (3D) approach and recommendations of the blower for cooling the 2.4 kW stack and the reactions.

Album



Sapling plantation by Dr. Nalin Shinghal, Chairman, Research Council, CSIR-CECRI on the occasion of 74th Research Council Meeting [November 13, 2024].

Outdoor corrosion exposure of chromate free coated specimens for aircraft applications

TSP-13/24

Division(s): CSIR-CECRI Mandapam Unit
PI: Dr. S. Sivaprakash
Co-PI(s): –
Funding Agency: CSIR-National Aerospace Laboratories, Bengaluru
Duration: 09.12.2024 to 08.01.2025
Budget (Rs. in Lakh): 2.95

Highlights

- Chromate free coating system for aircraft application samples have been loaded on test stand and completed the evaluation.
- Exposed samples are shown in Figure 1.

Objectives

- To extend outdoor atmospheric corrosion test facility to evaluate 12 samples.

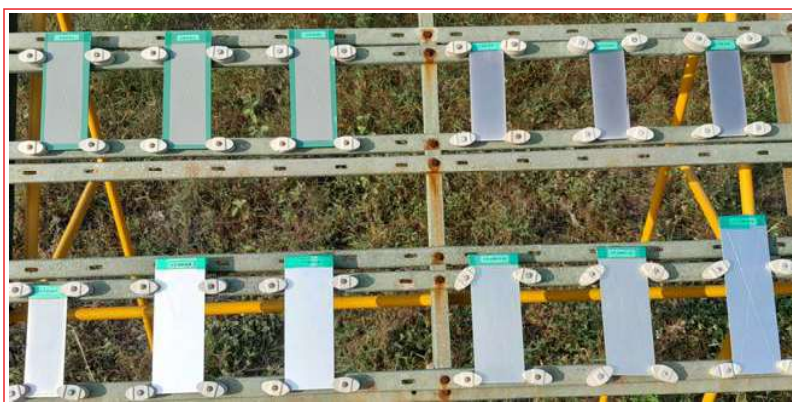


Figure 1. Testing of atmospheric corrosion samples in the open yard.

Album



74th Research Council Meeting of CSIR-CECRI [November 13, 2024].

Strip down analysis of lead acid batteries

TSP-14/24

Division(s): Electrochemical Power Sources

PI: Dr. Sundar Mayavan

Co-PI(s): Er. P. Seenichamy

Funding Agency: Schneider Electric, Bengaluru

Duration: 06.02.2025 to 05.02.2026

Budget (Rs. in Lakh): 19.44

Highlights

- Completed the Tear Down analysis of 36 number of new VRLA batteries used for UPS and data centers.
- Carried out tests to understand the design aspects of different makes of batteries used for UPS application with the following
 - Battery dimension
 - Grid design
 - Active Material Design
 - Grid Alloy
 - PAM composition
 - NAM Composition
 - Morphology – PAM& NAM
 - Electrical Performance – Capacity

Objectives

- Tear Down analysis of new/field failed VRLA batteries, which includes cut open analysis of the battery components like grid, NAM, PAM & Separator (using XRD/OES/CV/SEM if necessary).

Album



TOLIC Meeting [November 29, 2024].



NMC811 cathode material characterization for lithium-ion batteries

TSP-15/24

Division(s): Electrochemical Power Sources**PI:** Dr. Aiswarya Bhaskar**Co-PI(s):** Dr. S.T. Nishanthi**Funding Agency:** Powerstorm Technology Pvt. Ltd., Gujarat**Duration:** 08.03.2025 to 09.09.2025**Budget (Rs. in Lakh):** 7.89

Objectives

- Electrode fabrication of the NMC811 cathode active material (CAM); $\text{LiNi}_{0.8}\text{Ni}_{0.1}\text{Mn}_{0.1}\text{O}_2$ supplied by M/s. Powerstorm Technology Pvt. Ltd. (A total number of 12 samples, 2 per month), as per the slurry preparation protocol given by M/s. Powerstorm Technology Pvt. Ltd., using conductive additive and binder supplied by the company. Note that only for the first two samples, CECRI will fabricate the electrode. Rest of the electrodes will be supplied by M/s. Powerstorm Technology Pvt. Ltd..
- Coin cell assembly of the CECRI fabricated NMC811 CAM electrode and Powerstorm - supplied electrode against Lithium metal (half cells) using electrolyte mixture and coin cells provided by M/s. Powerstorm Technology Pvt. Ltd..
- Electrochemical characterization of the assembled coin cells: Cyclic voltammetry

studies (3 cycles), EIS (Initial) and galvanostatic cycling investigations for cycling stability and rate capability (50 cycles), in the voltage range and C-rate provided by M/s. Powerstorm Technology Pvt. Ltd.

