frontiers | Frontiers in Materials

TYPE Editorial
PUBLISHED 15 September 2023
DOI 10.3389/fmats.2023.1278259

OPEN ACCESS

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RECEIVED 16 August 2023
ACCEPTED 08 September 2023
PUBLISHED 15 September 2023

CITATION
Ibrahim OM (2023), Editorial: Advanced polymeric biomaterial technologies for biomedical applications.
Front. Mater. 10:1278259.
doi: 10.3389/fmats.2023.1278259

Editorial: Advanced polymeric biomaterial technologies for biomedical applications

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KEYWORDS

biomaterials, polymers, nanomaterials, drug delivery, regenerative medicine

Editorial on the Research Topic
Advanced polymeric biomaterial technologies for biomedical applications

The foundational bedrock of societal efficacy and global equilibrium lies in the optimization of human wellbeing, a critical determinant of both productive communal dynamics and global harmonization. The holistic welfare of humanity and the intricate web of global interdependence are intrinsically intertwined with the preservation and enhancement of human health. The advent of health-related cataclysms, encompassing a spectrum ranging from communicable afflictions to non-communicable pathologies, wields a profound and lasting impact on the overarching human experience. Neglected communicable morbidities (Boutayeb, 2006), spanning infectious ailments, antibiotic-resistant microbial infections, and viral pandemics, converge with the recent pandemic upheaval to cast a pervasive and disruptive shadow upon the socio-economic fabric. Concurrently, non-communicable diseases (Boutayeb, 2006), characterized by their enduring nature and chronicity, encompassing malignancies, metabolic disorders such as diabetes, and dysregulated immune-inflammatory conditions, wield a considerable potential to induce economic regression, thereby exerting a tangible influence upon the arc of human progress and evolution.

In spite of advancements in medical strategies, a multitude of these health concerns persist without resolution, actively evolving and ultimately contributing to the previous pandemic scenario. This underscores the imperative for the innovation of astute methodologies aimed at prophylaxis, diagnosis, and treatment of these health exigencies. For example, lipid nanoparticles were administered via COVID-19 mRNA vaccines to a vast population (Hou et al., 2021), effectively substantiating the long-envisioned potential of biomaterials, nanomaterials specifically, to redefine the domain of pharmaceutical dispensation. Within the context of innovative solutions grounded in nanotechnological paradigms, marked by the investigation of a myriad of promising applications, lipid nanoparticles conspicuously emerged as pivotal agents in effecting such transformative progress. In this context, novel biological materials have arisen as a swiftly emerging and pioneering modality, offering a creative perspective to tackle a myriad of health intricacies. Importantly, biomaterials hold promise for scalable industrial production and extensive proliferation.

From a therapeutic perspective, silver nanomaterials (AgNPs) exhibit strong antibacterial activity by generating reactive oxygen species (ROS), such as superoxide radicals and hydroxyl radicals, inducing oxidative stress in bacteria. ROS damage cellular components like DNA, proteins, and lipids, contributing to bacterial cytotoxicity. This dual mechanism renders AgNPs effective against both Gram-positive and Gram-negative bacteria, underscoring their potential in various applications (Tang and Zheng, 2018). However, AgNPs synthesized through chemical

methods display marked instability due to their tendency to aggregate, leading to silver atom oxidation. This aggregation-driven loss of antibacterial efficacy is compounded by the release of silver ions, posing health risks and environmental contamination. Furthermore, chemical synthesis of AgNPs is cumbersome, expensive, and requires the use of environmentally hazardous reagents like NaHB4 and citric acid (Lee and Jun, 2019). Polash et al. biogenically synthesized AgNPs from Diospyros malabarica fruit, demonstrating favourable hemocompatibility with human and rat red blood cells. These biogenic AgNPs also exhibited robust *in vivo* biocompatibility, particularly safe on liver and kidney functions. Similarly, Wypij et al. employed a mycogenic approach to synthesize AgNPs using the Fusarium culmorum strain JTW1. Loading AgNPs into a Pullulan composite offers controlled release characteristics, mitigating potential toxicities and offering novel prospects in food packaging applications.

