Recent Advances in Fish Scale-Based Polymer Biocomposite Scaffolds for Tissue Engineering

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Abstract

Within the last several years, tissue engineering (TE) has received widespread attention from scholars from multiple disciplines. The foundation of TE rests primarily on three critical components: cells, biomaterials, and cell-stimulating bioactive agents. Despite substantial advancements in biomaterials, a paramount challenge in TE remains the fabrication of scaffolds that are biocompatible, non-toxic, biodegradable, and possess high mechanical performance while being affordable. Synthetic polymers provide mechanical strength but are often biologically inert, whereas natural materials support cell interaction, yet they are typically weak. This review therefore explores the sustainable solution of developing advanced composite scaffolds engineered from fish scales and polymers, evaluating recent studies on collagen- and hydroxyapatite-rich fish scales as reinforcements for various polymers to form biocomposites for potential use in TE applications, particularly bone and skin. Key fabrication techniques, specifically electrospinning, 3D printing, and freeze-drying, have been employed to engineer porous, biomimetic structures with tailored mechanical and biological characteristics. As an abundant fishing industry byproduct, fish scales are a rich source of collagen and a bone-like mineralized structure, while also offering a safer and more acceptable biomaterial alternative by avoiding the disease risks and religious restrictions associated with mammalian sources. Fish scales not only can enable the creation of composites with the aforementioned specifications, but their use also reduces their negative environmental impact. These composites can offer a transformative, eco-friendly, and high-performance alternative for TE, promising to advance both clinical applications and environmental sustainability with further development.