ADDITIVES IN POLYMERS

Industrial Analysis and Applications
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Foreword

Loss of knowledge is an acute threat to companies. The crucial question is how existing knowledge and new technologies can be harnessed as a corporate resource. A major problem facing industry is retaining knowledge within the company, in particular in times of acceleration of innovation. Moreover, in industrial research there is an unmistakable shift from generating knowledge and solving problems by experimental work towards detecting, selecting and absorbing knowledge from the external knowledge infrastructure and adapting it to specific situations. This book contributes a great deal to preserving and critically evaluating knowledge in the field of the analytics of polymer additives.

Additives play a leading role in the success of commercial plastics, elastomers, rubbers, coatings and adhesives. Without additives, many polymers would simply be of limited use. Although polymer additive analysis claims a history of use spanning at least half a century it is, nevertheless, still a continuously evolving research area with new and modified procedures related to increasingly sophisticated products. In many ways, this has led to a plethora of traditional and new chemical, physico-chemical and physical techniques and applications that are confusing to the specialist and beginner alike. An overview of developments across all areas of polymer additive analysis is lacking and a unified approach should therefore be of considerable assistance. This work shows that industrially relevant polymer additive analysis has developed into a very broad and complex field, in retrospect at the limit for one single author and problem holder. Also, despite the many advances direct polymer additive analysis has not yet displaced conventional wet chemical routes.

In this respect, current state-of-the-art ends up in a draw. This book makes a substantial contribution to the current literature on the analytics of polymer additives, follows up an earlier industrial tradition and lays a foundation for the future. It will be of great value to a broad readership comprising industrial and academic (analytical) chemists, polymer scientists and physicists, technologists and engineers, and other professionals involved in R&D, production, use and re-use of polymers and additives in all areas of application, including manufacturers, formulators, compounders, end users, government legislators and their staff, forensic scientists, etc.

With a rapidly developing field as this one, this book can only be considered as a work in progress. Hopefully, this monograph will help users to avoid reinventing the classical analytical wheel, and abandon obsolete, old practices, to redirect their efforts eventually towards more appropriate, though sometimes complicated equipment, to become sufficiently proficient to solve real-life analytical problems efficiently and with confidence, or even to devise innovative and challenging new directions. Certainly, this book will save significant time and effort for those analysts faced with cracking complex polymer additive cocktails. As nothing holds true for ever, it will be most appropriate to review the field again within the next decade.

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Whenever textbooks on polymer chemistry deal with polymer analytical aspects, macromolecular characterisation is usually overemphasised giving the unsuspecting reader the incorrect impression that polymers and formulated polymeric materials are one and the same thing. This treatise, which attempts to remedy such an oversight, is concerned with the characterisation of additives embedded in a broad variety of polymeric matrices. The topic is particularly relevant in view of the impressive growth in the use of synthetic polymeric materials and significant analytical advances in terms of sample preparation, chromatography, detection systems, hyphenation and computation in the last two decades. In every field of science and engineering, it is convenient to have at one’s disposal an up-to-date handbook to provide specialists with a broad collection of technical details about the individual elements of the field. This has now come true for polymer/additive analysis.

The purpose of this monograph, the first to be dedicated exclusively to the analytics of additives in polymers, is to evaluate critically the extensive problem-solving experience in the polymer industry. Although this book is not intended to be a treatise on modern analytical tools in general or on polymer analysis en large, an outline of the principles and characteristics of relevant instrumental techniques (without hands-on details) was deemed necessary to clarify the current state-of-the-art of the analysis of additives in polymers and to accustom the reader to the unavoidable professional nomenclature. The book, which provides an in-depth overview of additive analysis by focusing on a wide array of applications in R&D, production, quality control and technical service, reflects the recent explosive development of the field. Rather than being a compendium, cookery book or laboratory manual for qualitative and/or quantitative analysis of specific additives in a variety of commercial polymers, with no limits to impractical academic exoticism (analysis for its own sake), the book focuses on the fundamental characteristics of the arsenal of techniques utilised industrially in direct relation to application in real-life polymer/additive analysis. The analyst requires expert knowledge, i.e. understanding of the strengths, weaknesses and limits of application of each technique and how they relate to practical problems. Therefore, the chapters are replete with selected and more common applications illustrating why particular additives are analysed by a specific method. By understanding the underlying principles, the mystery of the problem disappears. Expertise, of course, requires more than understanding of the principles alone. Consequently this book does not serve to become overnight expert in the area of polymer/additive analysis. Rather, it helps the emerging generation of polymer analysts to obtain a rapid grasp of the material in minimal time but is no substitute for personal experience.

