



## Book review

**Handbook of Thermal Analysis and Calorimetry**

Vol. 3, Applications to Polymers and Plastics, Stephen Z.D. Cheng (Ed.), Patrick K. Gallagher (Series Ed.), Elsevier, Amsterdam, 2002

This book, which appeared recently, is volume 3 from a series of 4. Each volume is bound in a beautiful green cover with golden letters, which gives the series a valuable and elegant look. Volume 1, edited by M.E. Brown and entitled “Principles and Practice”, describes extensively various thermal analysis and calorimetric techniques, together with basic background information; it appeared in 1998. The second volume that appeared (in 1999) was volume 4: “From Macromolecules to Man”, edited by R.B. Kemp. Volume 2, which should describe thermal analysis and calorimetry of inorganic materials, has not appeared up to now.

Before making some more comments on this work, let me first guide you through the contents of this work. The book contains 16 chapters, written by in total 27 contributors.

Chapter 1, by B. Wunderlich, deals with the heat capacity of polymers. A classical thermodynamic view as well as a quantum mechanic description are given. The complex heat capacity is also introduced. The Advanced Thermal Analysis System (ATHAS) is presented together with some examples of its use. Finally, an analysis of some applications of temperature-modulated DSC is given.

The measurement and the underlying physics of the glass transition are described by G.B. McKenna and S.L. Simon in chapter 2. First the apparent thermodynamic behaviour and the kinetics of the glass transition are discussed, then some microscopic theories are presented and finally physical aging effects are described.

S. Matsuoka writes about mechanical relaxation processes in polymers in chapter 3. It is explained what is meant by the relaxation process, on the exper-

imental scale as well as on the molecular scale. An interesting description of “intermolecular cooperativity” is given, together with a discussion of chemical structure in relation with the glass transition. The chapter ends with a description of viscoelasticity data analysis.

Chapter 4, written by P. Avakian, H.W. Starkweather, Jr. and W.G. Kampert, deals with dielectric analysis of polymers. Dielectric analysis is briefly introduced together with some words on the (complex) permittivity and on relaxations. In successive sections, the dielectric properties of polar and nonpolar polymers and of polymer blends are discussed. The chapter ends with some words on cold-crystallisation and frequency–temperature relations.

The crystallisation and melting of metastable crystalline polymers is treated by S.Z.D. Cheng and S. Jin in chapter 5. After thermodynamic definitions of the phase and phase transitions, polymer crystallisation and morphology and polymer crystal melting are discussed.

V.B.F. Mathot and H. Reynaers write about the crystallisation, melting and morphology of homogeneous ethylene copolymers in chapter 6. In the introduction it is explained when an ethylene copolymer is considered to be homogeneous or heterogeneous. The properties of ethylene–propene, ethylene–1-butene and ethylene–1-octane copolymers are discussed in separate sections.

Chapter 7 is written by Y. Li and deals with the recent advances in thermal analysis of thermotropic main-chain liquid crystalline polymers. After it is explained what liquid crystals and liquid crystalline polymers in general are, the view is focussed on main-chain liquid crystalline polymers. Then the behaviour of thermodynamic transitions is discussed. Finally, the effects of mesogenic groups and spacers on the stability of liquid crystalline phases are mentioned.

Polymer blends and copolymers are described by J. Runt and J. Huang in chapter 8. Background information to this subject is followed by a description of

the phase behaviour of polymer blends and examples of results obtained for crystalline polymer blends and copolymers.

A. Hale writes about thermosets in chapter 9. Some general concepts are followed by a description of the chemistry and some applications of different types of thermosetting polymers. It is explained how the extent of cure can be determined and several aspects of the glass transition temperature of thermosets are discussed. In separate sections reaction kinetics and photo-initiated polymerisation are treated. The last section deals with some applications of modulated-temperature DSC to thermosets.

In chapter 10 L. Zhu describes the thermal analysis of polymer films. First, some general experimental considerations in thermal analysis of polymer films are given. Then, for several specific polymer films, the application of different thermal analysis techniques is discussed.

The thermal analysis of polymer fibres is treated by A.J. Jing, A. Zhang and Z. Wu in chapter 11. After a general introduction, the determination of fibre structure is discussed. Then, some special remarks on the application of several thermal analysis techniques to fibres are given. Finally, the properties of a large number of conventional as well as high performance fibres are presented.

