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PROCEEDINGS ABSTRACT

The impact of polymeric nanoparticle-based drug delivery systems in cancer therapy: a review

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Cancer remains one of the leading causes of morbidity and mortality, requiring the development of more effective and targeted therapeutic strategies. Given the fact that conventional chemotherapy is often associated with significant limitations (including poor selectivity, systemic toxicity, and nonoptimal pharmacokinetics), polymeric nanoparticle-based drug delivery systems are considered a promising approach to the enhancement of the efficacy and safety of anticancer therapies. These nanocarriers offer unique physicochemical properties that enable improved drug solubility, prolonged circulation time, and controlled release behaviour. This review aims to provide an up-to-date overview of the classification, targeting mechanisms, drug-loading approaches, advantages, limitations, and future potential of polymeric nanoparticle-based drug delivery systems in cancer therapy. Polymeric nanoparticles are broadly classified based on their structure, origin, and functionality. Structurally, they can be classified as nanospheres, nanocapsules, polymeric micelles, dendrimers, and nanogels. Nanospheres consist of a solid polymer matrix in which drugs are uniformly dispersed, whereas nanocapsules possess a core–shell structure that allows the encapsulation of therapeutic agents within a confined cavity. Polymeric micelles, formed from amphiphilic block copolymers, are particularly suitable for delivering hydrophobic anticancer drugs due to their core–shell architecture. Dendrimers, which are highly branched, tree-like macromolecules, provide multiple functional sites for drug attachment and surface functionalization; to this end, targeting ligands such as antibodies, peptides, folic acid, transferrin, aptamers, and small molecules are commonly used in order to enhance the selective binding to overexpressed receptors on cancer cells and to improve cellular uptake efficiency. Finally, nanogels are cross-linked hydrophilic polymer networks capable of high drug loading and responsive release. Based on origin, polymeric nanoparticles may derive from natural polymers such as chitosan and alginate, or synthetic polymers such as poly(lactic-co-glycolic acid) (PLGA), polyethylene glycol (PEG), and polylactic acid. Functionally, polymeric nanoparticles can be engineered in targeted, stimuli-responsive, or multifunctional systems. The mechanism of tumour targeting by polymeric nanoparticles involves passive and active processes. The passive targeting is primarily mediated through the enhanced permeability and retention effect, where nanoparticles preferentially accumulate in tumour tissues due to leaky vasculature and impaired lymphatic drainage. Alternatively, active targeting is achieved through ligand-mediated interactions with cancer cell receptors, followed by cellular uptake *via* endocytosis. The drug is then released intracellularly in response to tumour-specific stimuli such as an acidic pH, enzymatic activity, or redox conditions, thereby ensuring localized and controlled therapeutic action. Drug loading within polymeric nanoparticles can be accomplished through several strategies,

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including physical encapsulation within the polymer matrix, adsorption onto the nanoparticle's surface, or chemical conjugation to the polymer's backbone. Each method influences drug stability, release kinetics, as well as the overall therapeutic performance. Encapsulation is known to protect the drug from premature degradation, while conjugation enables more precise control over the release profiles. Advances in formulation techniques have enabled higher drug-loading efficiencies and have improved the nanoparticle systems' stability. Overall, polymeric nanoparticle-based drug delivery systems, especially those based on PLGA and PEG, represent a versatile and powerful approach for improving cancer therapy. However, certain challenges related to large-scale manufacturing, biological variability, immune recognition, and clinical translation remain obstacles to their clinical applicability.

Keywords

cancer therapy; drug delivery; PEG; PLGA; polymeric nanoparticles

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Conflicts of interest statement

None to declare.

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