OPEN ACCESS Freely available online

ISSN: 2155-9589
Journal of Membrane Science & Technology

Perspective

Enhanced Delivery Systems: Biological Membrane-Wrapped Polymeric Nanoparticles in Oncology

Magdalena Grześkowiak*

Department of Biomedicine and Nanotechnology, Adam Mickiewicz University, Poznań, Poland

DESCRIPTION

Cancer remains a leading cause of mortality worldwide, driving the relentless pursuit of innovative therapies. One such potential approach is the use of Polymeric Nanoparticles (PNPs) wrapped in biological membranes for targeted anticancer treatment. This strategy combines the advantages of nanotechnology with the unique properties of biological membranes to create a sophisticated delivery system that enhances therapeutic efficacy while minimizing side effects.

Traditional cancer treatments, including chemotherapy and radiation, often lack specificity, affecting both cancerous and healthy cells. This non-specificity leads to severe side effects and limits the effectiveness of the treatment. Therefore, targeted cancer therapy, which aims to deliver therapeutic agents directly to cancer cells while sparing normal cells, has become a focal point of cancer research. Polymeric nanoparticles wrapped in biological membranes represent a cutting-edge approach to achieve this goal. Polymeric nanoparticles are engineered from biocompatible and biodegradable polymers such as Polylactic-co-Glycolic Acid (PLGA), Polycaprolactone (PCL), and Polyethylene Glycol (PEG). These nanoparticles can encapsulate a wide range of therapeutic agents, including chemotherapeutics, proteins, and nucleic acids. Their nanoscale size allows them to pass through biological barriers, and their surface properties can be modified to improve stability, drug loading capacity, and release profiles.

Importance of polymeric nanoparticles

Wrapping polymeric nanoparticles in biological membranes leverages the natural properties of these membranes to enhance the functionality of the nanoparticles. Biological membranes used for this purpose include cell membranes from Red Blood Cells (RBCs), cancer cells, and immune cells. Each type of membrane provides distinct advantages:

Red blood cell membranes: RBC membranes are inherently biocompatible and possess a long circulation time in the bloodstream. Wrapping nanoparticles with RBC membranes can help to evade the immune system, prolonging the nanoparticles' circulation time and enhancing drug delivery to the tumor site.

Cancer cell membranes: Using membranes derived from cancer cells can impart homotypic targeting abilities to the nanoparticles. This means that the nanoparticles can specifically recognize and bind to the same type of cancer cells from which the membrane was derived, improving the precision of drug delivery.

Immune cell membranes: Membranes from immune cells, such as macrophages or T cells, can help the nanoparticles actively target and penetrate tumors. These membranes can also carry immunomodulatory molecules, which can synergize with the encapsulated drugs to enhance the anticancer response.

Advantages of membrane-coated polymeric nanoparticles

The combination of polymeric nanoparticles and biological membranes offers several key advantages for targeted anticancer treatment such as enhanced targeting and uptake, immune evasion, biocompatibility and reduced toxicity, multifunctionality.

The biological membrane coating can provide specific targeting ligands that recognize and bind to receptors overexpressed on cancer cells. This specificity enhances the uptake of nanoparticles by cancer cells, reducing off-target effects. Biological membranes can cover the nanoparticles, helping them evade detection and clearance by the immune system. This prolonged circulation time increases the likelihood of nanoparticles reaching the tumor site. The use of natural biological membranes reduces the risk of adverse immune reactions and enhances the biocompatibility of the nanoparticles. This reduces the systemic toxicity often associated with conventional chemotherapy. Membrane-coated

Correspondence to: Magdalena Grześkowiak, Department of Biomedicine and Nanotechnology, Adam Mickiewicz University, Poznań, Poland, E-mail: magrzes@amu.edu.pl

Received: 20-May-2024, Manuscript No. JMST-24-26202; **Editor assigned:** 22-May-2024, Pre QC No. JMST-24-26202 (PQ); **Reviewed:** 05-Jun-2024, QC No. JMST-23-26202; **Revised:** 12-Jun-2024, Manuscript No. JMST-23-26202 (R); **Published:** 19-Jun-2024, DOI: 10.35248/2155-9589.24.14.388

Citation: Grześkowiak M (2024) Enhanced Delivery Systems: Biological Membrane-Wrapped Polymeric Nanoparticles in Oncology. J Membr Sci Technol. 14:388.

nanoparticles can be engineered to carry multiple therapeutic agents, including chemotherapeutics, gene therapies, and immunomodulators. This multifunctionality allows for a combination therapy approach, which can be more effective than single-agent treatments.

Recent advances and applications

Recent research has demonstrated the potential of polymeric nanoparticles wrapped in biological membranes for targeted anticancer treatment. For example, studies have shown that RBC membrane-coated nanoparticles loaded with doxorubicin, a common chemotherapeutic agent, and exhibit prolonged circulation time and enhanced accumulation in tumors, leading to improved therapeutic outcomes compared to free doxorubicin. Similarly, cancer cell membrane-coated nanoparticles have been used to deliver a combination of chemotherapeutic drugs and gene-silencing RNA molecules. This dual delivery system not only kills cancer cells but also silences oncogenes, providing a synergistic anticancer effect. Immune cell membrane-coated nanoparticles have also shown promise in preclinical studies. For instance, macrophage membrane-coated nanoparticles loaded with paclitaxel, another widely used chemotherapeutic, have demonstrated enhanced targeting to tumor sites and improved penetration into the tumor microenvironment, resulting in superior anticancer efficacy.

Challenges and future directions

Despite the promising potential, several challenges need to be addressed to translate this technology into clinical practice in terms of scalability and manufacturing, stability and storage, *in vivo* behavior and safety, regulatory approval. The production of membrane-coated nanoparticles needs to be scalable and reproducible to meet clinical demands. Developing standardized methods for membrane isolation, nanoparticle fabrication, and coating processes is important. Ensuring the stability of membrane-coated nanoparticles during storage and transportation is essential for their practical application. Strategies to preserve the integrity and functionality of the biological membranes over time are needed. Comprehensive studies on the *in vivo* behavior, biodistribution, and long-term safety of membrane-coated nanoparticles are necessary. Understanding how these nanoparticles interact with different tissues and organs will help optimize their design and minimize potential side effects. Navigating the regulatory landscape for the approval of membrane-coated nanoparticle-based therapies can be complex. Clear guidelines and thorough preclinical and clinical testing are required to demonstrate their safety and efficacy.

CONCLUSION

Polymeric nanoparticles wrapped in biological membranes represent a novel and potential approach for targeted anticancer treatment. By combining the versatility of polymeric nanoparticles with the natural properties of biological membranes, this technology offers enhanced targeting, immune evasion, and biocompatibility. While challenges remain, ongoing research and development hold the potential to overcome these hurdles and bring this innovative therapy to clinical reality. The future of cancer treatment may well lie in these sophisticated nanocarriers, offering hope for more effective and less toxic therapies for patients worldwide.