book reviews

Electrical Properties of Polymers—Chemical Principles

C. C. Ku and R. Liepins
Published by Carl Hanser, distributed by John Wiley & Sons, Chichester, 1988, ix+389 pages, £64.35
ISBN 0-446-14280-0

This is a book of considerable detail and based on a most extensive literature review. By discussing the electrical properties of polymers from the chemist's point of view, the authors have provided the reader with a totally fresh approach, in contrast to that normally taken by the physicist or electrical engineer.

In no way does this detract from the value of this book to physicists and electrical engineers but is an enhancement of the conventional text. In addition to describing the chemical and physical origins of the various electrical properties, the authors have courageously attempted to suggest how this information may be put to practical use. Each of the four main properties of dielectrics, namely dielectric constant tangent of dielectric loss, dielectric breakdown and electrical conduction, are comprehensively dealt with from a historical overview, through basic relationships and phenomena to possible mechanisms for controlling each factor by chemical or physical means.

This book is of value to final year undergraduate and postgraduate students in a variety of disciplines. All users of polymeric insulation from the polymer chemist and physicist to the manufacturing insulation engineer will find the text of great value.

B. R. Varlow
University of Manchester

Size Exclusion Chromatography

B. J. Hunt and S. R. Holding (Eds.)
Blackie and Son Ltd, Glasgow, 1988, ix+286 pages, £49.00
ISBN 0-216-92494-4

Gel permeation chromatography or, as now seems to be the preferred name, size exclusion chromatography (s.e.c.) has been treated in several books or chapters of books. The publishers and editors evidently approached the production of this new work with a reasonable degree of confidence that they were offering an up-to-date survey of newer developments for the established practitioner and/or an improved introduction for the beginner. On the whole, and with particular reference to the former of these aspects, it appears that their confidence was justified. The book is under the multiple authorship of 13 contributors and the 10 chapters are divided into three major sections: Part 1—Fundamentals, Part 2—Applications and Part 3—Special Techniques. There are also five useful appendices.

Part 1 is written entirely by the editors. In Chapter 1, Hunt gives a concise theoretical background and demonstrates that, unlike other non-s.e.c. liquid chromatographic separations, s.e.c. is an entropy controlled process. In the following chapter the same author provides adequate detail of the necessary equipment and hardware, the commercial sources of these being listed separately at the end of the book in Appendix 1. Despite, or perhaps because of the fact that data manipulation is normally effected via dedicated data-handling systems, the apparent ease of s.e.c. procedure often tends to mask the true complexity of the situation and results are regarded as more definitive than is truly warranted. This point is amplified in the last section of Part I 'Calibration and data analysis', where a constructive appraisal of the situation is presented by S. R. Holding, who is well-known in the UK especially for his expertise in operating a large s.e.c. facility with an equally large diversity of polymer samples examined. For this chapter, also, reference should be made to Appendix 2, which lists the recommended sources of narrow distribution calibrants.

The applications covered in Part 2 would by general concensus be regarded as those relating to systems which are not only practically important, but also rather difficult from the experimental and/or theoretical standpoint. Thus in Chapter 4, by Haddon and Hay, experimental procedures and findings are discussed for polymers which necessitate the use of s.e.c. at elevated temperature. These include polyethylene, polypropylene, poly(ethylene terephthalate), stereoregular forms of polystyrene as well as the newer engineering polymers, poly(ether ether ketone) and poly(phenylene sulphide). In the following chapter, 'Copolymer analysis', Mori leads us stepwise through the routes by which one can resolve the problem that properties of copolymers are influenced by distribution of not only molar mass (and hence size) but also of chemical composition. Procedures involving the combination of s.e.c. with other chromatographic methods are also discussed. Chapter 6, by Hillman and Heathcote, is concerned with industrially important species of low molecular mass ($\leqslant$*circa* 1000 g mol^{-1}). For solutions of these, viscosity effects which limit usable concentrations of high polymers are essentially absent. Many of the systems covered are important in their own right, whilst others have an obvious relevance to polymers, namely waxes and hydrocarbon oils, complex mixtures under the umbrella heading of asphalts and pitches, coal liquids, explosives and propellants, oligomers and additives such as plasticizers and antioxidants. Aqueous s.e.c., which forms a small final section, comprises the whole of the last chapter of Part II by Kato. Although there are many features in common with normal non-aqueous s.e.c., complications are introduced if sample-support interactions are other than steric ones. Examples are provided by neutral, anionic, cationic and amphoteric polymers (e.g. proteins) and a useful list is given of suitable (invariably multicomponent) eluents.

The first of the three chapters within Part III is devoted to field-flow fractionation (f.f.f.), an alternative to s.e.c., which has been written by a pioneer of the field, J. Calvin Giddings. F.f.f. was developed at about the same time as s.e.c., but has developed less rapidly and is less well known because of major instrumentation problems. New commercial instrumentation has largely overcome this hurdle and, although the purist may argue that f.f.f. is competitive with, rather than a branch of, s.e.c., this reviewer believes that the chapter is a welcome one. Indeed, the author writes with such clarity and enthusiasm that the reader is left with a feeling of inadequacy that he is not already exploiting the demonstrated advantages of the techniques. The advantages of supercritical fluid chromatography (s.f.c.) have been realized only comparatively recently, although chromatography using a fluid above its critical point as mobile phase was reported in 1962. In Chapter 9, Bartle, Davies and Raynor review the basic principles, mode of operation and applications to polymer systems of this technique. The final chapter, by McHugh, deals with 'Hydrodynamic Chromatography' (h.d.c.) which is an extremely interesting variant on the general s.e.c. process in the respects that the columns are packed with non-porous rather than porous beads and the material to be fractionated is particulate rather than molecular. Particular attention is paid to the application of h.d.c. to the analysis of particle size and particle size distribution of sub-micrometre colloidal systems. Commendably and unusually, the author is able to explain the mechanism without recourse to the existing rigid mathematical treatment.

