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Polymers

Polymers provide much of the physical structure of the world in which we live. Natural polymers such as wool, silk, and cotton are the basis of fibers which we use for clothing, while collagen and lignin provide some of the structural support for living tissues. In addition, natural polymers, for example, proteins and DNA, are themselves also the sources of information as well as the vehicles by which chemical transformations are made to occur. Some synthetic polymers, like rubbers, duplicate natural substances. Other synthetic polymers—polyesters, polyamides, polyimides—are the basis of important fibers. Many polymers have important structural applications because of their low density and high strength. Some polymeric materials have extraordinary physical properties that make them particularly useful in everyday life—slipperiness and stickiness, for example. This issue of *Science* addresses some of the current scientific work in the area of polymer chemistry, one of the many areas of polymer science that is developing rapidly in terms of both experiment and theory.

Almost all synthetic polymers are mixtures. A polymer sample consists of many molecules, each of which is itself quite large, and this collection of long-chain molecules has a distribution of molecular weights. Thus the polymer is a mixture, and its properties depend not only on its chemical composition but also on the molecular weights and their distribution. Much of the research described in this issue is directly concerned with problems related to such mixtures. Understanding how to control the distribution of polymer lengths and the physical consequences of the distributions is critical in developing new and important materials. Thus synthesis, measurement, and theory work together in a synergistic manner.

Webster describes new developments in living polymerization methods. The ends of the chains of living polymers remain reactive and do not transfer their reactivity to other molecules. Each chain, once initiated, continues to grow until the monomer concentration is exhausted. Consequently the distribution of chain lengths is quite narrow. New methodologies in this area give rise to novel materials. Until recently the chemical composition of polymers made by living polymerization methods was rather restricted.

Even the best attempts at synthesizing polymers with a narrow range of molecular weights may still result in a heterogeneous sample that can make the study of the physical properties of the polymer difficult. Pecora describes the use of recombinant DNA technology to produce DNA molecules of known composition so that a truly monodisperse polymer sample can be studied. Moreover, the length of the chain can be varied so that the correlation of physical properties and structure can be properly understood. The experiments provide a firm basis for development and tests of theories of polymer dynamics.

Bates addresses the problems of mixtures of polymers in terms of their phase behavior. A mixture may stay mixed, but it may also separate into different phases that can be microscopic or macroscopic in extent. Attention is concentrated on two distinct types of mixtures. The first involves binary mixtures of homopolymers, and the second involves intramolecular mixtures, that is, copolymers made up of chemically distinct blocks. The basic factors governing polymer-polymer phase behavior are discussed.

Polymers attached at one of their ends to an interface stretch away from the surface to avoid overlapping. The structure and dynamics of these polymer "brushes" are discussed by Milner. The theory of these systems may be important in models for a variety of interfacial systems, including polymeric surfactants and colloids.

It is hard to imagine returning to an earlier age when there were no synthetic polymers, and it is harder by far to imagine a world with no polymers at all, especially considering that they are present in the simplest forms of life. As our understanding of polymers continues to develop, we will see the creation of new and important materials and our insights into the behavior of natural macromolecules in living systems will be greatly strengthened.

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