Swaminathan Sivaram

Swaminathan Sivaram is a polymer chemist at the National Chemical Laboratory (NCL), Pune. He obtained his Ph D from Purdue University, after M Sc from the Indian Institute of Technology, Kanpur. Sivaram has worked both in academia and industry. He spearheaded several public–private partnerships during his term as the Director of NCL, and also established a research group in polymer science there.

Excerpts from his interview*

How has the field of polymer chemistry evolved over the years?

Polymer chemistry was born with the seminal contributions by Wallace Carothers in the early thirties when he showed that bond-forming reactions, when applied to di-functional molecules, lead to the formation of long macromolecular chains. This was a watershed moment, since it meant that the techniques of rational organic synthesis could be applied to make macromolecules. In the early forties, Paul Flory showed that principles of physical chemistry, thermodynamics and statistical mechanics could be used to understand the kinetics and mechanism of polymer formation by both step-growth and chain-growth reactions.

During the last two decades, polymer chemistry has evolved and matured in two directions. One, in terms of synthesis and the other in terms of understanding structure. Polymers can now be synthesized by a variety of techniques with precision, namely with control over copolymer composition, molecular weight, distribution of molecular weights, functionalities and their precise location, sequence of monomer placements in block copolymers, stereochemistry, regiochemistry and topology. It is now also possible to probe the structure of macromolecules (both at a molecular and supra-molecular level) using several physical tools with a great degree of certainty.

What do you see as things that have changed in the field of polymer chemistry and what do you think lies in the future?

Polymer chemistry has become truly an enabling science. Polymer chemists continue to be pre-occupied with creating new structures through synthesis. However, greater challenges wait in creating functions in synthetic polymers. Functional polymers have become important in many areas of contemporary applications, be it medicine, pharmaceuticals, energy, housing, transportation, water or environment. They are ubiquitous in information and communication technology products that we use every day.

Just like in other branches of chemistry, polymer chemists too are not merely asking what is it, but what does it do? Merely making a molecule is not enough anymore.

In many of these applications, polymers have to be used with other materials, namely inorganic, metals, biomolecules or natural polymers. Most functional materials are in some way either conjugates or hybrids. Consequently, polymer chemists will need greater understanding of surfaces and interfaces, since properties of dissimilar materials, in a hybrid or conjugate form, are determined by the molecular interaction at the interfaces. Polymers that self-assemble into large supra-molecular shapes and forms with hierarchical order, stimuli-responsive polymers, conjugated polymers with precise lengths, functional polymer networks, and other complex systems are becoming important in many applications. Complex polymer systems, using organized assemblies of block copolymers can be used to fabricate nanoscale objects. Polymeric systems with emergent properties are beginning to be better understood.

What kind of prospects do young polymer chemists have?

Polymer chemists have a bright future. Polymers are indispensible to human civilization, and their manufacture and consumption is expected to grow. Polymer chemists will continue to be contributors to both established and emerging science and technology. The world consumes over 250 mt of polymers today. The manufacturing technology, though mature, still requires new discoveries. Most of the polymers that we consume today come from fossil fuels. Is there a more sustainable basis for producing polymers? How can we use less polymers in the products we consume? Can we design polymers with an in-built trigger that will activate their degradation after a specified time? How can we make polymers truly biodegradable? In the emerging areas, polymer chemists can contribute to better methods of producing cleaner energy from either sun or hydrogen, help in producing potable water from sea water, enhance efficiency of water use in agriculture, create better drugs through targeted delivery, and create new prosthesis materials that can be implanted or substituted in a human body.

Polymer chemistry has given birth to materials such as plastics, which are a menace to the environment and health...

This is a wrong perception. No material is intrinsically good or bad. It is how we make use of it that makes it good or bad. Plastics are very useful materials, without which we cannot live even for an hour. Yet, we should treat every material with the respect it deserves. We must promote more responsible use of materials through education and inculcating civic sense amongst our citizens. Plastics can be easily recycled, provided we can collect them post-consumer use. Every plastic has a defined method of disposal, defined by its 'cradle to grave' life-cycle analysis. Used plastic material still has most of the calorific energy content that was part of the raw material from which it was made. This energy can be recovered. There is also a need to ensure that the right materials are used for the right applications. Plastics have played a significant role in reducing the energy consumption and enhancing the sustainability of the environment in our planet, as both population and consumption have grown substantially during the past century.

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*The full version of the interview can be found at: 10feb2012/385a.pdf.