Volume 4

Handbook of Engineering and Specialty Thermoplastics

Nylons

Edited by
Sabu Thomas and Visakh P.M.

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Scrivener Publishing
3 Winter Street, Suite 3
Salem, MA 01970

List of Contributors

Zulkifli Ahmad graduated with his doctoral degree from University of Reading, UK in 2005. His main research interest is the synthesis of high performance polymers with application in opto-electronic devices. He has published 50 papers in refereed journals and presented talks in several international conferences as well as authored a monograph on crystal structure of high performance polymers. At present he is at Universiti Sains Malaysia as an Associate Professor.

Carlos Alemán earned his PhD in Sciences at the Technical University of Catalonia in 1994 and is currently a full professor there. He has received several awards including the Distinction of the Generalitat de Catalunya to the University Research (2003), the I3 Research Award of MICINN (2006), and the ICREA-ACADEMIA from ICREA Foundation (2007). He is group leader of the "Innovation in Materials and Molecular Engineering" (Chemical Engineering Department) and "Nanochemistry/Conducting" (CRNE) laboratories.

Sabrina Carroccio is a researcher at the Institute of Chemistry and Technology of Polymers of the National Research Council (CNR), Catania, Italy. Her research interests on degradation of polymers include molecular characterization of macromolecules by advances mass spectrometry techniques, polymer pyrolysis, polymer thermo and photo oxidation mechanisms.

F.C. García is a professor in the Department of Chemistry at the University of Burgos, Spain. He received his PhD at the University of Burgos, Spain in 2001. His research interest is in polymers with sensing capabilities in water environments.

J.M. García is a professor in the Department of Chemistry at the University of Burgos, Spain. He received his PhD in Chemistry at the Complutense University of Madrid, Spain, in 1995. Prof. Garcia is a co-author of more than 50 peer reviewed scientific publications, books and book chapters, and has a number of patents. His principal areas of research are high performance materials, functional polymers, and sensory polymers as sensing materials for water environments.

Ghobad Azizi Ghahfarrokhi received his MS degree in 2008 in organic chemistry from Isfahan University of Technology, Isfahan, Iran, He is pursuing his PhD degree in organic chemistry and his research interests are organic synthesis in ionic liquid media, MW assisted reactions and organometallic catalyzed reactions.

Annarosa Gugliuzza is a senior researcher at the Institute on Membrane Technology, ITM-CNR, Italy. She has a degree with honours in Chemistry and a PhD in Chemical Science. She is a membrane technologist with solid expertise in advanced materials and development of highly structured membranes with specific functions at molecular scale by sophisticated nanotechnologies, including self-assembly and layer-by-layer techniques.

Abdolreza Hajipour received his MS degree in 1983 from Shiraz University, Iran and his PhD degree in organic chemistry from Wollongong University, Australia in 1994. He is a Professor of Organic Chemistry at Isfahan University of Technology. His research interests cover the synthesis of novel optically active polymers, microwave-assisted organic and polymerization reactions, solid-state reactions, new reagents for oxidation and reduction of organic compounds.

José I. Iribarren received his PhD in Sciences from the Technical University of Catalonia (Spain) in 1996. After many years developing his research activity in the structural characterization of chiral polyamides, in 2003 he joined the "Innovation in Materials and Molecular Engineering" group at the Technical University of Catalonia. His current research interests concern the protection against corrosion using conducting polymers.

Melek Kiristi is a PhD candidate with research interests in the synthesis and application of conducting and biopolymers. She holds a BS degree from Suleyman Demirel University in Isparta, Turkey and a MS degree from Suleyman Demirel University in Isparta, Turkey.

Giorgio Montaudo is a Professor in the Department of Chemistry, University of Catania, Italy. He has been the Director of ICTMP-Catania of the CNR of Italy. Dr. Montaudo received a PhD in chemistry from the University of Catania and has been active in the field of the synthesis, degradation, and characterization of polymeric materials by mass spectrometry. He is the author of more than 300 publications in international journals and chapters in books.

J.L. de la Peña is a Professor in the Department of Chemistry at the University of Burgos, Spain. He carried out his doctoral studies at the Institute of Polymer Science & Technology, Spanish National Research Council (CSIC), receiving his PhD in Chemistry at the Complutense University of Madrid, Spain, in 1972. His research interests cover all fields of polymer preparation and applications.

Concetto Puglisi is a Research Manager in the Institute of Chemistry and Technology of Polymers of the Italian National Research Council (CNR). He received his degree in Industrial Chemistry at the University of Catania in 1978. His research activity include thermal degradation and oxidation mechanisms of polymers, mechanisms of chemical exchange of polymer blends in the molten state and application of advanced mass spectrometry techniques to the analysis of polymers.

Jordi Puiggalí earned his PhD in Industrial Engineering at the Technical University of Catalonia (UPC) in 1987 and is currently full professor at the same University. His research activity is mainly focused in the development of biodegradable polymers for biomedical applications and in the structural studies of polyamides and polyesters. He is group leader of the "Synthetic Polymers: Structure and Properties" (http://psep.upc.edu), "Macromolecular Chemistry" and "Nanochemistry" (http://www.upc.edu/crne) laboratories of the Chemical Engineering Department of the UPC.

Fatemeh Rafiee received her MS degree in 2007 in organic chemistry from Isfahan University of Technology, Iran, She is pursuing her PhD degree in organic chemistry at the Isfahan University of Technology, Iran. Her research interests are organic synthesis in ionic liquid media, MW assisted reactions and organometallic catalyzed reactions.

