

Fourth Sivaram Endowment Lecture 2022

Recyclable and Degradable Polyethylene-Like Material Enabled by Catalytic Methods

by

Professor Stefan Mecking
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Germany

Date: December 10, 2023

Time: 09:45 am to 10:30 am

Venue: MACRO-2023 at Bhupen Hazarika Auditorium
IIT Guwahati

Organized by:



**The Society for
Polymer Science, India**

Abstract

Plastics are key components of virtually any technology today. The excellent materials properties of polyethylene, the largest produced synthetic plastic, originate from a crystalline packing of the (linear) hydrocarbon chains. Their inert nature hinders chemical recycling, however, and also renders material lost to the environment persistent for many decades.

These problems can be alleviated by low densities of in-chain double bonds. As a direct approach to such polymers, a step-growth polymerization of long-chain monomers, obtained from natural oils, yields polyesters or polycarbonates with solid state structures and materials and processing properties similar to polyethylene (HDPE). At the same time, these materials can be closed-loop recycled under mild conditions via the low-density of in-chain functional groups [1]. The rates of degradation by microorganisms can be tuned over a wide range by the choice of monomers and repeat units [2,3]. Such HDPE-like materials can also be formed from mixtures of monomers with different length, as could potentially be sourced from biomass or plastic waste [3]. Non-alternating copolymerization of ethylene with carbon monoxide by state-of-the-art nickel(II) complexes provides access to polyethylenes with isolated keto groups in the chain (keto-PEs). Due to their high molecular weights, their properties are on par with HDPE, but the in-chain keto groups render the material photolytically degradable [4].

Ongoing studies address the understanding and advancement of this polymerization catalysis, materials for applications that particularly call for closed-loop recycling and biodegradability, and quantification of the latter by means of (catalytic) isotope labelling.

References

- [1] M. Häußler, M. Eck, D. Rothauer, S. Mecking, *Nature* **2021**, 590, 423–427. [10.1038/s41586-020-03149-9](https://doi.org/10.1038/s41586-020-03149-9)
- [2] M. Eck, S. T. Schwab, T. F. Nelson, K. Wurst, S. Iberl, D. Schleheck, C. Link, G. Battagliarin, S. Mecking, *Angew. Chem. Int. Ed.* **2022**, 61, e202213438. [10.1002/anie.202213438](https://doi.org/10.1002/anie.202213438)
- [3] T. F. Nelson, D. Rothauer, M. Sander, S. Mecking, *Angew. Chem. Int. Ed.* **2023**, 62, e202310729. [10.1002/anie.202310729](https://doi.org/10.1002/anie.202310729)
- [4] M. Baur, F. Lin, T. O. Morgen, L. Odenwald, S. Mecking, *Science* **2021**, 374, 604–607. [10.1126/science.abi8183](https://doi.org/10.1126/science.abi8183)

About the speaker

Stefan Mecking received his undergraduate and graduate education at RWTH Aachen, where he was awarded a Ph.D. degree with Willi Keim for work on catalytic carbonylations in 1994. After a postdoctoral stay with Maurice Brookhart in Chapel Hill, North Carolina as a Feodor Lynen Fellow of the Alexander von Humboldt Foundation he joined the Hoechst Company in Frankfurt as a project leader. He later moved to the University of Freiburg, and since 2004 has been the Chair of Chemical Materials Science at the University of Konstanz. Honors and awards include the Otto-Roelen Medal, the BASF Catalysis Award, and more recently a six-month stay as an elected visiting fellow of Trinity College at the University of Oxford in 2019. His research on catalytic methods to generate degradable polyolefin materials is supported by an ERC Advanced Grant.

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About Dr. S. Sivaram

Dr. Sivaram is a polymer chemist, mentor and science manager of distinction. An alumnus of IIT-Kanpur (M.Sc. 1967), he received his Ph. D in Chemistry from Purdue University, W. Lafayette, Indiana, USA in 1971. He was a Research Associate with Professor J. P. Kennedy at the Institute of Polymer Science, the University of Akron, Akron, Ohio during 1971-73. Dr. Sivaram returned to India to begin his scientific career at the Indian Petrochemicals Corporation Limited, Vadodara and moved to National Chemical Laboratory (CSIR-NCL) in 1988 to lead the Polymer Chemistry Division. He later rose to the position of Director NCL from 2002-10. He was a CSIR Bhatnagar Fellow at NCL, Pune (2010-15) and INSA Senior Scientist at the Indian Institute of Science Education and Research (IISER), Pune (2016-19). Currently, he is an Honorary Professor Emeritus and INSA Emeritus Scientist, at IISER, Pune and an Honorary Professor of Chemistry at IISER-Kolkata.

Dr. Sivaram is a recipient of many honours for his scientific contributions. He is an elected fellow of all the learned academies of science and engineering in India. The President of India conferred on him the fourth highest civilian award, Padma Shri, in 2006 in recognition of his contributions to nation building. The Institute of Polymer Science, University of Akron honoured him with the H. A. Morton Distinguished Professorship in 2006. Purdue University conferred on him a degree of Doctor of Science(h.c) in 2010 in recognition of his exceptional merit and attainment. IIT Kanpur bestowed on him the distinguished alumnus award in 1998. He was honoured by the Japan Society of Polymer Science in 2018 with the International Award for his distinguished contributions to polymer science. The Chemical Research Society of India conferred on him its Gold Medal in 2019 for his life-time contributions to chemistry.

Dr. Sivaram is widely recognized for his contributions to polymer science, technology development, institution building and management of innovation in publicly funded organizations. He built a strong research school in polymer chemistry at NCL and brought global visibility, both, from academia and industry, to the activities of his group. He has trained a large number of students who occupy influential positions in India and outside. He also played a stellar role in creating the Society of Polymer Science, India (SPSI) and has nurtured it from its very inception to make it a vibrant forum for scientists and students involved with the discipline of Polymer Science in India. Through his myriad activities over five decades, Dr. Sivaram has brought respect to the discipline of polymer science in India, especially, among those practicing chemistry research, enhanced the global visibility for Indian polymer science research and continues to be one of the most visible and influential faces of science in India, in academia, government and industry.

About Sivaram Endowment Lecture

Dr. Sivaram endowment lecture has been instituted by his large family of students, associates, colleagues, mentors and well-wishers, from academia and industry and from within India and outside. The main objective of this lecture is to popularise polymer science and technology in the country and to inspire young researchers working in the area of chemistry, in general, and polymer science, in particular. The lecture shall be held once in two years co-terminus with the biannual MACRO conferences held under the auspices of The Society for Polymer Science, India (SPSI). The lecturer will also be encouraged to visit an educational institution in India to interact with young students. The society will strive to invite distinguished scholars from India and abroad to deliver the endowment lecture. We, his former students and associates, believe that this is the most fitting way to acknowledge the values that Dr. Sivaram taught us, namely, pursuit of excellence and relevance in scientific research and education, high standards of professional integrity and service to the scientific community.

Earlier Speakers

- 2017 : Professor M. Sawamoto, Kyoto University, Japan.
2018 : Professor Nikos Hadjichristidis, KAUST, Thuwal, Kingdom of Saudi Arabia.
2020 : Professor Richard Hoogenboom, Ghent University, Ghent, Belgium

