

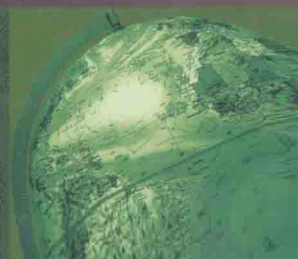
WILEY SERIES IN RENEWABLE RESOURCES

Industrial Applications of Natural Fibres

Structure, Properties and Technical Applications

Jörg Müssig
Editor

 WILEY



Industrial Applications of Natural Fibres

Structure, Properties and
Technical Applications

Edited by

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Industrial Applications of Natural Fibres

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in
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Dedication

In recent years, natural fibres have become increasingly popular for use in industrial applications, e.g. as reinforcement for plastics. This approach is also of growing interest in light of the discussion about sustainability and environmental issues. These aspects are commonly not included in the regular university education for engineers and natural scientists. This book will examine the value-added chain of natural fibres in order to bring more detailed information about this complex topic to students as well as to industry and research. The book will enable the reader to gain a fundamental understanding of the sometimes complex transformation of a natural fibre to final technical product.

This book is dedicated to professional industrial researchers working in production processing (from fibre separation to the final product – textiles and composites), in fibre characterisation and in standardisation and harmonisation, to academics researching in the field of technical applications of natural fibres, as well as to postgraduates on specific courses and research projects in the above areas.

Series Preface

Renewable resources, their use and modification are involved in a multitude of important processes with a major influence on our everyday lives. Applications can be found in the energy sector, chemistry, pharmacy, the textile industry, paints and coatings, to name but a few.

The area interconnects several scientific disciplines (agriculture, biochemistry, chemistry, technology, environmental sciences, forestry, . . .), which makes it very difficult to have an expert view on the complicated interaction. Therefore, the idea to create a series of scientific books, focussing on specific topics concerning renewable resources, has been very opportune and can help to clarify some of the underlying connections in this area.

In a very fast changing world, trends are not only characteristic of fashion and political standpoints, also science is not free from hypes and buzzwords. The use of renewable resources is again more important nowadays; however, it is not part of a hype or a fashion. As the lively discussions among scientists continue about how many years we will still be able to use fossil fuels, with opinions ranging from 50 years to 500 years, they do agree that the reserve is limited and that it is essential not only to search for new energy carriers but also for new material sources.

In this respect, renewable resources are a crucial area in the search for alternatives for fossil-based raw materials and energy. In the field of energy supply, biomass and renewable-based resources will be part of the solution, alongside other alternatives such as solar energy, wind energy, hydraulic power, hydrogen technology and nuclear energy.

In the field of material sciences, the impact of renewable resources will probably be even greater. Integral utilisation of crops and the use of waste streams in certain industries will grow in importance, leading to a more sustainable way of producing materials.

Although our society was much more (almost exclusively) based on renewable resources centuries ago, this disappeared in the Western world in the nineteenth century. Now it is time to focus again on this field of research. However, this should not mean a 'retour à la nature' but should be a multidisciplinary effort on a highly technological level to perform research into the development of new crops and products from renewable resources. This will be essential to guarantee a level of comfort for a growing number of people living on our planet. It is *the* challenge for the coming generations of scientists to develop more sustainable ways to create prosperity and to fight poverty and hunger in the world. A global approach is certainly favoured.

This challenge can only be dealt with if scientists are attracted to this area and are recognised for their efforts in this interdisciplinary field. It is therefore also essential that consumers recognise the fate of renewable resources in a number of products.

Furthermore, scientists do need to communicate and discuss the relevance of their work. The use and modification of renewable resources may not follow the path of the genetic engineering concept in view of consumer acceptance in Europe. In this regard, the series will certainly help to increase the visibility of the importance of renewable resources.

Being convinced of the value of the renewables approach for the industrial world, as well as for developing countries, I was myself delighted to collaborate on this series of books focusing on different aspects of renewable resources. I hope that readers become aware of the complexity, the interaction and interconnections and the challenges of this field, and that they will help to communicate the importance of renewable resources.

I certainly wish to thank the people at John Wiley & Sons, Chichester, especially David Hughes, Jenny Cossham and Lyn Roberts, in seeing the need for such a series of books on renewable resources, for initiating and supporting it and for helping to carry the project through to the end.

Last but not least, I would like to thank my family, especially my wife Hilde and my children Paulien and Pieter-Jan, for their patience and for giving me the time to work on the series when other activities seemed to be more inviting.

Christian V. Stevens
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June 2005

Preface

What makes natural fibres so fascinating? Representatives of different professional disciplines, like biologists, chemists, agronomical scientists, process engineers or preservation scientists, would certainly each answer this question quite differently, according to their own scientific interest and research. As a material scientist, I would like to describe my own perception and at the same time outline the leading thoughts of this book.

Material discoveries and material developments have in the history of mankind led to great progress in innovation, with far-reaching consequences for technology, economy and culture. The periodical division of prehistory and early history of mankind is mainly determined by the materials used in these periods (Stone Age, Bronze Age and Iron Age). Although the utilisation of natural fibres is verifiable in early archaeological cultures, it has not resulted in the naming of an epoch. There is no 'natural fibre age', although in history the usage of natural fibre has been quite varied and has repeatedly generated culturally significant innovations. Clothing textiles as well as technical textiles (e.g. nets) or composite materials (e.g. natural fibre compounded clay) are examples of such innovations. In this book these historical aspects of natural fibre usage are combined with possible future products.

