

Chemicals and Materials from Renewable Resources

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Chemicals and Materials from Renewable Resources

Joseph J. Bozell, EDITOR
National Renewable Energy Laboratory



American Chemical Society, Washington, DC



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Foreword

The ACS Symposium Series was first published in 1974 to provide a mechanism for publishing symposia quickly in book form. The purpose of the series is to publish timely, comprehensive books developed from ACS sponsored symposia based on current scientific research. Occasionally, books are developed from symposia sponsored by other organizations when the topic is of keen interest to the chemistry audience.

Before agreeing to publish a book, the proposed table of contents is reviewed for appropriate and comprehensive coverage and for interest to the audience. Some papers may be excluded to better focus the book; others may be added to provide comprehensiveness. When appropriate, overview or introductory chapters are added. Drafts of chapters are peer-reviewed prior to final acceptance or rejection, and manuscripts are prepared in camera-ready format.

As a rule, only original research papers and original review papers are included in the volumes. Verbatim reproductions of previously published papers are not accepted.

ACS Books Department

Preface

A symposium, *Chemicals and Materials from Renewable Resources*, was held at the 218th National Meeting of the American Chemical Society in New Orleans, Louisiana, from August 22 to August 26, 1999. This book contains a collection of some of the papers presented during the 1.5 days of the symposium.

Each new oil crisis seems to bring a rediscovery of the renewable to chemicals field. Yet the work in this area remains very diverse, making it difficult to present a coherent front to those who might fund new efforts in basic and applied research. In organizing the symposium, we were faced with a similar problem: Do we focus on a single narrow topic or present a broader sample of several aspects of the field? We eventually chose a middle road on a basis of an idea, which is described more fully in Chapter 1, that our understanding of how one can selectively manipulate renewable feedstocks requires (1) a broader range of renewables-based building blocks and (2) a much greater understanding of how transformations of those building blocks can be controlled at a molecular level. It is our hope that this sampling of different research efforts will stimulate a broader interest in this field and will promote better communication among those groups working in related areas.

At this writing, the price of crude oil is again on the rise and the American public is facing sharply higher gasoline prices. The United States possesses a vast amount of renewable and sustainable feedstocks that could supply a significant proportion of our chemical needs while not sacrificing our supply of necessary food, feed, and fiber requirements. Perhaps these chapters will serve to catalyze a much broader research effort in this fascinating field.

JOSEPH J. BOZELL
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401

Chapter 1

Chemicals and Materials from Renewable Resources

Joseph J. Bozell

National Renewable Energy Laboratory, 1617 Cole Boulevard,
Golden, CO 80401

Abstract: A symposium entitled “Chemicals and Materials from Renewable Resources” was held as part of the ACS National Meeting in August, 1999. This introductory chapter attempts to show that a good case can be made for the use of renewables as chemical feedstocks. While economic considerations certainly play a role, greater use of renewables is primarily prevented by a lack of technology development. The breadth of technology available for high yield, selective manipulation of renewable raw materials pales in comparison to that available in the petrochemical industry. It is hoped that the papers collected in this monograph will introduce the reader to new technology available for the use of renewables, and serve as a catalyst for broader coordination of efforts in this developing field.

The Case for Renewables

The symposium on which this book is based is certainly not the first to describe the concept of using renewables as chemical feedstocks. Well into the 20th century, renewable feedstocks supplied a significant portion of the nation's chemical needs. The chemurgy movement of the 1930s, led by such notables as William Hale and Henry Ford, promoted the use of farm products as a source of chemicals, with the belief that "*anything that can be made from a hydrocarbon could be made from a carbohydrate*" (1). It is only in the period of time between 1920 and 1950 that we have witnessed the transition to a nonrenewables based economy (2).

A vast amount of renewable carbon is produced in the biosphere; about 77×10^9 tons is fixed annually, an amount that could supply almost all domestic organic chemical needs, currently about 7 - 8% of our total nonrenewables consumption (3). When measured in energy terms, the amount of carbon synthesized is equivalent to about ten times the world consumption (4). Cellulose, the most abundant organic chemical on earth, has an annual production of about 100×10^9 tons. Lignin production by the pulp and paper industry is 30 - 50×10^6 tons/year (5). Yet our chemical feedstock supply is overwhelmingly dominated by nonrenewable carbon. Some of the largest industrial users of renewable feedstocks are the pulp and paper industry and the corn wet milling industry. However, the pulp and paper industry devotes only a small part of its production to chemicals, while the corn wet milling industry is focused largely on starch and its commercial derivatives, ethanol and corn syrup. Given such a plentiful potential source of chemicals and products, what are the barriers that stand between the promise of renewables and their wider use by the chemical industry?

Several advantages are frequently associated with renewables:

- The use of biomass has been suggested as a way to mitigate the buildup of greenhouse CO_2 in the atmosphere (6). Since biomass uses CO_2 for growth through photosynthesis, the use of biomass as a feedstock results in no net increase in atmospheric CO_2 content when the products break down in the environment (7).
- It is generally acknowledged that increased use of biomass would extend the lifetime of the available crude oil supplies. The Royal Dutch/Shell group has developed several scenarios for the impact of biomass on chemicals and fuel production. One scenario projects a biomass market in the first half of the 21st century of \$150 billion/year, with up to 30% of worldwide chemical and fuel needs supplied by renewable feedstocks in the same time period (8,9).
- A chemical industry incorporating a significant percentage of renewable materials is more secure because the feedstock supplies are domestic, leading to a lessened dependence on international "hot spots". The 1991 and 1996 events between Iraq and the U. S. and the immediate response of the oil