Edited by Robert T. Mathers
and Michael A.R. Meier

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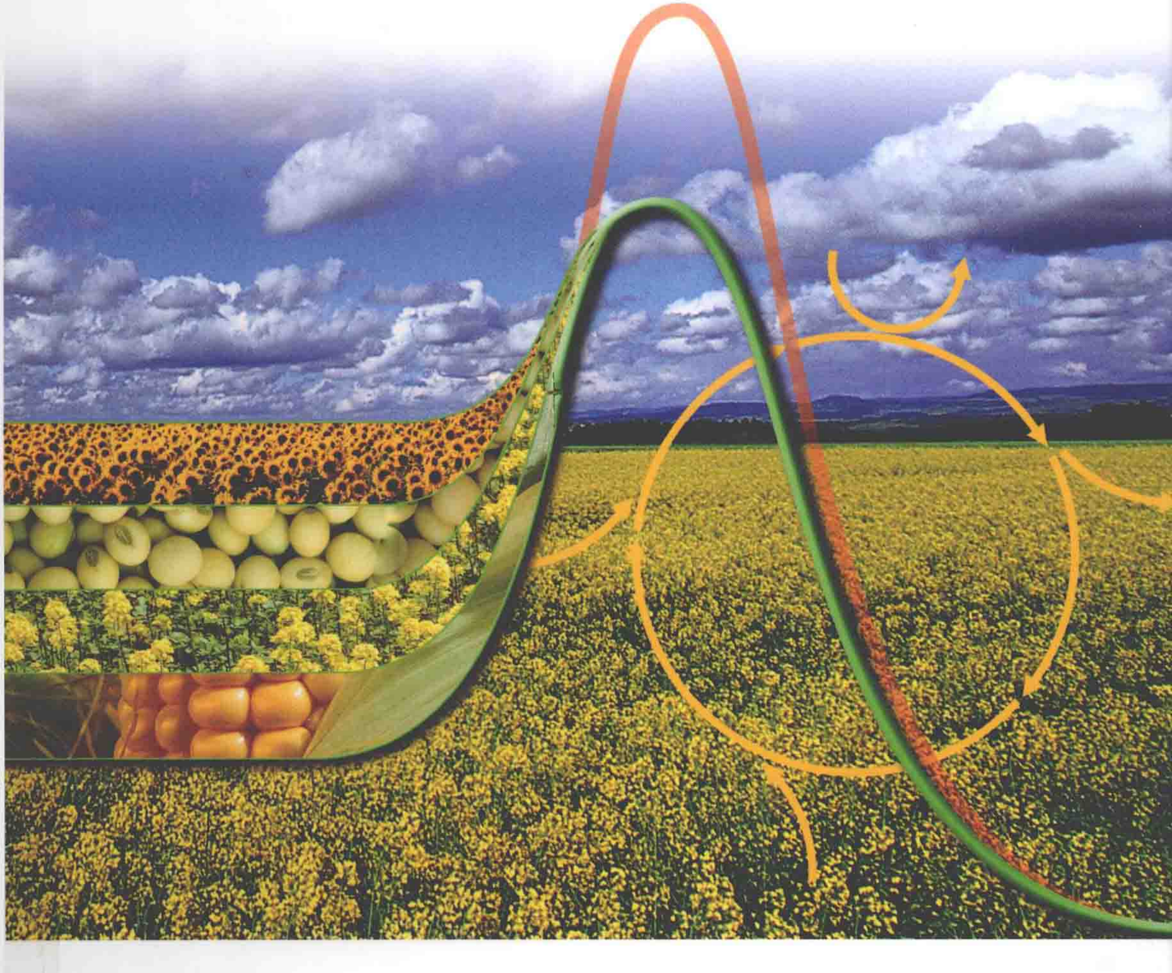
Green Polymerization Methods

Renewable Starting Materials, Catalysis
and Waste Reduction



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Introduction

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1
Why are Green Polymerization Methods Relevant to Society, Industry, and Academics?

