Mini Review
Volume 14:01, 2024

Journal of Bioengineering & Biomedical Science

ISSN: 2155-9538 Open Access

Engineered Cell Membrane-camouflaged Nanomaterials: A Revolution in Biomedical Applications

Adegnika Steffen*

Department of Microbiology, University of Medical Dokkyo, Tochigi, Japan

Abstract

Nanotechnology has been revolutionizing biomedical research and applications, offering innovative solutions to challenges in diagnostics, drug delivery, and therapeutics. One recent breakthrough in this field is the development of engineered cell membrane-camouflaged nanomaterials. By encapsulating synthetic nanoparticles within natural cell membranes, these hybrid constructs combine the functionalities of both synthetic and biological systems, resulting in enhanced biocompatibility, prolonged circulation time and targeted delivery. This article provides an in-depth exploration of the design principles, synthesis methods and biomedical applications of cell membrane-camouflaged nanomaterials, highlighting their potential to revolutionize various aspects of medicine.

Keywords: Therapeutics • Nanotechnology • Biocompatibility

Introduction

Nanotechnology has emerged as a powerful tool in biomedical research, offering unprecedented opportunities to diagnose and treat diseases at the molecular level. Nanomaterials, with their unique physical and chemical properties, hold immense potential for targeted drug delivery, imaging, and therapeutics. However, the clinical translation of synthetic nanoparticles faces several challenges, including immune recognition, rapid clearance from circulation, and off-target effects. To overcome these limitations, researchers have turned to nature-inspired strategies, leveraging the remarkable properties of cell membranes to cloak synthetic nanoparticles [1].

Literature Review

Cell membrane-camouflaged nanomaterials, also known as biomimetic nanovesicles or cell membrane-coated nanoparticles, represent a promising approach to harness the advantages of both synthetic and biological systems. By encapsulating synthetic cores with natural cell membranes, these hybrid constructs inherit the functionalities of the source cells while gaining the advantages of synthetic nanomaterials. This article discusses the design principles, fabrication techniques, and biomedical applications of engineered cell membrane-camouflaged nanomaterials, illustrating their potential to transform various fields of medicine [2]. The design of cell membrane-camouflaged nanomaterials involves the integration of synthetic nanoparticles with natural cell membranes, typically derived from red blood cells, platelets, immune cells, or cancer cells. The choice of source cell dictates the properties and functionalities of the resulting hybrid nanovesicles. For example, red blood cell membranes provide stealth properties, prolonging circulation time by evading immune surveillance, while cancer cell membranes offer targeting specificity for tumor tissues [3].

The fabrication process typically involves three main steps: nanoparticle synthesis, membrane extraction, and membrane coating. Synthetic nanoparticles, such as liposomes, polymeric nanoparticles, or inorganic nanocarriers, are first synthesized to encapsulate therapeutic agents or imaging agents. Subsequently, cell membranes are extracted from donor cells through various methods, such as hypotonic lysis, sonication, or extrusion. Finally, the synthetic nanoparticles are coated with the extracted cell membranes through membrane fusion or extrusion, resulting in cell membrane-camouflaged nanomaterials. Several techniques have been developed for the synthesis of cell membrane-camouflaged nanomaterials, each offering unique advantages in terms of scalability, reproducibility, and control over particle properties. In this approach, synthetic nanoparticles and cell membranes are co-extruded through a porous membrane, leading to the spontaneous coating of the nanoparticles with cell membranes. Extrusion enables precise control over the size and morphology of the resulting nanovesicles.

Discussion

Sonication involves the physical disruption of cell membranes to generate membrane fragments, which then spontaneously coat synthetic nanoparticles through self-assembly processes. Sonication is a simple and rapid method for membrane coating but may result in heterogeneous particle populations [4]. This method involves the co-incubation of synthetic nanoparticles and cell membrane vesicles in a solution, leading to the spontaneous fusion of membranes with nanoparticle surfaces. Co-solubilization allows for the encapsulation of membrane proteins and receptors on the nanoparticle surface. Microfluidic devices offer precise control over fluid flow and mixing, enabling the rapid and efficient coating of synthetic nanoparticles with cell membranes. Microfluidic synthesis allows for the synthesis of uniform nanovesicles with tunable properties.

