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From Synthesis to Biotechnological Applications: Cationic Polymer Nanoparticles and Nanogels

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Description

Aqueous polymeric dispersions created by polymerization procedures in dispersed media to produce polymeric particles with sizes in the colloidal range have attracted increasing interest from both academic and industry perspectives over the last several decades. Adhesives, water based coatings, textiles, paper, additives, and flocculants are just a few of the applications for these nanoparticles. They can also be used as fine or high-value polymeric materials in medical diagnostic tests, antibody purifications, drug delivery systems, and calibration material.
Monodisperse polymer colloids have shown to be excellent model systems for investigating a variety of colloidal phenomena and creating new industrial applications. The majority of the tests have been conducted using negatively charged particles, with positively charged samples receiving minimal attention. The term "cationic latexes" is commonly used in the literature of polymer colloids to refer to cationic polymeric particles. The manufacture of cationic polymer particles and nanogels by emulsion polymerization will be thoroughly discussed in this review. The kinetics of cationic systems will be studied in depth and compared to those of well-known anionic systems.

The polymeric and colloidal properties of cationic particles/nanogels will next be reviewed, followed by a detailed description of several biotechnological uses of cationic particles/nanogels. Nowadays, in the realm of cancer therapeutics, the concept of a carrier travelling to a specific target, either passively or actively, is crucial for effective drug doses to reach the diseased region of interest without harming the surrounding healthy cells or tissues. The "magic bullet" is based on this concept.

This could include a nanometric-sized delivery platform that can be precisely targeted to tumour tissue, preventing premature fragmentation and degradation and allowing for a more concentrated drug load to pass through the cellular membrane.

This integral system could show controlled delivery by being activated by one or more stimuli such as temperature, pH, light, and so on. It should be noted that in order to release concentrated drug loads in non-healthy tissues, a reliable delivery platform with the ability to precisely control drug release with prior activation by an external stimulus is required. Another factor to consider is that particle size and functional groups have a significant influence on biodistribution and pharmacokinetics. Nanoparticles with a positive charge, for example, have a faster removal velocity than those with a negative charge, and particles between 100 and 200 nm are promptly removed from the bloodstream by the mononuclear phagocyte system if they are not protected (MPS).

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However, adding biocompatible polymers like Polyethylene Glycol (PEG) to their surfaces (in the case of hard nanoparticles) prevents phagocyte activation due to steric interferences caused by the PEG chains on the nanoparticle surface, and significantly extends the average circulation life. Particles are trapped in the liver and spleen in a poor or unprotected manner. This form of surfacemodified nanoparticle can be thought of as immune system stealth, and it's employed to slow down the removal rate and prevent opsonization (labeling of nanoparticles with opsonin proteins which the macrophage recognizes, rejecting the foreign body). Because most nanocarriers target tumours passively and take advantage of their permeable vascularization and poor lymphatic drainage as a result of rapid and aggressive tumour angiogenesis, a prolonged circulation period, and thus an increase in bioavailability, is critical.