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PREDICTION OF DRUG-DRUG INTERACTION POTENTIAL NANOSPONGES: A NOVEL CLASS OF DRUG DELIVERY SYSTEM AND ITS APPLICATIONS

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Abstract:
Small, mesh-like structures called nanosponges have a size range of less than 1 m. They can readily bind poorly soluble pharmaceuticals because of their small size and porous structure, which improves the solubility and, in turn, the bioavailability of the same drugs.Both lipophilic and hydrophilic drugs can be loaded into nanosponges. Nanosponges play a major role in targeting drug delivery systems. These can move through the body until they come into contact with the intended target spot, where they adhere to the surface and start to release the medicine in a regulated and predictable manner.The application of nanosponges, its preparation processes, and assessment criteria have been covered in this review article. Nanosponges are solid by nature and can be produced as oral, parenteral, topical, or inhalation dosage forms.

Keywords: *Nanosponge , Drug delivery , Therapeutic applications.*

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INTRODUCTION:

The distribution of medications to the correct location in the body and controlling the drug's release to prevent overdosing have long had been a challenge for medical researchers. These issues may be resolved through the creation of novel, intricate molecules known as nanosponges. Nanosponges are a brand-new class of materials comprised of tiny particles having chambers that are only a few nanometers across and can contain a wide range of different chemicals. These particles have the capacity to transport both hydrophilic and lipophilic materials, as well as to increase the solubility of molecules that aren't very water soluble [1]. Early experiments suggest that this technique is up to five times more effective than current treatments for numerous Elements than nanosponges, which are tiny mesh-like structures.It could completely change how many diseases are treated, and preliminary research indicates that this technique is up to five times more effective than current delivery systems for medications treating breast cancer [2].

Alginate nanosponges, which are sponge-like nanoparticles with numerous pores that transport drug molecules, are examples of nanosponges. Nanoparticles are also enclosed in nanocapsules made of poly(isobutyl-cyanoacrylate, or IBCA). They have an aqueous core where drug molecules can be trapped. Complexing nanoparticles fall into the second kind; they draw molecules to them by electrostatic charges. Conjugating nanoparticles, which connect to pharmaceuticals by covalent bonds, are the third kind [3]. These nanosponges are a novel class of nanoparticles that are often made from natural compounds. They differ from other nanoparticles in that they are porous, non-toxic, insoluble in both water and organic solvents, and stable at temperatures up to 300 °C.

1. Nanoparticles that are enclosed:

Nanosponges and nanocapsules stand in for this type. Alginate nanosponges, which are sponge-like nanoparticles with numerous pores that transport drug molecules, are examples of nanosponges. Nanoparticles are also enclosed in nanocapsules made of poly (isobutyl cyanoacrylate, or IBCA). They have an aqueous core where drug molecules can be trapped.

2. Complexing Nanoparticles:

This category includes complexing nanoparticles, which attract the molecules by electrostatic charges.

3. Conjugating Nanoparticles:

These conjugating nanoparticles link to drugs through covalent bonds [4]

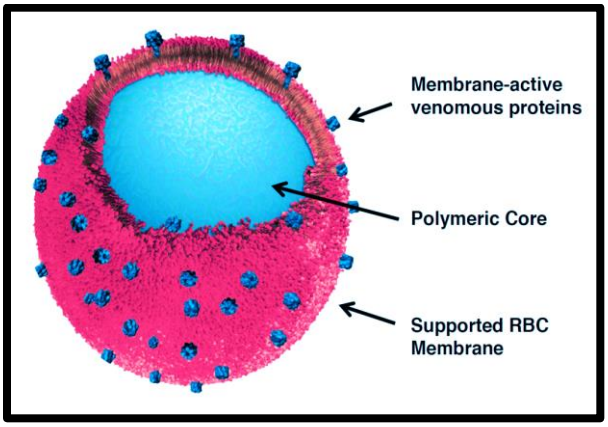

FIGURE 1 : 1 NANOSPONGE

Characteristics of Nanosponges: -

- The major function of nanosponges, which are porous particles with excellent aqueous solubility, is to encapsulate poorly soluble medicines.
- These Nanosponges may transport both hydrophilic and lipophilic medications.
- Nanosponges are compositions that can withstand temperatures of up to 130°C and a pH range of 1 to 11.
- Nanosponges do not cause irritation, are not mutagenic, allergenic, or poisonous.
- They guard the medication against physicochemical deterioration.
- Through the formation of inclusion and non-inclusion complexes, nanosponges can enclose different kinds of molecules.
- Then are able to purge water of its organic contaminants.[5]

