Book Reviews

Interpenetrating Polymer Networks and Related Materials

L. H. Sperling

Plenum Press, N.Y., 1981; xi+265 pp. ISBN 0-306-40539-3, price $35

Interpenetrating polymer networks (IPN's) are still relatively unfamiliar materials and, as most strictly defined, consist of a network of polymer A swollen by and interlaced with a network of a second polymer B. As such, IPN's are just one of many types of multicomponent polymer formed from combinations of two polymers which include such other materials as polyblends and block and graft copolymers. However, when the definition is broadened to include not only simultaneously interpenetrating networks (SIN's) but also semi-SIN's (maybe there's hope for some of us yet!), in which one component is not crosslinked, and given the variety of components which have already been incorporated into such structures, IPN's represent a large and complex group of materials at one end of the spectrum of multicomponent polymers.

Research directed specifically to the study of IPN's is still very much the perogative of a few groups, although other groups, some unwittingly, have produced and examined IPN's. The author of this volume is one of the prime exponents of this field and has stamped his personality on much research into IPN's as well as on this book.

Background topics, e.g. thermodynamics of polymer–polymer miscibility, relations between glass-transition temperatures and compositions of phases or microphases and relationships between dynamic mechanical properties of multicomponent polymers and the properties of the constituent homopolymers in terms of mechanical models, are not discussed in detail but are referred to briefly in simple terms and references are given to detailed discussions elsewhere.

Fundamental physical principles apply equally to IPN's and to other, simpler multicomponent materials. Sperling recognises that to reach a full understanding of IPN's it will be necessary to use information derived from simpler systems and he has included reference to some of them in this volume. However, IPN's have features which are distinctive (e.g. more severely restricted segregation of unlike components as a result of network constraints) and which can have a major influence on their morphologies. Consequently we may expect distinctive properties due to the intimate relationship between the different components and possible interactions between them.

Although most IPN's consist of at least two chemically different polymers, one chapter is devoted to the use of homopolymer IPN's (in which two chemically identical networks interpenetrate) as model networks. Interactions between the networks are explored through swelling behaviour, the results of which are used to obtain information on chain entanglements, etc.

Details of several syntheses are presented, illustrating the variety of IPN structures which can be prepared. Emphasis is placed on the fact that the detailed chemical architecture of IPN's depends on the sequence of operations employed in the synthesis to a greater extent than do the structures of simpler polymers. A nomenclature system, devised by the author, which describes the constitution of IPN's and which reflects the sequence of steps used in the synthesis is presented. Reaction conditions during synthesis, as well as subsequent sample treatment, may have a marked influence on the morphologies of the polymers.

The study of IPN's is still a young topic in polymer science and it is not yet possible to provide a quantitative description of IPN morphologies and properties from a knowledge of synthetic procedures. Consequently this monograph is not a definitive text, rather it describes information available on IPN's and attempts to correlate morphologies and properties with the synthetic procedures.

Two chapters, comprising 40% of the book, are devoted to the morphologies, transition behaviour and mechanical properties of IPN's. Shifts in glass-transition temperatures, compared with those of the constituent homopolymers, are discussed in terms of compositions of phases; incomplete separation of components can arise from inherent miscibility or from physically restricted separation. Absolute values of moduli between the two glass-transition temperatures of an IPN are discussed in terms of morphologies, specifically in terms of continuities of the phases. There are also general discussions of toughness, extensibility, etc. Although the main emphasis is on tensile properties there are also discussions of adhesion, electrical properties and ion-exchange behaviour.

A final chapter discusses proposed applications for IPN's ranging from noise damping systems and impact modifiers to contact lenses and dental fillings, in terms of the patent literature extant.

This volume is a useful addition to the literature of multicomponent polymers. It provides, in easily readable form, an up-to-date account of the state of knowledge of IPN's. In addition to many references to relevant literature within the text, it contains an extensive annotated bibliography to IPN's and some related materials. Several references are also given to important but often over-looked papers in the multicomponent polymer field. This book is worthy of examination by anyone interested in multicomponent polymers or otherwise interested in new types of polymeric materials.

G. C. Eastmond

Polymer Melt Rheology

F. N. Cogswell

(George Godwin, London, 1981)

PI xiv+178. Price £18.00

Polymer Melt Rheology is a text on the interaction between polymer structure and polymer processing. It comprises chapters on basic rheology, polymer melt rheometry, the effects of physical conditions, flow geometry and molecular structure on rheology, so-called adventitious flow phenomena (i.e. the effects of flow instabilities on processing), rheology in specific processing operations (extrusion, injection moulding, etc.) and finally a short discussion of possible future developments. There are also several short appendices amplifying or backing up points made within the main part of the text.

