Polymer engineering focusing on drug/gene delivery and tissue engineering

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Advances in polymer science – improved control of polymer molecular weight and polydispersity, structure, properties and functionality – have led to new materials for biomedical application, as well as to the development of novel systems designed for drug/gene delivery and tissue engineering, areas with pivotal role for both research/academic community and industry, generating new niche markets.

In this respect, recent years have witnessed an increased interest in the rational design of complex polymeric structures. The main objectives are related to the development of tailored polymer materials, engineered to exert distinct biological functions, implying multifunctionality as well as appropriate form/architectural features (with implication of nanotechnology), giving rise to specificity and high responsiveness.

Several types of macromolecular compounds (micelles, polymersomes, nano- and microparticles (-capsules/-spheres), molecular imprinting polymers, dendrimers, nanogels, hydrogels and interpenetrated polymer networks) have been developed and tested as potential systems of interest for the envisaged applications. To be of clinical importance the new materials must provide not only high physicochemical and biological performances but also processing ability. These demands often imply combination of natural and synthetic polymers (blends, block/graft copolymers, bioconjugates, interpenetrating networks, etc.), while improved performances may be mainly achieved through composite materials (inorganic/organic, biocomposites). The targeted application site or cargo may require specific material category (biodegradable, bioresorbable), dimension scale (micro/nano size) and topographic characteristics. Some of the existing essential obstacles and limitations may be surpassed by combining systems and approaches from apparently different application domains. Thus, controlled drug delivery and its application in tissue engineering for tissue growth support and stimulation attracted much attention over the last decade, while combination of gene therapy and tissue engineering within a single system resulting in a powerful synergism of treatment options for regenerative medicine (scaffold mediated gene therapy) seems to be the favored alternative for tissue healing.

The presentation summarizes the history and challenges in the discussed domains, pointing on polymers as a possible solution to specific challenges, and outlines the current state of the art, focusing on the newest strategies to improve systems effectiveness and responsiveness (design keys, preparative approaches). Some recent original results are briefly described and expected future directions are underlined.

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