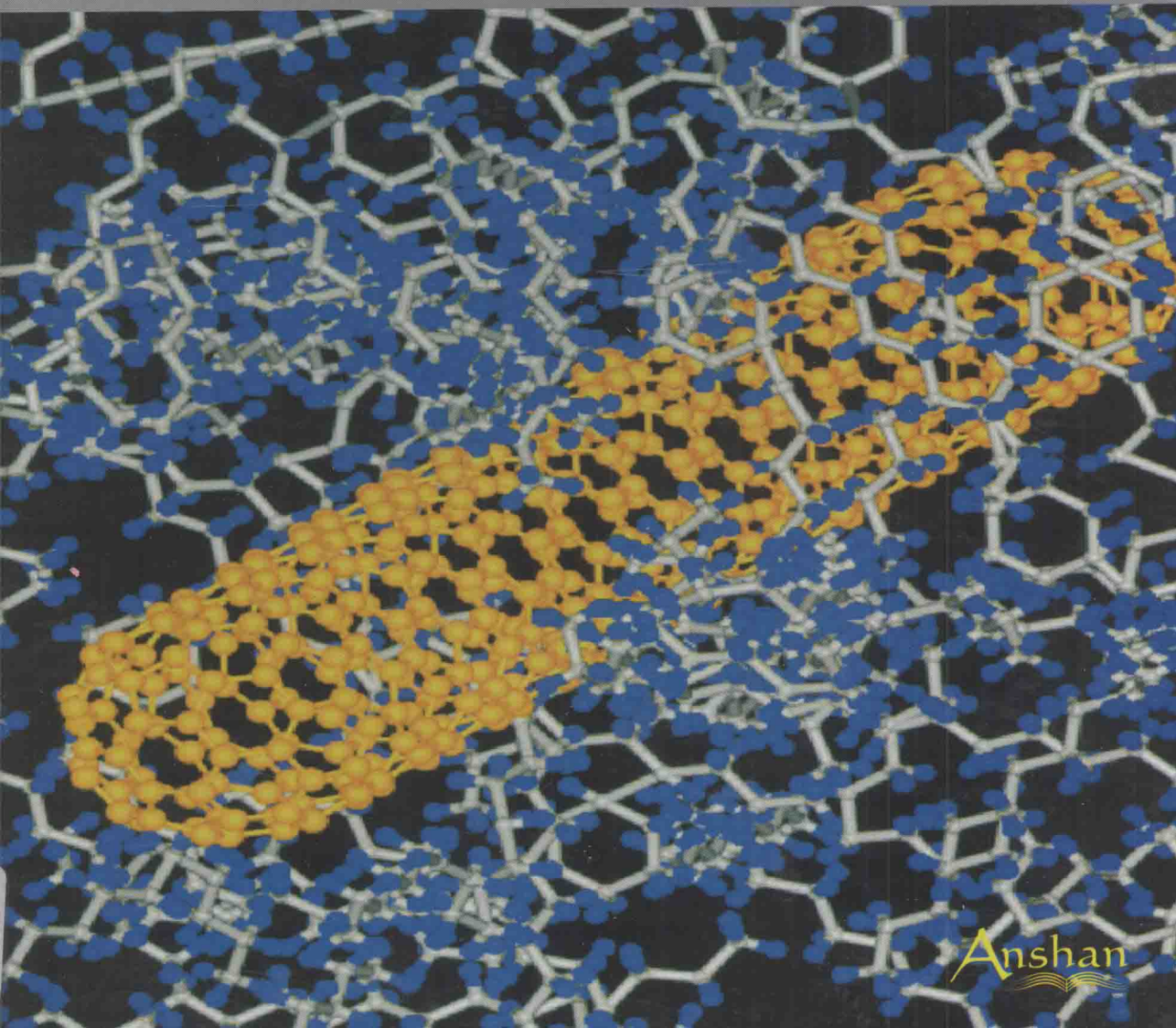


SPECIALTY POLYMERS

Materials and Applications

Editor
Faiz Mohammad



Anshan

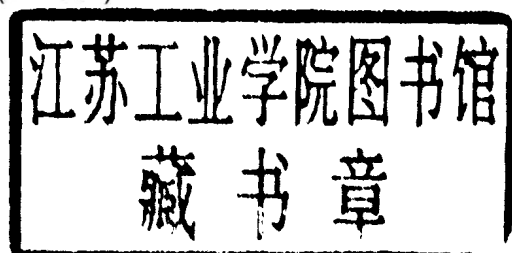
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Materials and Applications