- Long term cycling studies for the selected electrode material delivering good electrochemical performance (150 cycles) at selected C-rate.

Highlights

- NMC955 cathode active material, along with cell components, electrolyte, and separators, were supplied by M/s. Powerstorm Technology Pvt. Ltd.
- Systematically optimized the cell fabrication process by evaluating various configurations of the cell components to achieve optimal performance of the given material.
- Carried out the electrochemical characterization, including cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS) for the optimized cell configuration within the specified potential window and C-rate.
- Shared the results and discussed with M/s. Powerstorm Technology Pvt. Ltd.

Consultancy for the process of aluminium anodizing

CNP-01/24

Division(s): Electroplating & Electrometallurgy
PI: Dr. N. Rajasekaran
Co-PI(s): Dr. C. Naveen Kumar
Funding Agency: Ankit Fasteners Pvt. Ltd., Bengaluru
Duration: 19.04.2024 to 18.10.2024
Budget (Rs. in Lakh): 6.74

Objectives

- To provide an advice for route cause analysis for discoloration issue.
- To provide an advice for corrective action to solve the discoloration issue.
- Process audit will be done by the Team CECRI for identifying the technical gaps.

- To provide an advice for improving the quality of the aluminium anodizing process.

Highlights

- The client is the supplier of anodized aluminium fasteners for ISRO and the quality issues were experienced during the field application at VSSC.
- Team CECRI visited the client's anodizing production plant and the recommendations were provided to the client.
- Based on the recommendations, the client modified their operating parameter and practices. As a result, the quality issue was minimized drastically and the resulted products under trials.

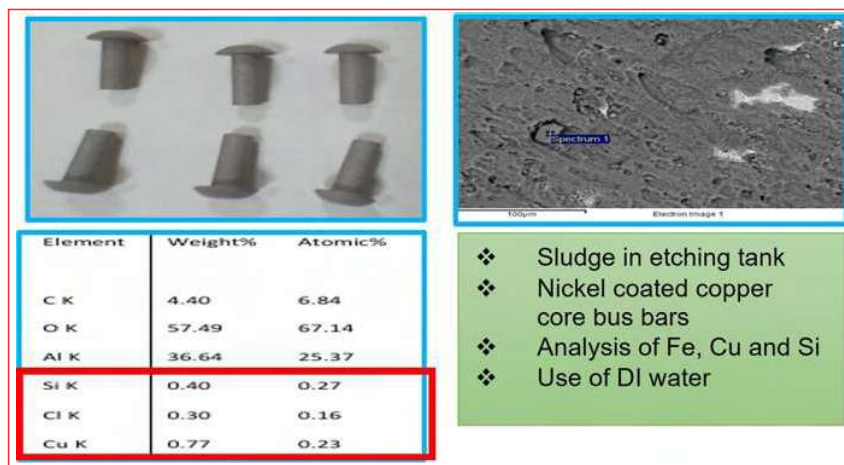


Figure 1. The photograph of samples, SEM image and compositional analysis.

Designing of sacrificial cathodic protection for hydraulic drain valve in sea water intake channel

CNP-02/24

Division(s): Corrosion & Materials Protection

PI: Er. R. Monika

Co-PI(s): Mr. T. Satyanarayana

Funding Agency: L&T Valves Ltd., Chennai

Duration: 01.08.2024 to 31.10.2024

Budget (Rs. in Lakh): 1.74

Objectives

- Corrosion risks faced by the hydraulic drain valve (HDV) components due to continuous exposure to seawater at the Kudankulam Nuclear Power Plant (KKNPP). L&T Valves provided Sacrificial cathodic protection (SCP) to the components of the valve.

- The objective is to carry out sacrificial cathodic protection design for hydraulic drain valve exposed in sea water for 30 years of service life.

