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Original Research Article

Nanosponges – A Review on Noval Drug Carriers

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Abstract:
Pharmaceutical nanotechnology, the pharmaceutical sciences' most recent subfield, offers new resources, chances, and possibilities that are anticipated to have a big impact on illness treatment and diagnosis.. Pharmaceutical nanotechnology comprised of nano-sized products which can be transformed in numerous ways to improve their characteristics. A Nanosponge is a novel and emerging technology which offers targeted & controlled drug delivery for topical as well as oral use. Nanosponges are based on nano, polymer-based spheres that can suspend or entrap a wide variety of substances and then be incorporated into a formulated product such as a gel, lotions,cream, ointments, liquid or powder. This technology offers entrapment of ingredients and thus reduced side effects, improved stability, increases elegance and enhanced formulation flexibility.A component of advanced medicine delivery is nanosponge. It is a special tool for the regulated administration of both lipophilic and hydrophilic medicines to specific patient populations.
Keyword: Nanosponges, Cyclodextrins,Drug delivery

Introduction

The targeted drug delivery system is used by the more recent and developing nanosponge technology to release the medicine to the targeted site in a controlled manner. Nano sponges are a class of materials that consist of microscopic, sponge-like structures with cavities that are just a few nanometers wide and have an average diameter of less than one millimetre. They cross-link the polyester segments to create a spherical shape with several holes for storing the medication. These small spaces can hold a variety of chemicals, including hydrophilic and lipophilic pharmacological compounds, increasing the solubility of the drug component that is weakly water soluble [1].

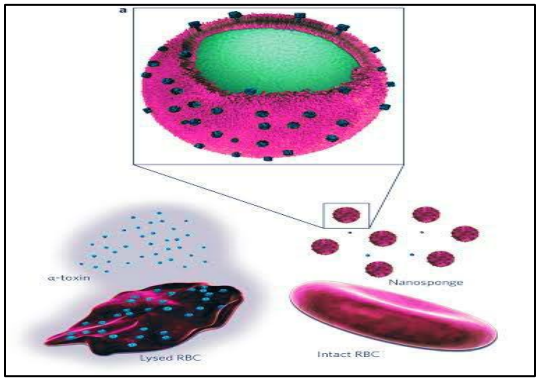

Figure1: Nanosponge

History:

DeQuan Li and Min Ma initially used the term "cyclodextrin nanosponges" to describe nanosponges in 1998. This phrase was employed because -cyclodextrin is cross-linked with organic diisocyanates. This structure contains an insoluble network with a high inclusion constant. Native cyclodextrins react with a cross-linking agent to generate these polymers; the latter affects the behaviour and characteristics of the entire unit .[2]

It wasn't until Trotta and colleagues' research realised cyclodextrin nanosponges had the potential to be drug carriers.[3] They synthesised different types of cyclodextrin nanosponges and identified a wide range of previously unconsidered possibilities .[2]

A Targeted Drug Delivery System :

The targeted drug delivery system is used by the more recent and developing nanosponge technology to release the medicine to the targeted site in a controlled manner. Nano sponges are a class of materials that consist of a microscopic, sponge-like structure with a small hollow that has an average diameter of less than one millimetre. They cross-link the polyester segments to create a spherical shape with several holes for storing the medication. These small spaces can be filled with a variety of materials that can carry both hydrophilic and lipophilic medicinal molecules, increasing the solubility of the latter class of drugs that are weakly water soluble [4].This technique provides regulated drug delivery systems for topical usage, and is regarded as a unique strategy. It effectively allows components with fewer negative effects, higher stability, increased elegance, and increased formulation flexibility to be trapped [5].

Target drug delivery through nanosponge carriers:

The most significant engineering revolution since the industrial period may be nanotechnology. Nanoparticles, nanocapsules, nanospheres, nanosuspensions, nanocrystals, nano-erythosomes, and other formulation variations have been produced thus far as a result of nanotechnology [6]. According to one definition of nanotechnology, it is the production and manipulation of materials at the nanoscale level to produce goods with unique properties[7].Recently, there has been a lot of interest in nanomaterials.A scientist at Cal Tech named Richard P. Feynman made a prediction regarding nanomaterials in 1959. He asserted that scaling down to the nanoscale and beginning from the bottom was the key to future success in nanotechnology, adding, "There is plenty of room at the bottom."Materials with at least one dimension in the 1-100 nm range are referred to as nanomaterials. Nanoparticles can be used for a wide range of things, including the delivery of drugs and DNA as well as the immobilisation of enzymes and the functionalization of textiles and biocompatible materials [8, 9].

