American Journal of Advanced Drug Delivery
ISSN: 2321-547X

Open access Short Communication

Strategies for Non-covalent Attachment of Antibodies to PEGylated Nanoparticles for Targeted Drug Delivery

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INTRODUCTION

Proteins and peptides are vital biological molecules that play crucial roles in various physiological processes, including enzymatic reactions, immune responses, cell signaling, and structural support. Given their pivotal roles, these biomolecules have become attractive candidates for therapeutic applications. However, the effective delivery of proteins and peptides as drugs faces significant challenges due to their complex structures, instability, and susceptibility to degradation.

DESCRIPTION

This article explores the importance of protein/peptide therapeutics, the challenges of delivering them, and the strategies developed to overcome these barriers. Proteins and peptides have several advantages as therapeutic agents. They offer high specificity, meaning they can target specific molecular pathways with minimal off-target effects. Unlike small-molecule drugs, proteins and peptides can mimic or inhibit natural biological functions more precisely, which is critical in treating diseases that involve complex molecular interactions, such as cancer, autoimmune diseases, and metabolic disorders. Proteins and peptides often have short half-lives in the body due to rapid clearance by the kidneys and liver. As a result, delivering them to intracellular targets poses a significant challenge. Some protein drugs can trigger immune responses, which may neutralize the therapeutic effect or cause adverse reactions. Modifying the protein to reduce immunogenicity without affecting its function is a key concern. To overcome these challenges, several strategies have been developed to enhance the delivery of proteins and peptides. Injectable formulations are the most common method for protein and peptide drug delivery. Intravenous, subcutaneous, and intramuscular injections bypass the proteolytic degradation in the GI tract, ensuring higher bioavailability [1-4]. Long-acting injectables and depot formulations (e.g., micro- or nanoparticle-based systems) have been developed to prolong the release of drugs, reducing the need for frequent dosing. These systems offer controlled drug release, helping to maintain therapeutic levels over extended periods. Nanotechnology-based systems, such as liposomes, polymeric nanoparticles, and lipid nanoparticles, have gained popularity for protein and peptide delivery. Lipid nanoparticles have been crucial in the delivery of mRNA vaccines, which indirectly emphasizes the potential for protein-based therapies. This success has spurred further research into how similar carriers can be applied for protein and peptide delivery. While oral administration is preferred for patient convenience, it poses significant challenges due to the degradation of proteins and peptides in the GI tract. Substances that increase the absorption of proteins and peptides by loosening the tight junctions between intestinal cells. While oral delivery of protein drugs like insulin has been a challenge, significant progress has been made in developing formulations that improve oral bioavailability.

CONCLUSION

Protein and peptide drugs offer immense therapeutic potential, but their delivery poses several challenges, including degradation, short half-life, and poor membrane permeability. Advances in nanotechnology, injectable systems, and alternative delivery routes have improved their bioavailability and efficacy. As research continues to innovate in this field, protein and peptide therapeutics will likely become more accessible and effective in treating a wide range of diseases, transforming the landscape of modern medicine.

ACKNOWLEDGEMENT

None.

CONFLICT OF INTEREST

The author's declared that they have no conflict of interest.

Received:	02-September-2024	**Manuscript No:**	IPAAD-24-21718
Editor assigned:	04-September-2024	**PreQC No:**	IPAAD-24-21718 (PQ)
Reviewed:	18-September-2024	**QC No:**	IPAAD-24-21718
Revised:	23-September-4202	**Manuscript No:**	IPAAD-24-21718 (R)
Published:	30-September-2024	**DOI:**	110.36648/2321-547X.12.3.29

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Citation Ho W (2024) Strategies for Non-covalent Attachment of Antibodies to PEGylated Nanoparticles for Targeted Drug Delivery. Am J Adv Drug Deliv. 12:29.

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