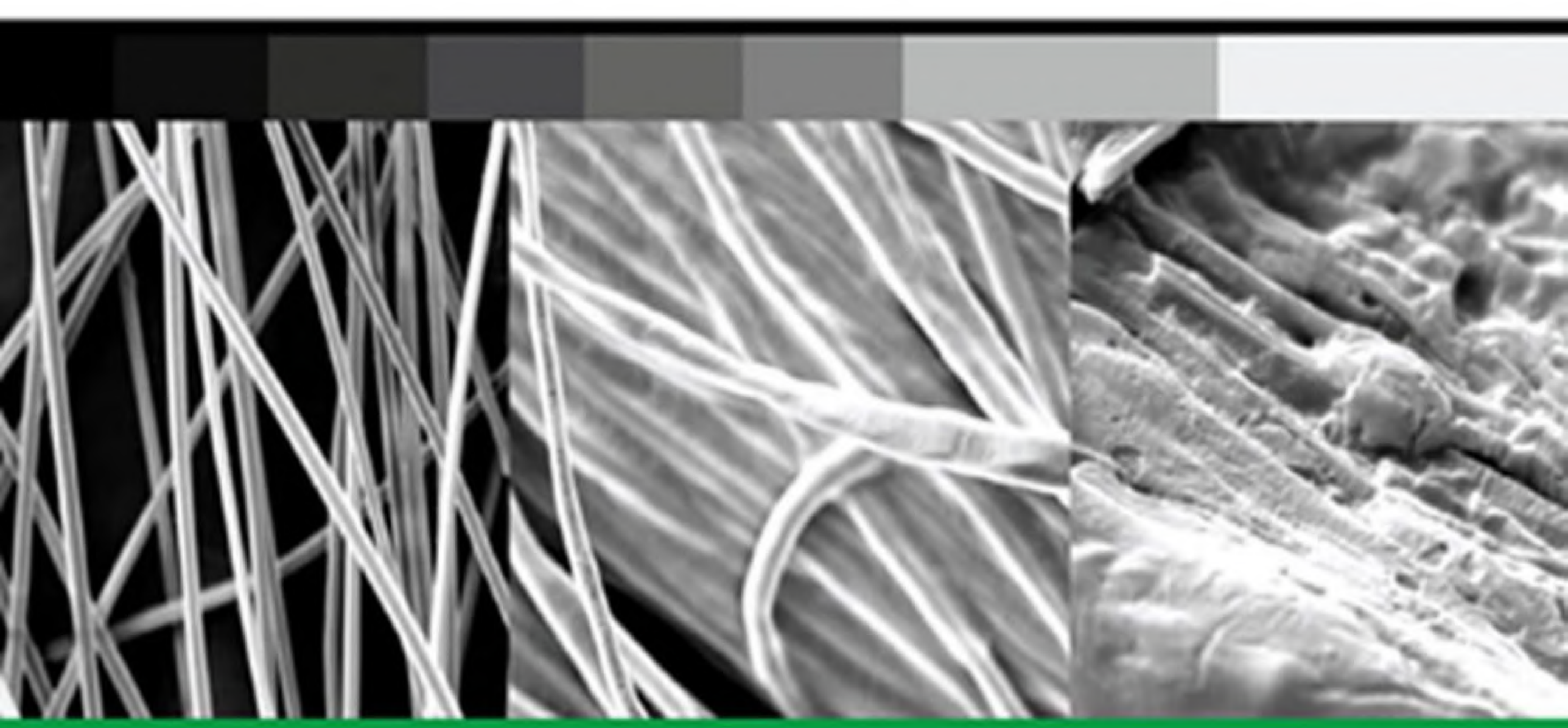
Monomers, Polymers and Composites from Renewable Resources



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Monomers, Polymers and Composites from Renewable Resources

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Foreword

Expert predictions about the future availability of fossil resources, viz. petrol, natural gas and coal, which are not renewable within a useful time scale, vary between one and three generations. The concern about the geopolitical situation related to these dwindling resources has therefore been increasing steadily in the last decade and has recently reached peak proportions with the apparently unstoppable soaring market prices of petrol.

