

217

Advances in Polymer Science

Editorial Board:

**A. Abe · A.-C. Albertsson · R. Duncan · K. Dušek · W. H. de Jeu
H.-H. Kausch · S. Kobayashi · K.-S. Lee · L. Leibler · T. E. Long
I. Manners · M. Möller · O. Nuyken · E. M. Terentjev
B. Voit · G. Wegner · U. Wiesner**

Advances in Polymer Science

Recently Published and Forthcoming Volumes

Self-Assembled Nanomaterials II

Nanotubes
Volume Editor: Shimizu, T.
Vol. 220, 2008

Self-Assembled Nanomaterials I

Nanofibers
Volume Editor: Shimizu, T.
Vol. 219, 2008

Interfacial Processes and Molecular Aggregation of Surfactants

Volume Editor: Narayanan, R.
Vol. 218, 2008

New Frontiers in Polymer Synthesis

Volume Editor: Kobayashi, S.
Vol. 217, 2008

Polymers for Fuel Cells II

Volume Editor: Scherer, G. G.
Vol. 216, 2008

Polymers for Fuel Cells I

Volume Editor: Scherer, G. G.
Vol. 215, 2008

Photoresponsive Polymers II

Volume Editors: Marder, S. R., Lee, K.-S.
Vol. 214, 2008

Photoresponsive Polymers I

Volume Editors: Marder, S. R., Lee, K.-S.
Vol. 213, 2008

Polyfluorenes

Volume Editors: Scherf, U., Neher, D.
Vol. 212, 2008

Chromatography for Sustainable Polymeric Materials

Renewable, Degradable and Recyclable
Volume Editors: Albertsson, A.-C.,
Hakkarainen, M.
Vol. 211, 2008

Wax Crystal Control · Nanocomposites Stimuli-Responsive Polymers

Vol. 210, 2008

Functional Materials and Biomaterials

Vol. 209, 2007

Phase-Separated Interpenetrating Polymer Networks

Authors: Lipatov, Y. S., Alekseeva, T.
Vol. 208, 2007

Hydrogen Bonded Polymers

Volume Editor: Binder, W.
Vol. 207, 2007

Oligomers · Polymer Composites Molecular Imprinting

Vol. 206, 2007

Polysaccharides II

Volume Editor: Klemm, D.
Vol. 205, 2006

Neodymium Based Ziegler Catalysts – Fundamental Chemistry

Volume Editor: Nuyken, O.
Vol. 204, 2006

Polymers for Regenerative Medicine

Volume Editor: Werner, C.
Vol. 203, 2006

New Frontiers in Polymer Synthesis

Volume Editor: Shiro Kobayashi

With contributions by

N. Ajioka · K. Endo · H. Kaneko · N. Kashiwa · N. Kawahara
T. Matsugi · S. Matsuo · J. Saito · A. Yokoyama · T. Yokozawa

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.

As a rule, contributions are specially commissioned. The editors and publishers will, however, always be pleased to receive suggestions and supplementary information. Papers are accepted for *Advances in Polymer Science* in English.

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

Springer WWW home page: springer.com

Visit the APS content at springerlink.com

ISBN 978-3-540-69807-4

e-ISBN 978-3-540-69808-1

DOI 10.1007/978-3-540-69808-1

Advances in Polymer Science ISSN 0065-3195

Library of Congress Control Number: 2008933505

© 2008 Springer-Verlag Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Cover design: WMXDesign GmbH, Heidelberg

Typesetting and Production: le-tex publishing services oHG, Leipzig

Printed on acid-free paper

9 8 7 6 5 4 3 2 1 0

springer.com

Volume Editor

Prof. Shiro Kobayashi

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

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, UK
DuncanR@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. Wim H. de Jeu

Polymer Science and Engineering
University of Massachusetts
120 Governors Drive
Amherst MA 01003, USA
dejeu@mail.pse.umass.edu

Prof. Hans-Henning Kausch

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

Prof. Shiro 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 Advanced Materials
Hannam University
561-6 Jeonmin-Dong
Yuseong-Gu 305-811
Daejeon, South Korea
kslee@hnu.kr

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
ian.manners@bristol.ac.uk

Prof. Martin Möller

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

Prof. Oskar Nuyken

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

Prof. E. M. Terentjev

Cavendish Laboratory
Madingley Road
Cambridge CB 3 0HE, UK
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
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

Advances in Polymer Science Also Available Electronically

For all customers who have a standing order to *Advances in Polymer Science*, we offer the electronic version via SpringerLink free of charge. Please contact your librarian who can receive a password or free access to the full articles by registering at:

springerlink.com

If you do not have a subscription, you can still view the tables of contents of the volumes and the abstract of each article by going to the SpringerLink Homepage, clicking on "Browse by Online Libraries", then "Chemical Sciences", and finally choose *Advances in Polymer Science*.