Highlights

The findings of the study are as follows:

- In order to protect the valve for a service life of 30 Years under complete immersion in seawater, the anode weight must be increased to 102.3 Kg, as the anode consumption rate is significantly higher in fully immersed conditions.
- However, if the seawater immersion period is limited to 100 days, the given anode weight of 32 Kg will achieve a service life of 34.26 Years.

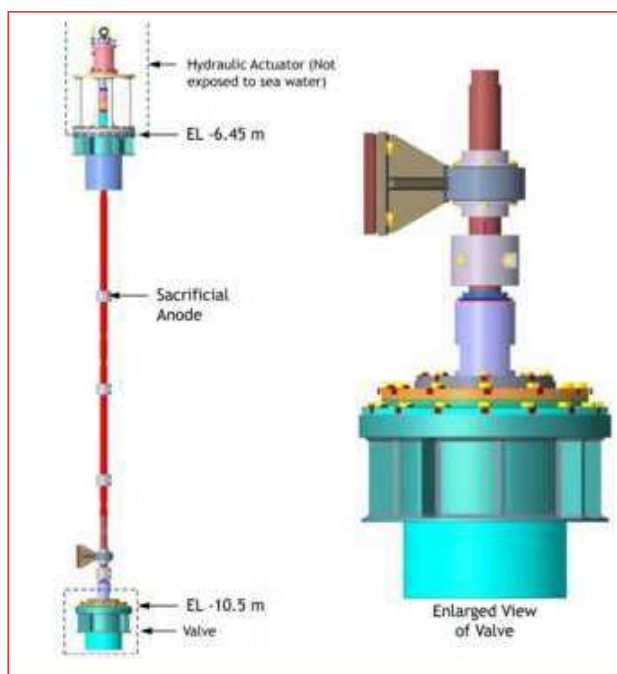


Figure 1. Hydraulic drain valve arrangement

Consultancy for the process of electroplating grade chromium trioxide storage

CNP-03/24

Division(s): Electroplating & Electrometallurgy
PI: Dr. N. Rajasekaran
Co-PI(s): Dr. C. Naveen Kumar
Funding Agency: Vishnu Chemicals Ltd., Hyderabad.
Duration: 11.09.2024 to 10.03.2025
Budget (Rs. in Lakh): 5.09

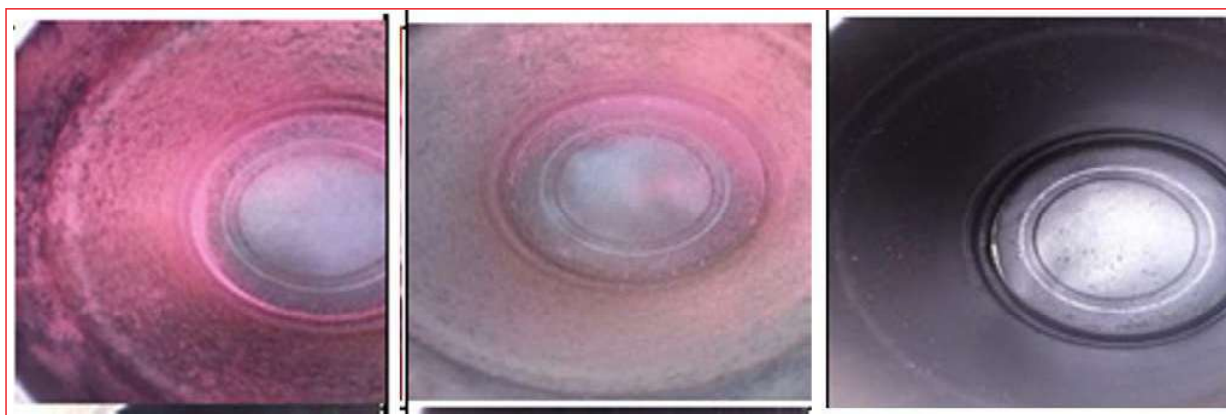
- To provide an advice for improving the quality of the chromium trioxide flakes..

Highlights

- The client experienced the sticky issues of chromium trioxide flakes on storage container walls. This created more consumption of water for washing and generates more effluents which the users need to do effluent treatment.
- The consultancy advice provided for chromic acid sticky issues on the storage drums to the clients. Advised the coatings on inner surface of the storage drums. The trial was successful and the inner surface of the storage drum not having chromium trioxide sticky issues. The long term observations under progress.

