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Microbial Chemistry–Based Pharmaceutical Nanocarriers for Advanced Drug Delivery

Ana Paula Ribeiro*

Department of Pharmaceutical Nanotechnology and Microbial Chemistry, University of São Paulo, Brazil,

***Corresponding author:** Ana Paula Ribeiro. Department of Pharmaceutical Nanotechnology and Microbial Chemistry, University of São Paulo, Brazil

Email: ana.ribeiro.nanocarrier@proton.me

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Abstract

Pharmaceutical nanocarriers are engineered systems designed to improve drug solubility, stability, targeting, and therapeutic efficacy. Microbial chemistry contributes significantly to the development of nanocarriers by providing biocompatible materials and biologically derived chemical components. Microorganisms synthesize polymers, lipids, and surface-active molecules that can be assembled into nanoscale drug delivery systems. This article explores the role of microbial chemistry in pharmaceutical nanocarrier design, emphasizing material properties, chemical functionality, and pharmaceutical applications.

***Keywords:** Microbial chemistry, pharmaceutical nanocarriers, drug delivery systems, nanotechnology, biocompatible materials*

Introduction

Pharmaceutical nanocarriers represent a major advancement in drug delivery technology, addressing challenges such as poor solubility, limited bioavailability, and non-specific drug distribution. Microbial chemistry offers innovative solutions by supplying naturally derived chemical materials suitable for nanoscale formulation. Microorganisms produce a range of biopolymers, lipids, and biosurfactants with chemical properties that support nanocarrier formation and stability. From a chemical perspective, these materials possess functional groups that enable drug encapsulation, controlled release, and surface modification for targeting purposes [1]. In recent years, microbial chemistry has emerged as an important complementary dimension of this field, revealing that microorganisms play a significant role in determining the chemical profile and biological performance of herbal medicines. Microorganisms residing in plant tissues, soil, and post-harvest environments can influence the biosynthesis and modification of phytochemicals through enzymatic processes[2]. From a chemical perspective, microbial

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transformation may convert inactive plant compounds into bioactive metabolites or alter functional groups that affect solubility, stability, and pharmacological activity[3]. These microbial processes contribute to the chemical diversity observed in herbal preparations and may explain variations in efficacy across different sources and processing methods. Microbial chemistry also plays a role during the fermentation of herbal products, where controlled microbial activity enhances bioavailability and reduces toxicity[4]. Analytical studies have demonstrated that microbial enzymes participate in hydrolysis, oxidation, and reduction reactions that modify plant secondary metabolites. Understanding these chemically mediated interactions is essential for standardizing herbal drugs and ensuring consistent therapeutic outcomes. As herbal medicines gain global acceptance, integrating microbial chemistry into herbal drug research strengthens quality assessment, safety evaluation, and rational formulation of plant-based therapeutics[5].

Conclusion

Microbial chemistry plays a crucial role in the development of pharmaceutical nanocarriers by providing functional, biocompatible materials for advanced drug delivery. Continued integration of microbial chemical insights into toxicological evaluation will strengthen risk assessment and promote the development of safer therapeutic and industrial chemicals. Microbial chemistry significantly enriches herbal drug research by influencing the chemical transformation and biological activity of plant-derived compounds. Incorporating microbial chemical insights into herbal research enhances the scientific validation, safety, and effectiveness of traditional and modern herbal medicines.

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