Editor

Faiz Mohammad

D.Phil. (Sussex)



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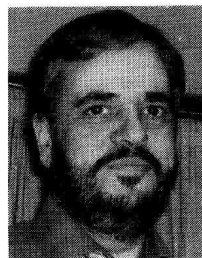
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Peter J.S. Foot

Foreword

During the initial period, the synthetic polymer industry was regarded with disapproval in many quarters. However, by the 1930s it became clear that without it, the material needs of mankind would soon outstrip the natural polymer supplies for clothing fibers, non-metallic structural materials and elastomers. During the World War II, several countries were forced to develop synthetic plastics and rubbers to replace unavailable natural commodities and this process turned into an apparently unstoppable expansion in the polymer industry.

Such an explosive growth has now ceased, but still the industry continues to expand steadily. Most of the excitement, in terms of scientific discovery and technical innovation, comes from Specialty Polymers, such as those discussed in the present book. The developments are driven by factors such as the global need for more efficient energy generation and storage, major biomedical and pharmaceutical breakthroughs, safe and clean new transportation systems and breathtaking advances in mass telecommunications and information technology. In all the cases, the technical requirements are increasingly stringent and the keynote is intelligent materials design, based on an unprecedented, sustained interdisciplinary cooperation. There have also been important developments in microprocessing and microstructural control, enabling full advantage to be taken of the improved molecular features.

Various aspects of the polymer-based advances are very well represented by the choice of topics in “**Specialty Polymers: Materials and Applications**”. The international team of academic and industrial authors includes experts representing the major interacting disciplines of organic

synthesis, polymer science, physics, engineering and medicine. The role of novel polymers and polymer composites in current applications is reviewed in detail, and the creation and structure-properties relationships of materials arising from on-going fundamental research are discussed. The pace of developments in this broad field being very rapid, it will be timely and helpful to have such a book, which will be of use to academic scholars, interested industrialists and postgraduate students as well as to advanced undergraduate students considering a career in advanced materials.

A handwritten signature in black ink, appearing to read 'P.J.S. Foot', with a stylized, cursive script.

Peter J.S. Foot

Preface

“Science is a game we play with God, to find out what his rules are” —**Krasel, Cornelius**

Hermann Staudinger, a German chemist, was the first to propound that the macromolecular (polymeric) chemical structure for natural rubber is made up of many isoprene units and thus, macromolecules are composed of more than 10,000 atoms. In 1953, he received the Nobel Prize for this research, which countered the prevailing understanding that macromolecules are collections of small molecules. Later on, synthetic polymeric materials began replacing natural polymeric materials owing to their light weight, mechanical strength and environmental stability.

Moreover, chemists, material scientists, engineers and technologists, all joined together in the research and development work on polymers. Their systematic research on the preparation, characterization and utilization of polymers resulted in new, better and often a set of several desirable properties in a single polymer and the polymers started finding place in various engineering applications. The last few decades have witnessed a closer partnership between scientists, engineers, technologists and industrialists, as polymers have become materials of common interest. Nowadays, polymers have found practical applications in almost every walk of life including automobiles, packaging, sanitary wares, detergents, cosmetics, pharmaceuticals, semiconductor devices, information technology, wireless and telecommunication etc.

“There is nothing permanent except change”

—**Heraclitus, Rogers, Students’
History of Philosophy**

Although the bulk of polymer production comprises of simple commodity polymers, the proportion of specially designed or tailor-made polymers for specific and sophisticated applications is increasing rapidly. The use of specialty polymers in specific and sophisticated applications holds the key to continuous scientific growth and technological advances in the new millennium. **Specialty Polymers: Materials and Applications** has been compiled to meet the need of the time.

