POLYMER BLENDS:
FORMULATION
POLYMER BLENDS

Volume 1: Formulation

Edited by

D. R. Paul
Department of Chemical Engineering
and Texas Materials Institute
The University of Texas at Austin
Austin, TX 78712-1062

C. B. Bucknall
School of Industrial and Manufacturing Science
Cranfield University
Cranfield, Bedford MK43 0AL, United Kingdom
Contents

<table>
<thead>
<tr>
<th>Preface</th>
<th>vii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributors, Volume 1</td>
<td>ix</td>
</tr>
<tr>
<td>Contents, Volume 2</td>
<td>xi</td>
</tr>
<tr>
<td>Contributors, Volume 2</td>
<td>xiii</td>
</tr>
<tr>
<td>1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td><em>D. R. Paul and C. B. Bucknall</em></td>
<td></td>
</tr>
<tr>
<td>THERMODYNAMICS</td>
<td></td>
</tr>
<tr>
<td>2 Statistical Thermodynamics of Polymer Solutions and Blends</td>
<td>15</td>
</tr>
<tr>
<td><em>I. C. Sanchez and M. T. Stone</em></td>
<td></td>
</tr>
<tr>
<td>3 Polymer–Polymer Interactions Based on Mean Field Approximations</td>
<td>55</td>
</tr>
<tr>
<td><em>G. D. Merfeld and D. R. Paul</em></td>
<td></td>
</tr>
<tr>
<td>4 Hydrogen Bonding Systems</td>
<td>93</td>
</tr>
<tr>
<td><em>P. C. Painter and M. M. Coleman</em></td>
<td></td>
</tr>
<tr>
<td>5 Polymer Blends as Viewed by Analogue Calorimetry</td>
<td>141</td>
</tr>
<tr>
<td><em>C. J. T. Landry</em></td>
<td></td>
</tr>
<tr>
<td>6 Crystalline Polymer Blends</td>
<td>167</td>
</tr>
<tr>
<td><em>J. P. Runt</em></td>
<td></td>
</tr>
<tr>
<td>7 Fundamentals of Blends of Rigid-Chain (Liquid Crystal) Polymers</td>
<td>187</td>
</tr>
<tr>
<td><em>M. Ballauff and J. R. Dorgan</em></td>
<td></td>
</tr>
<tr>
<td>8 Thermodynamics of Polyolefin Blends</td>
<td>219</td>
</tr>
<tr>
<td><em>D. J. Lohse and W. W. Graessley</em></td>
<td></td>
</tr>
<tr>
<td>CHARACTERIZATION</td>
<td></td>
</tr>
<tr>
<td>9 Morphology Characterization by Microscopy Techniques</td>
<td>239</td>
</tr>
<tr>
<td><em>S. Y. Hobbs and V. H. Watkins</em></td>
<td></td>
</tr>
</tbody>
</table>
Preface

The field of polymer blends, or alloys, has experienced enormous growth in size and sophistication over the past two decades in terms of both the scientific base and technological and commercial development. It has become clear to us that an appropriate summary of this progress is needed to educate and to guide professionals working in this area into the twenty-first century. This two-volume set is a multiauthored treatise that might be viewed as an updated version of the analogous set edited by Paul and Newman and published in 1978. (See the reading list at the end of Chapter 1.)

The book is intended to be a coherent entity rather than a collection of separate chapters, and a great deal of effort has been devoted to coordinating the content and style of the chapters. The editors intended each chapter to be far more than an encyclopedic summary of the literature or a review focusing only on the most recent advances in research. The authors were asked (a) to provide enough background in each chapter to enable beginners to work in the field by reading this book; (b) to sift critically through the literature and present only the most important issues (not every reference deserves mention); and (c) to write clearly but concisely, using carefully selected graphics, in order to make the important conceptual points and capture the attention of the browser.