Robert T. Mathers and Michael A. R. Meier

1.1
Status and Outlook for Environmentally Benign Processes

In June 1992, the "Rio Declaration on Environment and Development" (*Rio declaration*) of the United Nations Conference on Environment and Development (UNCED) announced in Principle 1 [1] that human beings are at the center of concerns for sustainable development and that they are entitled to a healthy and productive life in harmony with nature. Since the Rio declaration, the necessity for *sustainable development* has become obvious [2]. Most frequently, sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs [3]. Much has happened since then and the principles of *green chemistry* [4] are now known and applied by chemists worldwide. Recently, Paul T. Anastas stated in his keynote speech at the 2010 ACS (American Chemical Society) national meeting in San Francisco: "Building a sustainable world is the most taxing intellectual exercise we have ever engaged in. It is also the most important for the future of our world" [5]. Thus, great challenges remain and in the field of green chemistry there are plenty of possibilities in the future for innovation and environmentally friendlier consumer products.

As the use of polymers is becoming increasingly more common for many applications in modern society, *polymer science* is able to make diverse contributions to the rapidly growing field of green chemistry. In particular, polymer science offers manifold possibilities for the sustainable use of renewable raw materials. Even though utilizing renewable resources to meet current needs without creating adverse health or environmental impacts can be challenging, renewable resources offer potentially less toxic products as these resources can be expected to be biodegradable and, more importantly, biocompatible. However, we are fully aware that this is a generalization and a careful case by case evaluation is absolutely necessary! Moreover, nature offers a great synthetic potential to the polymer chemist, and it is up to us to develop new methods to incorporate renewable resources into polymeric materials. This development has to begin now in order to be ready to apply these methods industrially in a few decades, as fossil reserves continue to

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deplete and become more expensive. Equally important, we need more sustainable routes toward known polymeric products in order to avoid waste, contamination, high energy consumption, and many other environmental concerns. In the United States, the *National Research Council*, in its report entitled "Sustainability in the Chemical Industry: Grand Challenges and Research Needs," has advocated that all areas of the chemical industry focus on long-term strategies to minimize toxicity and environmental impact while creating sustainable processes [6].

Therefore, we are certain that this edited volume will assist in *training a future generation* of scientists and engineers to consider green chemistry and sustainability within the field of polymer science as the most beneficial long-term strategy. Because these peer-reviewed chapters come from departments of polymer science, chemical engineering, chemistry, and materials science, we anticipate that this volume will build upon previous polymer science [7, 8] and green chemistry [9] books to provide a *state-of-the-art resource for industry and academia*. Moreover, this variety clearly reflects the need for collaboration between these (and other) disciplines to reach our final goal of *sustainability*. Specifically, new catalytic and biomimetic methods, alternative reaction media, and the utilization of renewable resources are described in this edited volume. Additionally, these discussions cover emerging areas in condensation, controlled free radical, anionic, cationic, and metathesis polymerizations. Based on the excellent contributions in this volume, which originate from a number of science and engineering venues, we can only assume that the idea of a *green polymerization method* will continue to be an important part of polymer science for many years.

1.2
Importance of Catalysis

In 1836, Berzelius described his newly coined concept of "*catalysis*" and "*catalytic power*" in an article for *The Edinburgh New Philosophical Journal* entitled "Considerations respecting a New Power which acts in the Formation of Organic Bodies". He described these new idioms as "a power, which is capable of effecting chemical reactions in unorganized substances, as well as organized bodies" [10]. Years later, Karl Zeigler and Giudio Natta received the 1963 Nobel Prize for catalysis research related to polyolefins. More recently, Nobel prizes have been awarded for asymmetric catalysis (2001) and olefin metathesis catalysts (2005).

At the present time, refined ideas regarding catalysis have become very common in science and engineering disciplines, as evidenced by the large number of journal articles devoted to this subject each year. From an industrial standpoint, catalysts have played an integral role in the manufacture of chemical raw materials [11], polyolefins [12], and many other polymeric materials. To gain a perspective on the importance of catalysis in *green polymer chemistry*, it is helpful to mention that during the formulation of the principles of green chemistry [4], catalysis was described as a foundational pillar [13]. Since that time, major advances in organocatalysis and biocatalysis have continued to emerge as complementary methods to traditional