"A good book is the purest essence of a human soul"

—Thomas Carlyle

The present book is the result of the contributions of 35 experts from international scientific community. This book thoroughly covers the latest topics on specialty polymers and their applications in the most sophisticated and specialized areas. It gives the latest and in-depth coverage to the chemistry, physics, material science, and technology and device applications of specialty polymers. Based on more than 2500 references, 250 figures, 50 tables, 140 equations, 15 schemes and 45 chemical structures, this book will certainly prove thought-provoking to the researchers working in the fields of chemistry, biochemistry, biotechnology, medicine, polymer chemistry, semiconductor physics, material science, electrochemistry, biology, electronics, photonics, solid state physics, nanotechnology, electrical and electronics engineering, optical engineering, device engineering, data storage etc. Based on thematic topics, it contains the following 16 chapters:

Chapter 1: Liquid Crystal Conducting Polymers contains an overview of research on the effects of imparting liquid crystalline properties to electronically conducting polymers.

Chapter 2: Polyanilines: Materials and Applications describes the synthesis, characterization and most promising applications of polyanilines, such as in microelectronics, lithography, resists, coatings, ultra-thin membranes, secondary batteries, multi-color electrochromic devices, conductive textiles and so on.

Chapter 3: Polymer Nanofibers: Fabrication, Applications and Characterization provides a review on the fabrication techniques with special emphasis on electrospinning, applications of polymer nanofibers and characterization techniques pertaining to single nanofibers and nanofibrous mats or foams.

Chapter 4: Magnetic Polymer Microspheres summarizes the structure, preparation methods and applications of magnetic polymer microspheres. Magnetic polymer microspheres are finding applications in many areas such as in biomedical field, organic synthesis, waste water treatment and so on, because of their two very important properties. First that they can be rapidly and easily separated by application of magnetic field and second that their surface can be modified to different functional groups.

Chapter 5: *Intrinsically Conducting Polymers for Metallic Corrosion Protection* reviews the metallic corrosion protection properties and mechanisms of intrinsically conducting polymers (ICPs) as well as their composites with special emphasis on polyaniline (PANI) and polypyrrole (PPY), which can be synthesized chemically or electrochemically.

Chapter 6: *Inorganic Polymers for Advanced Applications* covers the main group metalloid-containing inorganic polymers, which are made up of boron (group 13: polyborazines), silicon/germanium/tin (group 14: polysilanes, polygermanes, and polystannanes) and phosphorous (group 15: polyphosphazenes) atoms as advanced materials, with special emphasis on silicon-containing polymers with unusual properties.

Chapter 7: *Light Weight Polymer Composite Materials for Automotive Industry* reviews the important issues in automotive composites such as design, manufacturing, material selection, the use of computers in automotive composite development, concurrent engineering, natural fiber composites in automobiles, recycling of automotive composites and future trends. A brief history and definition of automotive polymer composites and the benefits and disadvantages of polymer composites in automotive industry are also covered.

Chapter 8: *Conducting Polymer-Based Sensors* illustrates the possibilities offered by conducting polymers in the area of chemical sensors by using various examples.

Chapter 9: *Photo-Converters Based on Dye-Doped Polymers* considers the main approaches to molecular design of dye-doped polymers matrices. It also discusses the prospects for the applications of dye-doped polymer materials as passive Q-switches of solid-state lasers, as active laser media, as luminescent solar converters, as photovoltaic cells and as electroluminescent emitters. The advantages of such matrices over polymers and dyes are also analyzed in it.

Chapter 10: *Polymers in Medicine* reviews the use of polymers to fabricate biomedical materials and devices for tissue engineering, gene delivery, wound treatment, heart valves, angioplasty balloons and stents, nerve regeneration, drug delivery, breast implants, dental devices, orthopedic devices, ophthalmic devices, gynecological devices etc.

Chapter 11: *Luminescent Polymers* covers the synthesis of substituted conjugated polymers to regulate the emission color and improve the EL efficiency and processibility of the luminescent polymers.

Chapter 12: *Polymers in Electronics* explains the role of conducting polymers in various electronic devices such as LEDs, photovoltaic cells and FETs.

