

Abstract

Design and Evaluation of Advanced Nanocarriers for Targeted Delivery of Antitumor Agents: From Physicochemical Characterization to Preclinical Validation [†]

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The continuous evolution of nanotechnology has led to the development of innovative strategies for cancer treatment, particularly through nanosystems designed to deliver antitumor agents in a targeted and efficient manner. These platforms aim to enhance therapeutic efficacy while reducing systemic toxicity [1].

This research proposes an integrated approach focused on the design, synthesis, and characterization of advanced nanocarriers capable of transporting active molecules with specific antitumor properties, especially for pancreatic and hepatic cancers.

The planned study will explore several classes of nanosystems, like polymeric nanoparticles, liposomes, and nanocapsules, selected for their biocompatibility, functionalization potential, and ability to encapsulate both synthetic and natural bioactive compounds. Key formulation parameters, such as particle size, surface charge, drug loading efficiency, and release kinetics, will be optimized and evaluated using analytical techniques including dynamic light scattering, electron microscopy, Fourier-transform infrared spectroscopy, and differential scanning calorimetry [2].

To support the experimental design, a preliminary bibliographic screening will be conducted to identify current nanosystems, antitumor agents, and therapeutic strategies relevant to hepatocellular and pancreatic carcinomas. Data extracted from specialized databases will be synthesized into internal reports to guide the selection of nanocarriers and therapeutic payloads [3].

Nanocarriers will be loaded with both natural and synthetic compounds (e.g., quercetin, myricetin, curcumin, silibinin, resveratrol, doxorubicin, gemcitabine, and sorafenib) and evaluated for their potential synergistic effects and favorable toxicity profiles.

The bioactivity of the developed systems will be tested on monolayer cultures of tumor cells using conventional cytotoxicity assays alongside AI-assisted imaging techniques to monitor cellular behavior, including migration and morphological changes. To better mimic the in vivo tumor microenvironment, three-dimensional cell models—such as hepatic spheroids and liver-on-chip constructs—will be employed to assess nanosystem interaction and safety through transcriptomic profiling and other omics technologies.

Based on the in vitro outcomes, selected formulations may advance to in vivo-like simulations and ADME (absorption, distribution, metabolism, and excretion) modeling to explore their translational relevance. Ultimately, this research aims to support the



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development of adaptable, effective nanoscale delivery systems that integrate advanced formulation strategies with meaningful biological validation.

The final stage will involve disseminating the findings through scientific conferences and publications, thereby contributing to the growing body of knowledge in nanomedicine and offering valuable insights for future clinical translation in the treatment of liver and pancreatic cancers.

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