Advanced Nanoplatforms for Antimicrobial and Antioxidant Therapy

Venesa Lupçi
Mimoza Basholli Salihu
University of Prishtina, Faculty of Medicine, Str. Bulevardi i Dëshmorëve, Prishtina, Kosovo
venesa.lupci@student.uni-pr.edu

Antimicrobial resistance and oxidative tissue damage often work together, reducing the effectiveness of treatments. This review explores recent advancements in nanotechnology for addressing both challenges, focusing on the development of polymeric nanoparticles, liposomes, metal-organic frameworks, and other innovative nanosystems designed for dual antimicrobial and antioxidant therapies. Key preparation techniques, such as emulsion-solvent evaporation and environmentally friendly synthesis methods, are examined, alongside the impact of these systems on critical properties like particle size, charge, and release profiles. The review assesses the antimicrobial effectiveness of these nanosystems against a range of pathogens—including Gram-positive and Gram-negative bacteria, fungi, and biofilms—as well as their antioxidant activity in counteracting oxidative stress. Despite promising results, challenges remain in terms of reproducibility, stability under physiological conditions, and limited in vivo validation. The review emphasizes the potential of targeted, stimulus-responsive delivery systems and highlights the need for standardization across preclinical models to accelerate the translation of these next-generation therapies from the laboratory to clinical use.

Keywords: antimicrobial resistance, oxidative stress, co-delivery, nanocarriers, liposomes, polymeric, nanoparticles, metal–organic frameworks.

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