

Marine Corrosion and Biofouling Expertise



CSIR-Central Electrochemical Research Institute
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CSIR-Central Electrochemical Research Institute

has unique facilities to investigate marine corrosion and biofouling besides offering solutions for their mitigation by research, service and education, mainly through its centres at Tuticorin and Mandapam on the southeast coast of India.

Together, the centres are equipped to critically analyze and offer effective solutions to a complete range of complex problems in the realm of marine corrosion. More specifically, the centres provide natural exposure tests and field trials, and also carry out creative research in the following areas of corrosion:

- ✿ Atmospheric corrosion
- ✿ Seawater corrosion
- ✿ Evaluation of coatings
- ✿ Biofouling and biologically induced corrosion
- ✿ Passivity and its breakdown
- ✿ Cathodic protection

Unique capabilities



The Offshore Platform and Marine Electrochemistry Centre (OPMEC)

at Tuticorin is a matchless facility, being the only laboratory in the world located right on the ocean. The laboratory stands at a water depth of approximately 6 metres in the new harbour area of Tuticorin. This facility offers excellent conditions for investigating marine corrosion under the tropical Indian climate amid a round-the-year biofouling phenomenon.

The Corrosion Testing Centre at Mandapam

is an equally unique facility that provides the perfect setting for investigating marine atmospheric corrosion. Mandapam lies on a narrow strip of land projecting into the sea, which experiences strong monsoon winds and salty air. Over 35 years of historical exposure data exemplify this site as one of the world's most aggressive in terms of corrosion rate and paint deterioration.



Special facilities

'Well' openings on the Tuticorin platform facilitate suspension of rafts and specimens directly into coastal ocean waters. This particular feature of the platform makes it truly exceptional over other marine corrosion facilities across the world. The platform allows immersion of samples of various shapes and sizes, including cylindrical pipe materials and concrete blocks.



Electrochemical measurements for corrosion and passivity studies are supported by an AUTOLAB Potentiostat-Galvanostat (PGStat 30; Eco Chemie) with 10 A current capability and a GAMRY Reference-600 Workstation appropriate for outdoor work. These equipment support state-of-the-art DC and AC measurements.



Biofilm characterization of immersed surfaces is performed on Nikon Eclipse 80i fluorescence microscope equipped with filters for viewing and imaging bacteria, diatoms and other microorganisms associated with surfaces, antifouling paints and corrosion reactions. Microbiological facilities also support culturing and characterizing film-forming and corrosion-causing bacteria.



The Centres also have the following facilities for chemical oceanographic and marine biological studies:

- ✿ Water samplers and plankton nets with flow-meters (Hydrobios, Kiel)
- ✿ UV-VIS Spectrophotometer (Shimadzu 160S)
- ✿ Spectrofluorometer (Shimadzu RF-1501)
- ✿ Atomic Absorption Spectrophotometer (GBC 932 Plus)

Furthermore, research and development at the Tuticorin and Mandapam Centres takes advantage of sophisticated instrumentation facility at CSIR-CECRI headquarters, Karaikudi (for further information please visit www.cecni.res.in).

A glimpse of current research activities

Inventive research at the centres has recently established a strong beneficial effect of sunlight on the performance of stainless steels under natural marine immersion conditions. It has additionally been documented that sunlight promotes calcareous deposition and improves the efficiency of cathodic protection in seawater. Thus, the influence of sunlight on marine corrosion and cathodic protection forms a major activity of research at the centres. Research is also in progress to develop eco-friendly antifouling compounds from marine and terrestrial natural products. Recent research at the centres has produced important contributions like:

- ✿ M. Eashwar, G. Subramanian, S. Palanichamy, G. Rajagopal, S. Madhu, K. Kamaraj (2009) *Cathodic behaviour of stainless steel in coastal Indian seawater: calcareous deposits overwhelm biofilms*. **Biofouling** 25: 191-201.
- ✿ M. Eashwar, G. Subramanian, S. Palanichamy, G. Rajagopal (2011) *The influence of sunlight on the localized corrosion of UNS S31600 in natural seawater*. **Biofouling** 27: 837-849.
- ✿ S. Palanichamy, G. Subramanian, M. Eashwar (2012) *Corrosion behaviour and biofouling characteristics of structural steel in the Gulf of Mannar (Bay of Bengal), India*. **Biofouling** 28: 441-451.
- ✿ M. Eashwar, S. Sathish Kumar, R. Ravishankar, G. Subramanian (2012) *Sunlight enhances calcareous deposition on cathodic stainless steel in natural seawater*. **Biofouling** 28: in press.

