Industrial Polymers, Specialty Polymers, and Their Applications

Plastics Engineering Series

Manas Chanda
Salil K. Roy

CRC Press
Taylor & Francis Group

Industrial Polymers, Specialty Polymers, and Their Applications

Manas Chanda
Salil K. Roy

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

The material was previously published in *Plastics Technology Handbook, Fourth Edition* © Taylor & Francis 2007.

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number-13: 978-1-4200-8058-2 (Hardcover)

Library of Congress Cataloging-in-Publication Data

Chanda, Manas, 1940-
Industrial polymers, specialty polymers, and their applications / Manas Chanda and Salil K. Roy.
p. cm. -- (Plastics engineering ; 73)
Includes bibliographical references and index.
ISBN 978-1-4200-8058-2 (alk. paper)
1. Polymers. 2. Polymers--Industrial applications. I. Roy, Salil K., 1939- II. Title. III. Series.

TP1087.C43 2008
668.9--dc22 2008011622

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com

Industrial Polymers, Specialty Polymers, and Their Applications

PLASTICS ENGINEERING

Founding Editor

Donald E. Hudgin

Professor
Clemson University
Clemson, South Carolina

1. Plastics Waste: Recovery of Economic Value,
   Jacob Leidner
2. Polyester Molding Compounds,
   Robert Burns
3. Carbon Black-Polymer Composites: The Physics of Electrically Conducting Composites,
   edited by Enid Keil Sichel
4. The Strength and Stiffness of Polymers,
   edited by Anagnostis E. Zachariades and Roger S. Porter
5. Selecting Thermoplastics for Engineering Applications,
   Charles P. MacDermott
6. Engineering with Rigid PVC: Processability and Applications,
   edited by I. Luis Gomez
7. Computer-Aided Design of Polymers and Composites,
   D. H. Kaelble
8. Engineering Thermoplastics: Properties and Applications,
   edited by James M. Margolis
9. Structural Foam: A Purchasing and Design Guide,
   Bruce C. Wendle
10. Plastics in Architecture: A Guide to Acrylic and Polycarbonate,
    Ralph Montella
11. Metal-Filled Polymers: Properties and Applications,
    edited by Swapan K. Bhattacharya
12. Plastics Technology Handbook,
    Manas Chanda and Salil K. Roy
13. Reaction Injection Molding Machinery and Processes,
    F. Melvin Sweeney
14. Practical Thermoforming: Principles and Applications,
    John Florian
15. Injection and Compression Molding Fundamentals,
    edited by Avraam I. Isayev
16. Polymer Mixing and Extrusion Technology,
    Nicholas P. Cheremisinoff
17. High Modulus Polymers: Approaches to Design and Development,
    edited by Anagnostis E. Zachariades and Roger S. Porter
18. Corrosion-Resistant Plastic Composites in Chemical Plant Design,
    John H. Mallinson
19. Handbook of Elastomers: New Developments and Technology,
    edited by Anil K. Bhowmick and Howard L. Stephens
20. Rubber Compounding: Principles, Materials, and Techniques,
    Fred W. Barlow