Objectives

- To provide an advice for avoiding moisture contamination during packing process.
- To provide an advise for corrective action to avoid/minimise the hygroscopic moisture product of chromium trioxide.
- Process audit will be done by the Team CECRI for identifying the technical gaps.



Sticky nature of CrO_3 on storage drum without coating

Sticky nature of CrO_3 on storage drum with suitable coating

Surface nature of storage drum with Teflon coating after wash with less water

Consultation for optimization of fluid dynamics and other physical parameters in the self-lifting cells

CNP-04/24

Division(s): Electronics & Electrocatalysis

PI: Dr. P. Tamilarasan

Co-PI(s): Dr. J. Mathiyarasu

Funding Agency: Vaighai Chemical Industries Ltd., Karaikal

Duration: 01.10.2024 to 30.09.2025

Budget (Rs. in Lakh): 4.13

Highlights

- Personnel from industry visited CSIR-CECRI, Karaikudi thrice for consultation.
- Team from CSIR-CECRI visited twice the factory at Karaikal and made a complete assessment of the production line.
- Discussed in detail on the reactant flow in the process and suggested ways to improve the product recovery and thus improving the cell efficiency.

Objectives

- Optimization of fluid dynamics and other physical parameters in the self-lifting Potassium chlorate cells.

Album



Sensitization Workshop on Prevention of Sexual Harassment at Workplace [December 06, 2024].

Consultancy for the process of electrochemical production of copper powder

CNP-05/24

Division(s): Electroplating & Electrometallurgy
PI: Dr. N. Rajasekaran
Co-PI(s): Dr. C. Naveen Kumar
Funding Agency: The Metal Powder Company Ltd., Madurai.
Duration: 24.01.2025 to 23.10.2025
Budget (Rs. in Lakh): 12.36

Objectives

- To provide an advice for upgrading the electrochemical copper powder production plant.
- To provide a technical Specification for the plant. Layout will be done by Mepco.
- To provide a advise for trail in a single

electrolytic tank to achieve 99.7 % purity with dendritic shape.

- To provide a advise for increasing the current efficiency above 90 100%. Currently the C.E achieved is 66.6%.

Highlights

- The consultancy advice provided for improving the copper powder production efficiency and quality to M/s. The Metal Powder Company Ltd. Also, provided advice for new design of electrolytic copper powder production cell, anode design and specification, bus bar specification, basket design for efficient powder collection, etc. The production trials under progress.



Electrochemical copper powder production.

Therapeutic drug monitoring (TDM) of anticancer drug in human biological fluid: Graphene-wrapped plasmonic nanostructures as surface-enhanced raman scattering (SERS) substrate

CLP-06/23

Division(s): Electrodeics & Electrocatalysis

PI: Dr. P. Tamilarasan

Co-PI(s): -

Funding Agency: Department of Science & Technology, New Delhi

Duration: 31.03.2023 to 30.03.2025

Budget (Rs. in Lakh): 9.10

Objectives

- Synthesis of structurally-engineered plasmonic nanostructures for enhanced field strength at the hot-spot and wrapping with thickness- and roughness-controlled graphene oxide layer.
- Task-specific functionalization of graphene oxide (GO) surface to anchor flutamide for high electromagnetic and chemical enhancement of Raman signal.
- Fabrication of SERS substrate by deposition of functionalized graphene-wrapped nanostructure array on glass or silicon substrates.
- Development of assay for interference-free SERS based detection and quantification of ultra-low concentration (nM) of flutamide in buffer solution, mimicked and real human body fluids, and validate the method by conventional chromatography methods.

