NANOSPONGES: EMERGING DRUG DELIVERY SYSTEM

Renuka Sharma and Kamla Pathak*

Department of Pharmaceutics, Rajiv Academy for Pharmacy, Mathura – 281001,

Uttar Pradesh, India

ABSTRACT

Nanosponges have emerged as one of the most promising fields of science because of their perceived application in controlled drug delivery. Nanosponge delivery system can precisely control the release rates or target drugs to a specific body site and have an enormous impact on the health care system. This nanosized delivery system has definite advantages for the purpose of drug delivery because of its high stability, high carrier capacity and feasibility of incorporation of both hydrophilic and hydrophobic substances. The application of nanosponges for the targeted and localized delivery of therapeutic agents, is the driving force for the research in this area. This review focuses on the mechanism of action, methods of preparation and applications of nanosponges in the field of drug delivery.

Keywords: *Nanosponges, drug delivery, biodegradable, chemical sensor, oral delivery*

Introduction

Nanosponges constitute an important part to control the delivery rates of active agents to a predetermined site by virtue of their small size and efficient carrier characteristics. Nanosponge technology offers entrapment of ingredients and is believed to contribute towards reduced side effects by controlling the release, improved stability, increased elegance, and enhanced formulation flexibility. In addition, nanosponge systems are non-irritating, non-mutagenic, non-allergenic, and non-toxic (1). This technology is being used currently in cosmetics, over-the-counter (OTC) skin care, sunscreens and prescription products. Nanosponges are porous spheres having myriad of interconnected voids. These nanosponges have the capacity to entrap a wide range of active ingredients such as emollients, fragrances, essential oils, sunscreens and anti-infective, etc. are used as a topical carrier system.

Nanosponges can be prepared by optimizing formulation parameters such as drug: polymer ratio and agitation/stirring rate. Conventional formulations of topical drugs are intended to work on the outer layers of the skin. Typically, such products release their active ingredients upon application, producing a highly concentrated layer of active ingredient that is rapidly absorbed. The nanosponge system can prevent excessive accumulation of ingredients within the epidermis and the dermis. Potentially, the nanosponge system can significantly reduce the irritation of effective drugs without reducing their efficacy. Delivery systems comprising of a polymeric bead having network of pores with an active ingredient(s) held within have been developed to provide controlled release of the active ingredients whose final target is skin itself. Release can be controlled through diffusion or other triggers such as moisture, pH, friction, or temperature. Nanosponge delivery system can be incorporated into conventional dosage forms such as creams, lotions, gels, ointments, and powder and share a broad package of benefits. This system is employed for the improvement of performance of topically applied drugs (2). Nanosponge systems are made of biologically inert polymers. Extensive safety studies have demonstrated that the polymers are non-irritating, non-mutagenic, non-allergenic, non-toxic and non-biodegradable. As a result, the human body cannot convert them into other substances or break them down.

Mechanism of drug release from nanosponges

The active ingredient is added to vehicles in the entrapped form since the nanosponges particles have an open structure (they do not have continuous membrane surrounding them) the active substance is free to move in or out from the particles into the vehicle until equilibrium is reached when the vehicle become saturated. Once product is applied to skin, the active substance that is already in vehicle which will become unsaturated, therefore disturbing the equilibrium. This will start flow of active from nanosponges

*To whom correspondence should be addressed: kamla_rap@yahoo.co.in

particle into vehicle from it, to skin until vehicle is either dried or absorbed. Even after that nanosponges particle retained on the surface of stratum corneum will continue to gradually release active to skin providing prolonged release over time.

Preparation of nanosponges

Nanosponges are prepared depending on type of delivery system, polymers and nature of drug and solvents. Various approaches used for formation of nanosponges are (1):

1. Polymerization

The polymerization process leads to the formation of a reservoir type of system, which opens at the surface through pores. A solution of non-polar drug is made in the monomer, to which aqueous phase, usually containing surfactant and dispersant to promote suspension is added. Polymerization is effected, once suspension with the discrete droplets of the desired size is established; by activating the monomers either by catalysis or increased temperature.

2. Quasi-emulsion solvent diffusion

The nanosponges can also be prepared by quasi-emulsion solvent diffusion method using the different polymer amounts. To prepare the inner phase, Eudragit RS 100 was dissolved in suitable solvent. Then, drug can be added to solution and dissolved under ultrasonication at 35 °C. The inner phase was poured into the PVA solution in water (outer phase). Following 60 min of stirring, the mixture is filtered to separate the nanosponges. The nanosponges are dried in an air-heated oven at 40 °C for 12 hrs.

3. Emulsion solvent diffusion method

In this method the two phases used are organic and aqueous. Aqueous phase consists of polyvinyl alcohol and organic phase include drug and polymer. After dissolving drug and polymer to suitable organic solvent, this phase is added slowly to the aqueous phase and stirred for two or more hours and then nanosponges are collected by filtration washed and then dried in air at room temp or in vacuum oven at 40° C for 24 hours.

Applications of nanosponge system

Nanosponges as chemical sensors

Metal oxide "nanosponges" as chemical sensors used in highly sensitive detection of hydrogen using nanosponge titania. In a nanosponge structure, however, there are no contact points. Consequently, there is much less hindrance to electron transport and results in higher sensor stability. 3-dimensionally (3D) interconnected nanosponge titania (NST) is highly sensitive to H_2 gas. 3D interconnected metal oxide nanostructure is a promising class of sensor material through which the ultra-high chemical sensitivity of nanostructures can be harnessed in practical devices(3).

Nanosponge for Oral Delivery

In oral applications, the nanosponge system has pores that increase the rate of solubilization of poorly water-soluble drugs by entrapping such drugs in the pores. Due to nanosize, the surface area is significantly increased and this greatly increases the rate of solubilization. An added benefit is that the time the nanosponge system takes to traverse the small and large intestine is significantly increased thus maximizing the amount of drug that is absorbed.

Solubility enhancement

Formulation of crosslinked beta cyclodextrins based nanosponges of itraconazole has been reported to enhance the solubility of the poorly soluble drug. It was found that the solubility of itraconazole was enhanced more than 50-folds with a ternary solid dispersion system. Using copolyvidonum in conjunction with nanosponges helped to increase the solubilization efficiency of nanosponge(4).

Safety considerations

Safety substantiation of microsponges can be confirmed by skin irritation studies in rabbits; eye irritation studies in rabbits; oral toxicity studies in rats; mutagenicity in bacteria and allergenicity in guinea pigs(5).

Future prospects

Nanosponges are becoming promising carriers for specific delivery of drugs to lungs, liver, and spleen. Nanoporous titanium oxides have extremely wide applications ranging from chemical sensing to solar energy. A new and simple approach for preparing Pd/Ag and Pd/Ag/Au nanosponges, which comprise network nanowires has been reported in a study. This in situ strategy demonstrates for the first time how to prepare alloy nanosponges with network nanowires via self-regulated reduction of sodium dodecyl sulfate

(SDS) and adding the second or third metal salt in the synthesis period, without additional reduction agent (6). Sponge like alginate nanoparticles as a new potential system for the delivery of antisense oligonucleotides and study of their ability to protect ON from degradation in the presence of serum is also a focus area of research (7). Increasingly used in topical drug delivery systems leading to the release of active substances on the epidermis, coupled to their maintenance at the site of action and improved delivery systems maximizing the time of permanence of active compounds on the skin. Nanosponge delivery systems are used to enhance the safety, effectiveness and aesthetic quality of topical prescription, over-the-counter ("OTC") and personal care products.

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