

Contents

About the series — V

List of contributing authors — XI

Mark A. Benvenuto and Heinz Plaumann

1 Green chemical processes — 1

- 1.1 Introduction — 1
- 1.2 This volume — 2
 - 1.2.1 Green Centre Canada — 2
 - 1.2.2 Biomass dissolution and polyoxometallate catalysis — 3
 - 1.2.3 Ionic liquids — 3
 - 1.2.4 Liquid rinse fabric softeners — 3
 - 1.2.5 Renewable polyurethanes — 4
 - 1.2.6 Bark in bio-based materials — 4
 - 1.2.7 Aspirin in the lab — 4
- 1.3 Summary — 4

Philip G. Jessop and Laura M. Reyes

2 GreenCentre Canada: an experimental model for green chemistry commercialization — 7

- 2.1 Why do we need a new model for commercialization? — 7
- 2.2 Creating the subject-specific commercialization centre model — 10
 - 2.2.1 Commercializing chemistry technologies — 11
 - 2.2.2 Advantages of the SCC model — 12
- 2.3 Working with academia, SMEs, and industry — 13
 - 2.3.1 Working with academic researchers — 13
 - 2.3.2 Working with SMEs — 17
 - 2.3.3 Working with large enterprises in industry — 18
- 2.4 Green chemistry technologies at GreenCentre Canada — 18
- 2.5 Lessons for the future — 20
- References — 21

Steven P. Kelley, Paula Berton, Andreast Metlen and Robin D. Rogers

3 Polyoxometallate catalysts for biomass dissolution: understanding and design — 23

- 3.1 Introduction — 23
- 3.2 POM catalysts in IL-based biomass dissolution — 25
- 3.3 Crystal structures of $[\text{C}_2\text{mim}]_5[\text{PV}_2\text{Mo}_{10}\text{O}_{40}]$ and $[\text{C}_2\text{mim}]_4[\text{V}_4\text{O}_{12}]$ — 27

- 3.3.1 Crystal structure of $[\text{C}_2\text{mim}]_5[\text{PV}_2\text{Mo}_{10}\text{O}_{40}]$ — **27**
- 3.3.2 Crystal structure of $[\text{C}_2\text{mim}]_4[\text{V}_4\text{O}_{12}]$ — **30**
- 3.4 Conclusions — **34**
- 3.5 Experimental — **35**
- References — **37**

Keith E. Gutowski

4 Industrial uses and applications of ionic liquids — 43

- 4.1 Ionic liquids — **43**
- 4.2 Chemical processing — **44**
 - 4.2.1 Acid scavenging — **44**
 - 4.2.2 Hydrosilylation — **45**
 - 4.2.3 Hydroformylation — **46**
- 4.3 Polymer processing — **47**
 - 4.3.1 Cellulose and biomass — **47**
- 4.4 Metal processing — **48**
 - 4.4.1 Electroplating of aluminum — **48**
- 4.5 Separations — **49**
 - 4.5.1 Nuclear industry — **49**
- 4.6 Functional fluids — **50**
 - 4.6.1 Gas compression — **50**
 - 4.6.2 Gas capture and storage — **51**
- 4.7 Other (potential) applications — **53**
 - 4.7.1 Dye-sensitized solar cells — **53**
 - 4.7.2 Batteries — **54**
 - 4.7.3 Antistatics — **54**
 - 4.7.4 Consumer packaged goods — **54**
- 4.8 Outlook — **55**
- References — **56**

Philip G. Sliva

5 Greener chemistry opportunities in consumer products rinse added fabric softener — 59

- 5.1 Background — **59**
- 5.2 Chemistry — **60**
 - 5.2.1 Dialkyl dimethyl quat — **61**
 - 5.2.2 Imidazolinium quat — **61**
 - 5.2.3 Amidoamine quat — **61**
 - 5.2.4 Ester quat — **62**
- 5.3 Formulation — **63**
- 5.4 Conclusion — **66**
- References — **66**

Raymond Neff and Agnieszka Gajewski

- 6 Renewable building blocks for polyurethanes — 69**
- 6.1 Polyurethane chemistry and applications — 69
- 6.2 Traditional intermediates for polyurethanes — 71
- 6.3 Polyols and isocyanates from natural oils — 74
- 6.4 Sugar as a source for polyols and chain extenders — 78
- 6.5 Carbon dioxide as a building block (polyether carbonates) — 80
- 6.6 Future outlook — 81
- References — 81

Pei-Yu Kuo, Ning Yan, Nicole Tratnik and Jing Luo

- 7 Applications of bark for bio-based adhesives and foams — 83**
- 7.1 Barkvalorization toward a more sustainable future — 83
- 7.1.1 The rationale for bark — 84
- 7.1.2 Chemical composition of bark — 85
- 7.1.3 Aim of this article — 90
- 7.2 Bark conversion into chemical precursors — 91
- 7.2.1 Alkaline extraction – NaOH extraction — 92
- 7.2.2 Solvolytic liquefaction: phenolysis and alcoholysis — 93
- 7.2.3 Alkoxylation: Oxypropylation — 99
- 7.3 Bark-derived adhesives and foams — 102
- 7.3.1 Bark-derived adhesives — 102
- 7.3.2 Bark-derived foams — 109
- 7.4 Summary and outlook — 111
- References — 112

Steven J. Bachofer and Mark D. Lingwood

- 8 A green determination of an equilibrium constant: teaching new skills — 117**
- 8.1 Introduction — 117
- 8.2 Learning goals — 120
- 8.3 Details of experiment — 121
- 8.4 Student response — 123
- 8.5 Conclusion — 124
- References — 124

Index — 127