Plasmonic nanosponges:

Due to its distinctive 3D bi-continuous ligament-channel structure with substantial specific surface areas for applications in catalysis and sensors, nanoporous gold (NPG) has gained growing attention [10–13]. Additionally, it has been shown that NPG, because of its high surface-to-volume ratio and outstanding plasmonic characteristics, can be employed for biomolecule sensing with great sensitivity via surface enhanced Raman spectroscopy (SERS) [10,14,15]. NPG is often created by dealloying (selective leaching) Au-Ag alloys, which removes Ag, a less noble metal, and creates the nanoporous structure of Au. The book "Nanoporous Gold: From an Ancient Technology to a High-Tech Material" [16] provides an overview of some current advanced research on nanoporous gold.The NPG has some intriguing optical and plasmonic characteristics. Due to the nanoporous structure's ability to scatter light, the colour of the NPG changes from a dark dullness to that of the shiny sheen of the Au-Ag alloy after dealloying. Actually, the primary basis for NPG's use in optical sensing is its plasmonic characteristics. At the surface of metals or the interface between metal and dielectrics, incoming light can cause surface plasmon resonances (SPR), the resonant oscillation of conduction electrons. It is important to note that simultaneous activation of both propagating and localised surface plasmon resonances may be seen in the NPG membranes, suggesting that the structure of metals can either stimulate the propagating mode in thin films or the localised mode in nanoparticles.[17,18].

Nanosponges as protein delivery systems:

Cyclodextrin-based nanosponges (CD NSs) are polymeric substances formed of cyclodextrins (,, and cyclodextrins) that have been crosslinked with appropriate cross-linking agents. The fundamental benefit of polymerizing cyclodextrins (CDs) is the creation of a complex network where complexation can take place both inside the interior cavities of CDs and in the interstitial volumes between them. So, both hydrophobic and hydrophilic compounds can be captured by nanosponges. The polymeric framework that envelops each CD also helps to extend the amount of time that the entrapped guest molecules stay inside the CD cavity. The inclusion of functional groups, which respond to outside stimuli, allows for the modulation of the released molecules as well.They have attracted a lot of interest in nanomedicine due to their capacity to transport a variety of medications while enhancing their solubility, stability, activity, bioavailability, and enabling prolonged and/or stimuli-sensitive release. Medicines that have been effectively loaded into CD NSs include anticancer medications, polyphenols and their combination, medications for neurological illnesses (such as L-dopa), and non-steroidal anti-inflammatory drugs (NSAIDs). [19]

Mechanisms:

A group of cyclic glucopyranose oligomers known as cyclodextrins share the common structural formulas,, and. Three different types of cyclodextrins each include six, seven, and eight glucopyranose units. The molecular structure of cyclodextrins, which are biological nanomaterials, has a significant impact on their supramolecular characteristics. Enzymatic activity happens on hydrolyzed starch to create cyclodextrins .[2]

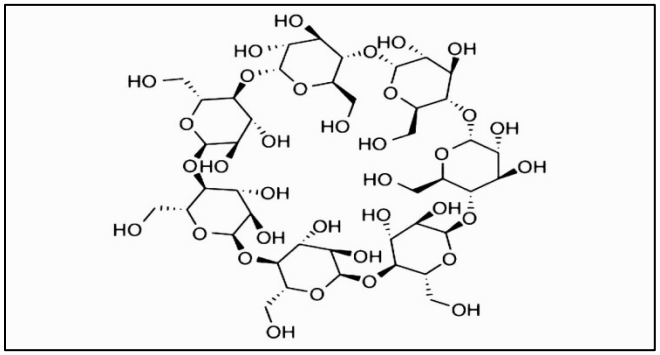

Figure 2: Cyclodextrin

A three-dimensional cross-linked polymer network is the basis of cyclodextrin nanosponges. They can be produced using cyclodextrins,, and. Depending on how much of the cross-linking agent is employed, the inclusion capacity and the solubilizing capacity of the nanosponges can be adjusted .[2]