It is the goal of these two volumes to be the authoritative source that professionals of the next decades will seek out to learn about this important field and use to set directions for future research and product development. The two volumes are roughly equal in length. Volume 1 is subtitled Formulation and is largely about the physics, chemistry, and processing issues associated with the formation of polymer blends and the evaluation and control of their structure. Volume 2 is subtitled Performance and is primarily concerned with how blends perform in practical situations. Naturally, there is a heavy emphasis on mechanical performance, but several chapters deal with a range of other properties as well. At some risk of oversimplification, it can be said that Volume 1 is about structure, while Volume 2 is about properties. Thus, the two-volume set provides a broad view of the structure–property relationships for polymer blends as seen by experts from around the world.

The editors have been friends and colleagues for many years. Their professional interests have been somewhat different over their careers, but there are many points of intersection. These differences and similarities have been helpful during the course of planning, which started in early 1994, and development of this book. A common view was needed in order to foster agreement on the scope, content, and choice of
authors. The differences in expertise led Don Paul to have primary responsibility for Volume 1 and Clive Bucknall to oversee Volume 2.

We are thankful to many colleagues and friends who have encouraged us and given us advice on many issues.

D. R. PAUL
C. B. BUCKNALL
Contributors, Volume 1

V. ARRIGHI, Department of Chemistry, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS, United Kingdom

M. BALLAUFF, Polymer-Institut der Universität Karlsruhe, Kaiserstrasse 12, 76128 Karlsruhe, Germany

J. M. BRADY, Plastics Additives Research Department, Rohm and Haas Company Research Laboratories, Bristol, PA 19007

C. B. BUCKNALL, School of Industrial and Manufacturing Science, Cranfield University, Cranfield, Bedford MK43 0AL, United Kingdom

D. G. BUCKNALL, Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, United Kingdom

M. M. COLEMAN, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802

C. A. CRUZ-RAMOS, Plastics Additives Research Department, Rohm and Haas Company Research Laboratories, Bristol, PA 19007

J. R. DORGAN, Chemical Engineering Department, Colorado School of Mines, Golden, CO 80401

B. D. FAVIS, Department of Chemical Engineering, University of Montréal, Ecole Polytechnique, Montréal, Québec H3C 3A7, Canada

W. W. GRAESSLEY, Department of Chemical Engineering, Princeton University, Princeton, NJ 08544

G. GROENINCKX, Department of Chemistry, Laboratory of Macromolecular Structural Chemistry, Catholic University of Leuven, B-3001 Heverlee, Belgium

S. Y. HOBBS, General Electric Company, Research and Development Center, Schenectady, NY 12301

S. D. HUDSON, Department of Macromolecular Science and Engineering, Case Western Reserve University, Cleveland, OH 44106

T. INOUE, Department of Organic and Polymeric Materials, Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152-8552, Japan
A. M. Jamieson, Department of Macromolecular Science and Engineering, Case Western Reserve University, Cleveland, OH 44106

D. S. Kalika, Department of Chemical and Materials Engineering, University of Kentucky, Lexington, KY 40506

T. Kyu, Institute of Polymer Engineering, University of Akron, Akron, OH 44325

C. J. T. Landry, Imaging Research Laboratories, Eastman Kodak Company, Rochester, NY 14650

D. J. Lohse, Corporate Research Labs, Exxon Research & Engineering Co., Annandale, NJ 08801

B. Majumdar, GE Plastics, Selkirk, NY 12158

G. D. Merfeld, General Electric Co., Research and Development Center, Schenectady, NY 12301

P. C. Painter, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802

J. P. Pascault, Institut National des Sciences Appliquées, Laboratoire des Matériaux Macromoléculaires, 69621 Villeurbanne Cedex, France

D. R. Paul, Department of Chemical Engineering and Texas Materials Institute, The University of Texas at Austin, Austin, TX 78712

J. P. Runt, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802

I. C. Sanchez, Department of Chemical Engineering, The University of Texas at Austin, Austin, TX 78712

M. Sarkissova, Department of Chemistry, Laboratory of Macromolecular Structural Chemistry, Catholic University of Leuven, B-3001 Heverlee, Belgium

M. T. Stone, Department of Chemical Engineering, The University of Texas at Austin, Austin, TX 78712

S. Thomas, Department of Chemistry, Laboratory of Macromolecular Structural Chemistry, Catholic University of Leuven, B-3001 Heverlee, Belgium