Chapter 13: *Ion Conducting Polymers* describes the preparation and characterization of polymer gel electrolyte systems viz., PVDF:(PC+DEC):LiClO₄ and P(VDF-HFP):(PC+DEC):LiClO₄. It also illustrates the results of two polymer gel electrolyte systems with regard to ionic conductivity, X-ray diffraction, fourier transform, infra-red spectroscopy and scanning electron microscopy. This is done keeping in view their applications in electrochemical energy storage and conversion devices such as advanced rechargeable lithium batteries and fuel cells, power source for wireless telecommunication devices and portable information technologies, electric and hybrid vehicles, electrochemical sensors and so on.

Chapter 14: *Specialty Coatings and Adhesives* discusses the specific areas in solvent borne coatings, waterborne coatings, UV radiation curable coatings, which are ripe for future innovations and further development. These are discussed with special emphasis on the recently developed, sustainable resource based coating materials. The structure and reactivity associated with the alkyd, polyester, acrylic, amino, epoxy and polyurethane resins, commonly used in coating formulations, are described with preparation, performance and cure reactions in the first part. The second part covers a brief history of development of various primitive and advanced adhesives such as epoxy, phenol formaldehyde and urea formaldehyde, with special emphasis on conductive adhesives, waterborne adhesives and sustainable resource-based adhesives as well as their characteristic properties, with a view on their significance in new technology.

Chapter 15: *Recombinant Polypeptides in Therapeutics* provides the latest general information on various aspects of therapeutic applications of selected rDNA products, especially hormones of therapeutic interest, haemopoietic growth factors, human blood coagulation products, thrombolytic agents, anticoagulants, human interferons, human interleukins and therapeutic enzymes, in view of the increasing importance of rDNA products for human healthcare.

Chapter 16: *Electrically Conducting Polymer Composites* details the different methods for producing electrically conducting polymer composite materials, their electrical properties and a variety of applications.

This book has indeed been the result of remarkable cooperation of many distinguished experts, who came together to contribute comprehensive, in-depth and up-to-date review chapters. I am thankful to all the contributing authors and their co-authors for their valued contributions to the book. I would also like to express my gratitude to all the publishers, authors and others for granting us the copyright permissions to use their illustrations, especially, AAAS, Abdul Hadi Abdullah, American Chemical Society, American Institute of Physics, BCC Research, Cambridge University Press, Elsevier Science Ltd., Edisysams

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I would also like to take this opportunity to express my gratitude to my mentors, Mr. Dinesh Chandra Jain (my Science teacher), Mr. Noor Mohammad (my elder brother and Math's teacher), Professor (Dr.) Wasi-ur-Rahman (Former Vice-Chancellor of Aligarh Muslim University), Dr. M.C. Nigam (Former Scientist of CIMAP, Lucknow), Dr. S.P. Manik (Former Executive Director of RDSO, Lucknow), Professor (Dr.) N.C. Billingham (University of Sussex) and Mr. Mohammad Khaleel Siddiqui (my local guardian during my stay at Sussex University). My special thanks also to my departmental colleagues Dr. Ali Mohammad, Dr. M.A. Quraishi, Dr. Asif Ali Khan, Dr. R.A.K. Rao, Dr. M. Mobin, Dr. M.Z.A. Rafiqui and Dr. Rais Ahmad, without whose continuous encouragement this book would have not been brought to its final form. Thanks are also due to my research students, Mr. Mohammad Khalid, Ms. Atika Khatoon, Mr. Shahid Parvez and Mr. Mohd. Omaish for their assistance from time to time. I would also like to acknowledge the sincere efforts of Ms. Sonia Mamgain, Mr. Arvind Mishra (from I.K. International Publishing House Pvt. Ltd.) in evolving this book into its final shape. Last but not the least, I am highly appreciative of the support of my brothers, sisters and the love of my family members, Shahina, Asif, Fatima, Tahir, Haleema, Zaib and Talib, during this exciting experience.

My sincere gratitude is also due to Prof. P.J.S. Foot for his insightful foreword.

Faiz Mohammad
Editor

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