Designing Bio-Inspired Nanocarriers for Advanced Drug Delivery Systems

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Overcoming biological barriers is essential for nanomedicines to reach their intended targets, requiring the exploration of "smarter" delivery nanosystems that can discern when and where to release specific compounds, thereby avoiding off-target effects. Translating this concept into clinical practice faces a significant challenge: effectively understanding and regulating the interaction mechanisms between synthesized nanocarriers and the complex living environment.

Increasing knowledge of how naturally occurring particles, including cells, pathogens (viruses), and exosomes, interact with bodily and cellular systems has spurred efforts to mimic their morphology and functions. Mimicking the complexity and dynamism of the cellular membrane, which regulates signaling, transport processes, and immune responses, and translating cell membrane features to nanomedicines offer exciting opportunities to fabricate next-generation biomimetic nanoformulations with enhanced pharmacokinetic and tissue-specific targeting capabilities. Biomimetic cell-derived nanocarriers that replicate various cellular compositions, including cancer cells, platelets, erythrocytes, leukocytes, and macrophages, have proven to be the future of bio-inspired synthetic nanocarriers for drug-delivery systems (*Adv. Biosys, 2020, 4 (3), 1900260; J. Nanobiotechnol. 2022, 20, 538; J .Nanobiotechnol., 2024, 22 (1), 10*). These biomimetic nanocarriers can be programmed for specific tasks such as immune escape, lymphocyte and dendritic cell activation, endothelial adhesion, and homotypic targeting. They can also be conferred with the ability to directly fuse with the plasma membrane, bypassing endo-lysosomal internalization pathways and delivering payloads directly into the cell cytosol. (*J. Colloid Interface Sci. 2023, 648, 488-496*).