The primary issue here is obviously energy, considering that more than 90 per cent of these resources are used as fuels, but the fact that the vast majority of organic chemicals and synthetic polymers are derived from them (as a result of the petrochemical 'revolution' of the post-Second World War boom), constitutes an equally serious challenge.

Whereas the energy issue is being vigorously debated through various alternative solutions (nuclear, biomass combustion, aeolian, geothermal, etc.), with the corresponding progressive implementations, the only alternative to fossil resources for the manufacture of commodity chemicals and polymers is the use of renewable vegetable and animal counterparts, that is, the biomass.

As a consequence, research initiatives to this effect are being implemented ubiquitously with a sense of increasing urgency, as witnessed by the growing investments assigned by the concerned ministries, supranational institutions (EU, UNIDO, etc.) and the private industrial sector. This is being accompanied by the dramatic increase in scientific publications, patents and international symposia covering the topic of the rational exploitation of renewable resources to produce commodities alternative to petrochemicals.

The incessant biological activities that the earth sustains thanks to solar energy provide not only the means of our survival, but also a variety of complementary substances and materials which have been exploited by mankind since its inception, albeit with a growing degree of sophistication. Suffice it to mention, as an example, wood as a source of shelter and, later, of paper. In modern times, the exploitation of renewable resources to prepare useful products and plastics was indeed quite prominent between about 1870 and 1940 (natural rubber for tyres, cellulose acetate and nitrate, plant-based dyes, drying oils, etc.). As already pointed out, however, a major shift in industrial chemistry took place, starting from the second quarter of the last century, which led to the supremacy of first coal and then petrol as the basis of its output in terms of most intermediates, commodities and polymers.

This trend witnessed its apex at the end of the last millennium, when competent assessments from various academic and industrial circles begun alerting the community about the need of returning to the exploitation of renewable resources, albeit, obviously, following a more rational and thorough strategy. The concept of the 'biomass refinery' puts forward an approach, similar to that of the classical petrol counterpart, in which each of the different components of a given natural resource is isolated by chemical or biochemical means with the aim of turning them into useful products. Thus, interesting chemicals and monomers for industry and medicine, compounds with a specific useful pristine structure, resins, natural fibres and oils (used as such or after adequate modification), as well as polymers produced by bacteria, could replace progressively petrol-based counterparts. To take wood again as an example, this strategy implies that its various components are separated and valorized, namely: (i) cellulose fibres, essentially for papermaking, but also as reinforcing elements in composite materials; (ii) lignin as a macromonomer for novel plastics, or as a source of valuable chemicals like vanillin; (iii) bark tannins for leather treatment and as components for resins and adhesives; (iv) specific minor chemicals present in knots for medical applications such as neutraceticals, etc.

In this way, the dependence on fossil resources steadily decreases and every country in the world profits equally from this radical change, since biomass is ubiquitous and the technologies associated with its refinery just have to be adapted to the local species.

Numerous countries have embarked on ambitious programmes devoted to these issues and some of them have already been turned into concrete achievements through collaboration between public and private sectors. This amply justifies the pursuit of further research and development activities.

The purpose of this book is to concentrate exclusively on one topic within this broad issue, namely the use of renewable resources as precursors or aids to novel macromolecular materials. It reflects the concerted effort of a number of specialists to propose a hopefully comprehensive scientific and technological appraisal of the state of the art and the perspectives related to the numerous facets of this realm. In the 15 years that have elapsed since the first, much more modest review on this topic was published by one of us*; progress has been astounding, both qualitatively and quantitatively. Hence, the initiative to prepare this collective volume, which we hope will constitute a useful working or consulting tool for all those involved, associated or simply interested in these important issues.

Given the global context, it does not seem preposterous to us to consider the materials discussed in this book as the *polymers of the future*.

The preparation of this book benefitted enormously from the unfailing editing advice of Joan Gandini, who devoted innumerable hours of her skills to help improve its quality. For this and for other precious heart-warming assistance, we are deeply grateful to her.

We wish to express our most sincere thanks to Vera Fernandes, who played a decisive role, with her secretarial competence and assiduity, in assuring the smooth progress of the different phases of the book construction.

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