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Editorial: Nanomaterial and nanostructures for cancer and pathogenic infection diagnosis and therapy

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Editorial on the Research Topic
Nanomaterial and nanostructures for cancer and pathogenic infection diagnosis and therapy

Nanoparticles are attractive therapeutic tools due to their distinctive characteristics, including more accurate drug delivery, improved bioavailability, and enhanced targeted therapy. Kumarasamy et al. provide a comprehensive review of the clinical applications of advanced nanoparticles, focusing on completed human clinical trials. The review covers a broad spectrum of medical fields, including oncology, infectious diseases, and neurology. The findings highlight significant progress in nanoparticle-based therapies, with improved drug delivery, bioavailability, and targeted therapy (Khafaji et al., 2022), and address the safety profiles and efficacy outcomes, emphasizing the transformative potential of nanoparticles in clinical practice. Among the various methods used to diagnose and predict cancer cell growth, the differences in physical properties and mechanical behavior between normal and cancer cells have always been significant (Ghahramani et al., 2024; Ghoytasi et al., 2024). A fascinating study on how these nanostructured pharmaceutical compounds affect the physicochemical behavior of cells and distinguish them from normal cells can provide valuable insights for researchers in cancer diagnosis and treatment. Understanding tumor growth highlights the importance of investigating the role of these nanostructures in diagnosing, assessing damage, and treating cancers. For instance, estimating the tension in healthy tissues or evaluating the model's potential to study the effect of temperature on cancer cell growth can enhance the effectiveness of hyperthermia-based diagnosis and treatment methods (Khafaji et al., 2019), as well as thermal radiation imaging techniques (Dehghanian et al., 2023a; Dehghanian et al., 2023b).

Jiang et al. present a comprehensive review on combining engineered nanomaterials with extracellular vesicles (EVs) for targeted drug delivery and biomedical applications. EVs, as natural carriers, offer a biocompatible platform for delivering therapeutic agents. The review delves into the methods for synthesizing and loading nanomaterials into EVs, emphasizing techniques like electron microscopy and light scattering for characterization. The potential applications in cancer therapy and vaccine development are particularly

noteworthy, although challenges like scalability and safety need to be addressed for clinical translation.

Boron nitride nanotubes (BNNTs) have emerged as promising nanocarriers for drug delivery due to their biocompatibility and wide bandgap. Mashhoun and Tavahodi have investigated using BNNTs as carriers for the anticancer molecule genistein. Their study, based on density functional theory, highlights the potential of BNNTs in multimodal cancer therapy. The research shows that Fe-doped BNNTs enhance the solubility and stability of genistein, suggesting that the (7,7) C3 complex is the most effective configuration for drug delivery. This study underscores the potential of BNNTs in improving the efficacy of cancer treatments and highlights the importance of nanocarrier design in therapeutic applications.

Lung injuries and respiratory disorders are increasingly prevalent due to various diseases causing alveolar damage. Rodríguez et al. have developed ibuprofen-loaded chitosan nanoparticles for targeted pulmonary therapy. Their study demonstrates the successful encapsulation of ibuprofen within a chitosan matrix, optimizing the dose for lung tissue cell viability and histological analysis. The controlled release mechanism ensures targeted delivery to the lungs, reducing inflammation and promoting alveolar regeneration. This innovative approach highlights the importance of dose optimization in enhancing the efficacy and safety of pulmonary treatments.

Hybrid nanostructures (HNSs) combine different materials at the nanoscale, offering unique synergistic properties that enhance their functionality (Khafaji et al., 2024). Harun-Ur-Rashid and Jahan discusses the pioneering advances in HNSs for modern therapy. The article covers synthesis methods, characterization techniques, and mechanisms of action in various therapeutic applications. Case studies demonstrate the efficacy of HNSs in treating cancer, neurodegenerative diseases, and cardiovascular disorders. The review calls for continued innovation and interdisciplinary collaboration to optimize these nanostructures for clinical applications. Future research should focus on enhancing biocompatibility, targeting capabilities, and integrating advanced imaging techniques and AI-driven applications to further improve the precision and efficacy of HNSs in therapy.

Inhalable nanoparticle-based dry powder formulations offer a novel drug delivery system that is simple, convenient, and stable. Naureen et al. review the development of these formulations for lung disease therapy. The review highlights the advantages of dry powder formulations, including deep penetration into lung tissues, enhanced deposition, and improved bioavailability. The study emphasizes the potential of these formulations to improve treatment compliance and therapeutic outcomes for various lung ailments. The salient features of dry formulations that illustrate their uniqueness are deep penetration to lung tissues, enhanced deposition in lung regions, improved solubility, elevated bioavailability, targeted drug delivery, stability at storage, convenience of use, and versatile and customizable formulation. This novel inhalable formulation is based on finely dried nanoparticles or freeze-dried particles. This formulation will contain an excessive amount of dried nanoparticles, and if it is combined with a beneficial tool, i.e., a spray, pump, or puffer, it will be a pleasant way to apply drugs directly to the lungs.

The papers reviewed in this editorial showcase the diverse approaches and significant advancements in this field. From the use of extracellular vesicles and boron nitride nanotubes to innovative hybrid nanostructures and inhalable dry powder formulations, these studies highlight the potential of nanotechnology to enhance therapeutic efficacy and safety. As research continues to evolve, interdisciplinary collaboration and innovation will be crucial in overcoming the challenges and translating these promising technologies into clinical practice.

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