

Editorial overview on Nanobiomaterials advances

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Dr. Narsimha Mamidi is a distinguished scientist at the University of Wisconsin–Madison, USA, specializing in the design and validation of innovative nano-biomaterials and nanotherapeutics for cancer immunotherapy and gene delivery. Formerly an Assistant Professor at Tecnológico de Monterrey (Tec), his team led research on advanced biomaterials with tailored properties for applications in drug delivery, tissue engineering, and biomedical implants. His team's translational work bridges fundamental science and clinical relevance, accelerating the development of next-generation therapeutics. Dr. Mamidi has published over 80 peer-reviewed articles, with an H-index of 30 and over 2500 citations. He has received prestigious honors including the Eli Lilly Award and multiple National Research System (SNI) recognitions. As an active editor for reputed biomaterials and nanomedicine journals, he continues to advance interdisciplinary innovations in therapeutic nanoscience.

The field of nano-biomaterials is advancing at an extraordinary pace, driven by the urgent need for innovative solutions to complex biomedical challenges. Nano-biomaterials have revolutionized biomedical engineering by integrating nanoscale materials with biological systems to address critical healthcare challenges [1–3]. These advanced constructs, ranging from nanoparticles and nanocomposites to nano-fibrous scaffolds, offer unprecedented control over cellular interactions, drug delivery, and tissue regeneration [4,5]. Recent progress in synthesis techniques such as layer-by-layer assembly and 3D bio-printing, has enhanced biocompatibility, targeting precision, and multi-functionality [6]. In cancer therapy, nano-biomaterials enable targeted delivery of chemotherapeutics, gene, and exosomes, improving efficacy while minimizing off-target effects [7,8]. This special issue highlights cutting-edge innovations in nano-biomaterials that are advancing clinical translation and personalized medicine.

This special issue, '*nanobiomaterials advances*', brings together five cutting-edge review articles that collectively highlight the transformative potential of engineered nanomaterials in modulating biological interfaces, combating antimicrobial resistance, enhancing tissue regeneration, and enabling targeted therapeutics. These contributions reflect a growing integration of material design with biological insight, therapeutic precision, and sustainable practice, pointing toward a future in which nanoscale tools are central to personalized and adaptive medical interventions.

In *engineering the neutrophil extracellular trap (NET)-biomaterial interface to treat disease*, Raghavan et al., explore how biomaterials can be designed to either suppress or replicate the functions of NETs [9]. The review underscores the dual nature of NETs, protective in infection but harmful in chronic inflammation and cancer and presents strategies for localized delivery of NET-modulating drugs, NET-inspired anti-microbial materials, and targeted degradation platforms. This work exemplifies the shift from systemic to localized, context-aware interventions and highlights the potential of biomaterials to precisely manipulate innate immune responses. In another review, Pal et al., address one of the most pressing global health threats by highlighting green-synthesized nanomaterials as sustainable, multi-functional tools to combat drug-resistant pathogens [10]. By leveraging plant, microbial, and waste-derived precursors, these materials offer mechanisms such as reactive oxygen species (ROS) generation, biofilm disruption, and quorum quenching [10]. This review bridges materials science with environmental and clinical stewardship, aligning with global sustainability goals while proposing scalable alternatives to conventional anti-microbial agents.

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Dr. Nasim Annabi is an Associate Professor in the Department of Chemical and Biomolecular Engineering at the University of California, Los Angeles (UCLA). Her team has pioneered the engineering innovative multi-functional biomaterials and nano-engineered systems for tissue engineering and drug delivery. Dr. Annabi has published over 180 peer-reviewed articles, with an H-index of 91 and over 32,000 citations. Her innovations have resulted in 20 issued patents and 7 invention disclosures, attracting significant commercial interest. She was named a Senior Member of the National Academy of Inventors (NAI) due to her remarkable achievements as an academic inventor, as well as her success in patents, licensing and commercialization. Dr. Annabi has been recognized as one of the world's most influential researchers in her field by Clarivate in 2022, 2023, and 2024. Furthermore, her work has garnered recognition through several prestigious awards including the 2021 Biomaterials Science Lectureship Award from the Royal Society of Chemistry (RSC), the 2021 Young Investigator Award from the Society for Biomaterials (SFB), and the 2020 Nanoscale Science and Engineering Forum (NSEF) Young Investigator Award from the American Institute of Chemical Engineers (AIChE) among several other notable honors.