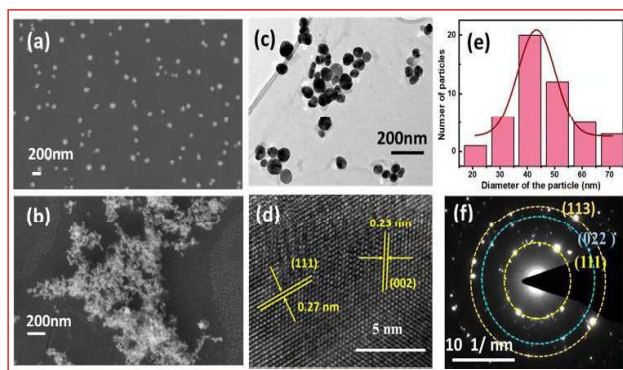


Figure 1. FESEM image of (a) pristine and (b) aggregated silver nanoparticles. (c) TEM image, (d) HRTEM image, (e) particle size distribution and (f) SAED pattern of silver nanoparticles.

Highlights

- Explored the ability of several salts for aggregation of AgNPs (Figure 1) to improve SERS signal enhancement for flutamide quantification (Figure 2).
- Among the sulphate, nitrate and chloride salts with different cations, MgSO_4 is found to be the best for AgNPs aggregation. Based on the degree of signal enhancement, the tested ions were arranged into a Hofmeister series.
- The signal strength of flutamide increases with MgSO_4 concentration while it decreases at higher pH of the sample. Under optimized conditions, AgNPs substrate shows 105 signal enhancement for flutamide, which is sufficient for the detection at ultra-trace levels.
- The substrate could detect flutamide in a range from 0 nM to 1000 nM with a limit of detection of 1 pM in phosphate buffer saline. Subsequently, the substrate has been tested for flutamide-spiked human serum where it showed detection limit of 0.3 nM.
- Overall, this study strongly suggests that aggregation is an effective strategy to improve SERS substrates.

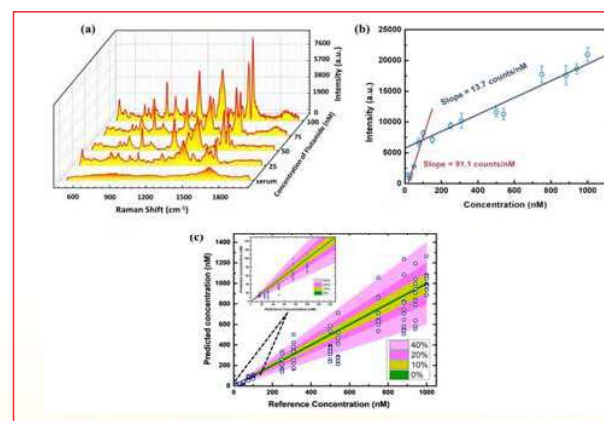


Figure 2. (a) SERS spectra of serum and flutamide-spiked serum, (b) calibration plot of SERS intensity at 1364 cm⁻¹ as a function of flutamide concentration and (c) error grid analysis of predicted flutamide concentration.

Long cycle life all-solid-state-lithium metal batteries encompassing polymer ceramic composite electrolytes

CLP-07/23

Division(s): Electrochemical Power Sources

PI: Dr. A. Manuel Stephan

Co-PI(s): Dr. A. Sivashanmugam

Funding Agency: Department of Science and Technology, New Delhi

Duration: 02.03.2023 to 02.03.2026

Budget (Rs. in Lakh): 09.45

Objectives

- Synthesis of superionic conductors and preparation of composite polymer electrolytes with superior ionic conductivity, thermal and mechanical properties.
- Systematic investigation of electrode/electrolyte interfacial properties by XPS and FT-IR studies.

- Design and synthesis of nano-structured sulfur composite cathode.
- Synthesis of LiFePO_4/C and Si/C composites and analyzing their structural and electrochemical properties.
- Assembly of all-solid-state- lithium polymer 2032-type coin and pouch cells and analyzing their charge-discharge studies at different C-rates and temperatures.

Highlights

- The superionic conductor, $\text{Li}_{10}\text{GeP}_2\text{S}_{12}$ was synthesized characterized.
- As a preliminary work $\gamma\text{-Li}_x\text{V}_2\text{O}_5$ /carbon composite has been prepared and their cycling studies were evaluated in both non-aqueous and aqueous liquid electrolytes.
- Composite polymer electrolytes are optimized in terms of ionic conductivity and flexibility.

