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Natural Fiber-Reinforced Composites

Thermal Properties and Applications

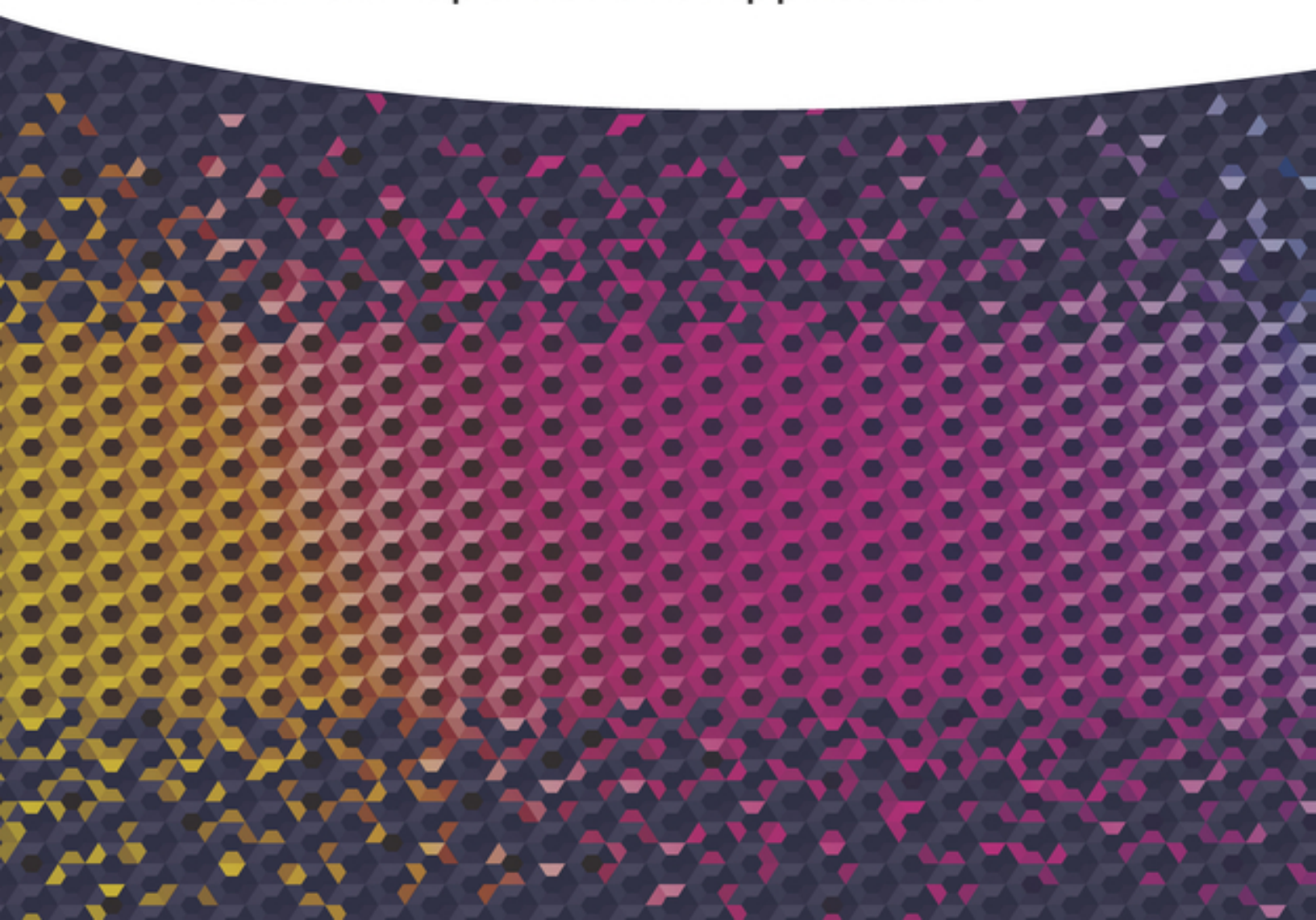


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Preface

We are glad to present the book entitled “Natural Fiber-Reinforced Composites: Thermal Properties and Applications” to thermal analysts, materials scientists, materials engineers, material chemists, and researchers working in the field of bio-composites.