V. H. Watkins, General Electric Company, Research and Development Center, Schenectady, NY 12301

R. J. J. Williams, Institute of Materials Science and Technology (INTEMA), University of Mar del Plata and National Research Council (CONICET), 7600 Mar del Plata, Argentina
Contents, Volume 2

Preface vii
Contributors, Volume 2 ix
Contents, Volume 1 xi
Contributors, Volume 1 xiii

MECHANICAL PROPERTIES AND FRACTURE RESISTANCE

19 Quasielastic Mechanical Properties 1
   F. J. Guild

20 Application of Fracture Mechanics for Characterization of Toughness of Polymer Blends 17
   Y.-W. Mai, S.-C. Wong, and X.-H. Chen

21 Characterizing Toughness using Standard Empirical Tests 59
   C. B. Bucknall

22 Deformation Mechanisms in Rubber-Toughened Polymers 83
   C. B. Bucknall

23 Strengthening Polymer-Polymer Interfaces 119
   H. R. Brown

24 Core–Shell Impact Modifiers 137
   C. A. Cruz-Ramos

25 Toughening Semicrystalline Thermoplastics 177
   R. J. Gaymans

26 Toughening of Epoxies 225
   A. F. Yee, J. Du, and M. D. Thouless

27 Fatigue-Crack Propagation in Polymer Blends 269
   R. A. Pearson and L. Pruitt
BLENDBING FOR SPECIFIC PERFORMANCE

28 Transmission and Reflection of Light in Multiphase Media
   R. Alexander-Katz
   301

29 Thermomechanical Performance of Polymer Blends
   J. J. Scobbo, Jr.
   335

30 Barrier Materials by Blending
   P. M. Subramanian and I. G. Plotzker
   359

REINFORCED BLENDS

31 Reinforced Polymer Blends
   J. Karger-Kocsis
   395

32 Liquid Crystalline Polymer Blends
   D. G. Baird and M. A. McLeod
   429

33 From Polymer Blends to Microfibrillar Reinforced Composites
   S. Fakirov, M. Evstatiev, and K. Friedrich
   455

ELASTOMERIC BLENDS

34 Elastomer Blends
   S. Datta
   477

35 Thermoplastic Vulcanizates
   S. Abdou-Sabet and S. Datta
   517

RECYCLING

36 Recycling of Polymer Blends and Mixtures
   T. S. Ellis
   557

Index
   583
Contributors, Volume 2

S. ABDOU-SABET, Advanced Elastomer Systems L.P., Akron, OH 44311
R. ALEXANDER-KATZ, Depto. de Física, Universidad Autónoma Metropolitana-Iztapalapa, 09340 México, D.F., México
D. G. BAIRD, Department of Chemical Engineering and the Center for Composite Materials and Structures, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0211
H. R. BROWN, BHP Steel Institute, University of Wollongong, Wollongong, NSW 2522, Australia
C. B. BUCKNALL, School of Industrial and Manufacturing Science, Cranfield University, Cranfield, Bedford MK43 0AL, United Kingdom
X. H. CHEN, Department of Mechanical Engineering, Center for Advanced Materials Technology, University of Sydney, Sydney, NSW 2006, Australia
C. A. CRUZ-RAMOS, Plastics Additives Research Department, Rohm and Haas Company Research Laboratories, Bristol, PA 19007
S. DATTA, Baytown Polymers Center, Exxon Chemical Co., Baytown, TX 77522-5200
J. DU, Department of Materials Science and Engineering, The University of Michigan, Ann Arbor, MI 48109
T. S. ELLIS, Delphi Automotive Systems Research and Development, Warren, MI 48090
M. EVSTATIEV, Laboratory for Structure and Properties of Polymers, University of Sofia, 1126 Sofia, Bulgaria
S. FAHIROV, Laboratory for Structure and Properties of Polymers, University of Sofia, 1126 Sofia, Bulgaria
K. FRIEDRICH, Institute for Composite Materials Ltd., University of Kaiserslautern, D-67663 Kaiserslautern, Germany
R. J. GAIMAN, Faculty of Chemical Technology, University of Twente, 7500 AE Enschede, The Netherlands
CONTRIBUTORS, VOLUME 2

