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Book review

Thermal Characterization of Polymeric Materials (Second Edition) Edited by Edith A. Turi, Academic Press, San Diego, California, 1997, 2420 pages (Price: $375.00)

When I was a Ph.D. student in Professor Wunderlich's research group at Rensselaer Polytechnic Institute in the early 1980s, the first reference book that I read for my Thermal Analysis course was Thermal Characterization of Polymeric Materials (first edition). This book proved to be extremely useful to me while I was learning to apply thermodynamics, kinetics and thermal analysis to polymeric materials. Although I was a poor graduate student living on my fellowship, I bought this book to supplement my studies. Later, I took this book with me when I joined the University of Akron and it has accompanied me during the past ten years of my career development. It is still on my bookshelf today, and from time to time I read it in my office. This book has also frequently been used as a reference in my advanced graduate course on Thermal Analysis of Polymeric Materials at Akron. When I learned that the second edition of this book would soon appear, I awaited its publication with excitement.

When this book first arrived on my desk, I was completely surprised by the size. With a total of 2420 pages contained in two volumes, my first impression was of the amount of work which must have been involved, for the editor as well as the contributors, in coalescing such a large amount of new information (the first edition was 960 pages). After quickly reviewing this work (which took me a solid week), I have been totally convinced as to the high quality and importance of this book. Overall, this book contains a very thorough and up-to-date review which covers many different thermal characterization areas of polymeric materials. Each of the ten chapters included in this book were written by distinguished contributors. One important and appealing feature is that this book is edited in a way that is oriented towards materials rather than techniques. It is essential to characterize polymeric materials using various methods that are specific for the levels of structure, morphology, and properties which are involved.

The first chapter, written by Gallagher, describes thermo-analytical instrumentation, techniques and methodology. This new chapter is needed to address the wide application of computers and robotics which has revolutionized this field by allowing the adoption of methods not known 15 years ago. This chapter also serves as a much needed introduction to classify most instruments used in thermal characterizations and to discuss their wide applications and limitations. In

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particular, combined techniques with thermal analysis are also discussed for the first time. This is a good introduction for a discussion in material characterizations.

The systematic and comprehensive discussion on the basis of thermal analysis by Wunderlich is, as always, a very well written monograph of the theory and practices of thermal analysis. A description of the microscopic structures of materials and their relationships with macroscopic material properties through statistical thermodynamics clearly identifies the important concepts of thermal analysis. The thermodynamic and kinetic theories which are involved in thermal analysis are broad and difficult to exhaust. Nevertheless, this chapter beautifully executes this task in a way understandable to the reader. Characterization of one-component and multiple component systems is the major issue of this chapter, and readers will find that the phase and phase transition behaviors in these systems have been clearly described.

Thermoplastic polymers may constitute the largest component of commercial production of polymers today. Chartoff has provided a thorough review on this topic, and readers will find it an in-depth guide to structure-property relationships of thermoplastic polymers such as glass transition, crystallization and melting transition behaviors, and viscoelasticity, as well as polymer relaxation processes. Many examples are closely associated with industrial applications. Multiple techniques have been introduced to solve characterization problems, which are always an important issue in determining material parameters and their effects on chemical and physical properties. In particular, the author has covered thermal aging phenomena which is very important in the research and application areas of thermoplastic polymers.

Polymer blends and block copolymers are the results of widely used developments in the chemical industry which improve material properties. Hale and Bair have clearly illustrated the importance of thermal analysis techniques to analyze these materials. Readers can find the criteria for the miscibility of polymer blends with an emphasis on the glass transition temperature as an indicator. Microphase separations in block copolymers can also be unmistakably determined through rheological measurements combined with other thermal characterization methods. Morphological information can also be deduced through correct association with the corresponding thermal characterization results. This chapter provides an up-to-date review in this critical area and has been urgently needed for a long time.

A thorough and comprehensive survey by Sircar, which includes a large amount of literature, is a worthy chapter for the applications of thermal analysis to elastomer systems. Readers can find a clear description of elastomer properties, formulations, processing, and ultimate usage. This chapter presents an in-depth discussion of thermal characterizations of single elastomers, elastomeric blends and thermoplastic elastomers as they are commonly applied in industry. The author provides detailed theoretical and practical explanations of the thermal analytical results for an abundance of examples, such as mechanical properties, curing process, kinetics of vulcanization and stability of elastomers.

The chapter on thermosets has been completely updated and substantially extended by Prime. This comprehensive review focuses on the fundamental chemical and physical aspects of thermosetting polymers and provides an authoritative guide in this rapidly developing area. Both physical and kinetic models are discussed in great detail, specifically in discussions of glass transition and conversion, and time-temperature superposition. Industrial applications of these materials, varying from aircraft interiors to medical devices, are described as areas where using multiple characterization methods of thermal analysis can be applied. In order to correctly characterize thermoset materials, innovative experimental design with careful data handling and accurate model application are necessary, as is clearly indicated in this review. This is truly a chapter that should be read by professionals who are active in thermosetting polymers.

The next two chapters are concentrated on the thermal characterization of dimensional differences in materials, i.e., fibers and films. Due to the structure anisotropy in these materials, characterization experiments need to be carefully designed. Jaffe, Menczel and Bessey have all put forth in-depth reviews of these two topics with large amounts of recent literature. In particular, the structure-property-processing relationships of fibers and films are carefully discussed and correlated with thermal analysis techniques. Examples include high performance fibers and films. Multiple thermal characterization methods are applied to study their phase transitions, dimensional stability and relaxation processes. The similarities and differences in characterizations between these two kinds of materials are clearly emphasized. Readers will find that these chapters are very useful sources for developing an understanding of these topics.

The last two chapters deal with macroscopically heterogeneous polymeric materials: composites and additives. Morgan addresses the importance of thermal characterizations in the areas of processing structure and effectuation of high performance, fiber reinforced composites. This is a new and valuable chapter to this edition and it covers several broad aspects of thermal properties such as coefficients of thermal expansion, thermal conductivity, diffusivity, and thermal mechanical and dynamic mechanical properties. Combined techniques are used to achieve an understanding of thermal history and environmental effects on composites. This chapter is unique in the sense that very few reviews are available on this topic. It was a wise decision to include this chapter in this edition, not only because of its practical economic importance, but also due to its scientific merits. Bair's enhanced and up-to-date chapter on additives is a valuable survey and guide for understanding the use of additives to improve polymer processibility and material performance. Thermal analysis is useful to determine compatibility, volatility, resistance to migration, etc. Readers will find that this chapter helps to select suitable additives for their polymer systems.

The second edition of this book has involved enormous amounts of hard work in order to put all of these chapters together. Credit and recognition should be given to the editor of this book, Dr. E. Turi. It is only because of her background, knowledge, experience, persistence and, above all, her extremely hard work, that the publication of the second edition became possible. I strongly recommend this book to all professionals who are working in both industry and academia as

their primary reference book and practical guidance in their research and development activities. I hope that this book will significantly enhance our current understanding of theory and applications of thermal analysis.

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