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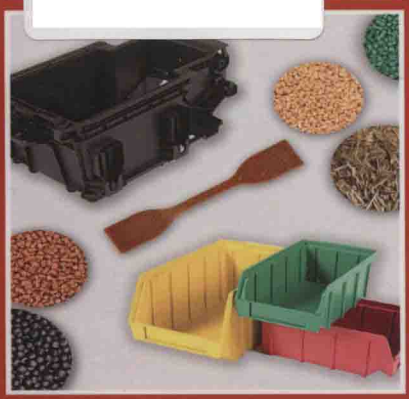

Biocomposites: Design and Mechanical Performance

Edited by Manjusri Misra,
Jitendra K. Pandey and Amar K. Mohanty

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WOODHEAD PUBLISHING

Woodhead Publishing Series in Composites Science and Engineering: Number 61

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Manjusri Misra
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ISBN: 978-1-78242-373-7 (print)
ISBN: 978-1-78242-394-2 (online)

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Control Number: 2015935091

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Printed in the United States of America

Biocomposites: Design and Mechanical Performance

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Preface

The well-known Green Revolution in the late 1960s was a groundbreaking agricultural initiative that resulted in high-yield crops, thereby satisfying the food demand of a growing population. History repeated in the 1990s, when agriculture—with other renewable resources—became the base for the growing biobased economy. In the developing bioeconomy era, the necessity for sustainable development has drawn a renewed interest for natural fiber composites in the manufacturing sector. Biocomposites and green-composites are gaining importance for their application in eco-friendly consumer products, rigid packaging, automotive parts, and housing structures.

The environmental awareness of our society has reached its highest level in decades. Most segments of society, particularly the burgeoning younger demographics, now realize the importance of alternative resources substituting the non-renewable and fast-depleting petroleum resources in different areas of application, such as energy, chemicals, and materials. The ever-increasing concern over climate change, growing greenhouse gas (GHG) emission, along with the growing population has necessitated the reinvention of sustainable development in the plastic-based manufacturing industries. Sustainable development can be realized with the overlap of its three foundational platforms: economic, social, and environmental benefits. Currently, we have to plan, design, and formulate new, alternative options from resources that are renewable, within acceptable timeframes.

Today, petroleum is the main feedstock for the production of polymeric materials. Almost 99% of the total global plastic production is from petroleum resources. Synthetic glass fiber has occupied the predominant place in the multi-billion-dollar composite industry. The long-standing R&D output in the area of natural fiber composites has created enough scientific data showing that several natural fibers can substitute certain types of glass fiber (like E-glass) in specific composite uses—with the added advantage of eco-friendliness. Many natural fibers are less expensive, are about half the density—thus lighter, have higher specific strength, require comparatively less energy to produce, have superior sound abatement features, and are biodegradable—as compared to E-glass fibers.

The material being lightweight, along with its competitive cost and performance attributes, is a driving force behind the use of natural fiber composites in automotive parts. The agro-based natural fibers, like flax, jute, kenaf, industrial hemp, sisal, and henequen, have been researched extensively in the biobased composites field. This class of long fibers has advantages in engineering fabric-based structural composites, alongside their use in injection molded short fiber composites. Forest resourced wood fiber has been used widely in wood-plastic composites. The purpose-grown perennial grasses, for example, switch grass and miscanthus, as well as agro-residues such as

wheat and rice straws, corn stovers, soy stalks, etc., demonstrate strong potential in injection molded composites application. For the manufacturing sector, the constant supply chain of natural fibers, and the logistics of their collection and transportation are some of the challenges hindering the fibers' large-scale implementation.

The biobased composite materials from petro-based plastics and natural fibers have achieved some commercial success. The most used biocomposites are natural fiber reinforced polypropylene, under the thermoplastic composites category, and natural fiber reinforced unsaturated polyester resin, under the thermoset class. New composite materials from plant derived natural fibers and crop derived bioplastics are gaining more and more importance with the growing environmental need to have truly green composites. The hybrid biocomposites, derived from mixed sources, for example, both from bio-resources and petro-resources, are gaining more market and commercial attraction because of their cost-performance attributes. At present, society is ready to accept biobased alternatives; however, not with cost and performance penalties. For these materials, scientists, in collaboration with chemists, physicists, mechanical and chemical engineers, are seeking ways to provide knowledge, and to offer technologies that can overcome the obstacles. Policy makers are the first element needed to move this plan forward. Governmental mandates are necessary to promote the production and utilization of bio-products in different industrial sectors.

With the present book, *Biocomposites: Design and Mechanical Performance*, we hope to contribute to the awareness of our society about the environment; provide a scientific approach to overcome obstacles with substitutes for petro-based polymeric materials; and encourage the policy makers to keep driving the industry sectors, and academic research, towards a sustainable future. This book consists of 17 chapters written by leading researchers. It is a single source of information about a wide range of bioplastics and biocomposites.

We would like to acknowledge all authors who contributed, as well as the Woodhead Publishing staff who helped us immensely in making this book possible.

Finally, we would like to dedicate this book to the numerous natural fiber growers, the stalwarts of the biomass producing industry, biopolymer compounders and equipment manufacturers, policy makers, those looking for value-added solutions to co-product streams of the bioproducts industry, and to all those looking to create a sustainable future for mankind in an environmentally conscious society.

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Foreword

Environmental concerns associated with the ever-expanding use of petro-based materials continue to grow, along with the rapid acceleration in global warming. Faster development of sustainable materials and green processes for mainstream markets is critically important for tackling both these issues. This is particularly true for composites and other petro-based products that combine two dissimilar materials, because, as of now, no environmentally friendly end-of-life solutions are available for them. Unfortunately, most composites end up in landfills. Replacing petro-based materials with their bio-based counterparts has great potential to limit and even reduce the accumulation of new fossil carbon in the atmosphere. It is no wonder that, over the past few years, an increasing number of scientific publications, reports, patents, international conferences, and symposia have been covering the exploration, development, and use of renewable resource- or plant-based materials as alternatives to petro-based materials in broad and diverse applications. Companies with long-term vision are already moving away from petro-based materials and chemicals, and at the same time, governments are enacting new regulations to increase the use of bio-based products, for a better tomorrow.

Natural fiber composites, developed from traditional and engineering plastics, are being widely researched, and these materials have begun to find their way into diverse industrial and sports applications. On the other hand, researchers are increasingly exploring the design and engineering of *green* biocomposites derived from bio-based plastics and natural fibers, because most of these products tend to be environmentally benign. More and more research initiatives are also aimed at realizing the full potential of such bio-based and biodegradable plastics and composite materials. Improvements in the performance, efficiency, durability, and cost effectiveness of these materials, through further research, can improve their competitiveness in the current market. Current bio-based materials research is focused on developing and evaluating a rich array of bioproducts. As we make an effort to substitute the traditional materials with bio-based products, we must learn to better assess these sustainable materials to ensure their quality and long-term performance, while enhancing their functionalities.

The success of these materials in every possible field of application requires a full understanding of the material properties and manufacturing technologies. For this reason, this book focuses on detailing the design and mechanical performance of biocomposites. The chapters in this book provide a comprehensive scientific and technological appraisal of the current research and perspectives related to biocomposites made from traditional and engineering plastics, bio-based plastics, and their blends

reinforced with natural fibers. This book should appeal to a broad range of research scientists, scholars, academics, industrialists, and government officials across various related fields.

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