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Review on Nanosponges

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ABSTRACT:
The recent advance in nanotechnology has led to the development of targeted drug delivery system. However, targeting a molecule to a particular site using a drug delivery system effectively requires a specialized drug delivery system. The discovery of nanosponges has become a significant step in overcoming certain problems such as drug toxicity, poor bioavailability and release of drug in a predictable fashion as they can accommodate both hydrophilic and hydrophobic drug. Nanosponges exhibit a porous structure in nature which has the unique ability to entrap the drug moieties and offers a merit of desire release. These tiny sponges can circulate around the body until they encounter the specific target site and stick on the surface and begin to release the drug in a controlled and predictable manner. Nanosponges can be referred to as solid porous particles having a capacity to load drugs and other actives into their nanocavity; they can be formulated as oral, parenteral, topical or inhalation dosage forms. In this, advantages, disadvantages, composition, methodsofpreparation, factors, application of nanosponges, & evaluation parameter have been discussed.

KEYWORDS: Targeted drug delivery system, Nanosponges, hydrophilic and hydrophobic drugs, Nanocavity.

I. INTRODUCTION :

Targeting the delivery of medicine has long been a retardant for medical researchers - the way to get them to the correct place within the body and the way to regulate the discharge of the drug to forestall overdoses. To get the mean result, targeting drug delivery systems are associate degree ambition for a protracted amount. In the starting, the Nanosponge drug delivery system appeared solely as a topical delivery system, however, within the twenty-first century, Nanosponges may be administered orally further as an endovenous (IV) route [1]. Nanosponge could be a fashionable class of fabric and is created from little particles with a slender cavity of few nanometers. These slender cavities may be stuffed with numerous styles of substances. These little particles square measure having a capability thanks to that it's ready to carry each hydrophilic and oleophilic drug substance and might increase the steadiness of poorly soluble drug substance or molecules. [2]

The nanosponge is concerning the scale of a deadly disease with a 'backbone' (a scaffold structure) of naturally degradable polyester. The long-length polyester strands are mixed in answer with little molecules known as cross-linkers that have associate affinity certainly parts of the polyester. They 'cross link' segments of the polyester to create a spherical form that has several pockets (or cavities) wherever medication is held on. [2]

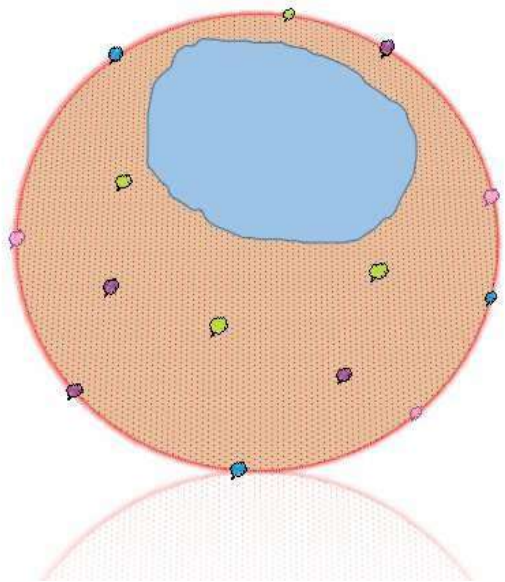

Fig. 1: Structure of a nanosponges showing a cavity for drug loading. [3]

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Advantages of Nanosponges:

- Improve the aqueous solubility of lipophilic drugs.
- Increase the aqueous solubility of the poorly water-soluble drug.
- Nanosponges drug delivery system minimizes side effects.
- To protect the molecules and to develop drug delivery systems for various administration routes.
- To mask the unpleasant taste.
- Reduce dosing frequency.
- Nanosponges can predictably release the drug molecules.
- Increase formulation stability and enhance the flexibility of the formulation.
- Better patient compliance.
- Nanosponges drug delivery systems are non-irritating and non-toxic.
- Nanosponges complexes are stable over a wide range of pH (i.e. 1- 11) and a temperature of 130 °C [4-6].

Disadvantages of Nanosponges: [7-8]

- They include only small molecule.
- They depend only upon the loading capacities.
- Dose dumping may occur at times
- Nanosponges have the capacity of encapsulating small molecules, not suitable for larger molecules.

Composition of Nanosponges :-

Polymer :-

The selection of chemical compounds will influence the formation together with the performance of Nano sponges. The cavity size should be appropriate to include the actual drug molecule. The chemical compound choice is predicated upon the specified unleash and drug to be enclosed. The chosen chemical compound ought to have the property to connect with specific ligands. [9]

Drug substance :

- Molecular weight between 100-400 Daltons.
- Drug molecule consists of less than five condensed ring
- Solubility in water is less than 10 mg/ml.
- Melting point of substance is below 250 °C. [9]

Cross linking agent: The cross-linking agent selection can be carried out depending on the structure of the polymer and the drug which is to be formulated.The different examples include Diphenyl carbonate, Dichloromethane,Diaryl carbonates, and Diisocyanates. [9]

Methods of preparation:

Emulsion solvent method :

