Department of Chemical Engineering, IIT Hyderabad
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Speaker: **Dr. S. Sridhar**
Affiliation: CSIR-IICT, Hyderabad
Title: Membrane Processes for Sustainable Development of Indian Industry and Society
Venue: LHC-01

Abstract

Membrane technology has made rapid strides in vast and varied fields owing to inherent features of process safety, environmental benignity, low capex, and opex. This work summarizes the constant efforts made by the CSIR-Indian Institute of Chemical Technology, Hyderabad, in the design of newer membranes and membrane processes in various industrial and societal applications. Niche applications for the mitigation of environmental pollution are demonstrated by highlighting different case studies. Extensive inroads were made to develop newer technologies to address challenging problems in multiple fields for fulfilling industrial growth and domestic, besides mitigation of global warming, environmental pollution, pandemics, and disasters. Within CSIR-IICT itself, there are 25 pilot and tabletop plants under daily operation to provide potable water to the entire campus as well as ultrapure water for biochemistry and laboratory purposes.
Pharmaceutical effluent was comprehensively treated by an electrodialysis-distillation hybrid process to separate the hazardous sodium azide and corrosive ammonium chloride salts to recover 30 Metric Tons of DMSO, which is used as a solvent medium for synthesis of the antiretroviral drug, Zidovudine. Similarly, other case studies include the successful establishment of ETPs with zero liquid discharge (ZLD) by treatment of acrylic fiber and aromatics manufacturing industrial effluents, besides coke oven wastewater reclamation in the steel industry.
Several membranes have been developed for application in fuel cells, which are eco-friendly alternatives that have zero emissions with the absence of any noise pollution. The first indigenous pilot gas separation pilot plant was commissioned for natural gas sweetening at ONGC, Hazira, Surat, to reduce circulation rates of the environmentally polluting amine solvent used in the absorption of the acid gases.

Laboratory experiments for olefin-paraffin separation have shown promise, especially while using Pebax and silver-incorporated Pebax membranes and polysulfone. Scale-up of these membranes could reduce energy requirements of the two tallest columns of C2 and C3 splitter in petroleum refineries.

As an import substitute, a cascaded RO membrane-resin hybrid system was designed to produce ultrapure water for medical, biochemistry, hand sanitizer, battery applications, and laboratory use in Niloufer Children's Hospital, besides various CSIR and Biotech labs. More than 2 lakh kidney patients have been treated at Nephroplus and ESIC hospitals using dialysis-grade water
produced by IICT's medical-grade water pilot plants. The institute has aimed to develop an indigenous low-cost hemodialysis membrane module for the treatment of patients suffering from chronic kidney disease (CKD) with a more prominent motto of making healthcare affordable to the common man. A manual hollow fiber spinning machine was designed with the incorporation of an indigenous spinneret to synthesize ultrafine hollow fiber membranes from Polysulfone in DMF solvent with PEG/PVP additives to enhance hydrophilicity and decrease the dialysis duration. Modules developed were observed to remove efficiently uremic toxins from the heparinized goat blood at a lab-scale dialysis process. As there are no such Indian-made products available in the market, it has high commercial viability for industrial clients.

To save ground water resources and also provide safe drinking water in the water-scarce arid zones, hilly terrains, border areas, and coastal belts for schools, armed forces, and coast guard, and CSIR-IICT designed Atmospheric Water Generators (AWG) that harvest the relative humidity. Designed and installed around 15 model defluoridation plants of 600-4000 L/h capacity for purification of ground water and 25 highly compact low-cost Nanofiltration systems of 250-1000 L/h capacity to treat surface water for more than 5 Million population affected by fluorosis, gastroenteritis, jaundice, typhoid and other water-borne diseases in villages of Telangana, Andhra Pradesh, Karnataka, and Tamil Nadu. More than 25 hand pump-operated systems have been deployed in response to floods for clarification and disinfection of the highly turbid and pathogen-infested flood water in seven affected states, including Kerala, West Bengal, Assam, and Bihar.