This book focuses on exploring the thermal properties of hybrid composites reinforced with natural fibers. As per literature, the thermal properties of these composites could be analyzed by the techniques such as differential scanning calorimetry (DSC), thermomechanical analysis (TMA), thermogravimetric analysis (TGA), and dynamic mechanical analysis (DMA). In lieu of this, all the chapters are designed to cover a broad audience with the aforementioned techniques on hybrid composites reinforced with natural fibers.

This book consists of 18 chapters and is structured as follows: [Chapters 1, 2, and 3](#) present the overview of thermal properties of natural fiber reinforced thermoset and thermoplastic hybrid composites. [Chapters 4 to 11](#) discuss the thermal properties of hybrid composites made up of different natural fibers such as sugar palm, sisal fiber, flax fiber, pineapple leaf fiber, grass/cane fiber, banana fiber, kenaf fiber and hemp fiber. [Chapters 12 to 16](#) provide insights on the effect of nanofillers (e.g. graphene, nanoclay, CNT, metal oxide) on thermal properties of natural fiber reinforced hybrid composites. [Chapter 17](#) discusses the effects of chemical treatments of hybrid composites on thermal properties. [Chapter 18](#) provides an overview of physical, mechanical, and thermal properties of hybrid polymer composites.

We thank our parents and sincerely appreciate the publisher, the typesetting professional associated with this book, and thank all the contributing authors for their valuable time and efforts in submitting their work to this book.

1

Thermal Characterization of the Natural Fiber-Based Hybrid Composites: An Overview

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1.1 Introduction

Hybrid composite is fabricated by adding two or more fibers into a single polymer system [1]. The resulting material has a unique feature that combines the advantages of each fiber. Since different fibers are added together, the benefits of one particular type of fiber property could be compensated with the other fiber lacking

a specific property. The performance of hybrid composites could be influenced by many factors [2-7]:

- i. Fiber length
- ii. Fiber loading
- iii. Fiber orientation
- iv. Fiber layer sequence
- v. Fiber/matrix interfacial bonding
- vi. Failure strain of fiber

The hybrid effect is termed as an apparent synergistic improvement of properties due to different fibers in a single matrix system. The selection of fibers and their properties is of main importance to achieve the enhanced properties for the hybrid composites. Besides the physical, chemical, and mechanical stabilities of fiber, the matrix system also defines the strength of the hybrid composites. The different types of hybrid composites are characterized as follows [8-12]:

- i. Tow by tow: the fibers are mixed up randomly or regularly.
- ii. Sandwich hybrid composites: one material is sandwiched between two different layers.
- iii. Inter-ply or laminated: two or more fiber layers are alternatively stacked regularly.
- iv. Intimately mixed fibers: various types of fibers are mixed up randomly.

Though the hybrid composites have many advantages, the prime challenges are replacing the synthetic fiber-reinforced composites using biocomposites. Biocomposites exhibit functional and structural stability during storage

and degrade upon disposal into the environment.

“Engineered natural fiber” is one of the exciting concepts to obtain the enhanced strength in the biocomposites, which involves the blending of the leaf and stem fibers. The correct blending of these two fibers exhibits optimum balance in mechanical properties, resulting in balanced stiffness-toughness properties [[13-15](#)].

The mechanical and physical characteristics of the natural fiber are influenced by many factors: (i) maturity of the plant fiber, (ii) harvesting time and region, (iii) soil condition, (iv) rain, (v) sun, etc. Since the natural fibers are nonabrasive and hypoallergenic, they could be processed efficiently. Amongst the various properties of natural fibers, the low density and the cellular structure allow them to exhibit better thermal properties. However, the amorphous hemicellulose on the fiber surface can be a potential threat to the better interfacial bonding between the matrix and the fiber, thereby reducing the properties. Hence, the mechanical and thermal properties of the biocomposites could be further enhanced through chemical treatments [[16](#)]. Natural fiber has cellulose, hemicellulose, and lignin susceptible to degradation on exposure to elevated temperature [[17-19](#)]. Thus, many studies exploring the thermal properties of the biocomposites have been published over the years [[20-22](#)]. By botanical type, the natural fibers are classified into six major types ([Table 1.1](#)).

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