

# Kaushal Kishore Memorial Award Lectures 2020

## AWARD LECTURE 1

### Trash to Treasure: The Key Role of Vitrimers

by

**Prof. Suryasarathi Bose**  
IISc Bangalore

Date: November 02, 2022 | Time: 12.15 pm

Venue: MACRO-2022 at CSIR-NCL Pune Auditorium  
CSIR-NCL, Pune

## AWARD LECTURE 2

### Insertion Polymerization of Ethylene: Quo Vadis?

by

**Dr. Samir H Chikkali**  
NCL Pune

Date: November 02, 2022 | Time: 03.00 pm

Venue: MACRO-2022 at CSIR-NCL Pune Auditorium  
CSIR-NCL, Pune

Organized by:



The Society for Polymer Science, India

## AWARD LECTURE 1

### Abstract

Thermoplastic Polyolefins are lightweight, inexpensive, and durable materials, which can be easily molded into a variety of products that finds use in a broad range of applications. India is ranked 12th among the countries mishandling plastic waste and the total plastic waste generation is about 3.47 MTA according to Central Pollution Control Board of India. Going by global statistics, municipal solid waste (MSW) typically contains more than 70 wt % plastics, amid food scraps, yard trimmings, textiles, paper, and other inorganic waste. This majorly (60%) consists of polyolefins (HDPE, LDPE, LLDPE, and PP) and the remaining fraction being PET, PVC, PS, and other minor polymers. In India, a large quantity of low-density polyethylene (LDPE) is being consumed in packaging milk. So, the growing volume of post-consumer milk pouches in MSW is creating a serious problem. Hence, recycling of used milk pouches has become very important in order to minimize or avoid their adverse environmental impact. Since milk pouches come under the category of SUP, their collection and recycling may be commercially attractive, assuming their conversion to value-added products. However, it is well established that recycling plastics often result in inferior properties and hence, it is blended with virgin polymer. The most likely reason for this inferior mechanical property is the post-consumer recycling (PCR) that has suffered from degradation during their subsequent reprocessing. The extent of degradation depends on polymer type, number of cycles and the severity of conditions applied during reprocessing operations. In this context, we have come up with a unique concept of introducing dynamic covalent bonds in PCR LDPE aided through transesterification and other such thermoreversible bonds which results in multiple covalent adaptable networks during recycling or subsequent reprocessing. Our Vitriimer-LDPE survived more than 4 cycles of reprocessing and thereby opens new avenues in managing PCR LDPE waste in MSW.

### About the speaker

Prof. Suryasarathi Bose is a Professor in the Department of Materials Engineering at the Indian Institute of Science (IISc), Bengaluru, where he leads the Polymer Processing Group. His research focuses on polymer processing, blends, nanocomposites, and sustainable materials, with applications in recycling, hydrogel systems, and circular economy technologies. He has published hundreds of peer-reviewed articles and books and received several prestigious awards, including the Swarnajayanti Fellowship, INSA Young Scientist Medal, Prof. Satish Dhawan Award, APA Young Scientist Award, and the SERB-TETRA Technology Translation Award. Prof. Bose serves on editorial boards of leading journals, has held international visiting appointments, and contributes actively to professional societies in polymer science and engineering.



## AWARD LECTURE 2

### Abstract

Today we produce about 300 million tons of polymers every year. Among these, polyolefins contribute more than half of the total volume of polymers produced. Most of these polyolefins are produced by a reaction called "Insertion Polymerization" or, more popularly, "Ziegler-Natta Polymerization".<sup>1</sup> Despite the seeming maturity, the insertion polymerization reaction continues to surprise us with growing complexity and is young as ever. My talk shall take a stock of the remaining challenges in Ziegler-Natta polymerization, briefly discuss current solutions, and reiterate the enormous potential of this seventy-year-old reaction to meet contemporary demand. The first part of my talk will deal with a material called disentangled ultrahigh molecular weight polyethylene (dPE) (which is claimed to be stronger than steel). Controlled reduction of titanium can produce a pseudo-single site heterogeneous catalyst that produces dPE.<sup>2</sup> The second part of my lecture will showcase our endeavor in insertion copolymerization of difunctional olefins with ethylene to prepare functional polyethylene.<sup>3-4</sup> Finally, the talk will reveal how the fundamental understanding developed in our group is then exploited to address real-world industrial challenges.<sup>5</sup>

### References:

1. Chikkali, S. H. (Eds.) in Metal Catalyzed Polymerization: Fundamentals to Applications (ISBN: 9781498767576). CRC Press, Taylor and Francis Group, Boca Raton, FL 33487, USA.
2. Gote, R. P.; Mandal, D.; Patel, K.; Chaudhuri, K.; Vinod, C. P.; Lele, A. K.; Chikkali, S. H.\* *Macromolecules*, 2018, 51, 4541-4552.
3. Gaikwad, S. R.; Deshmukh, S. S.; Koshti, V. S.; Poddar, S.; Gonnade, R. G.; Rajamohanam, P. R.; Chikkali, S. H.\* *Macromolecules*, 2017, 50, 5748-5758
4. Gaikwad, S. R.; Deshmukh, S. S.; Gonnade, R. G.; Rajamohanan, P. R.; Chikkali, S. H.\* *ACS Macro. Lett.* 2015, 4, 933-937
5. Pandey, S.; Raj, V. K. Shinde, D. R.; Vanka, K.; Kashyap, V.; Kurungot, S.; Vinod, C. P.; Chikkali, S. H.\* *J. Am. Chem. Soc.* 2018, 140, 4430-4439.