21. Thermoplastic Polymer Additives: Theory and Practice, *edited by John T. Lutz, Jr.*
22. Emulsion Polymer Technology, *Robert D. Athey, Jr.*
23. Mixing in Polymer Processing, *edited by Chris Rauwendaal*
24. Handbook of Polymer Synthesis, Parts A and B, *edited by Hans R. Kricheldorf*
25. Computational Modeling of Polymers, *edited by Jozef Bicerano*
26. Plastics Technology Handbook: Second Edition, Revised and Expanded, *Manas Chanda and Salil K. Roy*
27. Prediction of Polymer Properties, *Jozef Bicerano*
28. Ferroelectric Polymers: Chemistry, Physics, and Applications, *edited by Hari Singh Nalwa*
29. Degradable Polymers, Recycling, and Plastics Waste Management, *edited by Ann-Christine Albertsson and Samuel J. Huang*
30. Polymer Toughening, *edited by Charles B. Arends*
31. Handbook of Applied Polymer Processing Technology, *edited by Nicholas P. Cheremisinoff and Paul N. Cheremisinoff*
32. Diffusion in Polymers, *edited by P. Neogi*
33. Polymer Devolatilization, *edited by Ramon J. Albalak*
34. Anionic Polymerization: Principles and Practical Applications, *Henry L. Hsieh and Roderic P. Quirk*
35. Cationic Polymerizations: Mechanisms, Synthesis, and Applications, *edited by Krzysztof Matyjaszewski*
36. Polyimides: Fundamentals and Applications, *edited by Malay K. Ghosh and K. L. Mittal*
37. Thermoplastic Melt Rheology and Processing, *A. V. Shenoy and D. R. Saini*
38. Prediction of Polymer Properties: Second Edition, Revised and Expanded, *Jozef Bicerano*
39. Practical Thermoforming: Principles and Applications, Second Edition, Revised and Expanded, *John Florian*
40. Macromolecular Design of Polymeric Materials, *edited by Koichi Hatada, Tatsuki Kitayama, and Otto Vogl*
41. Handbook of Thermoplastics, *edited by Olagoke Olabisi*
42. Selecting Thermoplastics for Engineering Applications: Second Edition, Revised and Expanded, *Charles P. MacDermott and Aroon V. Shenoy*
43. Metallized Plastics, *edited by K. L. Mittal*
44. Oligomer Technology and Applications, *Constantin V. Uglea*
45. Electrical and Optical Polymer Systems: Fundamentals, Methods, and Applications, *edited by Donald L. Wise, Gary E. Wnek, Debra J. Trantolo, Thomas M. Cooper, and Joseph D. Gresser*
46. Structure and Properties of Multiphase Polymeric Materials, *edited by Takeo Araki, Qui Tran-Cong, and Mitsuhiro Shibayama*
47. Plastics Technology Handbook: Third Edition, Revised and Expanded, *Manas Chanda and Salil K. Roy*
48. Handbook of Radical Vinyl Polymerization, *edited by Munmaya K. Mishra and Yusef Yagci*

49. Photonic Polymer Systems: Fundamentals, Methods, and Applications,
edited by Donald L. Wise, Gary E. Wnek, Debra J. Trantolo, Thomas M. Cooper, and Joseph D. Gresser
50. Handbook of Polymer Testing: Physical Methods,
edited by Roger Brown
51. Handbook of Polypropylene and Polypropylene Composites,
edited by Harutun G. Karian
52. Polymer Blends and Alloys,
edited by Gabriel O. Shonaike and George P. Simon
53. Star and Hyperbranched Polymers,
edited by Munmaya K. Mishra and Shiro Kobayashi
54. Practical Extrusion Blow Molding,
edited by Samuel L. Belcher
55. Polymer Viscoelasticity: Stress and Strain in Practice,
Evaristo Riande, Ricardo Díaz-Calleja, Margarita G. Prolongo, Rosa M. Masegosa, and Catalina Salom
56. Handbook of Polycarbonate Science and Technology,
edited by Donald G. LeGrand and John T. Bendler
57. Handbook of Polyethylene: Structures, Properties, and Applications,
Andrew J. Peacock
58. Polymer and Composite Rheology: Second Edition, Revised and Expanded,
Rakesh K. Gupta
59. Handbook of Polyolefins: Second Edition, Revised and Expanded,
edited by Cornelia Vasile
60. Polymer Modification: Principles, Techniques, and Applications,
edited by John J. Meister
61. Handbook of Elastomers: Second Edition, Revised and Expanded,
edited by Anil K. Bhowmick and Howard L. Stephens
62. Polymer Modifiers and Additives,
edited by John T. Lutz, Jr., and Richard F. Grossman
63. Practical Injection Molding,
Bernie A. Olmsted and Martin E. Davis
64. Thermosetting Polymers,
Jean-Pierre Pascault, Henry Sautereau, Jacques Verdu, and Roberto J. J. Williams
65. Prediction of Polymer Properties: Third Edition, Revised and Expanded,
Jozef Bicerano
66. Fundamentals of Polymer Engineering,
Anil Kumar and Rakesh K. Gupta
67. Handbook of Polypropylene and Polymer,
Harutun Karian
68. Handbook of Plastic Analysis,
Hubert Lobo and Jose Bonilla
69. Computer-Aided Injection Mold Design and Manufacture,
J. Y. H. Fuh, Y. F. Zhang, A. Y. C. Nee, and M. W. Fu
70. Handbook of Polymer Synthesis: Second Edition,
Hans R. Kricheldorf and Graham Swift
71. Practical Guide to Injection Blow Molding,
Samuel L. Belcher
72. Plastics Technology Handbook: Fourth Edition,
Manas Chanda and Salil K. Roy
73. Industrial Polymers, Specialty Polymers, and Their Applications,
Manas Chanda and Salil K. Roy
74. Plastics Fundamentals, Properties, and Testing,
Manas Chanda and Salil K. Roy
75. Plastics Fabrication and Recycling,
Manas Chanda and Salil K. Roy