The main polymers employed in this methodology are alkyl radical polyose and polyvinyl alcohol in variable proportions. The form is made by adding alkyl radical polyose and therefore the accessible drug that is dissolved in 20ml of methylene chloride. The dropwise addition of the continuous part is ready by dissolving polyvinyl alcohol in a hundred and fifty cubic centimeters of water. Then the mixture is allowed to stir for 1000rpm for concerning two hrs. The obtained Nano sponges are collected, filtered, and dried in kitchen appliances for around one day and hold on in desiccators. [10]

Solvent used method:

The on-top of the used compound will be used at the side of some appropriate polar aprotic solvent like Dimethylformamide, and dimethyl sulfoxide and blend proportionately. Then to the current mixture, cross-linkers offered area unit else with a quantitative relation of 4: sixteen. A temperature is maintained from 10°C for the reaction of polymers for two days. Most of the carbonyl cross-linkers (Dimethyl carbonate and Carbonyl diimidazole) area units were used. once the reaction is complete the merchandise is unbroken to chill at temperature, then add the mixture with water for sick and filtered below air kitchen appliance and purification is finished by Soxhlet equipment else with grain alcohol for any extraction. once more select drying below vacuum and fine automatically to urge an unvaried white powder. [11]

Ultra-sound assisted synthesis:

Polymers square measure created to react with crosslinkers in a very flask while not the solvent. The flask is placed in AN ultrasound tub that is crammed with water and heated and also the mixture is sonicated for five h. Then the mixture is cooled right down to temperature then the merchandise is broken into rough items. At last, the non-reacting chemical compound is removed by laundry the merchandise with water and processing is completed by victimisation Soxhlet equipment (ethanol) to get nanosponges. [12]

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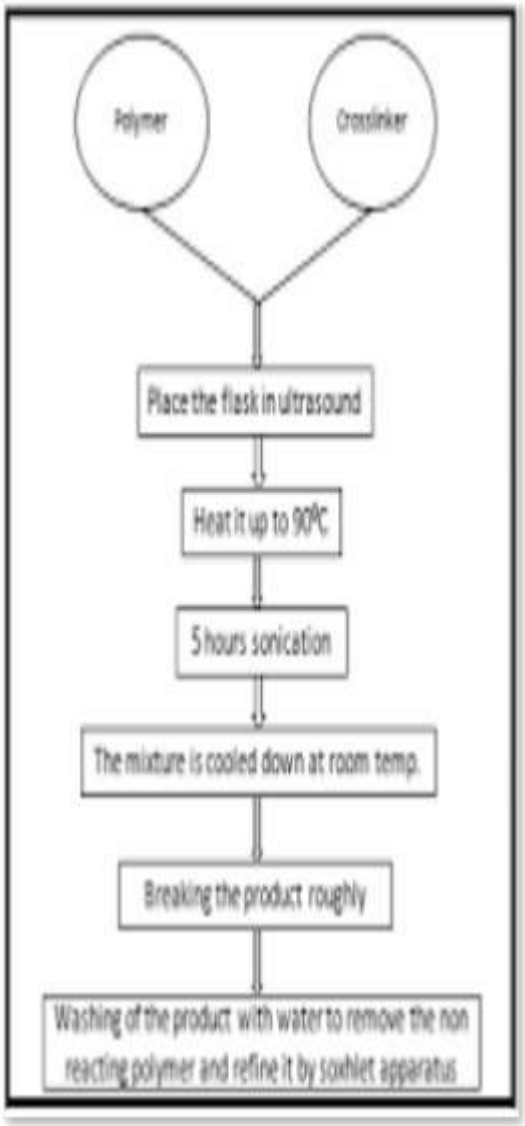

Fig.1 Flow diagram for the preparation of nanosponges by ultrasound-assisted method.

Loading of drug into nanosponges:

The nanosponges developed for the drug delivery 1st of all ought to be pretreated to get a mean particle size below 500nm. To obtain this variation, the nanosponges are dissolved or suspended in water. The suspended nanosponges are sonicated smartly to forestall the buildup. The suspension is centrifuged to supply a mixture fraction. The supernatant is separated and also the sample is dried employing a freeze appliance. Associate in a Nursing liquid suspension of nanosponges is ready.

This Solid Crystal structure of nanosponges has a crucial rule in complexation of the drug. The drug loading capacities of para crystalline nanosponges is lesser when compared to crystalline nanosponges. The drug loading takes place as a mechanical mixture in weakly crystalline Nanosponges. [13]

Factors influencing in the formulation of nanosponges :

Type of polymer :

The formation as well as the performance of nanosponge depends upon the selection of suitable polymer. The cavity or pore size of the nanosponge should be able to accommodate the drug molecule of suitable size. [14]

Type of drug :

- The molecular weight must be between 100 to 400 Daltons.
- The drug molecule structure should contain no more than five condensed rings.
- The solubility in water should be less than 10 mg/ml.
- The melting point should be less than 250 °C. [14]

Temperature:

Changes in the temperature can affect the complexation of drugs or nanosponges. Increasing the temperature generally decreases the extent of the stability constant of the drug or the nanosponge complex which may be due to the reduction of interaction forces such as hydrophobic forces and Van der Waal forces of drug/nanosponges with an increase in the temperature. [15]

Degree of substitution:

The number, position, and type of the substituent of the parent molecule can affect the ability of complexation of the nanosponges to a greater extent. [16]

Application of nanosponges:

Nanosponges as a sustained delivery system:

Acyclovir is one of the widely used antiviral agents for the treatment of herpes simplex virus infection. Its absorption in the GIT is slow and incomplete and highly variable. The in vitro release profile of the acyclovir from different types of Nano sponges showed sustained release of the drug. The percentage release of acyclovir from carb-nanosponges and nanosponges after the 3 h of administration was about 22% and 70%. The drug was not adsorbed on the nanosponges surface since no initial burst effect was not observed. [17, 18]

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Nanosponges for cancer therapy :

The most difficult work today within the pharmaceutical field is the delivery of malignant tumor drugs attributable to their low solubility. In one article they claim that nanosponges advanced is 3 times more practical to cut back the expansion of tumors than direct injection. The nanosponge's advanced load with a drug exposes a targeting amide that fastens tightly with a radiation-induced cell higher layer on the tumor receptor. [19]

Nanosponges as protective agent from light or degradation:

The Gamma–oryzanol can be encapsulated in the form of nanosponges which shows good protection from photodegradation. Gamma oryzanol is a ferulic acid mixture that is a natural antioxidant and is mainly used to stabilize food and pharmaceutical raw materials. Its application is limited because of its high instability and photodegradation. [20]

Nanosponges in drug delivery:

Nanosponges may be developed in totally different dose kinds like topical, parenteral, aerosol, pill, and capsules. Telmisartan (TEL) may be a drug with a dissolution rate restricted bioavailability. TEL was incorporated in nanosponges formulation. The saturation solubility and Vitro dissolution of β-CD complicated of TEL were compared with plain TEL and also the nanosponges complexes of TEL. the very best solubility and in vitro drug unleash were ascertained in inclusion complexes ready from nanosponges and NaHCO3. Paclitaxel is an associate degree antineoplastic drug with poor water solubility. β- CD-based mostly nanosponges square measure another to classical formulation in cremophor as a result of chromophore reduces the paclitaxel tissue penetration. [21]

Nanosponges as gas delivery system:

The deficiency of adequate chemical element offered named drive, is said to have numerous pathologies from inflammation to cancer. Cavalli et.al. developed a nanosponges formulation for chemical element delivery through a topical application. The safety of nanosponges was studied in Vero cells. [22]

Nanosponges as a carrier for biocatalyst:

Nanosponges act as a carrier for the delivery of enzymes, vaccines, proteins, and antibodies for diagnosing purposes. Proteins and different molecules are adsorbable and encapsulated in cyclodextrin nanosponges. [23]

Evaluation parameters of Nanosponges:

Solubility studies:

The most frequently used method includes the phase solubility method described by Higuchi and Connors which helps to determine the effects of nanosponges upon the solubility of the drug. The degree of complexation was indicated by the phase solubility diagram. [18]

Microscopic studies:

To study the microscopic aspects of a drug, a Nano sponge, or the product it can be subjected to Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). The difference in the crystallization state indicates the formation of inclusion complexes. [24]

Zeta potential :

Zeta potential is measured to find the surface charge. It can be measured by using additional electrode in particle size equipment. [23]

Thin layer chromatography (TLC) :

The RF values of the drug molecule diminish to considerable extend in thin layer chromatography and this helps in identifying the complex formation between the drug and nanosponge formulation. [25]

Infrared spectroscopy

The interaction between nanosponges and the drug in the solid state can be determined by using infrared spectroscopy. Nanosponges bands can slightly change during the formation of complexes. Few guest molecules attached in the complexes which are less than 25%, the drug spectrum can be easily masked by the spectrum of nanosponges. The technique is not appropriate to identify the inclusion complex over the other methods. [26]

Particle size and polydispersity:

Particle size is determined by the process of dynamic light scattering using 90Plus particle size determining software. Dynamic light scattering (DLS) is defined as a technique used to find out the size distribution profile of nanoparticles. At last, the final diameter of the particles and poly-dispersity index (PDI) can be found.

X-ray diffraction studies:

For the solid state, powder X-ray diffractometry can be used to determine the inclusion complexation. When the drug molecule is liquid and liquid has 0 diffraction pattern of its own

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the diffraction pattern of a newly formed substance differs from that of an uncomplexed nanosponges. This difference in the diffraction pattern indicates the complex formation. [27]

II. CONCLUSION

The nanosponges can include either lipophilic or hydrophilic drugs and release them in a controlled and predictable manner at the target site. Nanosponges can be incorporated into topical preparation such as lotions, creams, ointments, etc. and liquid or powder form. The advantage of this technology offers targeting the drug to a specific site reduces side effects, improves stability, and improves formulation flexibility and better patient compliance. Nanosponges offer the application in other areas such as cosmetics, biomedicine, bioremediation process, agrochemistry, catalysis, etc.

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