Cell membrane-camouflaged nanomaterials hold immense potential for a wide range of biomedical applications, including drug delivery, imaging, therapy, and immunomodulation. By functionalizing cell membrane-camouflaged nanomaterials with targeting ligands derived from source cells, such as antibodies or peptides, specific targeting of diseased tissues can be achieved. This approach minimizes off-target effects and enhances therapeutic efficacy. Cell membrane-camouflaged nanomaterials can be engineered to carry imaging agents, such as fluorescent dyes or contrast agents, for non-invasive imaging of disease biomarkers or cellular processes [5]. The stealth properties conferred by cell membranes enable prolonged circulation and enhanced accumulation at target sites. Cell membrane-camouflaged nanomaterials derived from immune cells can modulate immune responses, either by delivering immunomodulatory agents or by presenting antigenic peptides to stimulate immune activation. These immunotherapeutic nanovesicles hold

***Address for Correspondence:** Adegnika Steffen, Department of Microbiology, University of Medical Dokkyo, Tochigi, Japan, E-mail: degnika@steffen.jp*

Received: 27 January, 2024, Manuscript No. jbbs-24-133282; **Editor Assigned:** 29 January, 2024, PreQC No. P-133282; **Reviewed:** 14 February, 2024, QC No. Q-133282; **Revised:** 19 February, 2024, Manuscript No. R-133282; **Published:** 26 February, 2024, DOI: 10.37421/2155-9538.2024.14.399

promise for cancer immunotherapy and vaccine development. Cell membrane-camouflaged nanomaterials derived from stem cells or progenitor cells can promote tissue regeneration and repair by delivering growth factors, cytokines, or extracellular vesicles. These biomimetic nanovesicles mimic the native cell environment, facilitating cell-to-cell communication and tissue regeneration [6].

Conclusion

Engineered cell membrane-camouflaged nanomaterials represent a paradigm shift in biomedical research, offering a versatile platform for targeted drug delivery, imaging, therapy, and immunomodulation. By combining the advantages of synthetic nanoparticles with the biological functionalities of cell membranes, these hybrid constructs hold immense promise for clinical translation. Future research efforts should focus on optimizing fabrication techniques, elucidating structure-function relationships, and advancing preclinical and clinical studies to realize the full potential of cell membrane-camouflaged nanomaterials in improving human health.

Acknowledgement

None.

Conflict of Interest

None.

References

1. Gavas, Shreelaxmi, Sameer Quazi and Tomasz M. Karpiński. "Nanoparticles for cancer therapy: current progress and challenges." *Nanoscale Res Lett* 16 (2021): 173.
2. Fang, Xiaona, Qian Yan, Shan Liu and Xin-Yuan Guan. "Cancer stem cells in hepatocellular carcinoma: Intrinsic and extrinsic molecular mechanisms in stemness regulation." *Int J Mol Sci* 23 (2022): 12327.
3. Huang, Yanyan, Jinsong Ren and Xiaogang Qu. "Nanozymes: classification, catalytic mechanisms, activity regulation, and applications." *Chem Rev* 119 (2019): 4357-4412.
4. Fang, Ronnie H, Weiwei Gao and Liangfang Zhang. "Targeting drugs to tumours using cell membrane-coated nanoparticles." *Nat Rev Clin Oncol* 20 (2023): 33-48.
5. Mei, Heng, Shengsheng Cai, Dennis Huang and Huile Gao, et al. "Carrier-free nanodrugs with efficient drug delivery and release for cancer therapy: from intrinsic physicochemical properties to external modification." *Bioact Mater* 8 (2022): 220-240.
6. Suk, Jung Soo, Qingguo Xu, Namho Kim and Justin Hanes, et al. "PEGylation as a strategy for improving nanoparticle-based drug and gene delivery." *Adv Drug Deliv Rev* 99 (2016): 28-51.

How to cite this article: Steffen, Adegnika. "Engineered Cell Membrane-camouflaged Nanomaterials: A Revolution in Biomedical Applications." *J Bioengineer & Biomedical Sci* 14 (2024): 399.