Preface

Lignin is the largest source of renewable aromatics in the world. Most lignins are produced as a by-product in huge quantities by the pulp-and-paper industry in the form of black liquor (ca. 50 million tonnes/a) but are also expected to be a major by-product in emerging industries related to biofuels and bioproducts (ca. 2.7–8.1 million tonnes/a). Due to the highly stable structure of lignin that consists of cross-linked phenylpropane (C6–C3) units, most lignin by-products are combusted or used as a low-grade fuel rather than being upgraded to oil or gas or recovered to produce chemicals or materials. The present text provides state-of-the-art reviews; current research and prospects on lignin production; lignin biological, thermal and chemical conversion; and lignin technoeconomics. Fundamental topics related to lignin chemistry, properties, analysis, characterisation, depolymerisation mechanisms and enzymatic, fungal and bacterial degradation methods are covered. Practical topics related to technologies for lignin and ultra-pure lignin recovery, activated carbon, carbon fibre production and materials are covered. Biological conversion of lignin with fungi, bacteria or enzymes to produce chemicals is considered along with chemical, catalytic, thermochemical and solvolysis conversion methods. A case study is presented for practical polyurethane foam production from lignin. Lignin has a bright future and will be an essential feedstock for producing renewable chemicals, biofuels and value-added products.

This book is the sixth book of the series entitled, "Biofuels and Biorefineries", and it contains 13 chapters contributed by leading experts in the field. The text is arranged into four key areas:

Part I: Lignin and Its Production (Chapters 1–3)
Part II: Biological Conversion (Chapters 4–6)
Part III: Chemical Conversion (Chapters 7–12)
Part IV: Technoeconomics (Chapter 13)

Chapter 1 introduces lignin chemistry, characterisation techniques and general applications of lignin resources with a biorefinery concept. **Chapter 2** reviews methods for isolating lignin derivatives from pulping spent liquors and gives main

challenges and perspectives in the development of viable lignin production processes. **Chapter 3** presents new technologies for recovering ultra-pure lignins from alkaline liquor streams generated either from a pulp-and-paper mill or a lignocellulosic biofuels refinery. **Chapter 4** summarises recent advances in lignin-degrading enzymes (lignin-oxidising and lignin-degrading auxiliary enzymes) produced by wood-degrading fungi and bacteria. Structural and functional aspects of lignin-degrading auxiliary enzymes are covered along with discussion on genomic studies of lignin-degrading fungi. **Chapter 5** describes bacterial lignin-oxidising enzymes, such as dye-decolorising peroxidases, bacterial laccases and beta-etherase enzyme, the current knowledge of bacterial lignin degradation pathways and current efforts to produce renewable chemicals from polymeric lignin using bacterial fermentation. **Chapter 6** offers a critical overview of the latest concepts and achievements in lignin biological degradation, focusing on fungi, bacteria and enzymes as catalysts to produce chemicals and their use for novel applications. **Chapter 7** focuses on the chemical modifications of lignin for its selective depolymerisation to monomers as aromatic feedstock chemicals and on using lignin as the starting point for novel smart materials. **Chapter 8** introduces carbon materials from lignin and discusses the characterisation and potential applications of activated carbons, carbon fibres and nanostructured, hierarchical and highly ordered carbons. **Chapter 9** deals with the fundamentals of lignin pyrolysis and catalytic upgrading and reviews significant advances in this area. **Chapter 10** gives conceptual guidelines for using solvolysis with lignin and optimisation of lignin depolymerisation process for value-added chemical production. **Chapter 11** covers molecular mechanisms associated with the thermochemical conversion of lignins and provides principles for design of pyrolysis-based lignin conversion processes to produce specific bio-oils, chemicals and biofuels. **Chapter 12** introduces major works investigating the depolymerisation mechanisms of lignin and to provide pyrolysis product formation and distribution pathways through the combination of experimental results and computational simulations. **Chapter 13** uses multi-criteria analysis to give a comprehensive assessment of integrated lignin-based biorefinery processes. An industrial case study, involving a lignin recovery rate of up to 100 tonnes/day from a softwood kraft pulping mill for the production of polyurethane foam and carbon fibre, is demonstrated and analysed.

The text should be of interest to students, researchers, academicians and industrialists who are working in the areas of renewable energy, environmental and chemical sciences, engineering, resource development, biomass processing, sustainability, materials, biofuels and pulp-and-paper industries.

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