The institute focused on creating user-friendly technologies to mitigate COVID-19, including multilayered masks and face shields, during the recent pandemic. Around 6 lakh washable face masks and 2000 face shields were distributed in 20 States of India, including 1 lakh free face masks for frontline Covid warriors, to make a revenue of Rs 2 Crore for NGOs with employment for 500 women from self-help groups and senior citizens. Various healthcare devices were also developed, such as membrane-aided devices for producing alkaline water as an immunity booster, a UV

chamber for disinfecting edible and non-edible items, and a ventilator for emergency medical care.

The future scope of work includes developing solvent-resistant nanofiltration membranes for the pharmaceutical industry, a moving bed bioreactor for STP, and oily refinery wastewater treatment in the petroleum industry. Other challenges include scaling up indigenous membranes for pervaporation, solar-powered forward osmosis + reverse osmosis, and membrane distillation for desalination of seawater and brackish water.

Biography

Dr. S. Sridhar is a Chemical Engineer from College of Technology, Osmania University, Hyderabad, who has been working as a Scientist in the area of Membrane Technology at CSIR- IICT, Hyderabad for the past 27 years. He has developed and transferred several technologies for chemical & allied industries, besides having contributed immensely to rural welfare through water purification projects & face mask design, and academic progress via extensive HRD and lab development in several schools and colleges.

Major highlights of his career include the commissioning of several membrane pilot plants based on Electrodialysis, Nanofiltration, Gas Permeation, and Reverse osmosis of capacities varying from 500–5000 L/h for solvent recovery, effluent treatment, and gas purification in pharmaceutical, steel, textile, aroma chemicals, and petrochemical industries. He has designed and installed more than 70 water purification plants based on Nanofiltration, Ultrafiltration, and Reverse osmosis of 600 to 4000 L/h capacity for purification of ground water, surface, and flood water for 5 Million population affected by fluorosis, gastroenteritis, jaundice, typhoid and other water-borne diseases in 10 States of India. Free water camps based on compact system design were established by Dr. Sridhar in Hyderabad city besides Industrial and Science Exhibitions for the urban population, including pedestrians, drivers, and commuters of public and private transport, to provide safe and healthy water free of cost, since April 2016. Other innovations include a novel and affordable system for medical grade water for dialysis of more than 2 lakh patients suffering from chronic kidney disease in Nephroplus, ESIC, and Niloufer hospitals, apart from developing a prototype hemodialysis membrane module as an import substitute. He has designed an Atmospheric Water Generator of 60 to 1000 Lit/day capacities to produce remineralized drinking water from relative humidity in the air in water-scarce regions, coastal belts, border areas, hospitals, and railway stations. For mitigation of COVID-19, Dr. Sridhar designed novel multilayer masks and face

shields that were provided free of cost to more than 6 lakh population, including school children, police personnel, doctors, nurses and healthcare workers, municipality workers, village folk, orphanages, and old age homes. He designed a low-cost device for producing alkaline ionized water that is an immunity booster. Dr. Sridhar is an all-round sportsman who captained cricket, lawn tennis, and football teams at the State, University, and All India CSIR Level sports competitions, besides excelling in badminton, table tennis, and chess.

Dr. Sridhar has published 185 research papers in reputed international journals such as the Journal of Membrane Science, Industrial & Engineering Chemistry Research, and Macromolecules, which are widely cited by peers more than 11400 times with an h-index of 54. He is ranked among the Top 2% of Scientists in the world by Stanford University, USA, and Elsevier Science Publishers in 2021, 2022, 2023, and 2024. He has 20 patents to his credit, 4 Books, 51 Book Chapters, and trained 500 B.Tech./M.Tech & M.Sc. students from different universities and guided 14 scholars for the award of Ph.D. Dr. Sridhar is a recipient of more than 75 Prestigious Science Awards including 35 National Awards and 3 State Awards, such as CSIR Young Scientist Award 2007, Engineer of The Year Award 2009, Scopus Young Scientist Award 2011, NASI Reliance Industries Platinum Jubilee Award 2013, VNMM award from IIT-Roorkee 2015, five CIPET national awards for 2016-2020, Nina Saxena Excellence in Technology Award from IIT-Kharagpur in 2017, Director's Special Appreciation Award 2020 for contributions in Covid-19 projects, CSIR CAIRD National Award announced on 26 Sept, 2020, three HPCL NGIC Awards for 2019 and 2021, IIChE Jubilant Award, ASSOCHAM Award, in 2023 and FRSC in 2024.