Preface

The polymer industry consumes more than half of the total output of the organic chemical industry, but only a few polymers account for most of it. For example, the combined output of polypropylene, high-density polyethylene, and linear low-density polyethylene, all produced by polymerization with transition-metal catalysts, was responsible for 42% of the 41 million metric tons of thermoplastic resins produced in the United States in the year 2000, while another 40% represented a handful of polymers that are produced using a free-radical mechanism, namely, low-density polyethylene, poly (vinyl chloride), polystyrene, poly(vinyl alcohol), poly(methyl methacrylate), and poly(vinyl acetate). Most of the remaining 18% corresponded to polyurethanes and a few condensation polymers, such as poly(ethylene terephthalate), poly(butylene terephtahalate), polyamides, and polycarbonates. Even the period from 2000 to 2005, which witnessed considerable stress and change in the U.S. chemical industry, did not cause any significant change in the landscape (Villa, C. M. 2007. *Ind. Eng. Chem. Res.*, 46, 5815–5823). In the present book, all these polymers are prominently discussed in Chapter 1, which also includes other less widely used polymer types such as acrylics, ether polymers, cellulosics, sulfide polymers, silicones, polysulfones, polyether ether ketones, and polybenzimidazoles. Polyblends and interpenetrating network polymers are also included in this chapter.

Besides the aforesaid industrial polymers, most of which we often encounter in everyday life, there are hundreds of other polymers, polymer derivatives, and polymeric combinations that play special and often critical roles in diverse fields of human activities. Chapter 2 deals with such polymers. Some of these *specialty polymers* possess, inherently, one or more special properties that make them indispensable for specific applications, while there are many others that are tailor-made or made by modification of the aforesaid industrial polymers to meet specific and critical needs. For a systematic discussion, these polymers can be placed in different groups according to their properties and/or areas of uses, such as high-temperature and fire-resistant polymers, liquid crystal polymers, electroactive polymers, electrolytic polymers, photoresist polymers, ionic and ion-exchange polymers, packaging polymers, biodegradable polymers, adhesive polymers, polymers in optical information storage, polymeric sensors, conductive fiber fillers, polymeric optical fibers, polymer electrolyte membranes, biodegradable polymer scaffolds, scavenger resins, permselective polymer membranes, hydrogels, smart polymers, dendritic polymers, shape memory polymers, microencapsulation polymers, polymer nanocomposites, wood–polymer composites, and polymerization-filled composites.

As we live in a plastic age, the diverse fields of plastics technology are also undergoing rapid change both qualitatively and quantitatively with many newer applications of common polymers and specialty polymers coming to light. While there are continuous improvements in the established uses of polymers, new uses are being developed in such diverse areas as the automotive and aerospace industries, packaging, agriculture, horticulture, domestic and sports appliances, office equipment,

communication, electronics and electrical technology, and biomedical applications. Chapter 3 presents a comprehensive overview of new developments in polymer uses in all these areas.

The material in this book is included in our well-known *Plastics Technology Handbook* and it focuses on a wide range of polymers, both of common and special types, and their myriad applications. For readers who are not quite familiar with polymers and their characteristics, it would be advisable to read *Plastics Fundamentals, Properties, and Testing*, before taking up the present book. We thank Allison Shatkin, Materials Science and Chemical Engineering Editor at CRC Press/Taylor & Francis, who first conceived the idea of this book and took the initiative in publishing it.

Manas Chanda
Salil K. Roy

Authors

Manas Chanda has been a professor and is presently an emeritus professor in the Department of Chemical Engineering, Indian Institute of Science, Bangalore, India. He also worked as a summer-term visiting professor at the University of Waterloo, Ontario, Canada with regular summer visits from 1980 to 2000. A five-time recipient of the International Scientific Exchange Award from the Natural Sciences and Engineering Research Council, Canada, Dr. Chanda is the author or coauthor of nearly 100 scientific papers, articles, and books, including *Introduction to Polymer Science and Chemistry* (CRC Press/Taylor & Francis). A fellow of the Indian National Academy of Engineers and a member of the Indian Plastics Institute, he received a BS (1959) and MSc (1962) from Calcutta University, and a PhD (1966) from the Indian Institute of Science, Bangalore, India.

Salil K. Roy is a professor in the Postgraduate Program in Civil Engineering of the Petra Christian University, Surabaya, Indonesia. Earlier he worked as lecturer, senior lecturer, and associate professor at the National University of Singapore. Prior to that he was a research scientist at American Standard, Piscataway, New Jersey.

