

# Polymer Structure Characterization

## From Nano to Macro Organization



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# *Preface*

Behind the apparently innocuous smooth structure of hair or a polymer fibre lies a complex structure which dictates the physical properties of that material. This book attempts to give the reader the necessary background to understand the factors that influence molecular organization and control the way in which these structures are formed. The book is written to be useful as support material for undergraduate and postgraduate courses on molecular organization and structure. As the subtitle implies, in order to truly appreciate the factors that influence the properties of many molecular materials it is necessary to be able to observe the materials over length scales which range from nanometres to millimetres. Within this scale range many materials exhibit different levels of organization, and it is to understand the factors which control this structure building that is the aim of this book. The coverage of the book has been limited to consideration of the 'solid' state. Organization in the liquid state—colloids and lyotropic liquid crystals—has been included as it helps understand the way in which many biological systems are able to undertake self-assembly in solution prior to forming an ordered solid.

It is hoped that this book will aid the teaching of crystal growth in small molecules as well as polymers, development of an understanding of both the chemical and physical characteristics of liquid crystalline materials and provide the tools to attempt to rationalize the varied structures which nature creates. These topics are often covered as part of undergraduate courses in chemistry, physics and materials science. The more detailed discussion of the topics on polymer crystallization and morphology form part of postgraduate or advanced masters courses in materials science. This monograph does not attempt to produce a comprehensive review of the literature on these topics, but rather tries to illustrate some of the basic principles with selected examples. Large textbooks have been written on topics such as polymer crystallization, morphology, *etc.*, and it would be an impossible task to cover all aspects of the subject in detail in a small monograph. It is hoped, however, that this selected digest presents the topics at an understandable level and provides a good foundation upon which more detailed exploration of the literature can be based.

Similarly a number of the techniques used in the study of morphology and various related aspects have been summarized. Each technique is worth a

volume in its own right and the reader is encouraged to consult more specialist texts to gain a greater insight into their use and applications. It is hoped that the material presented will provide the reader with a sufficient appreciation of the methods to be able see how the information they provide can be used to gain greater insight into the way molecules are organized within solids.

Morphology and structure in solids are the results of a delicate interplay of forces which act at atomic, molecular and macroscopic levels. Liquid crystalline materials have become of importance through their use in displays; however, the principles underlying their organization and self-assembly are very important in understanding how simple molecules behave as well as biomolecular systems.

The general structure of the monograph follows the format that has been used for a number of years in teaching these subjects at undergraduate and postgraduate level. Each chapter should build on the previous chapters to help the reader gain an appreciation of the factors that are critical in determining that nature of the organization which is developed in a particular system. Whilst the thrust of the monograph is consideration of order; disordered systems play an important part in materials technology and the area of amorphous materials logically results from a combination of a number of factors influencing the 'structure' or rather the lack of it being developed in the solid.

To understand many of the topics covered in this book it is necessary to appreciate the way in which information has been obtained. Scattered through the book are sections on various experimental techniques. They have been introduced at appropriate points in the volume rather than, as is often done, being collected into a single chapter. It is hoped that this method of organization will be helpful. More detailed discussions of the methods are covered in specialist texts; however, it is hoped that the summaries presented here should give the reader sufficient understanding of the methods to be able to appreciate their use in the context of morphological investigations.

In preparing this monograph, a number of textbooks have been consulted and the arguments presented by certain authors have been adopted, where they present a clear and logical development of the topic. In particular the discussion of polymer crystal growth follows clearly that presented by Gedde in his textbook, *Polymer Physics*. For the interested reader a number of these excellent texts have been listed at the end of each chapter. Where appropriate in the text, specific examples of the research work at the University of Strathclyde have been included to assist with the discussion. This is primarily a teaching monograph and no attempt is made to be comprehensive in coverage of the literature or presenting all possible views on any particular topic. The author is very aware of the vast volume of information that is available on this general topic and only hopes that this simplified introduction will help students and researchers to make some progress in understanding this fascinating subject, the principles outlined in the monograph are generally applicable to all molecular systems; the principal differences arise as a result of the detailed balance between inter- and intramolecular contributions to the mean forces

field. It is hoped that armed with the general introduction to the subject, the reader may feel better equipped to approach the more specialist texts and the vast quantity of literature that exists on this subject. If this objective has been accomplished then the book will have succeeded.

I would like to acknowledge the contribution which my colleagues, former colleagues and collaborators have made to educating me in various aspects of the topics covered: Stanley Affrossman, Frank Leslie, John Sherwood, Kevin Roberts, Randell Richards and Christopher Viney. The content of this book is purely my responsibility, but they introduced me to some of the topics and helped me develop my understanding of these areas.

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