APPLICATIONS:

1. Nanosponges for drug delivery:

Nanosponges are excellent for carrying medications that are not soluble in water due to their nanoporous nature (Biopharmaceutical Classification System class-II drugs). These complexes can be used to speed up the solubility, stability, and dissolution of medications, cover up disagreeable flavours, and solidify liquid substances.β-Cyclodextrin based nanosponges are reported to deliver the drug to the target site three to five times more effectively than direct injection.Nanosponges for drug delivery Because of their nanoporous structure, Nanosponges can be used to convey medications that are insoluble in water (Biopharmaceutical Classification System class-II drugs). These complexes can be used to hide disagreeable odours, turn liquid substances into solids,

and increase the pace, solubility, and stability of drug dissolution. Cyclodextrin-based nanosponges are said to be three to five times more effective at delivering the drug to the target site than direct injection [2].

By loading into the nanosponges, medications that are particularly important for formulation in terms of their solubility can be properly supplied. The following is a list of some BCS Class II drugs that could be developed into nanosponges. These solid-natured substances can be made into dosage forms for oral, parenteral, topical, or inhalation use. The complexes may be dissolved in a matrix of excipients, diluents, lubricants, and anti-caking agents appropriate for the manufacture of capsules or tablets [4] for oral delivery. The compound can simply be transported in sterile water, saline, or other aqueous solutions for parenteral delivery [4]. They can be usefully included into topical hydrogel for topical administration [5,6] The nanosponges employed in the formulation of various medications.

2. Nanosponges are used to deliver and release enzymes, proteins, vaccines, and antibodies as well as biocatalysts.

Operations are linked to numerous industrial processes including chemical change.drawbacks. Low yields are a result of non-specific reactions, and frequent operation at high pressures and temperatures necessitates the use of significant volumes of cooling water in the downstream process. These negative aspects can all be avoided or The use of enzymes as biocatalysts greatly diminished. These enzymes are highly selective, have fast response times, and function under mild reaction conditions. They have a positive impact on the environment since they use less energy and produce fewer pollutants. Enzyme catalytic activity is primarily dependent on the proper orientation of the site in use [7]. The biological and therapeutic fields can also make use of proteins, peptides, enzymes, and their derivatives. Enzymes for proteolysis can be employed.

3. Cancer Treatment:

Tumors can be treated with anticancer drugs using nanosponges as delivery vehicles. They assert that compared to administering the medications directly into the tumour, their method is three to five times more successful at slowing tumour growth. A targeting peptide that binds to radiation-induced cell surface receptors on the tumour is exposed by the tiny nanosponges, which are packed with a drug load. The sponges are prompted to release their cargo when they come into contact with tumour cells because they cling to the surface. Less adverse effects and more effective treatment at the same dose are two advantages of targeted medicine delivery. Paclitaxel was used as the sponge load in studies conducted to date on animals.

4. Enhanced solubility:

The nanosponge system's pores help poorly soluble medications become more soluble faster by trapping them inside the pores. Surface area and solubilization rate both greatly enhanced as a result of nano size. medicines in the BS class-2 that have poor bioavailability and low solubility. However, they exhibit improved solubilization efficiency and the desirable drug release characteristics when they are combined with Nanosponge.

5.Antiviral Applications:-

In the ocular, nasal, and pulmonary delivery routes, nanosponges may be helpful. To specifically target viruses that cause RTIs, such as respiratory syncytial virus, influenza virus, and rhinovirus, nanocarriers can be used to carry antiviral medications or small interfering RNA (siRNA) to the nasal epithelia and lungs. Additionally, they can be utilised for HBV, HSV, and HIV. The medications zidovudine, saquinavir, interferon, and acyclovir are currently used as nano delivery systems.

6. Encapsulation of gases: Cyclodextrin

Inclusion complexes of 1-methylcyclopropene, oxygen, and carbon dioxide were created using carbonate nanosponge. Numerous biomedical applications of complexing oxygen or carbon dioxide may be beneficial. The oxygen-filled Nanosponge in particular could provide oxygen to the hypoxic tissues that are prevalent in a variety of illnesses. The Nanosponge's potential as an efficient gas carrier has also been investigated due to its extremely porous nature.

