162
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Radiation Effects on Polymers for Biological Use

With contributions by
N. Anjum, Y. Chevolot, B. Gupta, D. Léonard,
H. J. Mathieu, L. A. Pruitt, L. Ruiz-Taylor, M. Scholz

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This series presents critical reviews of the present and future trends in polymer and biopolymer science including chemistry, physical chemistry, physics and materials science. It is addressed to all scientists at universities and in industry who wish to keep abreast of advances in the topics covered.

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In references Advances in Polymer Science is abbreviated Adv Polym Sci and is cited as a journal.

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Preface

By polymers for biological use we understand biopolymers and living matter. Biomaterials are man-made or -modified materials which repair, reinforce or replace damaged functional parts of the (human) body. Hip joints, cardiovascular tubes or skin adhesives are just a few examples. Such materials are principally chosen for their mechanical performance (stiffness, strength, fatigue resistance). All mechanical and biological interactions between an implant and the body occur across the interface, which has to correspond as nearly as possible to its particular function. A natural surface is a complex (three-dimensional) structure, which has to fulfil many roles: recognition, adhesion (or rejection), transport or growth. We have to admit that at present biomaterials are far removed from such performance although new strategies in surface engineering have been adopted in which man tries to learn from nature.

Much of the progress in adapting polymer materials for use in a biological environment has been obtained through irradiation techniques. For this reason the most recent developments in 4 key areas are reviewed in this special volume. All surface engineering necessarily begins with an analysis of the topology and the elemental composition of a functional surface and of the degree of assimilation obtained by a particular modification. X-ray photoelectron spectroscopy (XPS) and time-of-flight secondary ion mass spectroscopy (ToF-SIMS) play a prominent role in such studies and these are detailed by H.J. Mathieu and his group from the Ecole Polytechnique Fédérale de Lausanne (EPFL). Generally, the first step towards procuring desired physico-chemical properties in a biomaterial substrate is a chemical modification of the surface. As pointed out by B. Gupta and N. Anjum from the Indian Institute of Technology (IIT), plasma- and radiation-induced grafting treatments are widely used since they have the particular advantage that they result in highly pure, sterile and versatile surfaces.

The sterilisation of implantable devices is a subject of great concern for the medical industry. Since ionising radiation is preferentially used for this purpose, attention must be paid to possible effects on the structural and mechanical properties of polymers (through chain scission or cross-linking). L. A. Pruitt from UC Berkeley has reviewed the specific behaviour of the different medical polymer classes to g- and high-energy electron irradiation and environmental effects. The biocidal efficiency relies on free radical formation and on the ability to reduce DNA replication in any bacterial spore present in a medical device.

The latter point, radiation effects on living cells and tissues, is the subject of the final contribution in this volume. M. Scholz from the Gesellschaft für Schwerio-

nenforschung (GSI) summarises the (damaging) biological effects of ion beam irradiation and the considerable differences with respect to conventional photon radiation. These studies are of particular importance for radiation protection and radiotherapy. The advantages of a tumor treatment by carbon ion beams (effectiveness, concentrated energy release, possibility to use the presence of positron emitting 10C and 11C isotopes for positron emission tomography) are also presented in a comprehensive way.

I hope that the combination in a single special volume of the Advances in Polymer Science of these highly complementary contributions is particularly helpful to scientists working in this rapidly developing area. I would also like to thank all the authors for their exemplary co-operation.

Lausanne, December 2002 H. H. Kausch

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- Editorial Board
- Aims and Scope
- Instructions for Authors
- Sample Contribution

Contents