Biomedical applications of polymer and biopolymer nanocomposites

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Abstract

Polymer and biopolymer nanocomposites are emerging as essential components in biomedical applications, including drug delivery, tissue engineering, antimicrobial therapies, and diagnostics. By integrating synthetic and natural polymers with nanoscale fillers, these materials offer tunable biocompatibility, biodegradability, and targeted therapeutic effects. They enable controlled drug release, enhance scaffold development for tissue regeneration, and provide antimicrobial properties for wound healing. In oncology, they support targeted drug delivery and biocompatible implants while also contributing to real-time disease monitoring through biosensors. Despite challenges in large-scale manufacturing, regulatory compliance, and long-term safety, innovations like AI-driven material design, 3D bioprinting, and green nanotechnology are advancing sustainable biomedical

solutions. This chapter examines the critical role of polymer and biopolymer nanocomposites in biomedical applications with a special focus on bone, cartilage, and skin tissue engineering. It also explores their significance in the design of controlled and targeted drug delivery systems. Furthermore, it reviews emerging trends in multifunctional nanocomposites for theranostic and sustainable healthcare applications, assessing their potential to improve access to treatments for neglected diseases and enhance point-of-care diagnostics. By synthesizing current progress in this interdisciplinary field, the chapter outlines future research directions and strategies to overcome translational barriers, ultimately aiming to accelerate the clinical adoption of polymer nanocomposite technologies for improved healthcare outcomes. © 2026 Elsevier Ltd. All rights reserved..

Author keywords

3D printing; biomedicine; Biopolymers; drug delivery; nanocomposites

Indexed keywords

Engineering controlled terms

Biocompatibility; Biomedical materials; Biomolecules; Bone; Clinical research; Controlled drug delivery; Diagnosis; Drug products; Ecodesign; Green manufacturing; Industrial research; Medical applications; Regulatory compliance; Scaffolds (biology); Tissue regeneration

Engineering uncontrolled terms

3-D printing; 3D-printing; Antimicrobial therapy; Application of polymers; Biomedical applications; Biomedicine; Nano-scale fillers; Polymers and biopolymers; Tissues engineerings; Tunables

Engineering main heading

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Abstract

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