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Advances in Polymer Science

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Advances in Polymer Science

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Volume Editor: Hans-Henning Kausch

With contributions by

J. L. Halary · H.-H. Kausch · F. Lauprêtre

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The series *Advances in Polymer Science* presents critical reviews of the present and future trends in polymer and biopolymer science including chemistry, physical chemistry, physics and material 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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Volume Editor

Prof. Dr. Hans-Henning Kausch

Ecole Polytechnique Fédérale de Lausanne
Science de Base
Station 6
1015 Lausanne, Switzerland
kausch.cully@bluewin.ch

Editorial Board

Prof. Akihiro Abe

Department of Industrial Chemistry
Tokyo Institute of Polytechnics
1583 Iiyama, Atsugi-shi 243-02, Japan
aabe@chem.t-kougei.ac.jp

Prof. A.-C. Albertsson

Department of Polymer Technology
The Royal Institute of Technology
10044 Stockholm, Sweden
aila@polymer.kth.se

Prof. Ruth Duncan

Welsh School of Pharmacy
Cardiff University
Redwood Building
King Edward VII Avenue
Cardiff CF 10 3XF
United Kingdom
duncan@cf.ac.uk

Prof. Karel Dušek

Institute of Macromolecular Chemistry,
Czech
Academy of Sciences of the Czech Republic
Heyrovský Sq. 2
16206 Prague 6, Czech Republic
dusek@imc.cas.cz

Prof. Dr. W. H. de Jeu

FOM-Institute AMOLF
Kruislaan 407
1098 SJ Amsterdam, The Netherlands
dejeu@amolf.nl
and Dutch Polymer Institute
Eindhoven University of Technology
PO Box 513
5600 MB Eindhoven, The Netherlands

Prof. Jean-François Joanny

Physicochimie Curie
Institut Curie section recherche
26 rue d'Ulm
75248 Paris cedex 05, France
jean-francois.joanny@curie.fr

Prof. Dr. Hans-Henning Kausch

Ecole Polytechnique Fédérale de Lausanne
Science de Base
Station 6
1015 Lausanne, Switzerland
kausch.cully@bluewin.ch

Prof. S. Kobayashi

R & D Center for Bio-based Materials
Kyoto Institute of Technology
Matsugasaki, Sakyo-ku
Kyoto 606-8585, Japan
kobayash@kit.ac.jp

Prof. Kwang-Sup Lee

Department of Polymer Science &
Engineering
Hannam University
133 Ojung-Dong Taejon
300-791, Korea
kslee@mail.hannam.ac.krr

Prof. L. Leibler

Matière Molle et Chimie
Ecole Supérieure de Physique
et Chimie Industrielles (ESPCI)
10 rue Vauquelin
75231 Paris Cedex 05, France
ludwik.leibler@espci.fr

Prof. Timothy E. Long

Department of Chemistry
and Research Institute
Virginia Tech
2110 Hahn Hall (0344)
Blacksburg, VA 24061, USA
telong@vt.edu

Prof. Ian Manners

School of Chemistry
University of Bristol
Cantock's Close
BS8 1TS Bristol, UK
r.musgrave@bristol.ac.uk

Prof. Dr. Martin Möller

Deutsches Wollforschungsinstitut
an der RWTH Aachen e.V.
Pauwelsstraße 8
52056 Aachen, Germany
moeller@dwi.rwth-aachen.de

Prof. Oskar Nuyken

Lehrstuhl für Makromolekulare Stoffe
TU München
Lichtenbergstr. 4
85747 Garching, Germany
oskar.nuyken@ch.tum.de

Dr. E. M. Terentjev

Cavendish Laboratory
Madingley Road
Cambridge CB 3 OHE
United Kingdom
emt1000@cam.ac.uk

Prof. Brigitte Voit

Institut für Polymerforschung Dresden
Hohe Straße 6
01069 Dresden, Germany
voit@ipfdd.de

Prof. Gerhard Wegner

Max-Planck-Institut
für Polymerforschung
Ackermannweg 10
Postfach 3148
55128 Mainz, Germany
wegner@mpip-mainz.mpg.de