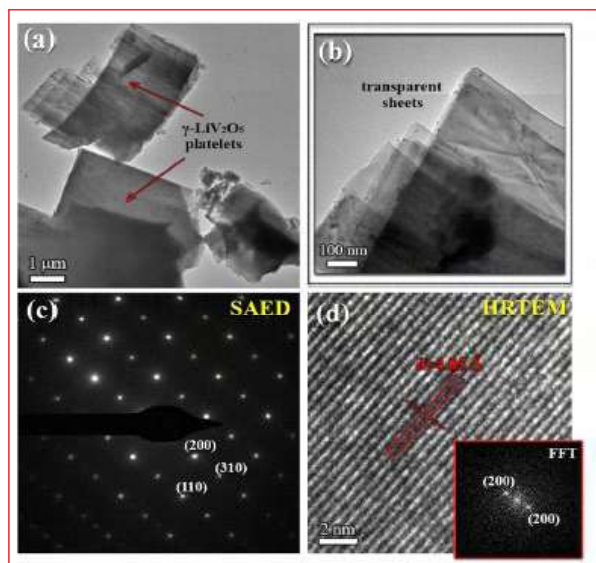


Figure 1. TEM analysis of the prepared $\gamma\text{-Li}_x\text{V}_2\text{O}_5$ powder: low magnification TEM micrograph of the sample (a); high magnification TEM micrograph showing the edge of a platelet, highlighting the layered structure of transparent sheets (b); representative SAED diffraction pattern from a single sheet (c); HRTEM micrograph of a selected sheet, with the measured interplanar spacing and corresponding FFT pattern shown in the inset (d).

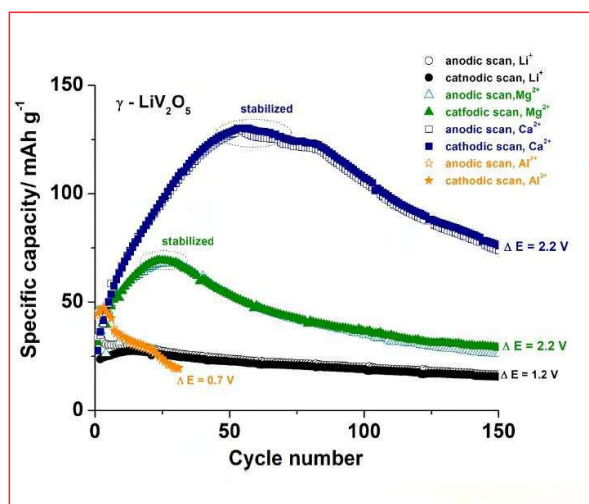


Figure 2. Cycling performance of $\gamma\text{-Li}_x\text{V}_2\text{O}_5$ in different nitrate-based aqueous electrolytes.

Surface-modified porous Ti-based implants produced by additive methods for cranio-maxillofacial and dental surgery

CLP-25/23

Division(s): Electroplating & Electrometallurgy

PI: Dr. B. Subramanian

Co-PI(s): Dr. V. Murugan

Funding Agency: Indo-Russia Joint project sponsored by Department of Science and Technology, International Division, New Delhi.

Duration: 28.11.2023 to 27.11.2026

Budget (Rs. in Lakh): 53.89

Objectives

- To develop porous Ti-based 3D printed orthodontic and cranio-maxillofacial surgical implants by additive manufacturing and to modify the surface for enhancing osseointegration with thin film of bio ceramics (Nano hydroxyapatite (nHAP) and Nano bioactive glass (nBAG) by electrophoretic (EP) and Physical Vapour Deposition (PVD).
- Development of new electrolyte compositions containing bioactive and bacterial components.
- To investigate the microstructure of the developed coatings by SEM, AFM and XRD and to find mechanical property Like, hardness, young's modulus, scratch and wear. To monitor electrochemical corrosion behavior of bioactive glass coated implants in artificial saliva solution and Simulated Body Fluid (SBF) under physiological conditions.
- Biological response includes cell adhesion,

proliferation and differentiation of osteoblastic cells. Determination of the level of alkaline phosphate activity in osteogenic differentiation.

- To evaluate the in vitro cytotoxicity for cell viability, cell proliferation and cell differentiation of coated samples in-vivo tests of osseointegration of surface-modified highly porous titanium implants in models of a critical cranial defect and a mouse femur defect.