F. J. GUILD, Department of Mechanical Engineering, Queen’s Building, University of Bristol, Bristol, BS8 1TR, United Kingdom

J. KARGER-KOCSIS, Institute for Composite Materials Ltd., University of Kaiserslautern, D-67663 Kaiserslautern, Germany

Y.-W. MAI, Department of Mechanical Engineering, Center for Advanced Materials Technology, University of Sydney, Sydney, NSW 2006, Australia

M. A. MCLEOD, Department of Chemical Engineering and the Center for Composite Materials and Structures, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0211

R. A. PEARSON, Department of Materials Science and Engineering, Lehigh University, Bethlehem, PA 18015

I. G. PLOTZKER, Central Research and Development, Du Pont Company, Wilmington, DE 19880-0323

L. PRUITT, Department of Mechanical Engineering, University of California at Berkeley, Berkeley, CA 94720

J. J. SCOBBO, GE Plastics, One Noryl Avenue, Selkirk, NY 12158

P. M. SUBRAMANIAN, S.P.M. Technologies, Hockessin, DE 19707

M. D. THOULESS, Department of Mechanical Engineering and Applied Mechanics, The University of Michigan, Ann Arbor, MI 48109

S.-C. WONG, Department of Mechanical Engineering, Center for Advanced Materials Technology, University of Sydney, Sydney, NSW 2006, Australia

A. F. YEE, Department of Materials Science and Engineering, The University of Michigan, Ann Arbor, MI 48109
POLYMER BLENDS:
PERFORMANCE
POLYMER BLENDS

Volume 2: Performance

Edited by

D. R. Paul
Department of Chemical Engineering
and Texas Materials Institute
The University of Texas at Austin
Austin, TX 78712-1062

C. B. Bucknall
School of Industrial and Manufacturing Science
Cranfield University
Cranfield, Bedford MK43 0AL, United Kingdom
Contents

Preface vii
Contributors, Volume 2 ix
Contents, Volume 1 xi
Contributors, Volume 1 xiii

MECHANICAL PROPERTIES AND FRACTURE RESISTANCE

19 Quasielastic Mechanical Properties 1
   F. J. Guild

20 Application of Fracture Mechanics for Characterization of Toughness of Polymer Blends 17
   Y.-W. Mai, S.-C. Wong, and X.-H. Chen

21 Characterizing Toughness using Standard Empirical Tests 59
   C. B. Bucknall

22 Deformation Mechanisms in Rubber-Toughened Polymers 83
   C. B. Bucknall

23 Strengthening Polymer–Polymer Interfaces 119
   H. R. Brown

24 Core–Shell Impact Modifiers 137
   C. A. Cruz-Ramos

25 Toughening Semicrystalline Thermoplastics 177
   R. J. Gaymans

26 Toughening of Epoxies 225
   A. F. Yee, J. Du, and M. D. Thouless

27 Fatigue-Crack Propagation in Polymer Blends 269
   R. A. Pearson and L. Pruitt
CONTENTS

BLENDING FOR SPECIFIC PERFORMANCE

28 Transmission and Reflection of Light in Multiphase Media 301
   R. Alexander-Katz

29 Thermomechanical Performance of Polymer Blends 335
   J. J. Scobbo, Jr.

30 Barrier Materials by Blending 359
   P. M. Subramanian and I. G. Plotzker

REINFORCED BLENDS

31 Reinforced Polymer Blends 395
   J. Karger-Kocsis

32 Liquid Crystalline Polymer Blends 429
   D. G. Baird and M. A. McLeod

33 From Polymer Blends to Microfibrillar Reinforced Composites 455
   S. Fakirov, M. Evstatiev, and K. Friedrich

ELASTOMERIC BLENDS

34 Elastomer Blends 477
   S. Datta

35 Thermoplastic Vulcanizates 517
   S. Abdou-Sabet and S. Datta

RECYCLING

36 Recycling of Polymer Blends and Mixtures 557
   T. S. Ellis

Index 583
Preface

The field of polymer blends, or alloys, has experienced enormous growth in size and sophistication over the past two decades in terms of both the scientific base and technological and commercial development. It has become clear to us that an appropriate summary of this progress is needed to educate and to guide professionals working in this area into the twenty-first century. This two-volume set is a multiauthored treatise that might be viewed as an updated version of the analogous set edited by Paul and Newman and published in 1978. (See the reading list at the end of Chapter 1.)

