

Bioactive PHB/LAPONITE®/Guar Gum Bio-Nanocomposite Films for Alveolar Bone Regeneration

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Abstract

Alveolar bone defects remain a major clinical challenge due to the limited availability of suitable grafting materials and the need for biomaterials capable of supporting bone regeneration. This study reports the development of bio-nanocomposite films based on polyhydroxybutyrate (PHB), LAPONITE® (LAP) nanoclay, and guar gum (GG) as potential bioresorbable scaffolds for alveolar bone regeneration. The films were fabricated using a solvent-casting method with varying concentrations of LAPONITE® and characterized for their physicochemical, mechanical, biological, and antimicrobial properties. Structural characterization using FESEM, EDX, FTIR, XRD, and TGA confirmed the successful incorporation of LAPONITE® into the PHB/GG matrix, resulting in improved surface morphology, reduced crystallinity, and enhanced thermal stability. The incorporation of LAPONITE® also increased film thickness and generated a porous microstructure favourable for tissue engineering applications. Among all formulations, the 5 wt% LAPONITE® bio-nanocomposite exhibited the most balanced performance, demonstrating a tensile strength of 123.90 ± 4.25 MPa, enhanced biomineralization in simulated body fluid, controlled degradation over 28 days, and effective antibacterial activity against *Staphylococcus aureus*. Cytocompatibility studies using the MG-63 osteoblast-like cell line confirmed that all developed films were non-cytotoxic, while the 3–5 wt% LAPONITE® formulations supported the highest cell viability. These findings demonstrate that PHB/LAPONITE®/guar gum bio-nanocomposite films possess favourable mechanical strength, bioactivity, controlled biodegradation, antibacterial properties, and cytocompatibility. The optimized 5 wt% formulation shows considerable promise as a bioresorbable biomaterial for future alveolar bone regeneration applications.

Keywords

Bio-nanocomposite, Laponite, PHB, Alveolar bone regeneration, and Biocompatibility.