F. Serna is Associate Professor in the Department of Chemistry at the University of Burgos, Spain. He carried out his doctoral studies at the Institute of Polymer Science & Technology, Spanish National Research Council (CSIC), receiving his PhD in Chemistry at the Complutense University of Madrid, Spain, in 1985. His research interest is related with polymers for advanced technologies.

Aysegul Uygun is a Professor of Chemistry at the Department of Chemistry in the Middle East Technical University, Turkey with expertise in polymer chemistry. Her research interests include conducting polymers. Prof.Uygun has more than 50 publications in scientific journals. She received her PhD degree from Suleyman Demirel University in Isparta, Turkey. She is the recipient of DFG and Fulbright Scholarships.

Contents

1

Engineering and Specialty Thermoplastics: Nylons

State of Art, New Challenges and Opportunities

Visakh. P. M[1] and Sabu Thomas[2]

[1,2]*School of Chemical Sciences, Mahatma Gandhi University, Kerala, INDIA*
[2]*Centre for Nanoscience and nanotechnology, Mahatma Gandhi University, Kerala, INDIA*

Abstract
This chapter discuses a brief account on various types of nitrogen containing engineering polymers. Synthesis, morphology, structure, properties and applications of all different types of nitrogen containing engineering polymers are summarized in a concise manner. The new challenges and opportunities are also discussed.

1.1 Polyamide-imides

Polyamide-imides are thermoplastic amorphous polymers that have exceptional mechanical, thermal and chemical resistant properties. These properties put polyamide-imides at the top of the price and performance pyramid. Polyamide-imides are produced by Solvay Advanced Polymers under the trademark Torlon. Other high-performance polymers in this same realm are polyetheretherketones and polyimides. Polyamide-imides hold, as the name suggests, a positive synergy of properties from both polyamides and polyimides, such as high strength, melt processibility, exceptional high heat capability, and broad chemical resistance.

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Polyamide-imide polymers can be processed into a wide variety of forms – from injection or compression molded parts and ingots – to coatings, films, fibers and adhesives. Generally these articles reach their maximum properties with a subsequent thermal cure process.

1.2 Polyetherimide (PEI)

Polyetherimide (PEI) is an amorphous, amber-to-transparent thermoplastic with characteristics similar to the related plastic PEEK. Relative to PEEK, PEI is cheaper, but less temperature-resistant and lower in impact strength. Polyetherimide combines high temperature resistance, rigidity, impact strength, and creep resistance. Glass-fiber-reinforced PEI plastic grades are available for general-purpose molding and extrusion; carbon-fiber-reinforced and other specialty grades also are produced for high-strength applications and PEI itself can be made into a high-performance thermoplastic fiber. PEI has found use in medical applications because of its heat and radiation resistance, hydrolytic stability, and transparency; in the electronics field, it is used to make burn-in sockets, bobbins, and printed circuit substrates; automotive uses include lamp sockets and under-hood temperature sensors; and PEI plastic sheeting is used in aircraft interiors. The PEI's history started in 1970, when USSR researchers (1) introduced the concept that the insertion of a flexible linkage into the polyimide chains considerably decreased glass transition temperatures without significantly lowering of thermal stability. Due to the wide range of PEI's applications, scientists continuously report studies concerning PEI synthesis from new monomers (2–4).

1.3 Poly(ether-block-amide)

Polyether block amide or PEBA is a thermoplastic elastomer (TPE). It is also known under the tradename of PEBAX® (Arkema). It is a block copolymer obtained by polycondensation of a carboxylic acid polyamide (PA6, PA11, PA12) with an alcohol termination polyether (PTMG, PEG). PEBA is a high performance thermoplastic elastomer. It is used to replace common elastomers – thermoplastic polyurethanes, polyester elastomers, and silicones - for these characteristics: lower density among TPE, superior mechanical and dynamic properties (flexibility, impact resistance, energy return, fatigue resistance) and keeping these properties at low temperature (lower than –40 °C), and good resistance against a wide range of chemicals. It is sensitive to UV degradation. Challenging high-performance polymeric materials are in high demand and poly(ether-block-amide) copolymers meet the requirements of advanced applications in various marketplaces. Thermoplastic elastomers with desired final properties can be tailored through addressed interplay of polymer segments having different chemical nature, length, and weight. Insightful investigations have suggested that the micro-phase separated morphology as the major factor for the outstanding properties of these copolymers that are not usually observed for each individual component. Excellent mechanical resistance enhanced chemical inertia and powerful perm-selective transport properties can be regarded as the result of the intricate interplay of the various constituents of these segmented copolymers. Excellent chemical, mechanical and transport properties of these polymers render them challenging systems for a broad range of applications, including high-performance waterproof breathable clothing, barrier films, engineered packaging, membrane separation processes. It is important to add that these materials are being used for many advanced industrial applications, including textile, packaging and medical devices. The latter appears to be a key issue to meet the requirements of advanced applications in textile, construction, food and waste processing, packaging and medical fields.

1.4 Aromatic Polyamides

Poly(amide)s, most commonly called polyamides, are polymers incorporating the amide group in their repeating unit (-CO-NH-) (5). Aromatic polyamides, wholly aromatic polyamides, or aramids, are considered to be high-performance materials owing to their outstanding thermal and mechanical resistance. The high performance properties of these materials can be attributed to their fully aromatic structure and amide linkages, which give rise to stiff rod-like macromolecular chains that interact with each other via strong and highly directional hydrogen bonds. These physical links deeply favor the development of effective crystalline micro-regions or domains, resulting in a compact intermolecular packing and cohesive energy. The better-known