Journal of Current Chemical and Pharmaceutical Sciences

Editorial | Vol 14 Iss 1

Microbial Chemistry–Enabled Nanotechnology in Advanced Drug Delivery Systems

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Received: april 04, 2024; **Accepted:** april 18, 2024; **Published:** april 27, 2024

Abstract

Nanotechnology in drug delivery has transformed pharmaceutical sciences by enabling targeted, controlled, and efficient transport of therapeutic agents. Microbial chemistry contributes significantly to this field through the production of biocompatible nanomaterials, surface-active biomolecules, and metabolite-derived carriers. Microorganisms synthesize polymers, lipids, and peptides that can be engineered into nanoscale drug delivery systems with enhanced stability and biological performance. This article examines the role of microbial chemistry in nanotechnology-based drug delivery, highlighting microbial-derived nanomaterials, their chemical properties, and their relevance in modern therapeutic applications.

Keywords:* *Microbial chemistry, nanotechnology, drug delivery, microbial nanomaterials, pharmaceutical systems

Introduction

Nanotechnology in drug delivery seeks to overcome limitations associated with conventional pharmaceutical formulations, such as poor solubility, low bioavailability, and non-specific distribution. Microbial chemistry offers innovative solutions to these challenges by providing naturally derived chemical components suitable for nanoscale drug carriers. Microorganisms produce a variety of biomolecules, including polysaccharides, proteins, lipids, and biosurfactants, that possess inherent biocompatibility and functional versatility. From a chemical perspective, these microbial products can be modified and assembled into nanoparticles, nanocapsules, and nanoemulsions capable of encapsulating therapeutic agents. Microbial polymers such as polysaccharides exhibit favorable chemical properties including biodegradability, chemical stability, and functional group diversity, allowing controlled drug release and surface modification. Biosurfactants produced by microbes facilitate nanoparticle stabilization and improve drug solubility through molecular self-assembly. The integration of microbial chemistry into

Citation: Fatima Noor El-Amin, Microbial Chemistry–Enabled Nanotechnology in Advanced Drug Delivery Systems. J Curr Chem Pharm Sc. 14(1):014.

nanotechnology enables precise control over particle size, surface charge, and chemical composition, which directly influence drug distribution and cellular uptake. Additionally, microbial synthesis of nanoparticles under mild conditions aligns with principles of green chemistry, reducing the need for toxic reagents. As pharmaceutical research increasingly prioritizes targeted and personalized therapies, microbial chemistry–based nanotechnology provides a sustainable and chemically versatile platform for advanced drug delivery systems.

Conclusion

Microbial chemistry plays a vital role in advancing nanotechnology for drug delivery by supplying chemically diverse, biocompatible, and sustainable materials. Continued research at the interface of microbial chemistry and nanotechnology will enhance the development of efficient and safe drug delivery platforms for future therapeutics.

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