

Polymeric Drug Delivery Systems: Production, Characterization, and Their In Vitro and In Vivo Biological Activities

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Abstract:

Polymeric drug delivery systems are produced using a variety of natural and synthetic polymers. Nano- and micro-scale drug delivery systems have been developed by employing synthetic polymers such as polylactic acid (PLA), polycaprolactone (PCL), poly(lactic-co-glycolic) acid (PLGA), and polyethylene glycol (PEG), as well as natural polymer-based materials like chitosan and collagen, or their composites. During the nanoparticle production phase, techniques such as solvent evaporation and emulsification are utilized; in nanofiber production, electrospinning and pressurized spinning methods are applied; and for microneedle and three-dimensional scaffold fabrication, 3D printing is used. These approaches aim to achieve ideal particle, fiber, and microneedle sizes, distributions, and morphological properties. By loading these systems with drugs or plant extracts possessing anticancer, anti-inflammatory, antidiabetic, and antioxidant properties, more effective therapies with fewer side effects can be offered.

Characterization of these systems is performed using techniques including dynamic light scattering (DLS), scanning electron microscopy (SEM), FTIR, XRD, drug delivery studies, and zeta potential measurements. In vitro experiments investigate cytotoxicity and intracellular distribution through cell culture models. In vivo studies focus on pharmacokinetic and pharmacodynamic analyses to evaluate the bioavailability, targeted tissue delivery, and therapeutic efficacy of the systems. The resulting data underscore the potential of polymeric carriers to create safe and effective drug release systems for clinical applications.

Currently, some drug delivery systems are actively used in the healthcare and food sectors. The conducted tests demonstrate the biological compatibility and therapeutic potential of these delivery systems, while also offering important insights for future clinical integration. This comprehensive analysis indicates that polymeric drug delivery systems can make a groundbreaking contribution to modern pharmaceutical applications.

Keywords: Drug delivery; nanoparticle; nanofiber; microneedle; nanotechnology