Dr. Roy is a fellow of the Institution of Diagnostic Engineers, U.K., and has published over 250 technical papers in professional journals and conference proceedings; he also holds several U.S. Patents. He received a BSc (1958) and MSc (Tech.) (1961) from the University of Calcutta, India, and a ScD (1966) from the Massachusetts Institute of Technology, Cambridge, Massachusetts. Dr. Roy is a subject of biographical record in the prestigious *Great Minds of the 21st Century* published by the American Biographical Institute, *Who's Who in the World* published by the Marquis Who's Who in the World, and *2000 Outstanding Intellectuals of the 21st Century* published by the International Biographical Centre, Cambridge, England.

A1

Trade Names for Some Industrial Polymers

Trade Name	Company	Type of Polymer
Abson	B. F. Goodrich	Acrylonitrile–butadiene–styrene terpolymer
Aclar, Aclon	Allied	Polychlorotrifluoroethylene
Acraldon	Bayer	Ethylene–vinyl acetate copolymers
Acrylan	Monsanto	Acrylic fiber
Acrylite	Cyanamid/Rohm	Acrylic resin
Acrypanel	Mitsubishi	Poly(methyl methacrylate)
Adiprene	Du Pont	Polyurethanes
Afcoryl	Pechiney–Saint-Gobain	Acrylonitrile–butadiene–styrene terpolymer
Aflas	Asahi Glass	Tetrafluorethylene–propylene+cure site monomer terpolymer
Aflon	Ashai Glass	Tetrafluoroethylene–ethylene copolymer
Akulon	Akzo	Nylon-6
Alathon	Du Pont	Low-density polyethylene
Algoflon	Montedison	Polytetrafluoroethylene
Alkathene	ICI	Low-density polyethylene
Alkox	Meisei Chemical Works	Poly(ethylene oxide)
Alloprene	ICI	Chlorinated natural rubber
Alpolit	Hoechst	Unsaturated polyester resins
Amberlite	Rohm & Haas	Ion-exchange resin
Ameripol-CB	B. F. Goodrich	Polybutadiene
Amidel	Union Carbide	Transparent amorphous Polyamide
Amilan, Amilon	Toray	Nylon-6
Antron	Du Pont	Polyamide fiber
Araldite	Ciba–Geigy	Epoxy resin
Ardel	Union Carbide	Polyarylate
Arnite	Akzo	Poly(ethylene terephthalate)
Arnite E	Akzo	Thermoplastic polyester elastomers
Arnite PBTP	Akzo	Poly(butylenes terephthalate)
Arnitel	Akzo	Thermoplastic polyester elastomer
Arotone	Du Pont	Polyaryletherketones (PEEK)
Arylef	Solvay	Polyarylate
Arylon	Du Pont	Polyarylates
Astrel	3M	Polyarylsulfone
Avimid	Du Pont	Polyimide

(continued)

Trade Name	Company	Type of Polymer
Bayblend	Bayer	Polycarbonate/ABS blend
Baygal, Baymidur	Bayer	Polyurethane casting resins
Baylon	Bayer	Polycarbonate
Baypern	Bayer	Polychloroprene
Beetle	British Industrial Plastics	Urea–formaldehyde resin
Benvic	Solvay	Poly(vinyl chloride)
Bipeau	Ato Chimie	Poly(vinyl chloride) (PVC)
Blendex	G.E.	Acrylonitrile–polybutadiene–styrene graft copolymers
Budene	Goodyear	Polybutadiene
Buna-N	Chem. Werke Hüls	Butadiene–acrylonitrile copolymer
Buna-S	Chem. Werke Hüls	Butadiene–styrene copolymer
Butacite	Du Pont	Poly(vinyl butyral)
Butakon	ICI	Butadiene copolymers
Butaprene	Firestone	Styrene–butadiene copolymers
Butvar	Shawinigan	Poly(vinyl butyral)
BXL	Union Carbide	Polysulfone
Cabelec	Cabot	Ethylene–vinyl acetate copolymers
Caprolan	Allied	Polyamide fiber
Capron	Allied	Polyamide resin
Caradol	Shell	Polyhydroxy compound for isocyanate cross-linking
Carbopol	B. F. Goodrich	Acrylic polyelectrolyte
Carboset	B. F. Goodrich	Acrylic polyelectrolyte
Carbowax	Union Carbide	Poly(ethylene oxide)
Cariflex I	Shell	*cis*-1,4-polyisoprene
Carina	Shell	Poly(vinyl chloride)
Carinex	Shell	Polystyrene
Cebian	Daicel	Styrene–acrylonitrile copolymers
Celanex	Celanese	Poly(butylene terephthalate)
Celcon	Celanese	Polyacetal
Cellioder B	Bayer	Cellulose acetate–butyrate
Cellit	Bayer	Cellulose acetate
Cellon	Dynamit-Nobel	Cellulose acetate
Cellosize	Union Carbide	Hydroxyethylcellulose
Celluloid	Dynamit Nobel	Cellulose nitrate plasticized with camphor
Chemfluor	Norton/Chemplast	Polyvinylidene fluoride
Chemigum	Goodyear	Polyurethane rubber
Cibamin	Ciba–Geigy	Urea–formaldehyde, melamine-formaldehyde resins
Cibanoid	Ciga-Geigy	Urea–formaldehyde resin
cis-4	Phillips	*cis*-1,4-polybutadiene
Clariflex TR	Shell	Styrene–diene–styrene triblock elastomer
Cobex	Bakelite Xylonite	Poly(vinyl chloride)
Colcolor	Degussa	Ethylene–vinylacetate copolymers
Coral	Firestone	*cis*-1,4-polyisoprene
Cordura	Du Pont	Polyamide fiber
Corvic	ICI	Poly(vinyl chloride)
Courtelle	Courtaulds	Polyacrylonitrile
Crastin	Ciba–Geigy	Poly(butylene terephthalate)
Craston	Ciba–Geigy	Polyphenylene sulfide
Creslan	Cyanamid	Acrylic fiber
Crofon	Du Pont	Poly(methyl methacrylate)
Crystic	Scott Bader	Polyester resins