In the third article, Mullick and Manna et al., provide a broad perspective on the regenerative and therapeutic applications of nano-biomaterials [11]. They cover bone and dental regeneration, anti-bacterial implant coatings, stimuli-responsive drug delivery, CRISPR-Cas9 nano-carriers, and theranostic platforms. The emphasis on biocompatibility, scalability, and clinical translation reflects the growing maturity of the field, while also acknowledging persistent hurdles in standardization and long-term safety that must be overcome for widespread adoption.

Mohammadi and Narayan, in *Nanomaterials for Controlled Drug Delivery in Wound Healing*, adopt a barrier-centric framework to evaluate how nanofibers, hydrogels, and nanoparticles can address the four key pathophysiological barriers in chronic wounds: biofilm persistence, oxidative stress, impaired angiogenesis, and dysregulated extracellular matrix (ECM) remodeling [12]. The review stands out for its clinical orientation, offering a roadmap toward closed-loop, AI-guided dressings that could revolutionize wound care. It emphasizes the need for multi-functional systems capable of simultaneous sensing, drug release, and real-time adaptation to wound microenvironment changes.

Finally, Kumar et al., delve into an emerging class of nanomaterials with exceptional photothermal, catalytic, and imaging capabilities [13]. MXene quantum dots are presented as versatile agents for combination therapies, with tunable surfaces and biocompatibility profiles that make them promising for theragnostic applications. The article also candidly discusses toxicity concerns and synthesis challenges, underscoring the critical balance between innovation and safety that must guide the development of next-generation nano-therapeutics.

Together, these articles underscore several cross-cutting themes: the move toward multifunctional, stimuli-responsive materials; the growing emphasis on sustainability and green synthesis; and the integration of computational tools and artificial intelligence to optimize design and predict behavior. While significant translational barriers remain including batch variability, long-term biocompatibility, and regulatory hurdles, the field is poised to embrace more intelligent, adaptive, and personalized systems. This special issue not only captures the current vibrancy of nanobiomaterials research but also provides a critical roadmap for future innovations at the intersection of materials science, biology, and medicine.

References

Papers of particular interest, published within the period of review, have been highlighted as:

- * of special interest
- ** of outstanding interest

1. Mamidi N, Delgadillo RMV, Sustaita AO, Lozano K, Yallapu MM: **Current nano-composite advances for biomedical and environmental application diversity.** *Med Res Rev* 2025, **45**:576–628.

This comprehensive review systematically addresses nanocomposite design principles and their dual-domain applications in healthcare and environmental remediation. The authors expertly survey metallic and nonmetallic nanofillers as reinforcing agents in polymeric matrices, emphasizing methodical engineering approaches. A valuable resource highlighting ongoing challenges and translational potential across biosensing, medical implants, and environmental sectors.

2. Mamidi N, et al.: **Multifaceted hydrogel scaffolds: bridging the gap between biomedical needs and environmental sustainability.** *Adv Healthcare Mater* 2024, **13**, 2401195.

This timely review uniquely bridges biomedical hydrogel engineering with environmental sustainability considerations. The authors present innovative strategies for designing multifunctional scaffolds that address clinical needs while incorporating sustainable materials and fabrication methods. Essential reading for researchers seeking to align tissue engineering with green chemistry principles.

3. Mamidi N, Velasco Delgadillo RM, Barrera EV, Ramakrishna S, Annabi N: **Carbonaceous nanomaterials incorporated biomaterials: the present and future of the flourishing field.** *Compos B Eng* 2022, **243**, 110150.

This authoritative review covers carbonaceous nanomaterials (CNMs) integrated into biomaterials for biomedical applications. The authors systematically address preparation methods for hydrogels, nanofibers, thin films, and nanoparticles, highlighting enhanced electrical conductivity, mechanical properties, and thermal stability. A foundational reference for orthopedic implants, bioimaging, and wearable biosensors.

4. Mamidi N, et al.: **Recent advances in designing fibrous biomaterials for the domain of biomedical, clinical, and environmental applications.** *ACS Biomater Sci Eng* 2022, **8**: 3690–3716.

This review consolidates advances in fibrous biomaterial design across multiple application domains. The authors detail fabrication strategies and structure-property relationships that enable tunable performance in tissue engineering, drug delivery, and environmental remediation. Particularly valuable for understanding how fiber architecture influences biological outcomes.

5. Mamidi N, Zuniga AE, Villela-Castrejon J: **Engineering and evaluation of forcespun functionalized carbon nano-onions reinforced poly (ϵ -caprolactone) composite nanofibers for pH-responsive drug release.** *Mater Sci Eng C* 2020, **112**, 110928.