Unfortunately the text and appendices

of this book do contain some instances of carelessness, e.g. omitted or incorrect units, wrong sign of exponent in 10-factor, misconception that 'schematic' is a noun rather than an adjective, use of both 'molecular weight' and 'molecular mass' despite the editors' assertion in the Preface to adopt uniformly only the latter term. However, these must be regarded as only minor irritants within an authoritative whole, which gives a wealth of up-to-date practical detail and current applications. It should provide a useful addition to all polymer characterization laboratories.

M. B. Huglin
University of Salford

Handbook of Plastics Test Methods 3rd Ed

P. Brown (Ed.)
Longman Scientific and Technical in association with the Plastics and Rubber Institute, 1988, 442 pages, ISBN 0-582-03015-3

We are all too well aware of the problems associated with having to define the material characteristics which are important in the end use of a polymer and testing becomes second nature to us all. However, with the wide diversity of new materials being produced and environments into which they are placed, making the appropriate measurement under the correct conditions can be something of a nightmare. Accordingly there are international and national standard test methods so that we can all make the same mistakes together and hopefully we can keep up-to-date with them in as many tests as is appropriate.

The alternative approach is to buy the Handbook, and be assured that you are reading the "up-to-date account of today's test procedure" for quality assurance and material specification. It is indeed invaluable in any quality control and material testing laboratory

The value of this Handbook to the average polymer scientist is apparent when it is appreciated that this is the 3rd edition of a monograph first published in 1971 by Ives, Mead and Riley. Although the style and layout has not changed appreciably over the years a great many new tests and procedures are dealt with extensively.

The 3rd edition considers the preparation and conditioning of polymer samples, processibility and polymer characterization as well as measurement of mechanical properties such as stress–strain behaviour, dynamic response, friction and wear, creep and fatigue. Electrical behaviour and optical properties are also considered. Heat flow and specific heat measurements and the effect of thermal history and temperature on material properties are extensively discussed. Environmental testing and flame resistance of polymers are considered as well as diffusivity to gas and vapours. Finally there are sections on non-destructive testing and testing products. In all a fairly comprehensive list of test procedures is given. Each topic is generally covered thoroughly and a few important, invariably recent, references to further sources are given.

The Handbook is strongly recommended and material testing laboratories should not be without a copy.

J. N. Hay
University of Birmingham

Atlas of Polymer and Plastics Analysis

D. O. Hummel and F. Scholl
VCH Verlagsgesellschaft, Weinheim, FRG,
Vol. 1, 1978, xxxi+671 pages, DM490.00
ISBN 3-527-25801-9
Vol. 2, 1988, xxviii+577 pages, DM580.00
ISBN 3-527-26091-9

These two volumes, both of which have been written and organized by Professor Dieter Hummel, represent a major contribution to the scientific literature. The first volume consists of 1900 infra-red spectra from about 4000 to 400 cm^{-1} (on a linear wavelength scale), most of which have been obtained with the Beckman Spectrophotometer IR-12 under the author's supervision.

The decimal classification system for polymers has been used, but there are also additional alphabetic, formula and author indices, which were found to be very useful.

The second volume is really a *vade mecum* for the industrial analyst, and embraces the whole range of techniques now available. It provides a comprehensive practical guide, fulfilling three major objectives. Firstly, it introduces the reader to the principles of each technique in an extremely accessible manner. Secondly, it describes in detail the appropriate experimental procedures, drawing on the author's extensive professional experience. Finally it provides an authoritative compendium of data on a very wide range of polymers.

As might be anticipated, in view of Professor Hummel's personal interest and experience in infra-red spectroscopy, this does form the largest section of Volume 2. Its most unique feature is probably the very comprehensive compendium of infra-red band assignments. It is a highly personalized account in places, which this reviewer found very illuminating. There is rather less emphasis on Raman spectroscopy, whereas some practising spectroscopists would consider that infra-red and Raman spectroscopy ought to be considered complementary.

Other techniques covered in Volume 2 include high resolution n.m.r., e.s.r. and photo electron spectroscopy (PES/-XPS/ESCA). In addition there are introductory chapters on the identification of polymers and analysis of degradation and decomposition.

In conclusion, these volumes are outstanding value for those concerned with the chemical analysis of polymers, and they also contain useful reference information for those interested in the structure of polymers, although subjects such as molecular orientation are not discussed in very great detail. This series of volumes is certainly a necessary part of any comprehensive library in polymer science and technology and the author is to be congratulated for maintaining a very high standard of exposition throughout.

I. M. Ward
(University of Leeds)

Microelectronic Polymers

M. S. Htoo (Ed.)
Marcel Dekker, Inc., New York, 1989, vii+424 pages, $162.00
ISBN 0-8247-7990-8

The book gives an excellent up-to-date account of the use of polymers in lithographic processes for microelectronic device fabrication. It is written by 11 leading experts from the USA, Japan and Europe. The style is remarkably uniform throughout in spite of the number of contributors involved.

Chapter 1 reviews the chemistry of polymers and contains a discussion of their use as either positive or negative resists. Mention is also made of packaging materials. Chapter 2 considers film deposition, attention being focused on spin coating of polymeric resists from solution. Chapter 3 contains a very interesting exposition of optical-imaging theory that is needed to explain the exposure methods and resolution limits of optical lithography. The treatment is very clear, and provides a sound basis for understanding the characteristics of different types of polymers and the methodology which has led to increases in packing densities in microelectronic devices. I feel this section will be very useful to research students.

The next generation of very large-scale integrated circuit devices (with 16 Mbit dynamic random access memory) require