(continued)

Trade Name	Company	Type of Polymer
Cyanaprene	American Cyanamid	Polyurethane casting resins
Cycolac	G.E.	Acrylonitrile–butadiene–styrene graft copolymers
Cymel	Cyanamid	Melamine–formaldehyde resin
Cyrolite	Röhm	Styrene–polybutadiene graft copolymers
Dacron	Du Pont	Poly(ethylene terephthalate) fiber
Daltocel	ICI	Rigid polyurethane foams
Daltoflex I	ICI	Polyurethane rubber
Dapon	FMC Corp.	Diallyl phthalate resins
Darvic	ICI	Poly(vinyl chloride)
De-acidite	Permutit Co.	Ion-exchange resin
Degaplast, Deglas	Degussa	Poly(methyl methacrylate)
Delmer, Delpet	Asahi Chemical	Poly(methyl methacrylate)
Delrin	Du Pont	Polyacetal
D.E.R.	Dow	Epoxy resin
Desmobond	Mobay	Epoxide resins
Desmopan	Bayer	Thermoplastic polyurethane elastomers
Desmophen	Bayer	Rigid polyurethane foams
Desmophen A	Bayer	Polyurethane rubber
Diakon	ICI	Poly(methyl methacrylate) molding powder
Diene	Firestone	Polybutadiene
Diofan	BASF	Vinyl chloride–vinylidene chloride–acrylonitrile copolymers
Diolen	ENKA-Glazstaff	Poly (ethylene terephthalate)
Dobeckot	BASF	Epoxide resins
Doctolex	Mitsubishi	Polyaryletherketones (PEEK)
Dorlastan	Bayer	Spandex fiber
Dowex	Dow	Ion-exchange resin
Dowlex	Dow	LLDPE
Duolite	Chemical Process Co.	Ion-exchange resins
Duracon	Daicel Polyplastics	Polyacetal
Durel	Hooker	Polyarylate
Durethan	Bayer	Nylon-6
Durethan A	Bayer	Nylon-6,6
Durethan B	Bayer	Nylon-6
Durethan U	Bayer	Thermoplastic polyurethanes
Durez	Occidental Chemical Corp.	Phenol–formaldehyde resins
Dutral	Montecatini	Ethylene–propylene copolymer
Dycryl	Du Pont	Photopolymer system
Dyflor	Dynamit Nobel	Poly(vinylidene fluoride)
Dylene	Arco Chemical	Styrene homopolymers
Dynel	Union Carbide	Vinyl chloride–acrylonitrile copolymer
Dynyl	Rhone-Poulenc	Elastomeric polyamides, copolyamides
Eccofoam	American Micro	Rigid polyurethane foam
Ecdel	Eastman Chem. Products	Thermoplastic polyester elastomer
Econol	Carborundum	Poly(*p*-hydroxybenzoic acid ester)
Ekcel	Carborundum	Aromatic polyester
Ekonol	Carborundum	Polycarbonate
Ektar	Eastman Chem. Intern.	Polyphenylenesulfide
Elvacet	Du Pont	Poly(vinyl acetate)
Elvanol	Du Pont	Poly(vinyl alcohol)
Elvic	Solvay	Poly(vinyl chloride)
Encron	Akzo	Polester fiber
Ensolite	Uniroyal	Poly(vinyl chloride)