Highlights

- synthesized nHAP in an Isopropanol suspension after sonication was coated over the substrate surface through the EPD process. The nHAP and HAp/TiO₂ nanocomposite coatings were obtained on the substrate for a deposition time of 5 minutes and an applied voltage of 15 V are the optimized conditions.
- The Ca/P ratio obtained from EDAX is 1.66, which is close to the stoichiometric HAP.
- Contact angle measurements showed that both the coatings are hydrophilic in nature.
- Protein adsorption studies revealed that both coatings show better protein adsorption ability when compared with the bare Ti alloy.
- The electrochemical corrosion studies showed that the bioceramic coatings exhibit better corrosion resistance properties when compared with the bare Ti6Al4V specimen.

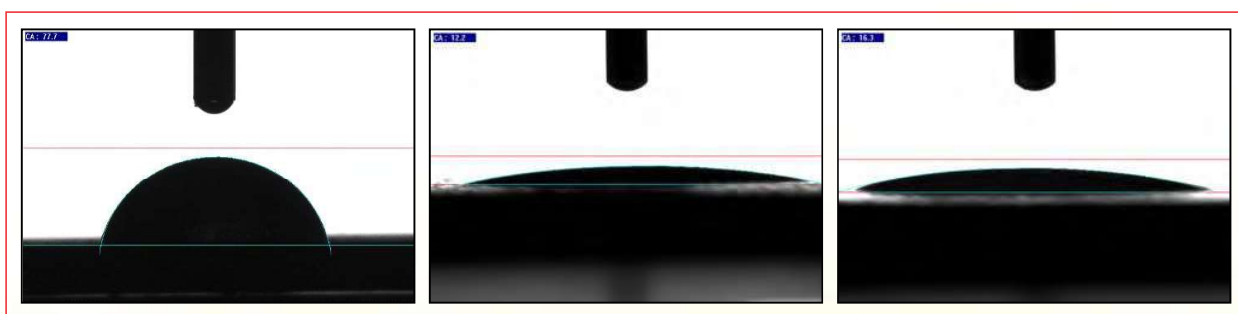


Figure 1. Contact angle measurements of bare Ti6Al4V, nHAP and HAp/TiO₂ nanocomposite coatings.



Development of 1000 prototype 18650 type cylindrical sodium-ion cells using the sodium ion cathode and anode materials provided by Tata Chemicals Ltd.

CLP-29/24

Division(s): CSIR-CECRI Chennai unit**PI:** Dr. A.S. Prakash**Co-PI(s):** Dr. A. Nagu**Funding Agency:** Tata Chemicals Ltd., Mumbai**Duration:** 03.03.2025 to 04.04.2025**Budget (Rs. in Lakh):** 53.32

Objectives

- Comprehending and interpreting the methodologies and protocols for Na-ion battery fabrication supplied by Tata Chemicals, specifically focusing on Na-based cathode chemistry.
- Developing a standardized operating procedure (SOP) for the fabrication of 18650-type Na-ion batteries based on the guidelines provided by Tata Chemicals.
- Optimizing the processes of slurry preparation, coating, and calendaring for cathode and anode materials, along with quality checks at each stage of these processes as a collaborative work.
- Fabricating 1000 prototype 18650 Na-ion cells within a dry room environment with less than 1% Relative Humidity (RH), adhering to the established SOP. Conducting electrochemical

studies on the cells to validate the SOP and making necessary modifications if required.

- Fabrication of 18650 Na-ion cells using the manpower of CECRI project staff. Delivering 1000 prototype 18650 cells to Tata Chemicals, produced through the outlined processes.

Highlights

- Carried out the comprehensive characterization of the cathode and anode materials supplied by M/s. Tata Chemicals Ltd., by using XRD, SEM, and XPS and confirmed their compatibility with large-format sodium-ion cell production.
- Developed a comprehensive Standard Operating Procedure (SOP) for the fabrication of 18650-type cylindrical sodium-ion cells, encompassing slurry preparation, electrode coating, calendaring.
- Fabricated industrially relevant cylindrical Na-ion cells with capacity of 1.0 - 1.1 Ah in collaboration with M/s. Tata Chemicals Ltd.
- Achieved reproducible electrochemical performance with stable capacity retention.
- Strengthened the CSIR-CECRI-Tata Chemicals Ltd., partnership in advancing sodium-ion battery technology.