Additives in Polymers: Industrial Analysis and Applications fulfils a need and provides information not currently available from another single literature source. This book is different from other books on polymer analysis in a number of ways. Instrumental methods are categorised according to general deformulation principles; there is more emphasis on effective problem solving and promoting understanding than on factual information or instrumental capabilities without focus on any specific analyte or polymer class. The tools of the trade are introduced when appropriate in the deformulation strategy, not on the basis of their general properties only. In particular, the author has tried to emphasise the importance of employing rational methods to laboratory, in situ and on-line polymer/additive analysis. The present text is an appraisal of the literature and methodology currently available (tool description), from which the inexperienced ‘deformulator’ can select those means necessary to tackle his own problem and finally write his own recipe and clear procedures in compliance with local instrumental possibilities. The critical evaluation of methods also indicates what still needs to be done. From an industry perspective, it is clear that above all there is a need to improve the quantitative aspects of the methods.
Although wide-ranging, the author does not claim to present a collection of 10 comprehensive reviews. Instead, illustrative examples, drawn from closely related fields (polymers, rubbers, coatings, adhesives), are given to outline the ranges of applicability. The value of the book stays in the applications. No book is perfect and no doubt equally deserving papers have been omitted and some undeserving ones have been included. However, with the number of techniques much greater than originally planned the text should be kept within reasonable bounds. The reader may keep in mind the lines

_For what there was none cared a jot._

_But all were wroth with what was not._

Theory and practice of polymer/additive analysis are not a regular part of analytical education, and usually require on-the-job training. The intention in writing this text was to appeal to as wide an audience as possible. Using an instructional approach, this reference book helps orienting chemists and technicians with little or no background in polymer/additive analysis who would like to gain rapidly a solid understanding of its fundamentals and industrial practice. Seasoned analysts of polymer formulations may use the text to quickly understand terms and techniques which fall outside of their immediate experience. The author has attempted to bring together many recent developments in the field in order to provide the reader with valuable insight into current trends and thinking. Finally, this book can also serve as a modern textbook for advanced undergraduate and graduate courses in many disciplines including analytical chemistry, polymer chemistry and industrial chemistry.

In planning this book the author has chosen a monograph in decathlon fashion. This allows critical comparisons between methods and has the advantage of a unified structure. The disadvantage is that no individual can have specialist knowledge in all fields equal to that of the sum of the experts. To overcome this drawback extensive peer review has been built in. For each individual technique more excellent textbooks are available, properly referenced, albeit with less focus on the analysis of additives in polymers. However, the steep growth curve during the past two decades has made reporting on this subject an almost elusive target. Each chapter of this monograph is essentially self-contained. The reader can consult any subchapter individually. Together they should give a good grounding of the basic tools for dealing with the subject matter.

The reader is well advised to read the two introductory chapters first, which define the analytical problem area and general deformation schemes. The next chapters tackle polymer/additive deformation strategically in an ever-increasing order of sophistication in analytical ingenuity. Conventional, indirect, polymer/additive analysis methods, mainly involving wet chemistry routes, are described in Chapters 3 to 9. The book is concluded with prospects in Chapter 10. Extensive appendices describe additive classes; a glossary of symbols, and databases. To facilitate rapid consultation the text has been provided with eye-catchers. Each chapter concludes with up-to-date references to the primary literature (no patent literature). Contributions from many of the top industrial research laboratories throughout the world are included in this book, which represents the most extensive compilation of polymer/additive analysis ever. Once more it comes true that most research is being carried out beyond one’s own R&D establishment.

The author has not tried to include a complete _ab-initio_ literature search in any particular area. The majority of references in the text are from recent publications (1980–2003). This is not because excellent older references are no longer relevant. Rather, these are frequently no longer used because: (i) more recent work is a fine-tuned extension of prior work; (ii) the ‘classic’ texts list extensive work up to 1980; and (iii) older methods are frequently based on inferior or obsolete technology and thus direct transfer of methods may be difficult or impossible. Readers familiar with the ‘classics’ in the field will find that almost everything has changed considerably.

As most (industrial) practitioners have access to rapid library search facilities, it is recommended that a literature search on the analysis of a specific additive in a given polymer be carried out at the time, in order to generate the most recent references. Consequently, the author does not apologise for omitting references to specific analyses. However, every effort has been made to keep the book up-to-date with the latest methodological developments. Each chapter comprises a critical list of recommended general reading (books, reviews) for those who want to explore the subjects in greater depth.

This book should convince even the most hardened of the ‘doubting Thomases’ that polymer/additive analysis has gone a long way. With a developing field such as this one, any report represents only work in progress and is not the last word.

Geleen
December 2003
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