book reviews

Applied Photochromic Polymer Systems

C. B. McArdle (Ed.)
Blackie & Son Ltd, Glasgow, 1991, 255 pages, £65.00
ISBN 0-216-93140-1

Photochromic compounds are able to change their colour, or more generally their absorption spectra, depending on whether they are exposed to light or dark conditions. The development of photochromic polymers and the large amount of experimental results which have appeared over the last two decades show, however, that photochromism can be of interest in connection with phenomena other than merely colour change. Photochromic polymers, in fact, are able to respond to light giving photoinduced variations of their properties, so they may be highly promising materials for application in optical technology, as well as in development of devices which can be photomodulated.

The purpose of this book is to review photochromic polymer systems from the perspective of their potential application, on the basis of literature published in the last twenty years, so its appearance is well-timed.

The text consists of six chapters written in the form of review articles. Chapter 1, by McArdle, reviews the possible applications of photochromic polymers in erasable optical storage and imaging systems, in optical signal-processing, and in integrated optics. Chapter 2, by Crano, Kwak and Welch, deals with spiroxazines as fatigue resistant compounds, suitable for obtaining photochromic ophthalmic lenses that darken automatically upon exposure to sunlight. Manufacturing of commercial plastic photochromic lenses is also described. Chapter 3, by Whittal, mainly deals with the fundamental photochemistry of fulgides and fulgimides and points out their potential use in actinometry, optical data storage, as well as eyewear applications. Chapter 4, by Krongauz, covers photochromic liquid crystal polymers. It reports extremely interesting examples of photoinduced changes of mesophase arrangement and discusses nonlinear optics as an emerging technology which uses photons for information and image processing. Chapter 5, by Irie, describes light-induced variations of polymer conformation in solution and in gels, which, in turn, are accompanied by photostimulated changes of viscosity, solubility and shape of gels. Finally the last chapter, by Kamogawa, provides an overview of redox photochromism in viologen-based solid state systems.

It is a pity that the text does not cover several other interesting systems. For instance, photoresponsive membranes, which have been found to give photostimulated variations of their potential and their permeability, are not described. Photochromic poly(aminoacid)s, which were found to undergo elegant and large photoinduced order-disorder conformational transitions, are completely ignored. Therefore, although still valuable, the book does not give a well-balanced account of the present state of photochromic polymers. This however, might be the personal opinion of the reviewer who should not privilege his own work.

The title of the book, 'Applied Photochromic Systems', is slightly incorrect as in practice it means 'possible application'. It is likely that the described systems will be used in photochemical devices, but most of them still require further research work for future applications. I think that the book will be of interest to a wide range of readers, although those looking for the fundamentals of photochromism may be rather disappointed and may turn to other compendia. However, as an introduction to the potential applications of photochromic polymers, the book meets its aim and may stimulate new ideas in the field of these fascinating materials.

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Internal Stresses, Dimensional Instabilities and Molecular Orientations in Plastics

L. C. E. Struik
John Wiley & Sons, Ltd, Chichester, UK, 1990, 480 pages, £45
ISBN 0-471-92642-6

Another title for this book might have been '*Not* the Physical Ageing of Amorphous Polymers and other Materials'. It is a measure of the impact made by Struik's earlier book on physical ageing that his name is associated to such a degree with that topic. In fact, the new book scarcely mentions ageing. It discusses a range of issues bearing on the prediction of quality of formed plastic products.

There is much interest at present in the development of software tools for designers of polymer products and processes, to predict the quality and performance of new components at the design stage, before the expensive commitment of cutting a mould or die. This book makes a useful contribution by discussing the underlying (mostly phenomenological) principles which govern the features of formed plastics listed in the title: three features which usually detract from product quality. It includes results from a remarkably comprehensive series of experiments carried out some years ago at the laboratories of TNO in The Netherlands, and gives a detailed theoretical interpretation. Most of the experimental data are not freely available elsewhere, so the book will be an important source. Struik has structured his book in four self-contained parts, each dealing with a different topic.

Part I is a short section (only 13 pages) titled 'Dimensional instabilities due to volume relaxation', discussing the gradual densification of glassy polymers following cooling through the glass transition. It is this structural evolution that causes the changes in properties now referred to as 'physical ageing'. The emphasis here, though, is not on the changes in properties but on the volume relaxation itself. This has obvious implications for the dimensional accuracy of components; but Struik also makes interesting comments on the effects on the performance of plastic lenses and capacitors.

A substantial Part II follows, concerned with the dimensional instability arising from a polymer's 'memory' of stresses which acted during processing. Two matters are dealt with in depth: thermal shrinkage under heating without restraint; and shrinkage tension which arises under heating with complete restraint. Both are of considerable practical importance, but have been notable until now for a lack of careful, well-documented experimental data. Struik not only provides this, but also shows how the data can be interpreted in terms of the theory of non-isothermal linear viscoelasticity. In doing so, he identifies some useful rules of thumb which may simplify the reduction of data in practice.

In Part III Struik moves on to the prediction of frozen-in thermal stresses arising from inhomogeneous cooling from temperatures above the glass transition temperature: the usual case when plastic products are cooled rapidly during manufacture. The starting point is the elementary analysis well-known from the literature for inorganic glasses, where the material is modelled as an inviscid fluid at temperatures above the glass transition temperature and a Hookean solid with constant modulus below the glass transition temperature. It is followed by a discussion of the refinements necessary to accommodate

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non-isothermal viscoelasticity: not an easy subject to explain. But it must be said that most of the points have been made before in journal papers, in a manner more accessible to most readers even if less thorough. The book nevertheless provides a useful service in demonstrating how to extend the analysis from the usual case of a flat plate to various axisymmetric geometries (e.g. cylinders, tubes).

