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Mesoporous Silica Carriers Improved Quercetin's Skin Delivery and Effect

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Introduction

Quercetin, a naturally occurring flavonoid, has gained significant attention for its wide range of biological benefits, including antioxidant, anti-inflammatory and anticancer properties. Despite its therapeutic potential, quercetin faces considerable challenges in clinical application, especially when used topically. Its poor solubility, low stability and limited skin permeability significantly reduce its efficacy. To overcome these limitations, recent research has focused on innovative drug delivery systems, with Mesoporous Silica Nanoparticles (MSNs) emerging as a promising solution. MSNs are characterized by their high surface area, tunable pore size and biocompatibility, making them ideal for loading and releasing bioactive molecules in a controlled manner. Their use in topical drug delivery aims not only to enhance the permeation of compounds like quercetin through the skin barrier but also to preserve their functional activity during and after delivery. The current approach leverages the structural and functional capabilities of mesoporous silica to address the formulation challenges of quercetin, thereby improving its clinical relevance in dermatological applications [1].

Description

In the study, mesoporous silica was synthesized and used to load quercetin through adsorption techniques. Characterization of the resulting nanocarriers was performed using various analytical methods, such as Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and Brunauer–Emmett–Teller (BET) analysis. These tools confirmed the successful incorporation of quercetin into the silica matrix and maintained the structural integrity of the nanoparticles. The porous architecture of the silica allowed for high drug loading efficiency, while its surface chemistry facilitated interactions that stabilized the quercetin molecules. In vitro release studies revealed a sustained and controlled release of quercetin from the nanocarriers, demonstrating their potential to maintain effective drug concentrations over time. This slow-release mechanism is crucial for topical applications, where prolonged exposure enhances therapeutic outcomes. Furthermore, the incorporation of quercetin into mesoporous silica was shown to protect it from oxidative degradation, ensuring that its bioactivity remained intact throughout the delivery process.

In biological assessments, the mesoporous silica-based quercetin formulation was tested for cytotoxicity and antioxidant activity using cultured skin cells. The results demonstrated that the nanocarrier system was biocompatible and non-toxic at therapeutic concentrations. Importantly, the formulation showed enhanced cellular uptake compared to free quercetin, indicating that the nanoparticles facilitated deeper and more efficient skin penetration. Antioxidant assays, such as DPPH and ABTS, confirmed that the encapsulated quercetin retained its ability to neutralize free radicals, which is essential for combating oxidative stress-related skin conditions. The study also reported reduced inflammation markers in treated cell cultures, supporting the anti-inflammatory potential of the system. Collectively, these findings suggest that mesoporous silica carriers significantly improve the pharmacological profile of quercetin for topical use, enabling better skin interaction and prolonged therapeutic action [2].

Conclusion

The use of mesoporous silica nanocarriers for quercetin delivery offers a compelling strategy to overcome the compound's inherent limitations in topical applications. By enhancing its stability, skin permeability and bioactivity, this delivery system can potentially revolutionize the therapeutic use of quercetin in dermatology. The results highlight not only the versatility of mesoporous silica as a drug carrier but also its promise in developing advanced topical formulations for improved skin health and disease treatment. Further research may explore in vivo efficacy and commercial viability to fully integrate this approach into clinical practice.

Acknowledgement

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Conflict of Interest

None.

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