The University of Akron
College of Polymer Science and Polymer Engineering

SPECIAL LECTURE

Friday, June 9, 2017
11:00 AM
Aggarwal Lecture Hall 130

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FUNCTIONAL AND POROUS POLYMERS AS SEPARATOR MEMBRANES FOR LITHIUM ION BATTERY

Functional polymers play a key role as advanced materials in many renewable energy applications, for both, generation and storage, such as selective proton conducting polymers as membrane electrode assembly for use in fuel cells, selective lithium ion transporting separator membranes and as anodes and cathodes in Li-ion batteries.

The separator membrane is a critical component of a battery. It provides a barrier between the anode and the cathode while enabling the exchange of ionic charge carriers from one side to the other. Separators currently used in Li-ion batteries are made of polyolefin-either polyethylene or polypropylene. They are rendered porous by a mechanical biaxial extrusion process. As the battery heats up, the protective layer on the anode breaks down, followed by breakdown of electrolytes into flammable gases. This in turn causes the polyolefin separators to undergo catastrophic shrinkages above 120° C leading to shorting of cells causing sparks that ignite the electrolyte, resulting in a fire. The inherent safety risks threatens the continued advances of Li-ion battery into applications requiring higher and higher energy density, such as, in smart phones and electric vehicles. A safer separator material is needed if devices powered by Li-ion batteries do not become a grenade.

Porosity is a profound and, yet, ubiquitous concept that is inherent in many materials, both, natural and synthetic. Biomaterials (skin, alveoli in the lungs), inorganic frameworks (zeolites, carbon, silica, clay), organic frameworks (supramolecular assemblies), plant materials (bamboo) and synthetic polymer membranes (water desalination membranes, kidney dialysis membrane) are all notable for their exquisite porous architectures, which are critical to its structure and functions. Porosity in polymers can be created either during its synthesis (“bottoms-up”) or by modifying preformed polymers (“top-down”) using techniques, such as, mechanical extension, phase inversion, hard templating, self-assembly and electrospining.

This lecture will address the issue of safer battery separator membranes from the point of view of alternative porous functional polymers. A new class of high Tg amorphous and porous heterocyclic polymer based separator membrane will be described. This lecture will present an overview of challenges encountered in creating porosity in such polymers. The talk will address three on-going themes in our laboratory:

1. Synthesis of soluble functional polymers with intrinsic micro porosity (PIM’s);
2. Creation of meso/macro porous polymer membranes by physical processes;
3. Surface modified porous polyolefin as membranes for facilitating the selective transport of lithium ions and at the same time inhibiting the transport of polysulfide anions in Li-sulfur battery.

We will address strategies used to create porosity, examine mobility of lithium ions across such porous membranes and understand the potential of such materials in this application.

Dr. S. Sivaram is presently an INSA Senior Scientist and Honorary Professor at the Indian Institute of Science Education and Research, Pune, India. Prior to this he held the position of CSIR Bhatnagar Fellow (2010-15), J.C. Bose National Fellow of the Department of Science and Technology (2007-15) and Director of CSIR-National Chemical Laboratory (NCL) Pune (2002-10).

Dr. S. Sivaram has over forty years of experience in basic research, process/product R&D and S&T management, both, in industry and academia. An alumnus of IIT-Kanpur, he received his Ph.D in Chemistry from Purdue University, W. Lafayette, Indiana, USA in 1971. He was a Research Associate at the Institute of Polymer Science, University of Akron, from 1971 to 1973. Thereafter he joined the Research Centre of Indian Petrochemicals Corporation Ltd., at Vadodara. India. In 1988, he moved to NCL as Head of the Polymer Chemistry Division.

The President of India honored Dr. Sivaram with the coveted civilian award, Padma Shri, in 2006. He was the Harold A. Morton Distinguished Visiting Professor, College of Polymer Science and Polymer Engineering, The University of Akron in the Fall of 2006. Dr. Sivaram was awarded the Doctor of Science (honoris causa) by Purdue University, USA in 2010 for his exceptional attainment and merit. He is an elected Fellow of all the learned academies of science and engineering in India, an elected Fellow of the Academy of Sciences for the Developing World, Trieste, Italy, a Fellow of the International Union of Pure and Applied Chemistry and a Fellow of the Royal Society of Chemistry (UK). He has mentored the Ph.D thesis of 36 students and over fifteen postdoctoral fellows. He has to his credit over 210 publications in peer reviewed scientific journals and is cited as an inventor in 50 granted European and US as well as 52 Indian patents. Dr. Sivaram serves on the advisory board of R&D of several companies, is a much sought after consultant to industry and serves on the board of directors of several companies in India.