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Microsponge: A Novel Drug Delivery

Miss. Gayatri Sanjay Gawande*, Dr. A. R. Jaiswal

P. R. Pote Patil College of Pharmacy, Amravati, India.

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ABSTRACT

Microsponge technology has emerged as an innovative and flexible platform for drug delivery. Its porous, sponge-like structure allows the encapsulation of various active ingredients, ensuring a controlled and sustained release. This enhances the stability of the drug, minimizes side effects, and enables localized action. Microsponge systems have found applications across pharmaceuticals, cosmetics, and personal care products. This review outlines the historical development of microsponge technology, its formulation techniques, drug release mechanisms, methods of preparation, and applications. A comparison between microsponges and microspheres will also be discussed, highlighting the advantages of microsponges in terms of efficiency and patient compliance.

Keywords: Microsponge, Controlled release, Porous structure, Drug delivery system, Microspheres

1. Introduction

Microsponge drug delivery systems (MDS) represent a novel approach to overcoming limitations in conventional drug delivery systems【1】. These porous polymeric microspheres, first introduced by Won in 1987, have a high capacity for drug encapsulation and gradual release, making them ideal for various applications, especially in topical formulations【2】. Unlike traditional delivery systems, MDS allow for the modification of drug release patterns and improve the stability of the active ingredients, enhancing therapeutic outcomes【3】.

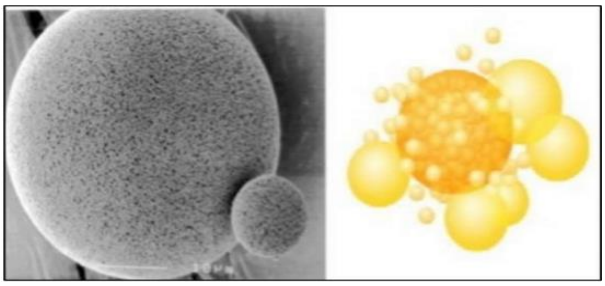

Fig no. 1 Microsponge (8)

2. History and Development

The concept of microsponges was patented by Advanced Polymer Systems Inc., who recognized their potential for both pharmaceutical and cosmetic applications【3】. Initially, microsponges were primarily used in topical products like Retin-A Micro® and Carac® for treating conditions such as acne and actinic keratoses【4】. Over time, the use of microsponges expanded to various drug delivery systems including oral and transdermal applications, with ongoing research focused on improving their drug loading capacity, drug release mechanisms, and overall efficacy【5】【6】.

3. Methods of Preparation

Various methods are used to prepare microsponges depending on the desired characteristics and applications. The most common techniques include:

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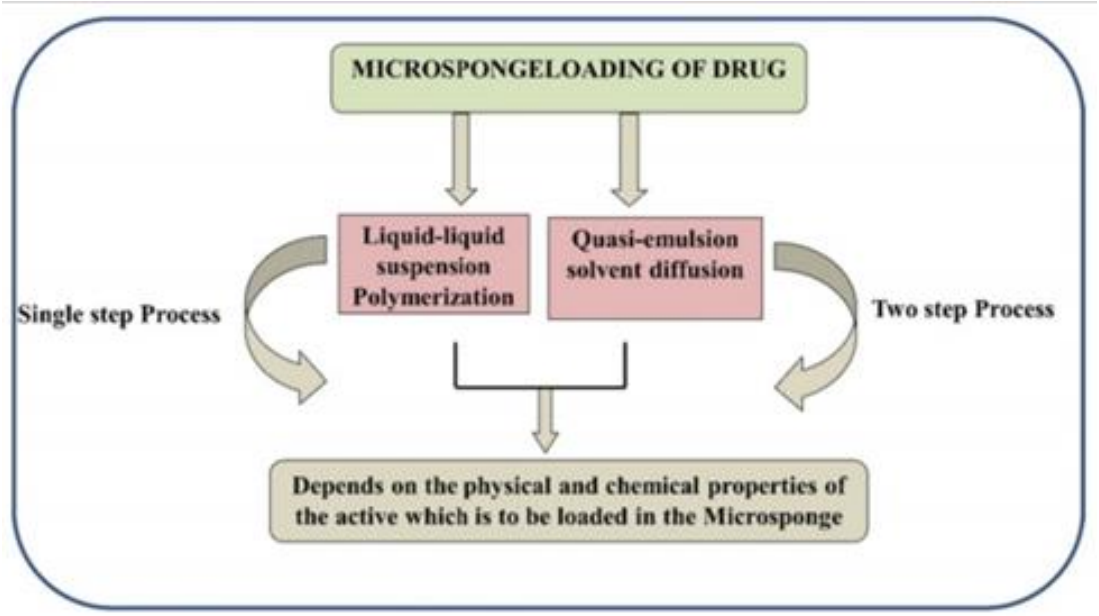

