Proceedings of the 10th World Congress on Recent Advances in Nanotechnology (RAN 2025)
Barcelona, Spain - April, 2025
Paper No. NDDTE 105
DOI: 10.11159/nddte25.105

Design, Characterization, and Evaluation of Liposomal and Cubosomal Drug Delivery Systems for Anti-Cancer and Antimicrobial Therapeutics

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Lipid-based drug delivery systems (DDS) have gained significant attention due to their ability to encapsulate and control the release of diverse drug molecules, including hydrophobic, hydrophilic, and amphiphilic compounds [1]. This study focuses on the design, development, and characterization of lipid-based vesicles (liposomes) and liquid crystalline cubic structures (cubosomes) to deliver therapeutic agents, such as anti-cancer and antimicrobial drugs. The primary objective is to elucidate the physicochemical and biological properties of these drug carriers, focusing on how drug properties and molecular attributes influence the interaction with lipid-based nanostructures. The study aims to investigate the phase transitions (through differential scanning calorimetry) and structural characteristics of cubosomes (through small angle X-ray scattering) under the effect of encapsulation of drugs. The amount of drug that can be encapsulated in cubosomes is influenced by factors such as the type of liquid crystalline phase, unit cell size, and cubosome geometry [2]. Understanding the internal structure of cubosomes and their phase behavior is critical, as these parameters directly impact cellular uptake, biodistribution, and cytotoxicity. To probe the interaction between drugs and liposome systems, isothermal titration calorimetry (ITC) was employed. These methods allow for the analysis of drug-lipid interactions, including drug partitioning, release kinetics, and binding with serum proteins. Small-angle X-ray scattering (SAXS) is used to examine the crystallographic geometry and lattice parameters of cubosomes without and after drug encapsulation, providing detailed insights into the structural changes induced by drug loading.

Results: Preliminary studies with drug-liposome systems revealed that hydrophilic drugs, such as 5-fluorouracil and kanamycin, exhibit a high binding affinity to the liposome membrane, with strong interaction coefficients indicating stable binding. Drug release via diffusion was minimal, suggesting the formation of stable delivery systems that may enable controlled and sustained drug release. In cubosome-based systems, SAXS data revealed changes in lattice parameters upon encapsulation of hydrophobic drugs with limited polar groups. These changes indicate the influence of drug encapsulation on cubosome's internal structure. Planned cytotoxicity assays on cancer and bacterial cell lines will assess the therapeutic potential of these cubosome formulations, aiming to correlate structural changes with biological efficacy. Overall, the study provides valuable insights into the interplay between drug structure and the architecture of lipid-based delivery systems, laying the groundwork for the rational design and optimization of DDS for various therapeutic applications.

References:

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