JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

REVIEW OF NANOSPONGES, A NEW CLASS OF DRUG DELIVERY SYSTEM

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ABSTRACT

For a very long time, effective targeted drug delivery systems have been a pipe dream, but they have mainly the complicated chemistry required for the creation of novel systems frustrates me. A big move towards solving these issues has been the development of nanosponges. A broad range of drugs can be placed inside nanosponges, which are tiny sponges about the size of a virus. These microscopic sponges can move through the body until they reach the intended target site, where they adhere to the surface and start to release the drug in a steady and controlled way. They can be made in oral, parenteral, topical, or inhalation dosage forms. Nanosponges are solid, porous particles with the ability to load medicines and other actives into their nanocavities.

The drug will be more potent for a given dosage because it can be released at the precise target spot rather than circulating throughout the body. The aqueous solubility of these sponges, which allows for the efficient use of these systems for drugs with low solubility, is another crucial characteristic of these materials. This article has discussions on the use of nanosponges, preparation techniques, and assessment criteria.

Keywords: nanotechnology, nanosponges, targeted delivery, cyclodextrin, solubility

INTRODUCTION

The delivery of drugs to the correct location in the body and controlling the drug's release to avoid overdoses have long been a challenge for medical researchers. These issues may be resolved by the creation of novel, intricate structures known as nanosponges. Nanosponges are a brand-new class of materials composed of tiny particles with cavities that are only a few nanometers wide and can contain a wide range of different substances. These particles can transport both hydrophilic and lipophilic materials, as well as help less water-soluble compounds become more soluble.

Early studies indicate that the technology of nanosponges, which are tiny mesh-like structures, is up to five times more effective at delivering drugs for breast cancer than traditional methods. Nanosponges may revolutionise the treatment of many diseases. The nanosponge has a "backbone" (a support structure) made of naturally biodegradable polyester and is about the size of a virus. Long polyester threads are combined in a solution with tiny molecules

known as cross-linkers, which have a preference for particular regions of the polyester. Segments of the polyester are "cross linked" to create a spherical structure with numerous pockets (or cavities) where drugs can be kept. Because the polyester degrades predictably in the body, the drug can be released on a predetermined timetable as it does so. The drug molecules are contained within the centre of the encapsulating nanoparticles known as nanosponges. The nanoparticles can be categorised into encapsulating, complexing, and conjugating nanoparticles based on how they interact with medicines. Nanosponges and Nanocapsules are examples of the first category. These nanosponges are a brand-new type of nanoparticles that are typically made from natural derivatives. They differ from other nanoparticles in that they are porous, non-toxic, insoluble in both water and organic solvents, and stable at temps up to 300 °C. In addition, nanosponges exhibit a surprising advantage over common nanoparticles in that they are readily regenerable through a variety of processes, including washing with environmentally friendly solvents, stripping with moderately inert hot gases, mild heating, or altering pH or ionic strength.

Composition of Nanosponges

Polymer

The efficacy and formation of Nano sponges can be affected by the polymer choice. The cavity dimension needs to be appropriate for incorporating the specific drug molecule. The drug to be enclosed and the necessary release determine the polymer to be used. The chosen polymer should have the ability to bind to particular compounds.

Cross linking agent

The choice of the cross-linking agent can be made based on the polymer's composition and the drug that is being developed. Diphenyl carbonate, dichloromethane, dialyl carbonates, and diisocyanates are a few of the various types.

Drug substance

- Molecular weight between 100-400 Daltons.
- A drug's molecule has no more than five compacted rings in total.
- Solubility is less than 10 mg/ml in water.
- The substance's melting point is lower than 250 °C.

Advantages of Nanosponges

- Increase the solubility of lipophilic medicines in water.
- To safeguard the molecules and create drug delivery systems for different routes of administration.
- They combine with water and are utilised as a fluid conveyance.
- To cover up disagreeable tastes.
- The NSs can bind precisely at the target site thanks to the chemical linkers.
- The existence of relatively straightforward polyester and crosslinking peptide chemistry accounts for NS's engineering potential.

Disadvantages of Nanosponges

- They only contain small molecules.
- They only rely on loading capabilities.

