GASOLINE, DIESEL, AND ETHANOL BIOFUELS FROM GRASSES AND PLANTS

The world is currently faced with two significant problems – fossil fuel depletion and environmental degradation – which are continuously being exacerbated due to increasing global energy consumption. As a substitute for petroleum, renewable fuels are receiving increasing attention due to a variety of environmental, economic, and societal benefits. First-generation biofuels – ethanol from sugar or corn and biodiesel from vegetable oils – are already on the market. The goal of this book is to introduce readers to the second-generation biofuels obtained from nonfood biomass, such as forest residue, agricultural residue, switchgrass, corn stover, waste wood, and municipal solid wastes. Various technologies are discussed, including cellulosic ethanol, biomass gasification, synthesis of diesel and gasoline, biocrude by hydrothermal liquefaction, bio-oil by fast pyrolysis, and the upgradation of biofuel. This book strives to serve as a comprehensive document presenting various technological pathways and environmental and economic issues related to biofuels.

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Preface

The world is currently faced with two significant problems: fossil fuel depletion and environmental degradation. The problems are continuously being exacerbated due to increasing global population and per capita energy consumption. To overcome the problems, renewable energy has been receiving increasing attention due to a variety of environmental, economic, and societal benefits. First-generation biofuels (ethanol from sugar or corn, and biodiesel from vegetable oils) are already in the market, and second-generation biofuels from nonfood biomass are under development. The goal of this book is to introduce readers to the biofuels obtained from nonfood biomass, and for reference to provide the technologies involved in first-generation biofuels derived from food sources.

Chapter 1 discusses various nonrenewable (petroleum, natural gas, coal) and renewable forms of energy, and describes air pollution and greenhouse gas emission caused by the use of fossil fuels. Recent concern about carbon dioxide emissions, carbon sequestration, and carbon credits are discussed in Chapter 2. Chapter 3 provides an in-depth description of various renewable energy sources, including biomass; hydropower; geothermal, wind, solar, and ocean energy; and biogas. For the production of biofuels, the global availability of biomass is discussed in Chapter 4 along with the characterization and variations of biomass.

Conventional ethanol production from corn or sugarcane by fermentation technology is discussed in Chapter 5. Current techniques and various unit operations involved are presented, including saccharification, fermentation, distillation, and dehydration. The second-generation ethanol from cellulose is described in Chapter 6. It provides an in-depth coverage of various pretreatment techniques that are critical to the cost-effective production of cellulosic ethanol. In addition, xylose fermentation to improve the ethanol yield is discussed.

Chapter 7 discusses the production of biodiesel from vegetable oil by transesterification. The fuel properties of biodiesel are compared with those of petroleum diesel. Chapter 8 concerns the production of diesel from biomass. Processing of biomass gasification followed by Fischer–Tropsch synthesis of diesel and other liquid fuels is discussed. Chapter 9 outlines the production of bio-oil from biomass by the pyrolysis process. Various reactor designs for fast pyrolysis are described along

with the fuel properties of bio-oil, including its upgradation. Chapter 10 deals with the production of biocrude by hydrothermal liquefaction of biomass, in which various aspects of production and upgradation are presented to obtain fuel comparable to petroleum liquids.

Chapter 11 discusses the use of wind and solar energies to enhance biofuel production from biomass. The process heating and electricity needs can be satisfied so that a higher amount of biomass carbon is converted to liquid fuels. Chapters 12 and 13 discuss the environmental and economic impacts of biofuels, respectively. Chapter 14 summarizes current biofuel policies of major countries that are promoting biofuel production and use.

This book strives to serve as a comprehensive document to present various technological pathways and environmental and economic issues related to biofuels. As petroleum reserves are depleted, the world is faced with finding alternatives. Currently, the transport sector depends almost entirely on petroleum liquids (diesel, gasoline, jet fuel, kerosene), and to fill the gap, biofuel can provide a replacement. However, alternatives to petroleum must be technically feasible, economically competitive, environmentally acceptable, and easily available.

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