14th World Congress on
Biopolymers and Biomaterials

August 18-19, 2025

Webinar

Biodegradable biomaterials for orthopedic regeneration

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The demand for biodegradable biomaterials in orthopedic applications has grown rapidly due to rising global cases of traumatic injuries and age-related bone disorders. This work investigates the structural, mechanical, and biological properties of biopolymer-based composites primarily polylactic acid (PLA), polycaprolactone (PCL), and collagen blends designed for bone regeneration scaffolds. Scaffolds were fabricated using 3D printing and freeze-drying to achieve interconnected porosity ranging between 60–85%, promoting nutrient perfusion and osteoblast proliferation. Incorporation of nano-hydroxyapatite (nHA) improved compressive strength by 48%, making the composite suitable for load-bearing applications. In vitro assays revealed a significant increase in alkaline phosphatase activity, collagen deposition, and mineralization in osteogenic cultures seeded on the biopolymer–nHA scaffolds compared with commercial equivalents. Degradation studies showed a controlled breakdown over 12–18 weeks, aligning with natural bone healing timelines. The biocompatibility profile demonstrated reduced inflammatory markers, reinforcing the safety of the composites. Furthermore, an animal model study involving rabbit femoral defects showed accelerated bone regeneration and complete bridging after 14 weeks.

Results confirm that biopolymer-based biodegradable scaffolds offer an excellent alternative to metallic implants, eliminating long-term complications such as implant failure, infection, and second surgeries. These materials hold strong potential for clinical translation in orthopedic tissue engineering.

Biography

Kofi Mensah is a leading biomaterials researcher at the University of Ghana with expertise in orthopedic tissue engineering and biodegradable polymer composites. His work focuses on developing low-cost, high-performance biomaterials tailored for resource-limited settings. He has published extensively in international journals and has led multiple funded projects in regenerative medicine. Prof. Mensah has received national recognition for his contributions to biomedical engineering and continues to mentor emerging scientists across Africa.

Received: 16 April, 2025; **Accepted**: 19 April, 2025; **Published**: November 28, 2025