Preface

The editors are pleased to present the book ***Plant and Animal Based Composites*** under the book series **Advanced Composites**. The book title was chosen as it depicts the upcoming trends in composite materials for the next decade. This book is a compilation of different plant- and animal-based composites or in common words, *natural composites*. Emphasis is on the achievements, progress and recent developments and their applications.

The increasing demand for environmentally friendly materials and the need for cheaper fibers that increase the desirable mechanical properties force us to search for natural products. Natural fibers/fillers are largely divided into two categories depending on their origin: plant based and animal based. The fibers, in case of plant-based composites, can be extracted from the various parts of the plant, that is, bark/stem, leaves, fruits and so on, whereas, in the case of animal-based ones, the same can be from the scale (fish), skin (animals), feather (birds, chicken, etc.), eggshell, shell (mollusks, sea urchins, crustaceans, turtles and tortoises, armadillos, etc.), animal waste and so on.

One of the major disadvantages of the usage of these fibers is moisture absorption. Most of the nature-based fibers or fillers are hydrophilic in nature owing to the presence of functional groups such as hydroxyl in their structure and also being porous. Hence, they absorb a considerable amount of moisture from the surrounding environment. The high moisture absorption leads to a number of problems when used as reinforcement materials such as:

(1) Fibers and fillers swell due to the absorption of moisture and shrink when moisture is removed due to the dry atmosphere and elevated temperatures. This frequent swelling–shrinking phenomena leads to the formation of cracks and hence leads to reduced mechanical performance and durability of the composites.
(2) High absorption of alkaline solution present within the matrix leads to the degradation of fibers with time. These result in deterioration of the properties of the composites.
(3) Moisture absorption of fibers and fillers leads to breakage of hydrogen bonds between the fiber and matrix and, therefore, weakens the fiber/matrix interface and, consequently, it deteriorates the mechanical strength.

Therefore, a number of fiber surface treatment methods are required to be undertaken to reduce the moisture absorption of fibers for applying them in composites.

At present, *Plant and Animal Based Composite* is a major discipline and many researchers and scholars are working in these areas. This book provides insight for all researchers, academicians, postgraduate or senior undergraduate students working in the area. The chapters in the book have been provided by researchers

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and academicians working in the field and have gained considerable success in the field.

The chapters in the book have been categorized into **three parts,** namely, **Part I: State of Art; Part II: Plant-Based Composites; and Part III: Animal-Based Composites.**

Part I contains **Chapters 1**–**3**, whereas **Part II** has **Chapters 4–7** and **Part III** with **Chapter 8.**

Part I starts with **Chapter 1**, which provides the readers an insight into recent developments in plant and animal fiber-reinforced composite. The chapter reviews the recent reports about the properties, fabrication processes, applications and advancements in the field of composites fabricated with different biodegradable plant and animal fiber-reinforced composites. Various types of matrix and reinforcements that are available to be used with biopolymers for best maintainable green composites have also been addressed. These natural composites can be created at a low cost, have practically identical mechanical properties with synthetic composites and maintain a balance between ecology, technology and the economy.

Chapter 2 elaborately deals with the advances in animal/plant–plastic composites. This chapter aims at exploring the preparation, characterization and applications of plant/animal fiber-reinforced polymer composites. The chapter starts with a thorough overview of the various forms of plant/animal fiber-reinforced polymer composites followed by examples of such composites and their promising future in terms of research and development and their application in domestic and engineering products. Considering forest conservation and the efficient use of agricultural as well as other renewable resources, such as solar, wind and tidal energy, the use of renewable materials, such as plant/animal fiber-reinforced polymeric composites, is slowly becoming a key design requirement in the design and development of parts for a wide range of industrial products. An extensive research into such composites can lead to an even greener and healthier environment, to some extent.