### About the speaker

Dr. Samir H. Chikkali is a distinguished polymer chemist and catalysis researcher at the CSIR-National Chemical Laboratory (NCL), Pune, where he serves as a Senior Principal Scientist and Professor under the Academy of Scientific and Innovative Research (AcSIR). He earned his Ph.D. from the University of Stuttgart, Germany, under the supervision of Prof. Dietrich Gudat, followed by postdoctoral research at the University of Amsterdam and the University of Konstanz, Germany, supported by prestigious fellowships including an Alexander von Humboldt postdoctoral fellowship and a Dutch Polymer Institute fellowship. He has published numerous high-impact journal articles, holds multiple patents, and serves in editorial roles, including Associate Editor for *Bulletin of Materials Science*. His work has been recognized with several honors, including the National Award for Technology Innovation (for breakthroughs in polymeric materials), the Ramanujan Fellowship (DST), and Scientist of the Year Awards from NCL-Research Foundation.



### About Professor Kaushal Kishore

Kaushal Kishore was one of the outstanding Polymer Scientists of our country. He was a professor at the department of Inorganic and Physical Chemistry at the Indian Institute of Science, Bangalore, till his untimely demise in 1999 at the age of 56. Kishore received his early education in chemistry from Lucknow University and his Ph.D. from the Gorakhpur University under the guidance of the distinguished physical chemist, Professor R. P. Rastogi. After a brief stint at Gorakhpur University as a lecturer, he moved to the Department of Inorganic and Physical Chemistry, at the Indian Institute of Science, as an Assistant Professor in 1974; he rose through the academic ladder to become a



full professor in 1984 and served as the head of the department during the years 1994-1998.

Kishore's formal training was in thermodynamics and combustion chemistry. His early work in collaboration with scientists at ISRO and DRDO led to several novel discoveries that shed light on the role of different components in solid propellants; one of the very significant findings was that the polymeric binders generated polyperoxides during aging and combustion, which in turn accelerated the combustion process. With this insight, he soon discovered a unique phenomenon that he termed "autopyrolysis", which catapulted him into fame. He contributed immensely to the field of polyperoxides, both in terms of understanding its formation and exploiting their potential for a variety of applications. Thus, in his early work, he brought to bear upon the phenomenon of combustion his deep understanding of chemical thermodynamics to formulate, quantify and provide a detailed mechanistic insight into this incredibly complex process. His early work on combustion steered him to several other important problems, namely flame retardancy, which led him to define a new dimensionless quantity he termed "Flammability Index", design of new additives that would retard/inhibit the flammability of polymeric materials, probing the molecular underpinnings of "plasticization", with a primary focus on the effect of molecular architecture on plasticizing efficacy. During his last years he studied a broad class of polymers he termed "weak-link" polymers; these were analogous to polyperoxides, such as polydisulfides and polyselenides; his main interest was to understand the degradation mechanism of these weak link polymers.

Kishore's work was always characterized by its ingenuity, depth and simplicity of analysis. He saw science in everything and had a strong conviction and motivation to understand all phenomena he observed at the microscopic and, if possible, at a molecular level. His solid foundation in chemical thermodynamics brought to polymer chemistry a much-needed "thermodynamic bias" – a term he often used to characterize his work. Using numerous tools, starting from thermal analytical methods, rheological measurements, NMR and computational methods, he attacked problems with passion and a characteristic zeal – which often culminated in nailing the issue on the head. His students and coworkers remember him with great fondness – for he was not only their research guide but also their friend and a confidant.

Recognition for his achievements came in many forms. Professor Kishore was awarded the Bhatnagar prize in 1988, was elected to the Fellowship of the Indian Academy of Sciences in 1991 and later to that of the Indian National Science Academy in 1999. Kishore served on several important decision-making bodies in the country – various assessment committees, research councils of national laboratories and in many others.

### About Kaushal Kishore Memorial Award

The Kaushal Kishore Memorial Award was instituted in 2014 to recognize young outstanding polymer scientists of our country who have made outstanding research contributions and have demonstrated the potential to become global leaders in their chosen fields of research. The corpus fund for this award was donated to the Society for Polymer Science (India) after the successful conduct of the FAPS-MACRO 2013 conference in Bangalore. The award is open to researchers, under 45 years of age, who are working in India and will be awarded biannually during the MACRO conference held under the auspices of SPSI. The award will carry a cash prize of Rs 100,000, along with a citation.

### Prof. K. Kishore Memorial Award Winners of The Society for Polymer Science, India

- |      |  |
|------|--|
| 2014 | 1) Dr. M. Jayakannan, IISER, Pune            |
|      | 2) Dr. Satish A. Patil, IISc, Bangalore      |
| 2017 | 1) Prof. Suhrit Ghosh, IACS, Kolkata         |
|      | 2) Prof. Rabibrata Mukherjee, IIT, Kharagpur |
| 2018 | 1) Dr. E. Bhoje Gowd, CSIR NIST, Trivandrum  |
|      | 2) Prof. Priyadarsi De, IISER, Kolkata       |