The book is intended to be a coherent entity rather than a collection of separate chapters, and a great deal of effort has been devoted to coordinating the content and style of the chapters. The editors intended each chapter to be far more than an encyclopedic summary of the literature or a review focusing only on the most recent advances in research. The authors were asked (a) to provide enough background in each chapter to enable beginners to work in the field by reading this book; (b) to sift critically through the literature and present only the most important issues (not every reference deserves mention); and (c) to write clearly but concisely, using carefully selected graphics, in order to make the important conceptual points and capture the attention of the browser.

It is the goal of these two volumes to be the authoritative source that professionals of the next decades will seek out to learn about this important field and use to set directions for future research and product development. The two volumes are roughly equal in length. Volume 1 is subtitled Formulation and is largely about the physics, chemistry, and processing issues associated with the formation of polymer blends and the evaluation and control of their structure. Volume 2 is subtitled Performance and is primarily concerned with how blends perform in practical situations. Naturally, there is a heavy emphasis on mechanical performance, but several chapters deal with a range of other properties as well. At some risk of oversimplification, it can be said that Volume 1 is about structure, while Volume 2 is about properties. Thus, the two-volume set provides a broad view of the structure–property relationships for polymer blends as seen by experts from around the world.

The editors have been friends and colleagues for many years. Their professional interests have been somewhat different over their careers, but there are many points of intersection. These differences and similarities have been helpful during the course of planning, which started in early 1994, and development of this book. A common view was needed in order to foster agreement on the scope, content, and choice of
authors. The differences in expertise led Don Paul to have primary responsibility for Volume 1 and Clive Bucknall to oversee Volume 2.

We are thankful to many colleagues and friends who have encouraged us and given us advice on many issues.

D. R. PAUL
C. B. BUCKNALL
Contributors, Volume 2

S. ABDOU-SABET, Advanced Elastomer Systems L.P., Akron, OH 44311
R. ALEXANDER-KATZ, Depto. de Física, Universidad Autónoma Metropolitana-Iztapalapa, 09340 México, D.F., México
D. G. BAIRD, Department of Chemical Engineering and the Center for Composite Materials and Structures, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0211
H. R. BROWN, BHP Steel Institute, University of Wollongong, Wollongong, NSW 2522, Australia
C. B. BUCKNALL, School of Industrial and Manufacturing Science, Cranfield University, Cranfield, Bedford MK43 0AL, United Kingdom
X. H. CHEN, Department of Mechanical Engineering, Center for Advanced Materials Technology, University of Sydney, Sydney, NSW 2006, Australia
C. A. CRUZ-RAMOS, Plastics Additives Research Department, Rohm and Haas Company Research Laboratories, Bristol, PA 19007
S. DATTA, Baytown Polymers Center, Exxon Chemical Co., Baytown, TX 77522-5200
J. DU, Department of Materials Science and Engineering, The University of Michigan, Ann Arbor, MI 48109
T. S. ELLIS, Delphi Automotive Systems Research and Development, Warren, MI 48090
M. EVSTATIEV, Laboratory for Structure and Properties of Polymers, University of Sofia, 1126 Sofia, Bulgaria
S. FAKIROV, Laboratory for Structure and Properties of Polymers, University of Sofia, 1126 Sofia, Bulgaria
K. FRIEDRICH, Institute for Composite Materials Ltd., University of Kaiserslautern, D-67663 Kaiserslautern, Germany
R. J. GAYMANS, Faculty of Chemical Technology, University of Twente, 7500 AE Enschede, The Netherlands
F. J. GUILD, Department of Mechanical Engineering, Queen’s Building, University of Bristol, Bristol, BS8 1TR, United Kingdom