Chapter 12 deals with the thermal properties of high-temperature polymer matrix fibrous composites. It has been written by R.J. Morgan, E.E. Shin and J.E. Lincoln. After a short introduction to these materials, some thermal analysis results obtained for several materials are presented and discussed.

D.J. Burlett and M.B. Altman have written chapter 13, which deals with thermal analysis and calorimetry of elastomers. Some specific properties of elastomers are presented in the introduction. Then the classes of elastomers are given. In two successive sections, first, properties of single elastomers are discussed, followed by those for blends. The effects of additives, curing (or vulcanisation) and the stability are treated. Finally, the use of thermal analysis and calorimetric techniques for quality control or quality assurance applications are described and some future opportunities are mentioned.

Polymer degradation is described by J.H. Flynn in chapter 14. After some general physical, structural and thermodynamic considerations, general thermal

degradation mechanisms, general thermo-oxidative mechanisms and general hydrolysis mechanisms are described. This is followed by a section on lifetime prediction of polymers by thermal analysis and some specific examples of degradation. The last section deals with (degradation of) copolymers, blends and mixtures.

B.B. Sauer presents recent developments in the characterisation and analysis of polymers using thermally stimulated currents (TSCs) in chapter 15. After an introduction of the techniques, TSC and TSC-thermal sampling (TSC-TS), some experimental considerations are presented. Then the analysis of TSC-TS data and the interpretation of global TSC and TSC-TS results are discussed. The chapter ends with some thermal stimulated currents applications.

Finally, in the last chapter, chapter 16, C. Schick describes the basics of temperature-modulated DSC and the applications to polymers. First, some basis considerations on (conventional) DSC are given. Then, the temperature-modulated technique is introduced thoroughly. Finally, some applications of TM-DSC are presented.

It is clear that this work covers almost all aspects of thermal research on polymeric materials. Although I must admit that I have not read all chapters completely, I think to have read enough of the work to conclude that it is of a very high standard. Researchers new to the field will find a very interesting and broad introduction, while the chapters treat the different subjects with enough depth to make the work interesting for experienced scientists too. It really is a very interesting handbook.

Having said this, I also have some comments and (small) points of criticism.

Firstly, I am puzzled by the title of this volume, "Applications to Polymers and Plastics". In my view plastics *are* polymers, or at least have polymeric material(s) as a main component.

Secondly, the choice of the contributors. As you can see from the description of the contents and as is stated by the editor in his preface, among the contributors are some of the most well-known pioneering scientists as well as currently active researchers and scientists of a new generation who are expected to make substantial progress in the future. I consider this a very interesting choice. However, although all contributors have written high-quality contributions,

it is in my opinion regrettable that of the 27 contributors only three are from countries other than the USA. For a prestigious standard work on research which is performed worldwide on a high level, I would expect the selection of contributors from more countries.

Finally, a point of criticism concerns the lack of cross-referencing between different chapters in this volume. I will give two examples: (i) the heat capacity of polymers is treated quite detailed by Wunderlich in chapter 1, but none of the other contributors refer to this chapter when they write about the heat capacity; (ii) temperature modulated DSC is described three times (chapters 1, 9, and 16) without any cross-referencing. This may be understandable because the authors, on writing their contributions, do not have access to the complete texts of the other chapters. On the other hand, a rough indication of the contents of the work should be available to all authors. More serious is the fact that none of the authors appear to be aware that the work to which they contributed is part of a series. In the whole work of more than 800 pages only one citation to volume 1 was found. It is surely an advantage that the book can well be read without consulting volume 1, but this should be accomplished with more references to this introductory volume.

The conclusion is that this work gives a broad, high-quality description of the possibilities of thermal analysis in the field of polymer research. I would recommend this work to anyone involved in the use of thermal analysis on polymers, either experienced or new to the field, either actually performing the experiments or only involved in the use of results obtained.

The list price of the book, which contains 850 pages, is €250 or US\$ 250. This makes the book by no means a cheap one. If the price of this volume is compared to that of the other available volumes (volume 1: €414/US\$ 414; volume 4: €496/US\$ 496), it is clear how exorbitantly high the other volumes are priced! The book is available from Elsevier Science B.V., P.O. Box 211, NL-1000 AE, Amsterdam, The Netherlands (for the USA and Canada: Elsevier Science Inc., P.O. Box 945, Madison Square Station, New York, NY 10159-0945, USA).

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