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Nanoparticles, Controlled Release and Cancer Therapy

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Editorial

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Introduction

Cancer remains one of the leading causes of mortality worldwide, and conventional chemotherapy is often limited by poor drug selectivity, systemic toxicity, and low therapeutic efficiency. Many anticancer drugs damage healthy tissues because they circulate throughout the body rather than acting specifically at tumor sites. To overcome these limitations, advanced drug delivery systems have been developed, among which nanoparticles have gained significant attention [1,2]. Nanoparticles are submicron-sized carriers that can encapsulate anticancer drugs and deliver them more precisely to tumor tissues. When combined with controlled release strategies, nanoparticles offer a promising approach to improve the effectiveness and safety of cancer therapy.

Discussion

Nanoparticles possess unique physicochemical properties such as small size, large surface area, and tunable surface chemistry, which make them ideal drug carriers. Common nanoparticle systems include polymeric nanoparticles, liposomes, solid lipid nanoparticles, and metallic nanoparticles. These carriers can protect drugs from premature degradation in the bloodstream and improve their solubility and stability [3,4].

Controlled release is a key advantage of nanoparticle-based drug delivery. Instead of releasing the drug immediately after administration, nanoparticles can be engineered to release their payload gradually over time. This sustained release maintains therapeutic drug concentrations at the tumor site for extended periods, reducing the need for frequent dosing and minimizing peak-related side effects. Controlled release can be achieved through biodegradable polymers, pH-sensitive materials, enzyme-responsive systems, or temperature-sensitive carriers [5].

In cancer therapy, nanoparticles exploit the enhanced permeability and retention (EPR) effect, a phenomenon where nanoparticles preferentially accumulate in tumor tissues due to leaky blood vessels and poor lymphatic drainage. Additionally, active targeting can be achieved by attaching ligands such as antibodies, peptides, or folic acid to the nanoparticle surface, enabling specific binding to cancer cell receptors. This dual strategy enhances drug accumulation in tumors while sparing healthy tissues.

Nanoparticles have been successfully used to deliver chemotherapeutic agents such as doxorubicin, paclitaxel, and cisplatin. Several nanoparticle-based formulations have already reached clinical use, demonstrating reduced toxicity and improved patient outcomes. Furthermore, nanoparticles can co-deliver multiple agents, such as drugs and genes, enabling combination therapy to overcome drug resistance.

Conclusion

Nanoparticles combined with controlled release strategies represent a major advancement in cancer therapy. By improving drug stability, targeting efficiency, and sustained delivery, nanoparticle-based systems address many limitations of conventional che-

motherapy. They enhance therapeutic efficacy while reducing systemic toxicity, leading to better patient compliance and outcomes. Although challenges such as large-scale production, long-term safety, and regulatory approval remain, ongoing research continues to refine these systems. Overall, nanoparticles with controlled release hold great promise for the future of more effective, safer, and personalized cancer treatment.

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