J. KARGER-KOCSIS, Institute for Composite Materials Ltd., University of Kaiserslautern, D-67663 Kaiserslautern, Germany

Y.-W. MAI, Department of Mechanical Engineering, Center for Advanced Materials Technology, University of Sydney, Sydney, NSW 2006, Australia

M. A. McLLEOD, Department of Chemical Engineering and the Center for Composite Materials and Structures, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0211

R. A. PEARSON, Department of Materials Science and Engineering, Lehigh University, Bethlehem, PA 18015

I. G. PLOTZKER, Central Research and Development, Du Pont Company, Wilmington, DE 19880-0323

L. PRUITT, Department of Mechanical Engineering, University of California at Berkeley, Berkeley, CA 94720

J. J. SCOBBO, GE Plastics, One Noryl Avenue, Selkirk, NY 12158

P. M. SUBRAMANIAN, S.P.M. Technologies, Hockessin, DE 19707

M. D. THOULESS, Department of Mechanical Engineering and Applied Mechanics, The University of Michigan, Ann Arbor, MI 48109

S.-C. WONG, Department of Mechanical Engineering, Center for Advanced Materials Technology, University of Sydney, Sydney, NSW 2006, Australia

A. F. YEE, Department of Materials Science and Engineering, The University of Michigan, Ann Arbor, MI 48109
## Contents, Volume 1

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td></td>
<td></td>
<td>vii</td>
</tr>
<tr>
<td>Contributors, Volume 1</td>
<td></td>
<td></td>
<td>ix</td>
</tr>
<tr>
<td>Contents, Volume 2</td>
<td></td>
<td></td>
<td>xi</td>
</tr>
<tr>
<td>Contributors, Volume 2</td>
<td></td>
<td></td>
<td>xiii</td>
</tr>
<tr>
<td><strong>1</strong> Introduction</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>D. R. Paul and C. B. Bucknall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>THERMODYNAMICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2</strong> Statistical Thermodynamics of Polymer Solutions and Blends</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>I. C. Sanchez and M. T. Stone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3</strong> Polymer–Polymer Interactions Based on Mean Field Approximations</td>
<td></td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>G. D. Merfeld and D. R. Paul</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4</strong> Hydrogen Bonding Systems</td>
<td></td>
<td></td>
<td>93</td>
</tr>
<tr>
<td>P. C. Painter and M. M. Coleman</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> Polymer Blends as Viewed by Analogue Calorimetry</td>
<td></td>
<td></td>
<td>141</td>
</tr>
<tr>
<td>C. J. T. Landry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6</strong> Crystalline Polymer Blends</td>
<td></td>
<td></td>
<td>167</td>
</tr>
<tr>
<td>J. P. Runt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7</strong> Fundamentals of Blends of Rigid-Chain (Liquid Crystal) Polymers</td>
<td></td>
<td></td>
<td>187</td>
</tr>
<tr>
<td>M. Ballauff and J. R. Dorgan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>8</strong> Thermodynamics of Polyolefin Blends</td>
<td></td>
<td></td>
<td>219</td>
</tr>
<tr>
<td>D. J. Lohse and W. W. Graessley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CHARACTERIZATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>9</strong> Morphology Characterization by Microscopy Techniques</td>
<td></td>
<td></td>
<td>239</td>
</tr>
<tr>
<td>S. Y. Hobbs and V. H. Watkins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xi</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CONTENTS, VOLUME 1

10 Viscoelastic Characterization of Polymer Blends 291
   D. S. Kalika

11 Optical Characterization: Light Scattering, Birefringence, and Ellipsometry 319
   T. Inoue and T. Kyu

12 Neutron Scattering and Polymer Blends 349
   D. G. Bucknall and V. Arrighi

STRUCTURE FORMATION

13 Formulation and Characterization of Thermoset–Thermoplastic Blends 379
   J. P. Pascault and R. J. J. Williams

14 Chemical Reactions in Blends Based on Condensation Polymers: Transreactions and Molecular and Morphological Characterization 417
   G. Groeninckx, M. Sarkissova, and S. Thomas

