Chapter 1
Physical and Chemical Properties of Bio-Nanocomposite Materials

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ABSTRACT

The escalating environmental concerns arising from excessive plastic use and fossil fuel dependency have prompted the scientific community to seek sustainable alternatives. Bionanocomposites, fusion of biopolymers and nanomaterials have emerged as promising candidates to address both performance and sustainability requirements. This chapter delves into the fundamental physical and chemical attributes of bionanocomposites and their unique structures influence functionality. They are used in the industries like food, environmental, medical, tissue engineering scaffolds and in electronics, where they contribute to flexible and lightweight devices. Recent developments have focused on overcoming these barriers through innovative approaches such as using waste-derived biomaterials, developing green synthesis

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pathways, and enhancing processing techniques like electrospinning, extrusion, and solvent casting. With the right interdisciplinary efforts, bionanocomposites could be key players in the development of next-generation eco-friendly technologies.

1. INTRODUCTION

Plastic materials are commonly employed to create a wide range of products and items for everyday household and industrial use. They satisfy all commercial and industrial market criteria, including cheap cost, durability, good performance, convenience, high mechanical variability, and other crucial properties (Brydson, 1999; Rosato, 2003). Packing accounts for a considerable share of plastic use (about 40%), which has escalated dramatically in the last decade of the twentieth century (Fomin & Guseev, 2001; Pilla, 2011). As plastic is extremely resistant to decomposition, humanity is currently faced with countless non-biodegradable wastes, with the amount only increasing every year as the demand and need for production is growing constantly. Most chemicals and polymers, primarily packaging, are all currently derived from the non renewable natural source, petroleum (Brydson, 1999). The fact that fossil resources are exhaustible is a massive concern. Materials, chemicals, as well as fuel, for example, are consumed much more quickly than the existing fossil fuels. Another challenge is carbon-containing materials and the emissions of carbon dioxide that come with them. The soaring depletion of fossil fuels has resulted in the creation of a radically distinct, artificial cycle. Its effect on global processes and the environment is becoming increasingly conspicuous, and it is now acknowledged as a worldwide environmental issue (Fomin & Guseev, 2001; Sudesh & Iwata, 2008; Golomb & Fay, 2004). A practical and feasible alternative is required to meet the global demands as well as check for environmental concern and protection. This led to research on newer substances, nanocomposites which has further become a better source as bio nanocomposite.

Nanocomposites are composites in which at least one phase has dimensions in the nanometer range (1 nm = 109 m) (Defonseka, 2014). It is divided as three different classes based on matrix materials: (i) Polymer Matrix Nanocomposites (PMNC), (ii) Metal Matrix Nanocomposites (MMNC), and (iii) Ceramic Matrix Nanocomposites (CMNC). In comparison to the micro or macro composites, Nacomposites show improved mechanical properties, synergistic flame retardant additives, excellent gas barrier properties, excellent thermal expansion, and improved dimensional stability. Selecting the proper matrix, synthetic systems, nano reinforcing materials, and surface modification of the reinforcing materials or polymers, as desired, could be used to generate polymer nanocomposites for a multitude of purposes. Polymer nanocomposites can be employed in industrial packaging and offer a number of advantages

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