J Current Biomed Report
ISSN: 2717-1906
2025, Volume 6, Number 2
Letters to Editor

Nanoemulsions as emerging antifungal carriers: Potential beyond conventional boundaries

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To the Editor

Article info:
Received: 4 Jun 2025
Accepted: 20 Jun 2025

Keywords:
Nanoemulsion
Antifungal therapy
Drug delivery system
Fungal infection

Fungal infections, particularly those caused by *Candida* species, continue to pose a major clinical challenge, especially in immunocompromised populations. Despite the availability of antifungal agents, their effectiveness is often limited by poor solubility, systemic toxicity, low bioavailability, and increasing resistance particularly to azoles and polyenes. In this context, nanoemulsion-based drug delivery systems have garnered increasing attention as a promising approach to overcome these pharmacokinetic and pharmacodynamic limitations [1,2].

Nanoemulsions are kinetically stable colloidal dispersions composed of oil, water, surfactants, and co-surfactants. These systems enhance the solubility and stability of hydrophobic drugs and facilitate their targeted delivery. Their nanoscale droplet size allows for improved penetration through biological barriers, offering both sustained release and reduced systemic exposure [3]. Furthermore, surface modification capabilities permit ligand-specific targeting and enhanced interaction with fungal biofilms. The scalability and relatively low production cost of nanoemulsions make them particularly attractive for translational research and application in resource-limited settings [4].

Mechanistically, nanoemulsions exert antifungal effects by compromising fungal cell membrane integrity. Surfactants within the formulation destabilize lipid bilayers, leading to membrane leakage and cell death. Their ability to penetrate the extracellular matrix of fungal biofilms increases local drug concentration and efficacy features particularly relevant for biofilm-associated and resistant infections [5–7].

Recent studies, including one exploring an eucalyptol-based nanoemulsion incorporating amphotericin B, have demonstrated promising anti-biofilm activity against *Candida albicans*, both in vitro and in infection models such as *Galleria mellonella* [8]. Such findings support the potential of nanoemulsions as an alternative platform to conventional antifungal therapies.

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Nonetheless, clinical adoption remains limited. Challenges such as formulation standardization, long-term stability, and human safety profiles must be addressed in future investigations. Unlike liposomal amphotericin B, nanoemulsion-based formulations may also offer non-invasive administration routes (e.g., topical, buccal, or intranasal), broadening their clinical utility.

In conclusion, nanoemulsions present a versatile and innovative strategy for enhancing antifungal efficacy. While preliminary evidence is encouraging, broader validation through well-designed clinical trials and multidisciplinary collaboration is essential to facilitate their clinical translation. Advancing from conventional drug development to optimized delivery systems may represent a necessary paradigm shift in antifungal therapeutics.

Authors' contributions

Conceptualization, Supervision, Review, and Editing: EL; Original draft, Review, and Editing: MK, AZ. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

Ethical declarations

Not applicable.

Financial support

Self-funded.

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