In some ways, the book is successful. It is easy to read. The style is engaging and the whole text is broken down into a sequence of sections, few of which are more than two pages long. In other ways, regrettably, the book is less successful. Some of the discussion is unnecessarily tendentious. Thus, for example, Cogswell claims that he has never encountered the phenomenon of stress overshoot '*except that it be associated with some secondary flow*' in the rheometer. Does he really write off all the evidence for the existence of the phenomenon? Some of the discussion is peculiarly sloppy, and stems from a lack of mathematical and/or physical rigour. This does not mean, of course, that advanced theory is what is required, merely that the theory (of whatever level) is used properly. This is rather a pity. What might otherwise have been a most recommendable book, based as it is on the considerable experience of Cogswell and also his many colleagues at ICI, is seriously flawed. For a short text, it is also rather expensive.

S. M. Richardson

Developments in Polymer Stabilisation – Volume 3

Editor G. Scott

Applied Science Publishers Ltd £16

The first two papers of this volume deal with the regenerative properties of some antioxidants. Denisov, with the help of model compound studies carried out in his laboratory and the considerable Russian literature advances reasons to explain why aromatic and hindered amines can inhibit more than one or two oxidative chains in their role as stabilisers.

De Jonge and Hope concern themselves solely with the regenerative capabilities of antioxidants based on 2,6-diphenylphenol in the presence of thiodipropionate esters; the effectiveness of such stabiliser combinations in

the thermal oxidation of polypropylene is demonstrated and a mechanism is proposed. This account gives some insight into the development of a commercial antioxidant system.

In his review of the dithiophosphates as antioxidants Ivanov considers their preparation and properties and discusses in detail their role as radical scavengers and peroxide decomposers.

The final two papers are concerned with what happens to stabilisers in polyolefins. Vink reviews the chemical fate of the common UV stabilisers. He points out that whereas hydroxybenzophenones and metal complexes are consumed in their roles as radical scavengers and peroxide decomposers respectively the benzotriazoles remain intact for some considerable time before they are diminished by interaction with polymer degradation products. From a comparison of rates of stabiliser consumption during photo-oxidation, inferences are drawn as to the stabilising mechanisms of the various groups of additives.

In the final paper of this volume the physical chemistry of polyethylene and polypropylene oxidation and stabilisation is reviewed by Billingham and Calvert. They consider the vital but often neglected question concerning the importance of oxygen diffusion in determining the rate of thermal and photo-oxidation and conclude that in film form at least it is not the controlling process. They also present evidence which indicates that oxidation is confined to the amorphous region and consider that crystalline morphology has lettle direct effect on the extent of oxidation.

Recognising that a stabiliser has to be retained by the host polymer if it is to be effective the authors develop a model in which additive retention is treated in terms of its volatility, diffusivity and solubility within the polymer. They argue that as the relevance of these three parameters are lost in model compound studies in solution and in accelerated ageing tests these two avenues of investigation should be explored with caution. This is a valuable review as it presents in a digestible form knowledgeable views on processes which are of practical importance.

The five articles in this volume contain detailed information and educated opinion on a wide range of specialised topics in polymer stabilisation and should be well received by those active in the field.

A. Davis

Principles of Polymerization. Second Edition

G. Odian

Wiley-Interscience, 1981. 731 + xxvi pp. £26.25

Following publication of the first edition in 1970, the reviewer commented (*Polymer*, 1972, **13**, 412) that the book could be recommended to those studying high polymers and, indeed, it has proved most useful during the past decade, both in teaching the subject and for consultation or reference on some unfamiliar item. One therefore welcomes the appearance of this very much enlarged and up-dated second edition.

Although there has been extensive revision, the author has retained his original treatment of the subject in presenting nine chapters, the first dealing with general concepts of chemical and physical structure and related properties. This is followed by others dealing specifically and in detail with the organic and physical chemical, kinetic and statistical aspects of polymer synthesis as accomplished by step (polycondensation), free radical, emulsion and ionic methods. Further chapters cover chain copolymerization, ring-opening syntheses, and stereoregular polymers and their formation, while the final chapter discusses reactions for the modification of polymers as well as their uses as supports or media for other reactions.

As would be expected, in order to record and discuss the many developments of recent years these revised chapters have much new material, notably in new polycondensates, radical, ionic and ring-opening syntheses, stereospecific polymerization, grafting, and polymers as reagents, catalysts and substrates. The reference lists (placed at the end of each chapter) contain many more literature entries—some as recent as 1980—as well as references to the considerable number of books on specific areas of polymer science which have been published in recent years. Some additions have been made also so as to exemplify the various processes adopted commercially for polymer manufacture but on the whole these are less adequate than is the extensive, thorough and informative treatment of the principles involved. It is noticed that, as with many other textbooks, this publication omits the important subject of polymer degradation and stabilization, of special interest to many polymer technologists. But this is perhaps regarded as 'depolymerization' rather than 'polymerization' and thus not within the remit of the title!

The numerous diagrams and tables are clearly presented (and generally revised to SI units where appropriate), printing errors are few, and the layout is pleasing, making it a book easy to read. It can be recommended to final and higher degree polymer science students and to those in research and development posts who wish to have at hand some source of reference over this widely ranging subject of polymer synthesis by the many methods and from the many precursors now available.

R. J. W. Reynolds