This original research demonstrates innovative forcespinning fabrication of carbon nano-onion reinforced PCL nanofibers for smart drug delivery. The authors achieve pH-responsive release behavior through functionalized carbon nano-onions, showcasing a scalable approach to engineer composite nanofibers with controlled therapeutic release profiles.

6. Mamidi N, Ijadi F, Norahan MH: **Leveraging the recent advancements in GelMA scaffolds for bone tissue engineering: an assessment of challenges and opportunities.** *Bio-macromolecules* 2023, **25**:2075–2113.

This comprehensive review critically examines gelatin methacryloyl (GelMA) hydrogel scaffolds for bone regeneration. The authors expertly balance the exceptional physicochemical and biological properties of GelMA against persistent challenges in mimicking complex bone architecture and achieving adequate mechanical stiffness. An essential guide for researchers navigating osteogenic additive selection and scaffold design.

7. Mamidi N, Mahmoudsalehi AO: **Advances in three-dimensional hydrogel networks for cancer immunotherapy.** *J Mater Chem B* 2025, **13**:10440–10459.

This forward-looking review explores 3D hydrogel networks as platforms for cancer immunotherapy. The authors highlight how engineered hydrogel architectures can modulate immune cell behavior, enable local immunomodulator delivery, and create tumor-mimetic microenvironments for therapeutic screening. A timely synthesis of materials science and immuno-oncology.

8. Mamidi N, Franco De Silva F, Orash Mahmoudsalehi A: **Advanced disease therapeutics using engineered living drug delivery systems.** *Nanoscale* 2025, **17**:7673–7696.

This innovative review introduces engineered living drug delivery systems that overcome biological barriers through stimuli-responsive mechanisms. The authors systematically analyze rational design across polymeric, lipid-based, inorganic, and hybrid nanomaterial classes. Particularly notable for elucidating structure-function relationships and stimulus-triggered strategies for precision oncology.

9. Raghavan P, Nwagwu C, Finbloom JA, Desai TA: **Engineering the NET-biomaterial interface to treat disease.** *Curr Opin Biomed Eng.* 2025, **36**, 100629.

This review addresses the emerging interface between biomaterials and neutrophil extracellular traps (NETs). The authors explore how engineered materials can modulate NET formation and function for therapeutic benefit in inflammatory and infectious diseases. A specialized perspective on a novel immunomodulatory target.

10. Pal A, Sable H, Uniyal A, Chaudhary V: **Green nano-semiconductors and nanometals to avert complex phenomena of antimicrobial resistance (AMR).** *Curr Opin Biomed Eng.* 2025, **36**, 100626.

The authors address antimicrobial resistance through the lens of green-synthesized nanomaterials. The authors highlight eco-friendly approaches to produce nano-semiconductors and nanometals with potent antimicrobial properties, offering sustainable alternatives to conventional antibiotics. Relevant for researchers combating AMR through nanotechnology.

11. Mullick P, Manna A: **Nano-biomaterials: emerging tools in biomedical innovation and therapy.** *Curr Opin Biomed Eng.* 2025, **36**, 100627.

This broad-scope review surveys recent innovations in nano-biomaterials for therapeutic applications. The authors provide a curated overview of emerging platforms, highlighting key advances in material design, functionalization strategies, and translational progress. A useful entry point for researchers new to the field.

12. Mohammadi N, Narayan M: **Nanomaterials for controlled drug delivery in wound healing: recent advances and future directions.** *Curr Opin Biomed Eng.* 2026, **37**, 100637.

This forward-looking review examines nanomaterial-based platforms for controlled drug delivery in wound healing applications. The authors discuss recent advances in nanoparticle design, stimulus-responsive release mechanisms, and integration with wound dressings. Highlights emerging strategies to address chronic wound management challenges.

13. Kumar R, Sahu A, Aadil KR, Mishra YK, Kaushik A: **Recent progress in multifunctional MXene quantum dots for cancer therapy.** *Curr. Opin. Biomed. Eng.* 2026, **37**, 100635.

This review consolidates the latest advances (2024-2025) in using MXene quantum dots (MQDs) for cancer therapy. The authors expertly highlight both the remarkable potential of MQDs, particularly their multifunctional capacity for combined therapy and imaging, and the critical challenges (synthesis control, biosafety) that must be addressed to enable clinical translation.