Development and characterization of polymeric biomaterials for regenerative medicine applications

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Regenerative medicine is a transformative field focused on repairing, replacing, or regenerating tissues or organs to restore physiological conditions. It involves tools and techniques such as tissue engineering, cellular therapies, and artificial organs to treat a wide range of conditions, from injuries to chronic diseases [1]. A key element in this field is the development and use of biomaterials, particularly those based on polymers. Polymers, which can be natural, synthetic, or semi-synthetic, are essential building blocks for creating devices that can be implanted into the body to restore physiological functions [2]. In tissue engineering, for the development of bio-engineered tissues, these devices often serve as three-dimensional scaffolds that mimic the extracellular matrix (ECM), supporting cell attachment, proliferation, and differentiation. Additionally, polymer-based devices can be implanted directly into the body to stimulate physiological healing processes by releasing bioactive molecules or genetic material that instruct cells to initiate the healing process [3]. To be effective, these materials must be non-immunogenic, cytocompatible, and biodegradable. They must support cellular activities, whether involving cells pre-seeded before implantation or host cells that migrate into the material post-implantation. They also need optimal mechanical properties to integrate seamlessly with body tissues. Through chemical synthesis and modification, it is possible to produce biomaterials with specific features that meet particular application requirements. Chemical functionalization techniques also enable the development of "smart" materials that respond to external or internal stimuli [4]. These materials can undergo chemical, physical, mechanical, or rheological changes, facilitating advanced therapeutic capabilities such as on-demand release of bioactive molecules, in situ sol-gel transitions, localized heat generation for hyperthermia treatments, or production of reactive oxygen species (ROS) for antimicrobial treatments and cancer therapy. In conclusion, polymeric biomaterials are integral to advancing regenerative medicine. Their versatility and precise chemical modifications create materials that support and enhance the body's healing processes.