7. Nanosponge in protein drug delivery:

Bovine serum albumin (BSA) protein is preserved in lyophilized form since it is unstable in solution form. The stability of proteins like BSA was improved by swellable poly(amidoamine) nanosponge based on cyclodextrin. Additionally, protein encapsulation and enzyme immobilisation with subsequent controlled distribution and stabilisation have been accomplished using nanosponges.

8. Topical agents:

A novel method for the controlled release of topical agents of prolonged drug release and retention of drug form on skin is the nanosponge delivery system. Among the classes of medications that are easily manufactured as topical nanosponges include local

anaesthetics, antifungals, and antibiotics. When active substances enter the skin, rashes or more severe adverse effects may develop. In contrast, this technique enables a steady and prolonged rate of release, minimising discomfort while preserving effectiveness. [10]

A designed product can have a wide range of ingredients, including gel, lotion, cream, ointment, liquid, and powder. Econazole nitrate, an antifungal that comes in cream, ointment, lotion, and solution, is applied topically to treat the symptoms of superficial candidiasis, dermatophytosis, versicolor, and skin infections. When econazole nitrate is applied to the skin, a small amount of adsorption occurs; therefore, a large concentration of active ingredients must be added for therapy to be effective. The emulsion solvent diffusion approach was used to create econazole nitrates Nanosponges, which were then placed in hydrogel to serve as a local depot for prolonged drug release. [8]

Loading of drug into nanosponges :-

To reach a mean particle size of less than 500 nm for drug delivery, nanosponges must be pretreated. Sonicate the nanosponges in water, and then centrifuge the suspension to separate the colloidal fraction and prevent the formation of aggregates. Dry the sample with freeze drying after separating the supernatant. The Nanosponge aqueous suspension should be prepared, any additional medication should be dispersed, and the suspension should be continuously agitated for the precise duration required for complexation. Centrifuge the complexed drug to separate it from the uncomplexed (undissolved) drug after complexation. then create the solid nanosponges crystals by solvent evaporation or freeze drying [11]. The crystal structure of the nanosponge has a significant impact on how it interacts with drugs. Compared to crystalline nanosponges, paracrystalline nanosponges were shown in a study.They have different loading capacities than nanosponges. Drug loading is higher in crystalline nanosponges than paracrystalline ones. Drug loading occurs mechanically in weakly crystalline nanosponges, as opposed to an inclusion complex.

Mechanism of drug release from NS:-

Up until equilibrium, the active atom is free to move into and out of the sponge atoms' open arrangement and into the vehicle. In the case of topical distribution, the active tissue is already in the vehicle and will be absorbed into it once the finished product is put to the target tissue. The equilibrium is upset by depleting the vehicle, which will become unsaturated. Starting from the sponge particle into the vehicle and then from there to the target tissue, this will cause a flow of the active ingredient until the vehicle is either dried out or absorbed. After then, the sponge particles that were left on the tissue's surface will still gradually release the active substance to it, giving it a sustained release over time [14].

Factors affecting drug loading and release from nanosponges:-

Drugs that are in a solution condition can still be put into the NS cavities. The influences on drug loading and release from NS are well known. The type and molar ratio of the cross-linker utilised, as well as the synthesis procedure, are the two crucial criteria that were examined. Using ultrasonography, loaded Camptothecin (CAM) in NS was synthesised in three distinct molar ratios, 1:2, 1:4 and 1:8 (-CD:cross-linker). They were discovered to be crystalline NS. The observed percentages of drug loading were 21% w/w, 37% w/w, and 13% w/w, respectively. A 10% w/w drug loading was provided by NS made using the traditional method of reflux heating, which resulted in paracrystalline NS. The largest drug loading and ideal level of cross-linking resulted in the greatest drug release at the 1:4 ratios. he 1:8 molar ratio, which caused low drug loading, was most likely brought on by inadequate NS network assembly as a result of the steric obstructions mentioned above. [10, 11]

CONCLUSION:

The medications can be incorporated into the nanosponges in either a lipophilic or hydrophilic form, and they will release at the target spot in a regulated and predictable way. The insoluble medications are made usable by nanosponges, which also shield the active molecules from physicochemical deterioration and regulated release. Nanosponges can be incorporated into gel, lotion, cream, ointment, liquid, powder, and tablet form for oral drug delivery due to their small size and spherical shape. They can also be used as parenteral, topical, aerosol, tablets, and capsules. This method allows for the loading of chemicals, which lowers side effects, increases elegance, increases stability, increases formulation flexibility, and speeds up the solubilization of medications that aren't very water soluble. An innovative technology for contemporary for drug delivery.

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