Fig no. 2 Method of preparation (8)

3.1 Liquid-Liquid Suspension Polymerization

In this method, monomers are dispersed in a liquid phase to form a stable suspension, followed by polymerization to form solid microsponges【7】. The technique is useful for encapsulating both hydrophilic and hydrophobic drugs. The monomers and porogens used in the dispersed phase determine the porosity and structure of the microsponges【8】.

3.2 Quasi-Emulsion Solvent Diffusion

This method involves dissolving the polymer and drug in a volatile organic solvent (e.g., dichloromethane) and then emulsifying this solution in an external aqueous phase containing a stabilizer【9】. The solvent diffuses into the external phase, causing the polymer to precipitate and form microsponges. This method is particularly efficient for controlling the size and porosity of microsponges, making it suitable for hydrophilic and hydrophobic drugs【10】.

3.3 Oil-in-Oil Emulsion Solvent Diffusion

In this method, a solution of the polymer and drug is emulsified in an external oil phase (e.g., liquid paraffin) and stabilized with agents like Span 80【11】. As the solvent diffuses into the external oil phase, the polymer solidifies into microsponges. This method is often used for encapsulating hydrophobic drugs【12】.

3.4 Lyophilization (Freeze-Drying)

Lyophilization is used to prepare temperature-sensitive drugs, where the microsponge suspension is frozen and subjected to vacuum conditions to remove solvents via sublimation. This helps retain the porous structure and prevents degradation of sensitive drugs【13】.

4. Drug Release Mechanisms

The porous structure of microsponges enables a controlled and sustained release of drugs, which occurs through mechanisms such as diffusion, pH changes, and external stimuli like temperature or pressure【14】【15】. Microsponge formulations can be tailored to specific therapeutic needs by adjusting polymer composition and drug encapsulation techniques, allowing for enhanced drug release profiles and greater control over therapeutic outcomes【16】【17】.

5. Differences between Microsponges and Microspheres

Microsponges and microspheres are both widely used in drug delivery systems, but they differ in structure, material composition, and drug release mechanisms. Microsponges have a sponge-like porous structure that allows for the gradual release of active ingredients, whereas microspheres are solid or hollow spherical particles that encapsulate drugs【18】. Microsponges are particularly advantageous in topical applications due to their ability to enhance drug stability and reduce irritation by controlling drug release rates【19】.

Tabel 1:- Difference between microsponge and microsphere【20】.

Microsponges	**Microspheres**
Porous sponge like structure	Solid or hollow spherical structure
Suitable for hydrophilic and hydropgobic drugs	Versatile material composition, typically biodegradable polymers
Controlled release via diffusion and environmental stimuli	Drug release through degradation, erosion, or diffusion

6. Applications

Microsponge technology has wide applications in pharmaceuticals and cosmetics. It is used for topical drug delivery to treat conditions such as acne, eczema, and psoriasis【21】. Furthermore, microsponges are increasingly used in oral formulations, as well as in cosmetic products to enhance the release of active ingredients like sunscreens and anti-aging compounds【22】.

7. Conclusion

Microsponge technology represents a significant advancement in drug delivery systems due to its ability to provide controlled and sustained release of active ingredients. Its flexibility, combined with a wide range of applications in both pharmaceutical and cosmetic industries, positions it as a highly effective platform for enhancing therapeutic efficacy. Ongoing research into improving microsponge formulation techniques and addressing the challenges of drug loading and scalability will further solidify its role in future drug delivery innovations.

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