(continued)

Trade Name	Company	Type of Polymer
Epicote	Dow	Epoxide resins
Epodite	Showa Highpolymer	Epoxide resins
Epon	Shell	Epoxide resins
Epi-Rez	Celanese	Epoxide resins
Escor	Exxon	Ethylene–vinyl acetate copolymers
Escorene	Exxon	Polyethylenes
Eska	Mitsubishi	Poly(methyl methacrylate)
Estamid	Upjohn	Nylon-12 elastomers
Estane	B. F. Goodrich	Thermoplastic polyurethane elastomer
Estar	Eastman Kodak	Polyester film
Etar	Eastman Chem. Intern.	Polyethylene terephthalate
Ethocel	Dow	Ethylcellulose
Evatane	Ato Chimie	Ethylene–vinyl acetate copolymers
Evatate	Sumitomo	Ethylene–vinyl acetate copolymers
Extrel	Exxon	Polypropylene
Fertene	Himont	Polyethylenes (HD, LD)
Fiberloc	B. F. Goodrich	Poly(vinyl chloride)
Flemion	Asahi Glass	Carboxylated fluoropolymer
Flovic	ICI	Poly(vinyl acetate)
Fluon	ICI	Polytetrafluoroethylene
Fluorel	3M	Vinylidene fluoride–hexafluoropropylene copolymer
Foraflon	Ato Chimie	Polytetrafluoroethylene
Formica	Cyanamid	Melamine–formaldehyde resin
Forticel	Celanese	Cellulose propionate
Fortron	Hoechst	Polyphenylenesulfide
Gafite	Hoechst	Poly(butylenes terephthalate)
Gaflex	Hoechst	Thermoplastic polyester elastomers
Gaftuf	Hoechst	Poly(butylenes terephthalate)
Gecet	G.E.	Polyphenylene ether
Geloy	G.E.	Styrene–acrylonitrile copolymers
Gelvatol	Shawinigan	Poly(vinyl alcohol)
Genal	G.E.	Phenol–formaldehyde resins
Genopak, Genotherm	Hoechst	Poly(vinyl chloride)
Geon	B. F. Goodrich	Poly(vinyl chloride)
Grilamid	Ems Chemie	Nylon-12
Grilamid ELY 60	Ems Chemie	Polyamide elastomers
Grilamid TR	Emser Werke	Transparent amorphous polyamide
Grilon	Ems Chemie	Nylon-6
Grilonit	Ems Chemie	Epoxide resins
Grilpet	Ems Chemie	Poly(ethylene terephthalate)
Halar	Ausimont	Ethylene–chlorotrifluoroethylene copolymer
Halon	Ausimont	Polytetrafluoroethylene
Herculoid	Du Pont	Celulose nitrate
H-film	Du Pont	Polyamide from pyromellitic anhydride and 4,4′-diaminodiphenyl ether
Hi-fax	Hitachi	Polyethylene
Hitalex	Hitachi	Polyethylene
Hostadur	Hoechst	Poly (ethylene terphthalate)
Hostaflon ET	Hoechst	Tetrafluoroethylene–ethylene copolymer
Hostaflon FEP	Hoechst	Tetrafluoroethylene–hexafluoropropylene copolymer
Hostaflon TF	Hoechst	Polytetrafluoroethylene
Hostaflon TFA	Hoechst	Perfluoroalkoxy copolymers

(continued)

