Introduction: Polymerization

The *Oxford English Dictionary* defines polymer in its broadest sense as "a substance with a molecular structure formed from many identical small molecules bonded together." Polymers, in their many diverse forms, are the remarkable materials constituting the essential "stuff" from which everything, from living organisms to computer components to common household goods, is formed. In the area of synthetic abiotic organic polymers, the past two decades have witnessed a dramatic explosion in research activity, driven by appreciation for the remarkable properties that synthetic polymers can have and the desire to productively put the creation and understanding of their properties on a firm scientific footing. The ultimate goal is to synthesize materials with greatly enhanced, targeted properties that can be produced on a large scale. Such an endeavor requires the following three elements. (*i*) New efficient and selective ways to create polymer structures (polymerization); this effort has involved organic/macromolecular, organometallic, and catalytic chemical scientists. (*ii*) The application of advanced physical characterization techniques to understand in detail the structural and dynamic nature of the substances created in polymerization processes and at multiple length scales; this effort has involved a broad spectrum of researchers in spectroscopy, scattering, as well as macromolecular flow and mechanical properties. (*iii*) Theory describing the interplay of chain microstructure and bulk properties such as mechanical strength and toughness, flow properties, phase stability, permeability, solubility, optical and charge transport properties, etc. This effort has involved both "pencil-and-paper" theorists as well as computational researchers.

The focus of this PNAS special feature is on recent advances in polymerization science. The remarkable role that the atomistic features of such processes can have on macroscopic polymer properties is nicely illustrated by examples involving polyolefins. Relatively minor substituent changes in a well defined organotitanium or organozirconium catalyst molecular structure can produce a polyolefin, comprised of simple linked ethylene or propylene molecules, with properties ranging from a strong, flexible film, to a sticky "goo," a "crunchy" solid, a wax, or a free-flowing oil. In a number of cases, these "high-tech" polymeric materials are produced on truly massive scales (billions of kilograms per year). That catalysts can be used to efficiently produce useful materials rather than small molecules is a subtheme of this special feature. The purpose of this special feature, then, is to bring together an internationally recognized group of experts working in the field of polymerization and report on some of the advances that are taking place. It is, of course, impossible for such a PNAS "symposium in print" to be all-inclusive. However, it is hoped that both specialists and nonspecialists will find the present compendium stimulating and informative.

For several years, PNAS has published special feature issues on many cutting edge research topics. Some of the themes of past special features have included: Tissue Engineering, Social and Behavioral Sciences, Asymmetric Catalysis, Science and Technology for Sustainable Development, Long-Range Electron Transfer, and, most recently, Cluster Chemistry and Dynamics and Interstellar Chemistry. Scheduled for future issues of the journal are special features on Nitrogen Fixation, Eukaryotic Transposable Elements and Genome Evolution, and High-Pressure Geoscience. One objective of these special features is to advance the journal's ongoing initiative to expand its coverage of the physical and social sciences and mathematics. PNAS continues to encourage and welcome research articles in all areas of the natural and social sciences and mathematics.

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