You will find information about the

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

at springer.com using the search function.

Color figures are published in full color within the electronic version on SpringerLink.

Preface

It is generally accepted that a new material is often developed by finding a new synthesis method of reaction or a new reaction catalyst. Historically, a typical example may be referred to as a Ziegler–Natta catalyst, which has allowed large-scale production of petroleum-based polyolefins since the middle of the 20th century. New polymer synthesis, therefore, will hopefully lead to creation of new polymer materials in the 21st century. This special issue contributed by three groups focuses on recent advances in polymer synthesis methods, which handle the cutting-edge aspects of the advanced technology.

The first article by Yokozawa and coworkers contains an overview of the reaction control in various condensation polymerizations (polycondensations). Advanced technologies enabled the control of stereochemistry (regio-, geometrical-, and enantio-selections), chemoselectivity, chain topology, and stoichiometry of monomers, giving a high molecular weight polymer. It has been recognized for a long time, however, that polycondensation is a difficult process in controlling the reaction pathway, because the reaction is of step-growth and the reactivity of monomers, oligomers, and polymers are almost the same during the reaction and hence, the molecular weight of polymers and its distribution (M_w/M_n) are impossible to regulate. The authors' group developed a new reaction system (chain-growth condensation polymerization), changing the nature of polycondensation from step-growth to chain-growth; namely the propagating chain-end is active, allowing for control of the product molecular weight as well as the distribution. With a specific initiator and/or catalyst, the chain-growth condensation polymerization came close in behavior to that of an addition polymerization; a M_w/M_n value being even less than 1.2, like a living system, compared with that of a most probable value 2.0 for conventional polycondensations.

The second article by Kawahara and his coworkers focuses on polyolefin (PO)-based hybrid materials (POH), in view of their synthesis, structures, and properties. POs are currently the most widely and conveniently used polymeric materials as recognized by the production amount of over one hundred million tons annually in the world, due to the cheap price yet good properties. They are basically hydrocarbon polymers, and hence hydrophobic and less polar. These basic properties are to be modified by introducing a polar function for a wider use in practical applications. Preparation of POHs is one of the best ways to

provide a variety of desired properties with POs. There are three main synthetic routes to POHs; starting from PO macroinitiators, PO macromonomers, and reactive POs. Polymerization or copolymerization using these macroinitiators and macromonomers are carried out by recently developed methods (living polymerization, ATRP, RAFT, NMP, etc) to produce POHs of block, graft, or branched-type structures. Reactive POs can be coupled with other components to give POHs. In addition, living polymerization of olefins can also be a route for POH synthesis. A wide range of applications of these product POHs are exemplified.

The third article by Endo reviews synthesis and properties of cyclic polymers. Polymer structure is basically divided into two classes; linear and cyclic. Combinations of linear and/or cyclic structures yield a variety of architectures such as branched, graft, block, star, ladder, dendritic, catenane, rotaxane and other complicated structures through covalent and noncovalent bonds. A linear or cyclic structure has been an important, fundamental problem since the early stages of polymer science, and yet it is still new. Fortunately, recent developments of analytical methods enabled the structural elucidation of many of these architectures. The synthesis principle to lead to cyclic polymers can be cited as two main methods. One is the utilization of the ring-chain equilibrium, occurring in many polycondensations and ring-opening polymerizations. The other is the end-to-end cyclization (ring-closure reaction) method from α,ω -difunctional linear precursors, via bimolecular or unimolecular processes. Synthesis of a number of cyclic polymers has been achieved by addition, condensation, oxidation, metathesis, and ring-opening polymerizations as well as by polyaddition. A typical difference in physical property between cyclic polymers and linear polymers is also demonstrated.

We hope the readers will learn something new at the forefront of the polymer synthesis field from the above contributions.

May 2008, Kyoto

Shiro Kobayashi

Contents

Reaction Control in Condensation Polymerization	
T. Yokozawa · N. Ajioka · A. Yokoyama	1
Polymer Hybrids Based on Polyolefins – Syntheses, Structures, and Properties	
N. Kawahara · J. Saito · S. Matsuo · H. Kaneko T. Matsugi · N. Kashiwa	79
Synthesis and Properties of Cyclic Polymers	
K. Endo	121
Subject Index	185