Trade Name	Company	Type of Polymer
Hostaform	Hoechst	Polyoxymethylene
Hostalen	Hoechst	Polyethylenes (HD, LD)
Hostalen GUR	Hoechst	Ultrahigh-molecular weight polyethylene
Hostalen PP	Hoechst	Polypropylene
Hostalit	Hoechst	Poly(vinyl chloride) and blends
Hostamid	Hoechst	Transparent amorphous polyamide
Hostatec	Hoechst	Polyether ketone
Hycar	B. F. Goodrich	Polyacrylate
Hydrin	B. F. Goodrich	Epichlorohydrin rubber
Hylar	Du Pont	Poly(ethylene terephthalate)
Hypalon	Du Pont	Sulfochlorinated polyethylene
Hytrel	Du Pont	Thermoplastic polyester elastomers
Hyvis	BP Chemicals	Polyisobutylene
Icdal Ti40	Dynamit Nobel	Polyesterimide
Impet	Hoechst	Poly(ethylene terephthalate)
Ionac	Ionac Co.	Ion-exchange resins
Irrathene	G.E.	PE, cross-linked by radiation
Isonol	Dow	Rigid polyurethane foams
Ixan	Solvay	Vinyl chloride–vinylidene chloride–acrylonitrile copolymers
Ixef	Solvay	Aromatic polyamide
Jupilon	Mitsubishi	Polycarbonate
Kadel	Amoco	Polyaryletherketones (PEEK)
Kalrez	Du Pont	Fluoroelastomer
Kamax	Rohm & Hass	Polyacrylic esterimide
Kapton	Du Pont	Polyimide film
Kardel	Union Carbide	Styrene homopolymers
Kel-F	3M	Polychlorotrifluoroethylene, poly(vinyl fluoride)
Kel-F elastomer	3M	Vinylidene fluoride–chlorotrifluoroethylene copolymer
Kematal	Hoechst	Acetal homopolymers
Kermel	Rhone-Poulenc	Polyimide fiber
Kerimid	Rhone-Poulenc	Polimide
Kinel	Rhone-Poulenc	Polybismaleinimide
Kodapak	Eastman Chem. Intern.	Poly(butylenes terephthalate)
Kodar PETG	Eastman Chem. Intern.	Copolyester based on 1,4-cyclohexylene glycol and a mixture of terephthalic and isophthalic acids
Kodel	Eastman Chem. Intern.	Polyester fiber
Kralastic	Uniroyal	Acrylonitrile–butadiene–styrene copolymer
Kraton	Shell	Thermoplastic styrene block copolymer
Kuralon	Kuraray (Japan)	Poly (vinyl alchol) fiber
Kynar	Pennwalt	Poly(vinylidene fluoride)
Laminac	Cyanamid	Polyester resins
Leguval	Bayer	Unsaturated polyester resins
Lekutherm	Bayer	Epoxide resins
Levapren	Bayer	Ethylene–vinyl acetate copolymer
Levasint	Bayer	Ethylene–vinyl alcohol copolymers
Lewatit	Bayer	Ion-exchange resins
Lexan	G.E.	Polycarbonate
Localen	BASF	Ethylene–vinyl acetate copolymers
Lomod	G.E.	Thermoplastic polyester elastomers

(continued)

Trade Name	Company	Type of Polymer
Lucite	Du Pont	Poly(methyl methacrylate) and copolymers
Lucryl	BASF	Poly(methyl methacrylate)
Lupolen	BASF	Ethylene–vinyl acetate copolymers
Luran	BASF	Styrene–acrylonitrile copolymers
Luranyl	BASF	Poly(ethylene oxide) blend
Lustran	Monsanto	Acrylonitrile–butadiene–styrene terpolymer
Lustrex	Monsanto	Polystyrene
Lycra	Du Pont	Spandex fiber
Makrolon	Röhm	Polycarbonate
Maplen	Himont	Polyethylenes (HD, LD)
Maranyl	ICI	Nylon-6
Maranyl A	ICI	Nylon-6,6
Marlex	Phillips	Polyethylene, polypropylene
Marlex TR 130	Phillips	Polyethylene (LLD)
Melinar, Melinite	ICI	Poly(ethylene terephthalate)
Melinex	ICI	Polyester film
Melopas	Ciba–Geigy	Melamine–formaldehyde resins
Merlon	Mobay	Polycarbonate
Methocel	Dow	Methyl cellulose
Minlon	Du Pont	Nylon-6,6
Moltopren	Bayer	Rigid polyurethane foam
Moplen	Himont	Polypropylene
Mowicoll	Hoechst	Poly(vinyl acetate) dispersions
Mowilith	Hoechst	Poly(vinyl acetate)
Mowiol	Hoechst	Poly(vinyl alcohol)
Mowital	Hoechst	Poly(vinyl butyral)
Mylar	Du Pont	Poly(ethylene terephthalate) film
Nafion	Du Pont	Persulfonated fluoropolymer
Nalcite	National Aluminate Corp.	Ion-exchange resins
Napryl	Pechiney–Saint-Gobain	Polypropylene
Natene	Pechiney–Saint-Gobain	Polyethylenes
Natsyn	Goodyear	Polyisoprene
Necofene	Ashland	Polyphenylene ether
Neosepta F	Tokoyama Soda	Ionic membrane (based on fluoropolymer)
Nikalet	Nippon Carbide	Epoxide resins
Nipoflex	Toyo Soda	Ethylene–vinyl acetate copolymer
Nipolon	Toyo Soda	Polyethylenes (HD, LD)
Nitron	Monsanto	Cellulose nitrate
Noblen	Mitsubishi	Polypropylene
Nolimid (adhesives)	Rhone-Poulenc	Polybismaleinimide
Nomex	Du Pont	Poly(*m*-phenylene isophthalimide)
Nordel	Du Pont	Ethylene–propylene–diene terpolymer
Noryl	G.E	Poly(phenylene oxide)–polystyrene blend
Novadur	Mitsubishi	Poly(butylene terephthalate)
Novarex	Mitsubishi	Polycarbonate
Novatec	Mitsubishi	Polypropylene, polyethylenes (HD, LD)
Novatex	Mitsubishi	Polyethylene (LLD)
Novex	BP Chemicals	Polyethylenes (HD, LD)
Novodur	Bayer	Acrylonitrile–polybutadiene–styrene graft copolymers
Oppanol B	BASF	Polyisobutylene
Oppanol C	BASF	Poly(vinyl isobutyl ether)