Our clients include Defence, Nuclear Power and Aerospace departments. A list of particularly significant projects is given below.

- ✿ Effects of Coastal Water Quality on the Corrosion and Biofouling Characteristics of Marine Engineering Alloys (2005-2009)
Ministry of Environment and Forests, New Delhi.
- ✿ Studies on the Development of High Durability and Multi-functional Concrete (2007-2012)
Yonsei University, Seoul, South Korea.
- ✿ Studies on the Galvanic Compatibility of Interfacial Ring Components and Corrosion Behaviour of Canister in Seawater (2007-2009)
Defence Research and Development Laboratory, Hyderabad.
- ✿ Development of Electroless Nickel Coating on Maraging Steel Components (2007-2011)
Aeronautical Development Agency, Bangalore.
- ✿ Testing and Evaluation of Foul-release Coatings for Heat Exchangers and Condensers (2009)
Multicoat Surfaces Private Limited, Kolkata.
- ✿ Long-term Corrosion Protection Scheme for Aerospace Articles Immersed in Sea (2009-2011)
Defence Research and Development Laboratory, Hyderabad.
- ✿ Modelling for Service Life Prediction of Concrete Structures (2010-2013)
Board of Research for Nuclear Science, Mumbai.
- ✿ Development of Wear and Corrosion Resistant Electroless Nickel Plating for High Strength Titanium Alloys (2011-2013)
Aeronautical Development Agency, Bangalore.

A technology by title '**A novel, eco-friendly technology for de-rusting iron and steel components**' has been developed, and licensed to Larsen and Toubro Limited, Puducherry in December 2011.

The following dedicated scientists work exclusively at these centres:



Dr. M. Eashwar obtained his Ph.D. in marine science (Madurai Kamaraj University) and pursued post-doctoral research at the College of Marine Studies, University of Delaware. Over nearly three decades at CSIR-CECRI, he has worked on biofouling ecology, marine corrosion and biologically induced corrosion. His contributions, especially on the localized corrosion and passivity of stainless steels in seawater, are quite renowned. He is endeavouring to establish a surprisingly crucial role for sunlight in marine corrosion and cathodic protection phenomena.



Dr. G. Subramanian received his Ph.D. in marine science (Madurai Kamaraj University) for his work on marine corrosion and fouling. His research since 1983 has focussed on a range of topics including atmospheric corrosion, evaluation of paints and coatings, marine biofouling prevention and corrosion in seawater. He is particularly well known for his long-term studies of seawater corrosion. Besides well cited publications, he has seven Indian patents and one U.S. patent to his credit.



Dr. S. Palanichamy worked on marine chemistry for his Ph.D. at the Centre of Advanced Study in Marine Biology (Annamalai University). At CSIR-CECRI, he was instrumental in establishing a strong database on chemical oceanographic features of coastal ocean waters, including Tuticorin and Mandapam regions. Simultaneously, he also investigated the effects of water chemistry and local pollution on corrosion and biofouling phenomena. Currently, he is developing antifouling formulations from marine natural products.



Dr. S. Chellammal took her Ph.D. in chemistry from Madurai Kamaraj University. She is specialized in the area of environmental electrochemistry. Her significant contributions are in electrolytic recovery of metals from marine industrial effluents. She is currently working to develop bioelectrodes using marine microbes for application in bioelectrochemical systems.

CSIR-CECRI

The CSIR-Central Electrochemical Research Institute (CSIR-CECRI), founded in 1948, is a constituent laboratory of the Council of Scientific and Industrial Research (CSIR), Department of Science and Technology, Government of India, New Delhi.

It represents the largest research establishment for electrochemistry in South Asia and is a launching pad for a multitude of technologies for the Indian electrochemical industry.

CSIR-CECRI works on a gamut of problems covering all facets of Electrochemical Science and Technology: Corrosion Science and Engineering, Electrochemical Materials Science, Functional Materials, Nanoscale Electrochemistry, Electrochemical Power Sources, Electrochemical Pollution Control, Electrochemicals, Electrodeics and Electrocatalysis, Electrometallurgy, Industrial Metal Finishing, and Instrumentation.

The Institute provides a unique canopy under which all aspects of Electrochemistry and related areas are researched upon in all their dimensions. Marine Corrosion and Biofouling is a flagship theme of CSIR-CECRI.

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