

Application of Nanosponges Drug Delivery System for the benefit of Pharmaceutical Area: A Mini-Review

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Abstract

As the name refers, Nanosponges are nano-sized particles that resemble red blood cells in appearance. Nanosponges are an advancement in nanotechnology and they are said to deliver the drugs at specific sites or targets. Having numerous pores in its structure they can trap a drug and control its release, it releases the drug when required. Nanosponges are mostly used to remove toxins from our bodies. They are polyester networks that look like a scaffold. In the 21st century, nanosponges not only can be used topically but also orally and intravenously. This review focuses on wide applications of Nanosponges for the benefit of mankind.

Keywords: Nanosponge, bioavailability, BCS, lipophilic, encapsulating.

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Received: 13 November 2020

Revised: 7 December 2020

Accepted: 11 December 2020

Published: 30 December 2020

Introduction

Nanosponges are a novel drug delivery system that is non-toxic, they produce less adverse effects to the body.^[1] In order to improve the bioavailability of poorly water-soluble drugs, these nanosponges tend to increase the water solubility of the drug moiety.^[2] They target the drugs at specific sites to prolong the release in a controlled manner. Nanosponges are a good carrier of both hydrophilic and lipophilic drugs within their pockets of few nanometre sizes. The cross-linking of polyesters generates a spherical structure with several cavities where the drug loading is favored. Several drugs having low solubility and high permeability like Lorazepam, Amiodarone, Warfarin, Terfenadine, Cyclosporin, Digoxin, Ritonavir, etc. can be introduced into nanosponges for target-specific actions. They are non-toxic, non-irritating, thermostable (up to 300°C) nanoparticles with several uses.^[3]

Advantages of Nanosponges^[1]

1. Wide routes of delivery
2. Increased water solubility of BCS class II drugs
3. Predictable release of drugs
4. Less side effects which promote better patient compliance
5. Easy removal of toxic substances from the body
6. Less dosing frequency

Disadvantages of Nanosponges^[1]

1. Not used for encapsulating molecules of bigger size
2. Though it is a novel approach but chances of dose dumping are there sometimes.

Applications

Nanosponges are a method of drug delivery that can carry hydrophilic as well as hydrophobic drugs. In the pharmaceutical industry, nanosponge technology has broad applications. Drugs produced by this technology ensure the safe and efficient release of the drug in a sustained and controlled way.

Application of nanosponge for treatment of Cancer:

Most antineoplastic agents are having poor solubility that brings great complications in the pharmacy field. Nanosponges are much effective in the reduction of the growth of the tumor. The nanosponges attack the surface of tumor cells and soon release the drug. As a result, the therapeutic effect is obtained fast and side effects are less.^[4]

As a target-specific drug delivery:

Nanosponges greatly increase the dissolution rate, stability as well as solubility of drugs with low solubility and high permeability. The nanosponges with cross-linked cyclodextrins are more effective in delivering drugs to the specific site. Solid nanosponges are used for the preparation of extravascular, intravenous, inhalational dosage form.^[5]

As an antifungal:

Severe fungal infections like athlete's foot, infections caused by ringworm, vaginal infections are largely treated by econazole. This antifungal drug is delivered in the form of 'hydrogel' that produces sustained release topical preparation.^[6,7]

Several antifungal drugs that belong to class II of the biopharmaceutical classification system increase their solubility and dissolution by cross-linked beta cyclodextrins of nanosponges. Example: Itraconazole.^[7]

As a Carrier of Protein drug delivery:

The loss of quaternary, tertiary and secondary native state structure of the protein and nucleic acid by external stress or compound as the strong base or acid is called denaturation of the protein. Nanosponges increase the stability of the native form of protein and sustain their action, for example serum albumin of bovine animals.^[8]

In the treatment of Rheumatoid Arthritis:

It has been identified that the use of nanosponges is one of the best treatment strategies to cure rheumatoid arthritis.

The nanosponges are said to cause neutralization of Rheumatoid Arthritis causing Proteins. They are coated with the nanoparticle of biodegradable polymer and the cell membrane is made up of a type of white blood cell namely neutrophil. When Rheumatoid Arthritis happens in the body, the cells which are in the affected area of the joints produce inflammatory mediators - cytokines. These mediators trigger neutrophils to enter the joints and they together cause inflammation. Nanosponges prevent this triggering of neutrophils by the cytokines and reduce the occurrence of inflammation.^[9] Nanosponges also reduce the occurrence of inflammation in mice having Rheumatoid Arthritis and protect the cells that are prone to get attacked by HIV and Zika Virus.^[10]

To treat skin lesions caused by Methicillin-Resistant Staphylococcus Aureus:

The 'nanosponge- hydrogel' - a gel-filled with nanosponges that can absorb toxins is said to be effective in treating skin lesions caused by MRSA (Methicillin-Resistant Staphylococcus Aureus). This hydrogel-based nanosponge reduces the growth of lesions caused by the said disease even without the application of antibiotics as a treatment.

It serves as an Oxygen Delivery System:

Nanosponge's structures are mostly made up of cyclodextrins, it is a very important oxygen delivery system. Combining Nanosponges and hydrogels is said to increase oxygen permeation. The slow release of Oxygen is regulated by these nanosponges. The tissues which are hypoxic that is there is a deficiency of Oxygen gets maximally benefitted due to this characteristic of nanosponges.^[10]

Ultra-purification of water in Power Plants:

The water used in power plants most of the time contains organic pollutants that are required to be removed. As we

all know Nanosponges are made up of beta cyclodextrins, they can remove the volatile components, the organic carbon present in the dissolved state for the ultra-purification of water.^[11]

Improve the aqueous solubility of water-insoluble drugs:

The cyclodextrin-based nanosponges are said to enhance the water solubility of those drug entities that shows less affinity toward the water. As a result, there is an improvement of both rates of dissolution and bioavailability of the drug.

Application as an Antiviral:

Nanosponges serve as a carrier for the delivery of several antiviral drugs through nasal route or pulmonary routes. It genuinely targets virus-like Influenza virus that is responsible for Respiratory tract infection.^[11]

Other Uses:

It can be largely used to remove toxic substances from the blood cells. Like normal sponges, they can soak the toxin and absorb it. Our body gets immensely benefitted by the nanosponges.^[12] The action of nanosponges against toxins can be well explained by its action against Escherichia coli and many other stronger bacteria.

Conclusion

Though the nanoparticles are much smaller in size than the Red Blood Cells, still a huge number of drug moieties can get trapped into it, but the size of the trapped moieties has to be small because they cannot trap molecules with bigger sizes. To immune the cells of our body it tries to detect the presence of toxins and remove it as early as possible. Considering the growth of medical science nanosponges are one of the leading discoveries under process, that is dragging the interest of many researchers for the last few decades. It is one of the best drug delivery systems that deliver most of the drugs at the desired site, offers minimum adverse effects, provides patient satisfaction. Nanosponges can be formulated as topical as well as intravenous preparation. They provide many other beneficial effects to mankind and their applications are widely increasing day by day. Apart from the mentioned applications hope there will be much more application of this Nanosponges that will be beneficial for both researchers and human being. These Nanosponges are definitely a boon to the drug delivery system.

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How to cite this article: Chakraborty M, Mukherjee S. Application of Nanosponges Drug Delivery System for the benefit of Pharmaceutical Area: A Mini-Review. *Adv Clin Med Res*. 2020; 1(1):12-14.

Source of Support: Nil, **Conflict of Interest:** None declared.