(continued)

Trade Name	Company	Type of Polymer
Oppanol O	BASF	Copolymer from 90% isobutylene and 10% styrene
Orgalan	Ato Chimie	Polycarbonate
Orgamide	Ato Chimie	Nylon-6
Orgavyl	Ato Chimie	Poly(vinyl chloride)
Orlon	Du Pont	Acrylic fiber
Oroglas	Rohm & Haas	Poly(methyl methacrylate)
Paraglas	Degussa	Poly(methyl methacrylate)
Paraplex	Rohm & Haas	Epoxide resins
Parapol	Exxon	Polyisobutylene
Parlon	Hercules	Chlorinated rubber
Paxon	Allied	Polyethylene
Pebax	Ato Chimie	Polyamide elastomers
Pelaspan	Dow	Polystyrene (expandable)
Pelprene	Toyobo	Thermoplastic polyurethane elastomer
Perbunan N	Bayer	Butadiene–acrylonitrile copolymers
Perlenka	Akzo	Nylon-6
Permutit	Permutit Co.	Ion-exchange resins
Perspex	ICI	Poly(methyl methacrylate) sheet
Petlon	Mobay	Poly(ethylene terephthalate)
Petra	Allied Signal	Poly(ethylene terephthalate)
Petrothene	USI Chemical	Polyethylenes (HD, LD, LLD)
Pevalon	May & Baker	Poly(vinyl alcohol)
Plastazote	American Micro	Polyethylene foam
Plexiglas	Rohm & Haas	Poly(methyl methacrylate)
Plexigum	Rohm & Haas	Acrylate and methacrylate resins
Pliofilm	Goodyear	Rubber hydrochloride
Pliolite	Goodyear	Styrene–butadiene copolymers
Pliovic	Goodyear	Poly(vinyl chloride)
Pocan	Bayer	Poly(butylenes terephthalate)
Polybond	BP Chemicals	Ethylene–vinyl acetate copolymers
Polycal	Ato Chimie	Poly(vinyl chloride)
Poly-Eth	Gulf Oil	Polyethylene
Polymidal	Raychem	Polyimide
Polymin	BASF	Polyethyleneimine
Polyox	Union Carbide	Poly(ethylene oxide)
PolyPro	Mitsui Petrochemcial	Polypropylene
Polysizer	Showa Highpolymer	Poly(vinyl alcohol)
Polythene	Du Pont	Low-density polyethylene
Polyviol	Wacker Chemie	Poly(vinyl alcohol)
Prevex	Borg Warner	Poly(phenylene oxide) blend
Prodorit	T.I.B. Chemie	Epoxide resins
Profax	Himont	Polypropylene
Propathene	ICI	Polypropylene
Pulse	Dow	(ABS+Polycarbonate) polymer blends
Pyralin	Du Pont	Polyimide
Pyre ML	Du Pont	Polyimide coating
Qiana	Du Pont	Polyamide fiber from bis(*p*-aminocyclohexyl)methane and dodecanedioic acid
Radel	Union Carbide	Polyether sulfone
Ravinil	EniChem	Poly(vinyl chloride)
Resolite	Ciba–Geigy	Urea–formaldehyde resin
Rilsan A	Ato Chimie	Nylon-12
Rilsan B	Ato Chimie	Nylon-11
Rimplast	Petrarch Systems	Silicone resins and molding compounds

(continued)