From a diagnostic perspective, some diseases such as Hepatic alveolar echinococcosis (HAE) poses a challenge in early detection due to its late-stage presentation, resembling cancer-like progression and inflicting significant harm on human health. However, effective methods for early diagnosis of HAE microlesions have remained elusive. Alifu et al. developed an integrative fluorescence imaging system for second near-infrared window (NIR-II) fluorescence microscopic imaging (NIR-II-FMI). NIR-II offers advantages of reduced light scattering and tissue autofluorescence, making it well-suited for high-resolution, deep-tissue imaging. The authors revealed robust NIR-II fluorescence signals upon 808 nm laser excitation within the NIR-II-FMI system. Additionally, indocyanine green exhibited remarkable labelling efficacy for normal liver tissues and cells using the NIR-II-FMI system. Subsequently, distinct stages of HAE progression (early, middle, and late stages) were established. This study exemplifies the utilization of indocyanine green as a negative targeting fluorescent probe within the NIR-II-FMI system, guided by an 808 nm laser, for the detection of HAE microlesions at various infection stages. Notably, this novel approach successfully identified E. multilocularis infections during early, middle, and late stages.

From a controlled drug delivery perspective, Abdullah et al. developed a pH-responsive hydrogel system for the sustained release of Tramadol HCl (TRD), an opioid analgesic indicated for pain management. The authors formulated pH-responsive hydrogel network, AvT-co-poly hydrogel, using aloe vera gel, tamarind gum, monomer, and crosslinker through free radical polymerization, establishing the biocompatibility and safety of the formulated hydrogel system and optimizing the desirable therapeutic profile with minimized adverse effects. This hydrogel system can offer sustained opioids levels, optimizing pain relief while minimizing potential fluctuations in drug concentration.

Biomaterials can also be bioengineered to combine versatile platform comprising imaging, delivery systems and therapeutic functionalities. The use of photosensitizers (PS) as fluorescence imaging agents has garnered substantial attention for their capacity to facilitate real-time visualization of living cells, tumour tissues, and systemic distribution with high precision and sensitivity for Photodynamic therapy (PDT). Yu et al. engineered morpholinyl-substituted silicon phthalocyanine water soluble polymeric nanoparticle (DSPE@M-SiPc) variant that showcased near-infrared (NIR) emission, multifunctionalities including targeting cell lysosomal vulnerability, and two-photon fluorescence bioimaging capabilities. The favourable traits of DSPE@M-SiPc, namely, low toxicity, water solubility, and two-photon fluorescence emission, position it as a potential two-photon probe for lysosomal labelling. Furthermore, DSPE@M-SiPc demonstrated capacity for intracellular ROS generation, leading to pronounced nano-phototoxic effects in breast cancer model through lysosomal dysfunction-mediated apoptosis.

Collectively, this Research Topic has introduced bioengineering solutions using polymeric materials to address unmet medical needs across therapeutic, diagnostic, and controlled drug delivery contexts. These innovations showcase the potential of precision drug delivery, accurate diagnostics, and enhanced therapies. By seamlessly integrating biomaterials with biotechnological and bioengineered approaches, these advancements redefine medical possibilities and optimize patient care.

Author contributions

OI: Conceptualization, Writing–original draft, Writing–review and editing.

Funding

OI is supported by the American Society of Hematology (ASH) MHGA2023 Award.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Boutayeb, A. (2006). The double burden of communicable and non-communicable diseases in developing countries. *Trans. R. Soc. Trop. Med. Hyg.* 100, 191–199. doi:10.1016/j.trstmh.2005.07.021

Hou, X., Zaks, T., Langer, R., and Dong, Y. (2021). Lipid nanoparticles for mRNA delivery. *Nat. Rev. Mater.* 6, 1078–1094. doi:10.1038/s41578-021-00358-0

Lee, S. H., and Jun, B. H. (2019). Silver nanoparticles: synthesis and application for nanomedicine. *Int. J. Mol. Sci.* 20, 865. doi:10.3390/ijms20040865

Tang, S., and Zheng, J. (2018). Antibacterial activity of silver nanoparticles: structural effects. *Adv. Healthc. Mater.* 7, 1701503. doi:10.1002/adhm.201701503