The final part is called 'Molecular orientations due to processing' and deals with the effects of preferred orientation, as manifest in anisotropy in a variety of physical properties (birefringence, thermal expansion, thermal conductivity and stiffness). For the reviewer, the interest lay primarily in the rather successful attempt to show correlations between the development of anisotropy in several properties, with increasing degrees of molecular orientation. If these apply generally, they are likely to be highly useful predictive tools. Just *why* the correlations work, however, is explained less convincingly, as controversial physical assumptions are invoked with little justification (for example, 'Reuss' coupling of elementary units when computing thermal expansion or elastic compliance of a partially oriented polymer).

Taken together, the four parts of the book provide access to the results of a major study of an aspect of polymer behaviour of real practical significance. And the discussion benefits from frequent shafts of the physical and mathematical insight so characteristic of its author. These features alone will make the book a 'must' for serious students of the thermo-mechanical behaviour of polymers. Unfortunately, however, it is not without a few blemishes. There are distracting instances of excessive elaboration of minor experimental matters which seem out of place in a book, and some of the theoretical excursions are dense and apparently lacking in justification. Furthermore occasional, but irritating, editorial slips have crept in [inconsistencies in nomenclature—both terms 'reduced time' and 'effective time' are used for the temperature-modified time-scale—and errors in equations (e.g. equations (16), (21) and (22))]. It is to be hoped that these relatively minor defects will not deter the fainthearted. Struik has provided a thorough survey of an important aspect of polymer behaviour, and this is to be welcomed. The book will certainly find its way onto library shelves as a useful work of reference, and many polymer viscoelasticians will want to possess a copy. Whether it will reach a wider and possibly more important audience—those production engineers grappling daily with the idiosyncrasies of polymers listed in the title—is rather doubtful which is a pity. Perhaps another book is needed to communicate the message to those outside the research community.

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High Performance Polymers and Composites: Encyclopedia Report Series

Jacqueline I. Kroschwitz (Ed.)
John Wiley & Sons, New York, 1991, 992 pp. + xxviii, £74.35
ISBN 0-471-54366-7

This book comprises 31 self-contained articles on the science and technology of high performance polymers, including carbon fibres, electrically conductive polymers and polymer composites. Apart from the article on polycarbonates written by a team from Bayer AG, Germany, one article on polymer blends by Paul and his colleagues and another on thermoplastic polyesters by Jadhav and Kanter from the University of Massachussetts, the articles are all written by distinguished scientists, who are working or have worked for the major US industrial organizations such as Du Pont, Hoechst-Celanese, General Electric, Allied-Signal, Monsanto and Phillips Petroleum. Inevitably this rather restricted choice of authors gives the articles a somewhat inbred quality and a strong emphasis on US science and technology. As would be expected from the careful selection of contributors however, the articles are of uniformly high quality. The science is dealt with in a succinct, authoritative fashion, but with no concessions to the uninformed. More importantly, the technological implications are discussed in terms of both processing and product applications. The book is essentially an encyclopedia for industrial scientists and engineers but will also be very helpful to those in academia concerned with the teaching of polymer science and technology.

The text contains substantial reviews of high modulus fibres, including carbon, aramid, polyethylene, silica and alumina-based fibres. Composites are thoroughly covered, with separate articles focusing on properties and applications, fabrication and testing. These are separate reviews of all high performance plastics, including polyesters, polyamides, polycarbonates, polyetheretherketones, polyimides, polysulphones, poly(arylene sulphides) and polybenzimidazoles.

The articles give the reader an excellent historical perspective leading through the science and technology to production processes, the fabrication and applications of plastics, fibres and composites. Practical issues are discussed alongside the fundamental science in a very attractive and useful way. The book is an excellent source of information for the practising applied scientists in either industry or academia, who will be informed of the key facts whilst being reminded of the basic science.

In summary, this encyclopedia can be highly recommended for library use, and it is reasonably priced taking into account the comprehensive coverage. It is very well produced, and each article includes a substantial list of references.

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Polymer Year Book 6

R. A. Pethrick, G. E. Zaikov, T. Tsuruta and N. Koide (Eds)
Harwood Academic Publishers, 1990, $190.00
ISSN 0738-1743

Polymer Year Book was originally conceived by Professor Hans-Georg Elias as a practical current awareness book for active polymer scientists. In the sixth volume the editors continue with this original idea. It is divided into four sections: the first of these is 'Data on Polymeric Materials', the second is a section containing commissioned reviews, the third is a series of short papers under the general title of 'Progress of Polymer Science in Japan', and the final major section, 'Current Awareness', contains lists of recent publications in polymer science.

The first section, 'Data on Polymeric Materials', deals with physical properties, synthesis and applications of thermoplastic polymers. Data are presented on 13 common thermoplastics. For most materials a brief history of the development of the polymer is included along with polymerization details and tables of physical properties. Tabulated properties of a range of copolymer systems are also included in this chapter. The chapter finishes with a large table of data on a very comprehensive list of thermoplastics. These data include values of density, transition temperatures and enthalpies of melting. In addition, there is information on the processing conditions commonly used for commercial thermoplastics.

The review section contains three articles. The first of these is by K. Adachi and T. Kotaka on 'Mechanical and Dielectric Relaxations of Guest Polymer Molecules in Networks'. The second is on 'Functional Polymers' and was written by R. N. Young. Finally, there is a review of 'Polymer Cohesion