influences from different fields of science. Their efforts toward explanation and generalization of the matrix formalism reflect important insights and contributions which appeared subsequent to the 1969 publication of Flory's text. The practicing engineer and researcher alike will appreciate the large number of references to RIS studies of organic and inorganic polymers to date. For the casual user, the ready access to references that provide definitions of the necessary RIS matrices for a particular polymer of interest circumvents one of the most often-encountered hurdles to application of the method. Nevertheless, the treatment of topics in the later chapters becomes noticeably terse, with markedly little explanatory material. For example, one of the more stimulating areas of recent development in RIS theory, so-called dynamic RIS, the application to time-dependent behavior, is summarized, in a section of only six pages. For a fuller explanation, the interested student must resort back to the literature, or else await the next update, perhaps in 25 years. In the meantime, this book represents the definitive text on RIS theory and application in polymer science and engineering.

Gregory C. Rutledge
Dept. of Chemical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

Polymers and Neutron Scattering

By Julia S. Higgins and Henri C. Benoit, Oxford University Press, Oxford, England, 1994, 436 pp., $98.00.

In his classical book titled *Principles of Polymer Chemistry* (Cornell Press, 1953), Paul Flory made his case, largely based on intuitive logic, for the existence of the unperturbed random coil as the configurational state of a macromolecule in undiluted amorphous polymeric materials. Periodically, experimental observations would arise to challenge Flory's views, but the often heated debates were largely inconclusive. Flory, never doubting the correctness of his views, despaired only of the apparently impossible task of constructing the appropriate experiment to prove himself right. In his second book, *Statistical Mechanics of Chain Molecules* (Interscience, 1969), Flory wrote: "Thus, in the bulk amorphous state perturbations of the configuration may be predicted to vanish. These assertions follow from considerations of a theoretical nature which are at once simple and virtually incontrovertible. They are not readily susceptible to experimental verification, however, owning to difficulties attending determination of molecular dimensions at high concentrations."

Within a few years of Flory's writing of this passage, European-based teams of polymer scientists began to exploit a then-unique experimental resource, the high flux cold neutron beam at the Institut Laue-Langevin in Grenoble, France. In the early 1970s, these groups began publishing the results of their small angle neutron scattering (SANS) studies, which proved beyond doubt that Flory's vision of macromolecules in the bulk amorphous state was entirely correct. Deuterium-labeled polymer chains embedded in a sea of otherwise identical proteopolymer chains provided the essential ingredients for the previously unattainable experimental requirements: sufficient contrast for scattering *and* essentially no thermodynamic mismatch between the labeled and unlabeled chains.

This "golden ring" of polymer research was thus snared by the Europeans. The U.S. polymer community scrambled to catch up, finding interesting problems to solve in the area of complex ordered polymer and copolymer systems and by examining in more detail the "zero interaction" hypothesis of the early deuterium labeling studies.

Twenty years later, we find an adequate supply of state-of-the-art neutron scattering facilities in the U.S. and abroad. Teams of polymer scientists and engineers from academia and industry now use neutron scattering almost routinely as one of their characterization tools, in both-basic scientific inquiry and in problem-driven R&D activities. This apparently tranquil, productive state of affairs, however, has produced another problem. Molecular-based engineers and scientists who desire to add SANS experiments to their repertoire have been largely required to learn the basics of the technique by word of mouth (from a handful of practitioners attached to neutron scattering facilities) or via a laborious, nomenclature-nightmarish plowing through the literature. A basic and thorough textbook on the subject has been greatly needed.

Once again, it is the Europeans to the rescue. Julia Higgins of the Department of Chemical Engineering at Imperial College, London, and Henri Benoit, Université Louis Pasteur, Strasbourg (leader of one of the early SANS teams of the 1970s) have collaborated to produce the very text we have been waiting for. In *Polymers and Neutron Scattering*, these authors succeed completely in their stated goal to "*provide an introductory work which will help the newcomer both to find his or her feet among the experimental techniques and to penetrate the complexities of the theoretical formulae needed to interpret the results.*" After a brief, but skillfully-crafted Introduction, there are two chapters on hardware, neutron sources and spectrometers, and one on scattering theory. These three chapters provide just the right amount of background for the nonspecialist to approach SANS experiments intelligently. The chapter on deuterium labeling (and the Appendix that beautifully clarifies the interrelations between contrast factors for various types of scattering experiments) will be heavily used by researchers in the preparation of the actual polymer samples for SANS experiments; it becomes immediately clear why the capability to synthesize specially designed and labeled macromolecules is so central to success in the field of polymer SANS. Methods of SANS data interpretation and a carefully distilled compilation of experimental results from the vast SANS literature comprise another three chapters. The text ends with one chapter on neutron scattering experiments designed to probe polymer chain dynamics and the other on neutron reflection experiments used for studying polymer surfaces and interfaces.

These ten chapters result in a concise 400-page text in which there are few if any wasted words, figures or equations. The nomenclature is clear and consistent throughout. There is ample guidance to the reader toward the primary literature for more depth and detail. In sum, the authors have written the perfectly-timed book, aiming at just the right audience—the large community of problem- or product-driven, molecular-based engineers and scientists who are neither specialists in nor practitioners of scattering physics. As neutron scattering experiments continue to become an integral component of the pursuit of new and otherwise unattainable information, members of this community will find this book to be essential reading.

Robert E. Cohen
Dept. of Chemical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139