15 Morphology and Properties of Blends Containing Block Copolymers 461
   S. D. Hudson and A. M. Jamieson

16 Factors Influencing the Morphology of Immiscible Polymer Blends in Melt Processing 501
   B. D. Favis

17 Reactive Compatibilization 539
   B. Majumdar and D. R. Paul

18 Processing Aids 581
   J. M. Brady and C. A. Cruz-Ramos

Index 595
Contributors, Volume 1

V. Arrighi, Department of Chemistry, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS United Kingdom

M. Balluff, Polymer-Institut der Universität Karlsruhe, Kaiserstrasse 12, 76128 Karlsruhe, Germany

J. M. Brady, Plastics Additives Research Department, Rohm and Haas Company Research Laboratories, Bristol, PA 19007

C. B. Bucknall, School of Industrial and Manufacturing Science, Cranfield University, Cranfield, Bedford MK43 0AL, United Kingdom

D. G. Bucknall, Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, United Kingdom

M. M. Coleman, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802

C. A. Cruz-Ramos, Plastics Additives Research Department, Rohm and Haas Company Research Laboratories, Bristol, PA 19007

J. R. Dorgan, Chemical Engineering Department, Colorado School of Mines, Golden, CO 80401

B. D. Favis, Department of Chemical Engineering, University of Montréal, École Polytechnique, Montréal, Québec H3C 3A7, Canada

W. W. Graessley, Department of Chemical Engineering, Princeton University, Princeton, NJ 08544

G. Groeninckx, Department of Chemistry, Laboratory of Macromolecular Structural Chemistry, Catholic University of Leuven, B-3001 Heverlee, Belgium

S. Y. Hobbs, General Electric Company, Research and Development Center, Schenectady, NY 12301

S. D. Hudson, Department of Macromolecular Science and Engineering, Case Western Reserve University, Cleveland, OH 44106

T. Inoue, Department of Organic and Polymeric Materials, Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152-8552, Japan
A. M. Jamieson, Department of Macromolecular Science and Engineering, Case Western Reserve University, Cleveland, OH 44106

D. S. Kalika, Department of Chemical and Materials Engineering, University of Kentucky, Lexington, KY 40506

T. Kyu, Institute of Polymer Engineering, University of Akron, Akron, OH 44325

C. J. T. Landry, Imaging Research Laboratories, Eastman Kodak Company, Rochester, NY 14650

D. J. Lohse, Corporate Research Labs, Exxon Research & Engineering Co., Annandale, NJ 08801

B. Majumdar, GE Plastics, Selkirk, NY 12158

G. D. Merfeld, General Electric Co., Research and Development Center, Schenectady, NY 12301

P. C. Painter, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802

J. P. Pascault, Institut National des Sciences Appliquées, Laboratoire des Matériaux Macromoléculaires, 69621 Villeurbanne Cedex, France

D. R. Paul, Department of Chemical Engineering and Texas Materials Institute, The University of Texas at Austin, Austin, TX 78712

J. P. Runt, Department of Materials Science and Engineering, The Pennsylvania State University, University Park, PA 16802

I. C. Sanchez, Department of Chemical Engineering, The University of Texas at Austin, Austin, TX 78712

M. Sarkissova, Department of Chemistry, Laboratory of Macromolecular Structural Chemistry, Catholic University of Leuven, B-3001 Heverlee, Belgium

M. T. Stone, Department of Chemical Engineering, The University of Texas at Austin, Austin, TX 78712

S. Thomas, Department of Chemistry, Laboratory of Macromolecular Structural Chemistry, Catholic University of Leuven, B-3001 Heverlee, Belgium

V. H. Watkins, General Electric Company, Research and Development Center, Schenectady, NY 12301

R. J. J. Williams, Institute of Materials Science and Technology (INTEMA), University of Mar del Plata and National Research Council (CONICET), 7600 Mar del Plata, Argentina