

Nanocarriers: Transforming targeted drug delivery.

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Introduction

This review explores the recent advancements in polymeric nanocarriers, specifically focusing on their application in targeted cancer drug delivery. It highlights how these systems offer enhanced therapeutic efficacy and reduced side effects compared to traditional treatments by improving drug bioavailability and selectivity. The article also discusses current challenges and future directions for clinical translation [1].

This article examines the potential of lipid-based nanocarriers for delivering drugs across the blood-brain barrier (BBB) to treat neurological disorders. It outlines the inherent challenges in brain drug delivery, such as the BBB's tight junctions, and identifies opportunities where lipid nanocarriers can overcome these obstacles, emphasizing strategies like surface modification and active targeting [2].

This review delves into the latest advancements in metallic nanocarriers for targeted cancer therapy. It discusses the unique properties of various metallic nanoparticles, such as gold and silver nanoparticles, and their applications in delivering therapeutic agents, enhancing imaging, and enabling photothermal or photodynamic therapies, while also addressing their biocompatibility and toxicity concerns [3].

The article provides an overview of polymeric nanocarriers specifically designed for ocular drug delivery, a challenging area due to the eye's protective barriers. It explores various polymer-based strategies, like micelles, nanoparticles, and hydrogels, aimed at improving drug penetration, increasing residence time, and enhancing therapeutic outcomes for eye diseases, highlighting current achievements and future research directions [4].

This review focuses on stimuli-responsive nanocarriers, which are engineered to release their cargo in response to specific internal or external triggers, making them ideal for smart cancer therapy. It discusses how these systems, reacting to pH, temperature, enzymes, or light, can improve drug specificity and efficacy, minimizing systemic toxicity and paving the way for advanced clinical applications [5].

The article explores exosome-mimetic nanocarriers, which are synthetic or biohybrid particles designed to replicate the biological functions of natural exosomes for targeted drug delivery. It highlights their advantages, such as low immunogenicity and excellent biocompatibility, for delivering diverse therapeutic agents, especially to hard-to-reach tissues, while also addressing challenges in large-scale production and standardization [6].

This review focuses on lipid nanoparticles (LNPs), which have become crucial for mRNA delivery, especially highlighted by their success in COVID-19 vaccines. It details the mechanisms by which LNPs protect mRNA, facilitate cellular uptake, and enable efficient translation, discussing their structural components, formulation strategies, and ongoing research to broaden their application beyond vaccines [7].

The article provides an in-depth look at nanocarriers for gene therapy, which aim to deliver genetic material (DNA, RNA, CRISPR components) safely and effectively into target cells. It reviews different types of nanocarriers, including viral and non-viral vectors, discussing their design principles, strategies for improving gene transfection efficiency and specificity, and the challenges in clinical translation for treating genetic diseases [8].

This review addresses the critical role of nanocarriers in overcoming the blood-brain barrier for effective drug delivery to the central nervous system. It explores various strategies, such as receptor-mediated transcytosis and disruptive mechanisms, employed by different nanocarrier systems to enhance brain accumulation of therapeutics for neurological conditions, while also discussing the barriers to clinical translation [9].

The article discusses the opportunities and challenges of using nanocarriers for oral drug delivery, which offers significant patient convenience but faces obstacles like enzymatic degradation, low permeability, and poor solubility in the gastrointestinal tract. It highlights innovative nanocarrier designs, including mucoadhesive and pH-sensitive systems, aimed at improving oral bioavailability and enabling targeted delivery within the digestive system [10].

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Conclusion

Nanocarriers are transforming drug delivery by enabling precise targeting and improving therapeutic outcomes across many medical applications. You see this with polymeric nanocarriers for cancer therapy, where they boost drug availability and targeting, cutting down on side effects compared to older treatments. Metallic nanocarriers, including gold and silver nanoparticles, also show promise in cancer for delivering agents, better imaging, and photothermal therapies, though there are still questions about their biocompatibility. Stimuli-responsive nanocarriers, designed to react to things like pH or temperature, offer smart cancer therapy by making drugs more specific and less toxic to the body.

Beyond cancer, lipid-based nanocarriers are getting a lot of attention for delivering drugs to the brain, helping them cross the tough blood-brain barrier using tricks like surface modification. This effort is mirrored in ocular drug delivery, a hard area because of the eye's natural defenses, where polymeric nanocarriers are improving drug penetration and how long they stay active. For broader applications, exosome-mimetic nanocarriers look good because they're well-tolerated and can deliver many different therapeutic agents, even to places that are usually hard to reach.

Lipid Nanoparticles (LNPs) have truly changed mRNA delivery, especially clear with their success in COVID-19 vaccines, by protecting mRNA and getting it into cells efficiently. Gene therapy also uses nanocarriers, both viral and non-viral, to safely deliver genetic material for treating genetic diseases, though getting these into widespread clinical use has its own set of challenges. Finally, oral drug delivery, which would be super convenient for patients, runs into problems like digestion and poor absorption. Here, innovative nanocarriers, such as those that stick to mucus or react to pH, are being developed to improve how well drugs are absorbed and where they go in the digestive system. All this work shows the huge

potential and ongoing drive to make nanocarrier technologies more precise and effective for medical treatments.

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