

Third Sivaram Endowment Lecture

Supramolecular Polymer Materials

by

Professor Richard Hoogenboom

Supramolecular Chemistry Group,
Centre of Macromolecular Chemistry,
Department of Organic and Macromolecular Chemistry,
Ghent University, Ghent, Belgium
Krijgslaan 281-S4, 9000 Ghent, Belgium

Date: November 2, 2022

Time: 14.15 pm

Venue: MACRO-2022 at CSIR-NCL Pune Auditorium
CSIR - National Chemical Laboratory, Pune

Organized by:



**The Society for
Polymer Science, India**

Abstract

Supramolecular interactions are omnipresent in nature and are at the basis of all adaptive and responsive processes in natural systems. Importantly, natural polymer structures based on supramolecular interactions provide a highly sophisticated level of control over the properties of the materials, ranging from information storage and read-out, via self-replication to transport of molecules and materials with high mechanical strength and efficient energy dissipation. Inspired by these natural systems, we aim to develop advanced materials based on the combination of polymer materials with supramolecular interactions which will be discussed.

At first, the utilization of thermoresponsive polymers as basis for smart polymeric sensors with a memory function will be discussed.¹ It is demonstrated that thermal phase transitions with large hysteresis (up to 40K) could be obtained based on supramolecular host-guest association, which could be exploited as memory function for the thermal history of the solution.² When transferring these host-guest systems to polymeric hydrogels, the supramolecular association of the hydrogel with a tetracationic macrocyclic host was found to induce strong swelling of the hydrogels.³ Combining this hydrogel with a thermoresponsive polymer that contains a stronger binding electron rich host in solution allows shuttling of the macrocyclic host between the solution and the hydrogel. As such, this multicomponent supramolecular system revealed heating induced swelling of the hydrogel and cooling induced shrinkage.

Secondly, poly(2-isopropenyl-2-oxazoline) (PIPOx) will be presented as broadly applicable building block for making responsive materials. PIPOx is hydrophilic and biocompatible while modification is straightforward through coupling of carboxylic acids to the side-chain 2-oxazoline units. This allows modification of the hydrophilic-hydrophobic balance to make thermoresponsive polymers,³ but also can be used to introduce side-chain functionalities, such as azobenzenes for sensing or photoresponsive behavior. In addition, the use of difunctional carboxylic acids leads to straightforward preparation of crosslinked hydrogels.⁴ The preparation of strong and energy dissipating hydrogels will be discussed based on poly(2-isopropenyl-2-oxazoline) that is crosslinked with either a pillar[5]arene as supramolecular crosslinker or with terpyridine metal complexes.⁵

References

- [1] De la Rosa, V. R.; Woisel, P.; Hoogenboom, R. *Mater. Today* 2016, 19, 44.
- [2] De la Rosa, V. R.; Hoogenboom, R. *Chem. – Eur. J.* 2015, 21, 1302; Sambé, L.; De la Rosa, V. R.; Belal, K.; Stoffelbach, F.; Lyskawa, J.; Delattre, F.; Bria, M.; Cooke, G.; Hoogenboom, R.; Woisel, P. *Angew. Chem. Int. Ed.* 2014, 53, 5044.
- [3] Belal, K.; Stoffelbach, F.; Lyskawa, J.; Marcellan, A.; De Smet, L.; De la Rosa, V. R.; Cooke, G.; Hoogenboom, R.; Woisel, P., et. al. *Angew. Chem. Int. Ed.* 2016, 55, 13974.
- [4] F. A. Jerca, V. V. Jerca, A. M. Anghelache, D. M. Vuluga, R. Hoogenboom, *Polym. Chem.* 2018, 9, 3473; F. A. Jerca, V. V. Jerca, R. Hoogenboom, *J. Polym. Sci., Part A: Polym. Chem.* 2019, 57, 360.
- [5] F. A. Jerca, V. V. Jerca, R. Hoogenboom, et al. *Chem. Mater.* 2018, 30, 7938 & *Mater. Horiz.* 2020, 7, 566 & *Adv. Funct. Mater.* 2019, 1904886 & *Macromolecules* 2020, 53, 6566.

About the speaker

Prof. Richard Hoogenboom is full professor at Ghent University, heading the Supramolecular Chemistry (SC) group that focuses on poly(2-oxazolines), supramolecular materials and responsive polymers. He obtained a PhD from Eindhoven University of Technology under supervision of Prof. Ulrich S. Schubert and performed postdoctoral research with Prof. Martin Möller (RWTH Aachen) and Prof. Roeland Nolte (Radboud University Nijmegen). Prof. Hoogenboom has published more than 500 refereed scientific articles that received 23,500+ citations (h-index 71) and he is listed as inventor on 21 patent families. He is currently Editor-in-Chief for *European Polymer Journal* and Associate Editor for *Australian Journal of Chemistry*. Prof. Hoogenboom is the recipient of the inaugural RSC Polymer Chemistry award (2015), the PI IUPAC Young Investigator award (2016), the ACS Macromolecules/ Biomacromolecules Young Investigator award (2017), the ACS Carl S. Marvel Creative Polymer Chemistry Award (2021), the 2022 ACS POLY fellows award and is an elected fellow of the RSC and the Young Academy of Europe. Since January 2018, Prof. Hoogenboom is also cofounder of Avroxa BV that commercializes poly(2-oxazoline)s as Ultroxa®.



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.