Prof. Ulrich Wiesner

Materials Science & Engineering
Cornell University
329 Bard Hall
Ithaca, NY 14853
USA
ubw1@cornell.edu

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Preface

The enormous length of macromolecules and the low intra- and intermolecular barriers opposing rotation and displacement of molecular groups or of even longer segments are at the origin of the unique visco- and rubber-elastic behaviour of polymer solids. Molecular mobility influences all phases of processing and use of such materials. Thus segregation and phase separation in the melt as well as structure development through crystallization depend on chain dynamics. The same is true for most deformation mechanisms, sample stiffness and ultimate properties such as toughness. Considerable progress has been obtained in the last decade in the understanding of the mutual relationship between the primary molecular parameters chain configuration, architecture and molecular weight (MW) on the one hand, and the response of a loaded entanglement network, the nature of the processes limiting stress transfer and the resulting mode of mechanical breakdown on the other. In view of the large technical importance of mechanical performance it seems to be adequate to review this subject, the *Intrinsic Molecular Mobility and Toughness of Polymers*.

In their introductory contribution Kausch and Michler discuss the elementary, time-dependent molecular deformation mechanisms, the competition between them, and their influence on the different failure modes of thermoplastic polymers (crazing, creep, yielding and flow, fracture through crack propagation). By establishing a *micro-morphological model* of polymer deformation and durability the authors highlight the dual role of segmental jumps and displacements to improve toughness by energy dissipation and relaxation of critical stresses and to influence without exception all damage mechanisms.

The dynamic response of a chain segment to thermo-mechanical excitation strongly depends on in-chain cooperative motions. By combining the powerful techniques of multi-dimensional Nuclear Magnetic Resonance and of dielectric and dynamic mechanical analysis Monnerie, Lauprêtre and Halary have investigated the *intensity and molecular origin of sub- T_g relaxations* and their degree of coupling for five structurally quite different amorphous polymers. Their important findings are reported in two comprehensive reviews treating the effect of chain configuration on segmental mobility and its effect on the toughness of these materials, respectively.

Essential features of the entanglement network and of the morphology of semi-crystalline polymers are determined through the crystallization process.

Chan and Li review homogeneous and heterogeneous nucleation. Using the new hot-stage in-situ AFM technique they particularly investigate the propagation of *founding lamellae*, their branching, interaction and development into lamellar sheaves and spherulites. In her contribution Grein gives a thorough *analysis of the influence of phase structure* (α - and β -crystalline polypropylene) as compared to the effect of elastomeric modifier particles. She concludes that the capacity of a matrix to deform remains an essential requirement for high toughness materials.

Stress cracking environments are known to enhance the mobility in the affected surface regions. Altstädt shows that the rate of fatigue crack propagation at *constant stress intensity factor* K proves to be a sensitive quantitative measure of the influence of active media. He also points to the dual role of segmental mobility, permitting stress relaxation followed by strain hardening or unstable softening, respectively. The complex conditions of *fracture during sliding contact* are reviewed by Chateauminois and Baietto-Duboug. They arrive at the conclusion that the main wear mechanism of glassy polymers, asperity scratching, is strongly controlled by competition between crazing processes and shear yielding. In the final contribution Estevez and van der Giessen present a computational analysis of the fracture of glassy polymers. The *applied cohesive zone model* takes into consideration the three steps of crazing (initiation, thickening and breakdown) and seems to be sufficiently flexible to adapt to future refinements.

The editor wishes to thank all authors for their willingness to cooperate in this joint effort, which so heavily depended on the concurrence of their special expertise. It is hoped that the resulting detailed overview will be of help to more fully exploit the large potential offered by polymeric systems. Unfortunately the comprehensive treatment has made it necessary to publish the above, closely related eight contributions in two consecutive volumes of the *Advances in Polymer Science*, Vols. 187 and 188. However, a common *Subject Index* in both volumes and the reproduction of the two *List of Contents* should make it easy for the reader to find the desired information.

Lausanne, September 2005

Hans-Henning Kausch

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