Again, in **Chapter 3**, the last chapter of this part, a detailed review of the ductile attributes of natural fiber composites has been put forward. Normal fiber-strengthened composites are a developing territory in the polymer discipline. Hence, this chapter presents a detailed effort on the characteristics of natural fiber composites with an exceptional testimonial to the types of fibers, fabrication method and ductile attributes. This is a very pertinent problem as these natural fiber composites are biodegradable and noncoarse, and they exhibit the explicit attributes that are practically identical to those of regular fiber composites. Due to their low cost, equally great mechanical attributes, extremely explicit quality, nonrasping, eco-friendly and ecological attributes, they have gained a lot of ground and the ductile characters are essentially impacted by the hook-up attachment among the matrix and the fibers.

Chapter 4, the next chapter of the book and the first chapter of **Part II**, provides the reader with an exclusive study of plant-based fibers and resins in composites. In the present era, the use of sustainable crude materials in the composite industry is turning out to be progressively well known in view of the natural aftercare and the necessity to replace fossil resources. Plant oils with triglyceride spines can be artificially altered and used to integrate resin from inexhaustible assets. Plant oils contain a dominance of triglyceride, the glycerol esters of unsaturated fats. Five important types of unsaturated fats of the unsaturated fat chain are obtained as one of the outputs from the hydrolysis process of triglyceride with 16 to 18 carbons with 0 to 3 times the securities. The five unsaturated fats are oleic, linolenic, palmitic, linoleic and stearic acids. The percentage of specific unsaturated fat varies in different plant oils and also in similar plant oils. The variation depends on the plant species, weather and plant growth states. This chapter puts emphasis on plant-based fibers, resins and fillers derived from different plants.

In **Chapter 5**, an orthopedic application of plant-based composites has been described. Orthotic calipers have been fabricated and tested with plant-based composites. The main objective of the chapter was to use bark-based and fruit-based reinforcement with epoxy as the matrix to create the braces for orthotic calipers. The void content and mechanical behavior, including tensile and flexural test, were performed and then compared with the currently used materials. After comparison, it is observed that the specific strength and stiffness of bark-based reinforced composite are better than that of the presently used aluminum alloy.

In **Chapter 6**, the next chapter of the book, the content experimentally illustrates the mechanical potential of the polypropylene, jute and coir fiber-based composites. Three types of composite specimens – polypropylene, polypropylene reinforced with jute and polypropylene reinforced with jute and coir composites –, are prepared using the injection molding method. The experimental results show that the incorporation of jute and coir fibers into the polypropylene matrix resulted in improvement of the tensile, flexural and impact properties of the composites.

Chapter 7, the last chapter of the section, provides the mechanical properties of a very common plant-based composite, *rice straw fibre reinforced with epoxy*. The chapter discusses the preparation of different types of rice straw fiber with epoxy composite: rice straw fiber has been used without any surface treatment and treated with hot water and NaOH with different volume fractions. The fibers are used in aligned and cross-conditions with different layers. Mechanical properties as per the standard have been analyzed and compared.

The only chapter of **Part III** and the last chapter of the book, that is, **Chapter 8** presents the thermomechanical properties of forcespun polycaprolactone (PCL) fibers infused with fish scale-based hydroxyapatite (HA). This chapter highlights the usage of animal-based reinforcement. In one word, this chapter deals with a completely biodegradable composite, as both the matrix and the reinforcement are biodegradable. HA is a biomaterial with excellent characteristics that is suitable for biomedical applications. In this chapter, HA is synthesized from carpa fish scales by the calcination method and nanomilled for particle size reduction, and these particles were characterized using X-ray diffraction, scanning electron microscopy and transmission electron microscopy. A novel forcespinning technique was used to fabricate microfibers from PCL infused with synthesized HA. Thermomechanical properties of the PCL/HA fiber mats were investigated using differential scanning calorimetry, dynamic mechanical analysis and tensile tests. The analyses suggest that infusing the HA in moderate quantities will enhance the thermomechanical properties of the composite fibers.

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