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Polylactide-Based Bionanocomposites: A Promising class of Hybrid Materials

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ABSTRACT

Polylactide (PLA) is the oldest and potentially one of the most interesting and useful biodegradable man-made polymers because of its renewable origin, controlled synthesis, good mechanical properties, and inherent biocompatibility. The blending of PLA with functional nanoparticles can yield a new class of hybrid materials, commonly known as bionanocomposites, where 1-5% nanoparticles by volume are molecularly dispersed within the PLA matrix. The dispersed nanoparticles with their large surface areas and low percolation thresholds both can improve the properties significantly in comparison with neat PLA and can introduce new value-added properties. Recently, researchers have made extraordinary progress in the practical processing and development of products from PLA bionanocomposites. The variation of the nanofillers with different functionalities can lead to many bionanocomposite applications including environmentally friendly packaging, materials for construction, automobiles, and tissue regeneration, and load-bearing scaffolds for bone reconstruction. This Account focuses on these recent research efforts, processing techniques, and key research challenges in the development of PLA-based bionanocomposites for use in applications from green plastics to biomedical applications. Growing concerns over environmental issues and high demand for advanced polymeric materials with balanced properties have led to the development of bionanocomposites of PLA and natural origin fillers, such as nanoclays. The combination of nanoclays with the PLA matrix allows us to develop green nanocomposites that possess several superior properties. For example, adding plus minus 5 vol % clay to PLA improved the storage modulus, tensile strength, break elongation, crystallization rate, and other mechanical properties. More importantly, the addition of clay decreases the gas and water vapor permeation, increases the heat distortion temperature and scratch resistance, and controls the biodegradation of the PLA matrix. In biomedicine, researchers have employed the design rules found in nature to fabricate PLA-based bionanocomposites. The incorporation of functional nanoparticles in the PLA matrix has improved the physical properties and changed the surface characteristics of the matrix that are important for tissue engineering and artificial bone reconstruction, such as its thermal and electrical conductivity, surface roughness, and wettability. Finally, of the introduction of bionanocomposite biocompatible surfaces on drugs, such as antibiotics, could produce delivery systems that act locally.