Current primary medical research:

The majority of current research is focused on the use of nanosponges in medicine to treat venoms from snakes and other animals as well as bacterial infections (sepsis, pneumonia, and skin and soft tissue infections), viral infections (zika, HIV, and influenza), autoimmune diseases (rheumatoid arthritis), and viral infections (HIV, and influenza) .[20]

Characteristic Features of Nanosponges [21,22]

1. Nanosponges offer a variety of sizes (1 m or less) with adjustable cavity polarity.
2. By altering the cross linker to polymer ratio, it is possible to create nanosponges of a particular size.
3. Depending on the circumstances of the processing, they take on paracrystalline or crystalline forms. Nanosponges' crystal structure is essential for the complexation of medicines with them.
4. The degree of crystallisation determines the drug loading capacity.
5. Paracrystalline nanosponges can demonstrate a range of drug loading capabilities.
6. They contain porous particles that are non-toxic, insoluble in the majority of organic solvents, and stable up to 300 °C.
7. In the pH range of 1 to 11, they are stable.
8. In water, they create an opalescent and transparent suspension.
9. Simple thermal desorption, solvent extraction, microwaves, and ultrasounds can all be used to duplicate them.
10. Their three-dimensional design enables the capture, transport, and controlled release of several chemicals.

Applications of Nanosponges:

1. Solubility enhancement: Nanosponges can enhance the solubility and wetting of molecules with very low water solubility. The dissolution process can be skipped if the medications are molecularly disseminated inside the nanosponge structure and subsequently released as molecules. As a result, the drug's perceived solubility can be improved. By increasing a substance's solubility and dissolving rate, many formulation and bioavailability issues can be resolved, and nanosponges can significantly increase a drug's solubility [23].

2. Nanosponges for drug delivery: The nanosponges can be made into dosage forms for oral, parenteral, topical, or inhalation use. They are solid by nature. The complexes may be disseminated in a matrix of excipients, diluents, lubricants, and anticaking agents appropriate for the manufacture of capsules or tablets for oral delivery. The compound can easily be transported in sterile water, saline, or other aqueous solutions for parenteral administration. They can be successfully integrated into topical hydrogel for topical delivery [24].

Disadvantages:

1. Only small molecules can be included by nanosponges.
2. Nanosponges may be crystalline or paracrystalline in nature.
3. The degree of crystallisation is the main factor determining the loading capacity of nanosponges.
4. Different loading capacities can be seen in paracrystalline nanosponges

Factors influencing the formation of Nanosponge [25,26,27] :

1. Polymer and cross-linkers: The kind of polymer used can affect how nanosponges are formulated as well as how well they work. Molecular nanocavities are transformed into a three-dimensional nanoporous structure by an effective cross-linker. Using hydrophilic nanosponge, they are created.

2. Drug Types and Interaction Medium: The drug molecule used in nanosponge formulation should have the following properties. Molecules with a weight of 100 to 400 daltons. A drug's molecule has no more than five condensed rings in total. Water has a solubility of less than 10 mg/ml. The substance's melting point is lower than 250°C.

3. Complicatedness Temperature: Variations in temperature affect a complex's stability constant. The relationship between the stability constant and temperature increase is inverse. The apparent stability constant's magnitude decreases with temperature due to a weakening of the forces that interact drugs and nanosponge molecules. Therefore, when making nanosponges, a strict temperature control should be kept.

Conclusion:

The nanosponge can transport both hydrophilic and hydrophobic medicines by creating inclusion and non-inclusion complexes, nanosponges represent a novel class of biocompatible, flexible drug carriers. Initially designed for topical medication administration, nanosponge. Since their use can solubilize poorly water soluble medications and give delayed release, as well as boosting pharmaceuticals bioavailability and in some cases changing its pharmacokinetics parameters, colloidal carriers have recently been created and proposed for drug delivery. A nanosponge's average diameter is less than 1 m, though fractions as small as 500 nm can be chosen. Nanosponge technology finds extensive use in the pharmaceutical industry.

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