Method of Preparation

- Nano sponges made from hyper cross-linked β-cyclodextrins
- Solvent used method
- Emulsion solvent method
- Ultrasound-assisted synthesis

Emulsion solvent method

Ethyl cellulose and polyvinyl alcohol are the two primary polymers used in this method in varying amounts. The accessible drug is dissolved in 20 ml of dichloromethane before being combined with ethyl cellulose to create the dispersed phase. In order to prepare the drop-by-drop continuous phase addition, polyvinyl alcohol is dissolved in 150 cc of distilled water. The mixture is then permitted to stir for approximately two hours at 1000 rpm. The acquired Nano sponges are gathered, filtered, and oven-dried for approximately one day before being placed in desiccators.

Loading of drug into nanosponge

The nanosponges created for medication delivery should first undergo pretreatment to reduce the mean particle size to under 500 nm. To prevent the formation of aggregates, the nanosponges are then suspended in water for a while and exposed to sonication. To produce a colloidal fraction, centrifugation is applied to the product suspension that has been obtained. Supernatant from the finished product is removed, and sample is then dried using freeze drying. Another method is to make and disperse a nanosponge aqueous suspension while stirring continuously for a set amount of time. The liquid is evaporated to produce the nanosponge solid crystals, or the crystals are frozen dried. The crystal structure of the nanosponge is a key factor in how the medication complexes with it. In comparison to paracrystalline nanosponge, crystalline nanosponge has a higher drug concentration. Drug loading takes place mechanically rather than as an inclusion complex in nanosponges with a weak crystalline structure.

Evaluation of Nanosponges

Microscopic studies

Scanning electron microscopy (SEM) and transmission electron microscopy can be used to examine the microscopic features of a drug, Nano sponge, or object. (TEM). The different crystallisation condition reveals inclusion complexes were formed.

Loading efficiency

It can be found by quantitatively estimating the amount of drug that is loaded into the nanosponge using an HPLC method or a UV spectrophotometer. You can figure out the loading effectiveness by using

$$\mathbf{LE} = \frac{\text{Actual drug content in nanosponges}}{\text{Theoretical drug content}} \text{ X } 100$$

Solubility studies

The phase solubility method introduced by Higuchi and Connors, which aids in determining how a nanosponge affects a drug's solubility, is the approach that is most frequently employed. Phase solubility diagrams provided an indication of the degree of complexation.

X ray diffraction studies

Powder X-ray diffractiometry can be used to ascertain the inclusion complexation for solids. The diffraction pattern of a freshly formed substance clearly differs from that of an uncomplicated nanosponge when the drug molecule is liquid and liquids have no inherent diffraction pattern. The complex formation is indicated by this variation in the diffraction pattern. The diffractogram of the complex and that of the mechanical mixture of the drug and polymer molecules must be compared when the drug compound is a solid material.

Infra – red spectroscopy

This spectroscopy technique is primarily used to calculate the interaction between a drug molecule and a nanosponge in solid form. Nanosponge bands change frequently after complex formation, and if less than 25% of the guest molecules are encapsulated in the complex, bands that could be attributed to the included portion of the guest molecules are readily covered up by the bands of the nanosponges' spectrum. The use of infrared spectroscopy is restricted to medications with distinguishing lines like carbonyl or sulfonyl groups. The role of hydrogen in different functional groups is revealed by infrared spectral investigations.

Thin layer chromatography

Thin layer chromatography causes the drug molecule's RF values to significantly decrease, which aids in finding the complex formation between the drug and nanosponge formulation.

Particle size and polydispersity

By using a 90 plus particle sizer outfitted with MAS OPTION particle sizing software, dynamic light scattering can be used to measure the particle size of a nanosponge formulation. The obtained data can be used to calculate the polydispersity score and mean diameter.

Zeta potential

To determine the surface charge, the zeta potential is determined. With the aid of an additional electrode and particle size tools, it can be measured.

Production yield

Calculating the initial weight of raw materials and the final weight of nanosponges will give the production yield.

$$\text{product yield} = \frac{\text{practical mass of nanosponge}}{\text{Theoretical mass}} \times 100$$

Conclusion

The drugs can be incorporated into the nanosponges in either a lipophilic or hydrophilic form, and they will release at the target location in a controlled and predictable way. The particle size and discharge rate can be adjusted by varying the cross-linker to polymer ratio. The insoluble medicines are made usable by nanosponges, which also shield the active molecules from physicochemical deterioration and controlled release. Nanosponges can be made into a variety of dosage forms, including parenteral, aerosol, topical, pills, and capsules, due to their tiny size and spherical shape. The benefit of this technology is that it can target the drug to a particular location, reducing side effects while improving stability, formulation flexibility, and patient compliance. Other industries that nanosponges can be used in include agrochemistry, biomedicine, skincare, bioremediation, and catalysis.

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