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Editorial

Polymer Surface Treatments for Drug Delivery and Wound Healing

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Nanomedicine is a cutting-edge field at the intersection of nanotechnology and medicine that has experienced significant advancements in recent decades [1,2]. Various nanosystems, such as polymeric, lipid, and inorganic nanoparticles, have been applied in drug delivery and wound healing applications. They show great promise in enhancing the efficacy, safety, and stability of conventional dosage forms [3]. Polymeric nanoparticles are constructed from biocompatible and biodegradable polymers, such as poly(lactic-co-glycolic acid) and chitosan. They can encapsulate various drugs, offering controlled drug release, enhancing drug stability and bioavailability, and reducing side effects [4]. Moreover, their nanosize facilitates improved tissue penetration, enabling targeted delivery to specific cells or tissues, thereby minimizing systemic toxicity and maximizing therapeutic efficacy [5]. Lipid nanoparticles, which are formulated from biocompatible lipids, play a pivotal role in nanomedicine [6]. They include liposomes, nanoemulsions, solid lipid nanoparticles (SLNs), nanostructured lipid carriers (NLCs), and other modified lipid-based nanoparticles. Lipid nanoparticles exhibit enhanced encapsulation capacity and efficient transport of both hydrophilic and hydrophobic drugs to targeted sites [7]. Inorganic nanoparticles, including gold and silica nanoparticles, offer tunable physicochemical properties and straightforward surface functionalization. They can enable precise drug delivery and promote wound healing by stimulating cellular regeneration and tissue repair [8,9]. Gold nanoparticles have been explored for their ability to promote tissue regeneration and enhance wound healing [10,11]. Silica nanoparticles have a high surface area and can be loaded with various drugs for wound dressings and drug delivery [12,13].

Surface modifications in nanomedicine play a pivotal role in enhancing the properties and optimizing the performance of nanoparticles for drug delivery and wound healing applications [14]. Tailoring the surface characteristics of nanoparticles can improve their biocompatibility. Surface modifications with suitable polymers can enhance the stability of nanoparticles in physiological environments, preventing their aggregation and degradation and prolonging their circulation time in the bloodstream [15]. Coating the nanoparticles with biocompatible polymers, such as polyethylene glycol (PEG), can improve stability and reduce immune recognition and clearance by the reticuloendothelial system, thereby increasing their circulation time and enhancing drug delivery to the target site [16]. Following polymer coating, additional ligands, antibodies, or peptides can be attached to the nanoparticle surface, which helps them selectively bind to specific receptors overexpressed on the surface of target cells or tissues. In cancer treatment, nanoparticles functionalized with tumor-targeting ligands can selectively accumulate in tumor tissues, increasing drug concentrations within the tumor and improving cancer cell killing while minimizing damage to healthy tissues [17,18]. Surface modifications also enable the controlled release of drugs, where drug release can be triggered in response to environmental factors such as pH, temperature, or enzyme concentrations [19]. The surface modification of nanoparticles can alter the surface charge, thereby enhancing mucoadhesion and drug absorption. Positively charged nanoparticles can adhere to negatively charged mucosal surfaces, promoting mucoadhesion and prolonging the residence time at the target site [20]. Changing

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the surface charge of nanocarriers from negative to positive can increase the electrostatic attraction between them and mucus [21]. Chitosan coating of ferulic acid-loaded SLNs increases mucoadhesive strength, drug accumulation in the brain, and cognitive ability in Alzheimer's disease-induced rats [22]. The surface modification of asenapine-loaded NLCs with glycol chitosan improves drug accumulation in the brain and enhances pharmacokinetics [23]. In addition, surface modifications can improve the cellular uptake of nanoparticles. The surface-modified polymers can trigger the opening of tight junctions between epithelial cells to enhance drug transport [24]. They can also interact with cellular membranes, facilitating endocytosis or transcytosis.

Although surface modifications of nanoparticles have shown great potential for enhancing stability, controlled drug release, and active targeting, further comprehensive studies are essential to thoroughly investigate their safety and efficacy. The interactions between surface-modified nanoparticles and the body should be studied to assess their biocompatibility, potential toxicity, and long-term effects. In addition, the fate of these nanoparticles in the body, such as their biodistribution, metabolism, and clearance mechanisms, must be thoroughly elucidated to ensure their controlled and safe delivery to target tissues and organs [25,26]. The stability of surface-modified nanoparticles under various physiological conditions should be assessed to guarantee their integrity during storage, administration, and circulation [27]. Furthermore, potential immunogenic responses or adverse reactions arising from the surface modifications must also be thoroughly evaluated [28]. The potential of surface-modified nanoparticles for drug delivery and wound healing has been demonstrated in various studies. More comprehensive studies are required to assess the safety and efficacy of these nanoparticles, paving the way for their successful translation from the laboratory to clinical applications. Considering these, the Special Issue "Polymer Surface Treatments for Drug Delivery and Wound Healing" publishes original research involving the development of polymer-based surface-modified drug delivery systems for different administration routes and diseases, the applications of polymer surface treatment for wound healing, and the utilization of polymer surface treatment to improve the properties of nanoparticles. In addition, this Special Issue collects comprehensive reviews on the recent development and applications of polymer surface treatments for drug delivery and wound healing.

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