In our progressively globalised world with unforeseeable demographic, economic and ecological challenges, management of resources and sustainability are increasingly becoming the focus of debate and discussion. The utilisation of materials is a key factor, and natural fibres in particular, being a natural resource, provide opportunities for technical innovation and sustainability.

The use of natural fibres, e.g. in technical applications, needs to be in line with the three essential pillars of sustainability – economy, ecology and society. To ensure that this remains so now and in the future, the worldwide raw material turnaround and its effects on the selection of materials must be critically examined on the basis of sustainability criteria.

The main argument against the industrial use of natural fibres is often that the quality of the fibres depends on the year in which they were grown. It is nevertheless possible to obtain fibres of consistent quality, as well as reliable data, enhancing the predictability of the properties of natural fibre products by using a quality management system that starts for plant fibres at the cultivation stage and that is based on reproducible proof of origin and harvesting parameters. This book will combine the different steps of processing, from agriculture, fibre separation and fibre processing to the manufacture of the final product. Each step will be linked to the fibre properties, the possibilities to characterise them, and how the different natural fibres will influence the product properties.

In order to understand why and how a natural fibre influences a product property, their chemical as well as structural qualities are thoroughly described. The fundamental understanding of the hierarchy and construction of natural fibre structures allow for a specific and selective design of natural fibre products.

However, natural fibres and their function in biological systems also offer an exceedingly interesting model for the development of biomimetic and bio-inspired materials. Here, also, a fundamental understanding of the functions enhances the transfer from biological system to technological appliance.

The subject of natural fibres is an interdisciplinary field of research and, among others, touches the fields of cultivation, biochemistry, agricultural science, biology, material science and engineering. The aim and objective of writing this book was to provide a substantiated overview of the status of current research on the subject of natural fibres and technical natural fibre usage, including the perspectives of other disciplines.

I would like to thank the authors, who have shown great interest in this interdisciplinary book project.

As a combination of different areas of research may cause problems of understanding, there has been great emphasis on using consistent terminology. This will enhance understanding across the borders of scientific fields. In this context, I would again like to thank the authors, who worked very cooperatively in this project. A special focus was to present the graphic elements in this book consistently and appealingly. Using mainly handwritten graphics and diagrams, we have attempted a new way of illustration in this book. My special thanks to Tanja Sloodmaker and Anja Müssig for their creative work.

I would like to thank the staff at John Wiley & Sons, Chichester, especially Richard Davies, Sarah Hall and Jenny Cossham, for supporting the book project through to the end.

I would also like to thank my family and friends for their patience and the time they have given me for the conception and writing of this book.

I hope while reading this book you will experience some of the fascination of 'natural fibres' that I have been experiencing for years now, being engaged in this highly interesting area of research.

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Editor *Industrial Applications of Natural Fibres*

January 2010

Foreword

In the past, when synthetics became used as alternative construction materials instead of metals, a lot of damage happened to different components. This resulted in a very negative estimation of the performance of synthetics. Soon it became clear that metals could not simply be replaced by synthetics and the designer had to learn how to deal with these new materials. This time of apprenticeship was injurious to the image and the reputation of synthetics, and as a consequence similar developments have to be avoided, if new materials like natural fibres are to be technically applied in the future. Thus, knowledge of structure and properties as well as interconnection with shaping is necessary for material selection.

It is therefore highly appreciated that the publishers John Wiley & Sons, Chichester, have initiated a series of scientific books on special subjects of renewable resources. This particular volume “Industrial Applications of Natural Fibres” is edited by Jörg Müssig, a very active young Professor of Biological Materials. He is both the initiator and scientific head of numerous research projects on the value-added chain of natural fibres in the field of technical applications, starting from agriculture and ending with the final product.

Bulk properties of materials are mainly determined by their chemical composition and atomic structure. Technically, geometrical and test conditions additionally influence parameters of construction materials. As all of them have their own life history, these facts have to be known if materials are to be used sustainably in industrial applications. This means that modern procedures using statistical methods of testing and evaluation are necessary. Particularly in the case of natural fibres, the whole distribution of property should be known.

Thanks to the thorough and extensive activities of the editor, a great number of internationally well-known experts in the field of natural fibres have contributed their expertise, writing articles on this interdisciplinary field of research and application, and thus making a comprehensive compendium available. Many of the chapters refer to the requirements mentioned above. The uniformity of the structure of each chapter, the well coordinated contents with links to corresponding chapters and the consistent terminology of the combined contributions will be of great advantage for every reader. Of particular note are the handwritten graphics and diagrams. They are very informative, and in combination with historical drawings of plants, the information presented becomes clear and vivid. The reader not only gets general information but also detailed facts on a scientific basis with links to comprehensive lists of well investigated current publications.

It was a great pleasure to read the manuscript and hopefully many students, as well as academic and industrial researchers in the field of technical applications of natural fibres will contribute to the development of these advanced materials by studying this highly professional compendium.

I congratulate and thank the editor and the authors for their ambitious work.

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