GREEN CHEMISTRY AND CHEMICAL ENGINEERING

Resource Recovery to Approach Zero Municipal Waste

Edited by
Mohammad J. Taherzadeh
Tobias Richards

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Series Preface

The subjects and disciplines of chemistry and chemical engineering have encountered a new landmark in the way of thinking about, developing, and designing chemical products and processes. This revolutionary philosophy, termed *green chemistry and chemical engineering*, focuses on the designs of products and processes that are conducive to reducing or eliminating the use and generation of hazardous substances. In dealing with hazardous or potentially hazardous substances, there may be some overlaps and interrelationships between environmental chemistry and green chemistry. While environmental chemistry is the chemistry of the natural environment and the pollutant chemicals in nature, green chemistry proactively aims to reduce and prevent pollution at its very source. In essence, the philosophies of green chemistry and chemical engineering tend to focus more on industrial application and practice rather than academic principles and phenomenological science. However, as both chemistry and chemical engineering philosophy, green chemistry and chemical engineering derive from and build upon organic chemistry, inorganic chemistry, polymer chemistry, fuel chemistry, biochemistry, analytical chemistry, physical chemistry, environmental chemistry, thermodynamics, chemical reaction engineering, transport phenomena, chemical process design, separation technology, automatic process control, and more. In short, green chemistry and chemical engineering are the rigorous use of chemistry and chemical engineering for pollution prevention and environmental protection.

The Pollution Prevention Act of 1990 in the United States established a national policy to prevent or reduce pollution at its source whenever feasible. And adhering to the spirit of this policy, the Environmental Protection Agency launched its Green Chemistry Program to promote innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and use of chemical products. Global efforts in green chemistry and chemical engineering have recently gained a substantial amount of support from the international community of science, engineering, academia, industry, and governments in all phases and aspects. Some of the successful examples and key technological developments include the use of supercritical carbon dioxide as a green solvent in separation technologies; application of supercritical water oxidation for destruction of harmful substances; process integration with carbon dioxide sequestration steps; solvent-free synthesis of chemicals and polymeric materials; exploitation of biologically degradable materials; use of aqueous hydrogen peroxide for efficient oxidation; development of hydrogen proton exchange membrane fuel cells for a variety of power generation needs; advanced biofuel productions; devulcanization of spent tire rubber; avoidance of the use of chemicals and processes causing generation of volatile organic compounds; replacement of traditional petrochemical processes by microorganism-based bioengineering processes; replacement of chlorofluorocarbons with nonhazardous alternatives; advances in design of energy-efficient processes; use of clean, alternative, and renewable energy sources in manufacturing;

and much more. This list, even though it is only a partial compilation, is undoubtedly growing exponentially.

This book series (Green Chemistry and Chemical Engineering) by CRC Press/Taylor & Francis is designed to meet the new challenges of the twenty-first century in the chemistry and chemical engineering disciplines by publishing books and monographs based on cutting-edge research and development to affect reducing adverse impacts on the environment by chemical enterprise. And in achieving this, the series will detail the development of alternative sustainable technologies that will minimize the hazard and maximize the efficiency of any chemical choice. The series aims at delivering readers in academia and industry with an authoritative information source in the field of green chemistry and chemical engineering. The publisher and its series editor are fully aware of the rapidly evolving nature of the subject and its long-lasting impact on the quality of human life in both the present and future. As such, the team is committed to making this series the most comprehensive and accurate literary source in the field of green chemistry and chemical engineering.

Sunggyu Lee
Ohio University

Preface

A population of 7 billion in the world means 7 billion waste producers. The widespread current practice of getting rid of municipal solid wastes (MSW) in the world is through landfill. These wastes represent a mixture of resources, but knowledge has not developed enough to enable their utilization in a proper and economical way. This results in an almost linear utilization of our resources, wherein the material passes through society only once before being dumped in a landfill; this practice is not sustainable in the long term. It means that we should aim for zero landfill and to completely recover our resources in order to realize a sustainable society. Although landfilling of all organic wastes is forbidden in Europe, there are only a few countries, such as Sweden, Germany, Belgium, and Switzerland, that have approached zero landfill, using a variety of technologies to recover resources from MSW.

This book provides a holistic approach to resource recovery from MSW toward zero waste. It is a complex subject with several technical, social, environmental, management, and sustainability aspects. However, there are cities and countries where zero waste is a reality, although continuous development is still ongoing. This book starts with an overview of solid waste management toward zero waste. It has several examples from Sweden and particularly from one city (Borås), where this topic has been on the agenda since 1986. After this, a discussion of sustainability aspects together with laws and regulations of waste management follows. One important choice, which is considered in Chapter 1, is whether people should separate their MSW at home or let machines and workers do it. When the waste is separated in different fractions, then we have several technologies to take care of them and convert them to different resources. Organic or biological wastes can be converted to compost or biogas and biofertilizers. We have combustion, pyrolysis, and gasification for the rejects. There are different recycling technologies, of which this book covers metals, electronic wastes, thermoset composites, papers, and fibers. Other technologies, such as glass recycling, are covered in the introduction (Chapter 1). However, in order to have good recycling, the recycling should be considered when the products are designed and produced. This is discussed in Chapters 9 through 12. Finally, if the materials are landfilled, then landfill mining should be considered. This is the topic of Chapter 14.

This book is designed to be suitable for teaching at the higher education level, as well as for researchers and companies and municipalities. We hope that it contributes to a better global environment and more sustainable societies.

Editors

Mohammad J. Taherzadeh earned a PhD in bioscience and an MSc in chemical engineering. He has been a professor in bioprocess technology since 2004 and research leader at the Swedish Centre for Resource Recovery (SCRR), University of Borås, Sweden. With about 50 researchers, the SCRR covers technical, environmental, and social aspects of sustainable resource recovery. Professor Taherzadeh is working on converting wastes and residuals to ethanol, biogas, animal feed, and biopolymers, focusing on fermentation development using bacteria, yeast, and filamentous fungi. He has to his credit more than 160 publications in peer-reviewed science journals, 12 book chapters, and 3 patents, and he is currently the main supervisor of more than 10 PhD students and several postdoctoral fellows. Dr. Taherzadeh collaborates with several companies, and some of his research results have been industrialized. More information about him is available at www.adm.hb.se/~mjt/.

Tobias Richards has been a professor in energy recovery since 2010 at SCRR, University of Borås in Sweden. He is the leader of the group working on combustion and thermal treatment. Professor Richards focus area is treatment by thermal processes of different materials, especially mixed materials such as waste. His aim is to get valuable products such as electricity, heat, synthesis gas, and pyrolysis oil and, when necessary, destroy potential harmful substances. Professor Richards has to his credit 30 peer-reviewed and published articles and 2 book chapters and is currently supervising 5 PhD students.

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