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Nanosponge Gel: A novel therapeutic approach for Rheumatoid Arthritis Treatment

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ABSTRACT

Nanotechnology and nanomedicines being vast research field offers solutions to many unresolved problems of drug delivery and therapeutics and is an expanding branch of science. Among the available nanoparticles based dosage forms, nanosponges (NS) vanquish the lead because it solubilizes poorly water soluble drugs and prolongs the release of drugs. Nanosponges are very tiny, nanoscopic, sponge-like particles, that consists of a number of cavities filled with medications. Nanosponges have gained attention due to its distinctive characteristics to improve medication delivery systems among the several alternatives. Rheumatoid Arthritis is an autoimmune disease and causes inflammation in the affected parts of the body. Nanosponge gel will be potentially useful for the treatment of Rheumatoid Arthritis. It ensures controlled and prolonged drug release and a good stability. The aqueous solubility of nanosponges allows them to be used efficiently for medications having low solubility. Nanosponges can also act as a vehicle for enzymes, proteins, vaccines and antibodies. The targeting of drug delivery systems by nanosponges is available as a topical administration. The porous shape of nanosponges gives a distinct capacity to entrap medicament and side by side provides the desired release rate. On topical administration it penetrates at the site of action and binds to the receptor site and release the drug in a desirable and predictable manner. The ingredients used, methods of preparation, its characterization, applications as drug delivery system in the field of nanotechnology world are presented in this paper

INTRODUCTION

Nanotechnology, the manipulation of matter on an atomic, molecular, and supramolecular scale, has emerged as revolutionary field with far- reaching implications for various industries, including medicine, energy, electronics, and materials science. The prefix "nano," derived from the Greek word for "dwarf," refers to the extremely small size of the materials and systems being engineered, typically ranging from 1 to 100 nanometers. At this scale, the physical, chemical, and biological properties of materials can be tailored to exhibit unique and improved characteristics, enabling the development of innovative products and applications. With its potential to transform various aspects of our lives, nanotechnology has become a rapidly growing field, with significant investments in research and development, and a wide range of applications already being explored and commercialized.

Nanosponges

Nanosponges are tiny, porous particles made of biocompatible materials, typically polymers or lipids. They have a sponge like structure with a large surface area, allowing them to absorb and hold large amounts of substances, such as drugs, proteins, or other molecules

Characteristics:

1. **Tiny size:** Nanosponges are typically between 100-1000 nm in sizes
2. **Porous structure:** They have a sponge- like structure with a large surface area.
3. **Biocompatibility:** Nanosponges are made of biocompatible materials, reducing toxicity and improving safety.
4. **High loading capacity:** Nanosponges can absorb and hold large amounts of substances.

Benefits:

1. **Improved efficacy:** Nanosponges can improve the efficacy of drugs and other substances.
2. **Reduced toxicity:** Nanosponges can reduce the toxicity of drugs and other substances
3. **Targeted delivery:** Nanosponges can deliver substances in a targeted and controlled manner.
4. **Biocompatibility:**Nanosponges are made of biocompatible materials, reducing the risk of adverse reactions.

Table no. 1: Advantages & disadvantages:

Sl no.	Advantages	Disadvantages
1.	Targeted and controlled release	Complexity of Formulation
2.	Improved Bioavailability	Scalability Issues
3.	Enhanced skin permeation	High Cost
4.	Reduced toxicity	Limited Understanding of Long- Term Effects
5.	Improved stability	Potential for Toxicity
6.	Easy to Administer	Instability in Certain Environments
7.	Biocompatibility	Difficulty in Characterizing Nanosponge Structure
8.	Scalability	Limited Control over Release Kinetics
9.	Flexibility	Potential for Immunogenicity
10.	Cost- Effective	Regulatory Challenges

Materials and Method of preparation

Drug, ethyl cellulose, polyvinylalcohol, dichloromethane, distilled water, carbopol934, methyl paraben, propyl paraben, propylene glycol are the ingredients used in the preparation of nanosponge gel. The different methods of preparation of nanosponges:

a. **Solvent evaporation method**: Nanosponges can be formulated using ethyl cellulose and polyvinylalcohol. Here, an organic solvent, dichloromethane was used to dissolve the dispersed phase ethyl cellulose and then it was thoroughly mixed with the polyvinylalcohol aqueous solution, which is the continuous aqueous phase. The reaction is then continued via magnetic stirring for 5 hrs. Then finally after filtration, the product was dried for 24 hrs at 40°C in an oven.

b. **Emulsion solvent evaporation method**: Mix the polymer with a suitable polar aprotic solvent such as dimethylformamide, dimethylsulfoxide. Then add this mixture to excess quantity of the cross-linker, preferably in crosslinker/polymer molar ratio of 4 to 16. Carry out the reaction at temperature ranging from 10° C to the reflux temperature of the solvent, for time ranging from 1 to 48hr. After completion of the reaction, allow the solution to cool at room temperature, then add the product to large excess of distilled water and recover the product by filtration under vacuum and subsequently purify by Soxhlet apparatus with ethanol. Dry the product under vacuum and grind in a mechanical mill to obtain homogeneous powder.

c. **Ultrasound- Assisted synthesis:** In this method nanosponges can be obtained by reacting polymers with cross-linkers in the absence of solvent and under sonication and the obtained nanosponges will be spherical and uniform in size. Mix the polymer and the cross-linker in a particular molar ratio in a flask and keep in an ultrasound bath filled with water and heat it to 90°C. Sonicate the mixture for 5hours. Then allow the mixture to cool and break the product roughly. Wash the product with water to remove the nonreacted polymer and subsequently purify by prolonged Soxhlet extraction with ethanol. Dry the obtained product under vacuum and store at 25° C until further use.

d. **Melt method:** The crosslinker and ß-cyclodextrins are fused when using the melting technique. The remaining fixings are finely homogenized and added to a 250 ml jar preheated to 100°C. The reaction is then carried out for 5 hours by magnetic mixing. The mixture is allowed to cool, after which the result is broken down and repeatedly washed well with suitable solvents like ethanol, to eliminate the excipients and byproducts that have not reacted completely.

Evaluation Parameters

1. **Particle size and distribution:** Nanosponge size and distribution can affect their stability, toxicity, and efficacy. Techniques like DLS (Dynamic Light Scattering) and SEM (Scanning Electron Microscopy) are used to evaluate particle size and distribution.
2. **Morphology:** The shape and structure of nanosponges can influence their interactions with cells and tissues. SEM and TEM (Transmission Electron Microscopy) are used to evaluate nanosaponge morphology.
3. **Surface Area and Pore Size:** This can impact their drug loading and release properties. Techniques like BET (Brunauer-Emmett-Teller) and BJH (Barett-Halenda) arev used to evaluate surface area and pore size.
4. **Drug Loading and Release:** Techniques like HPLC (High Performance Liquid Chromatography) and UV-Vis spectroscopy are used to evaluate drug loading and release.
5. **Stability and shelf-life:** Technique like zeta potential measurements are used to evaluate nanosponge stability.
6. ***In Vitro* and *In Vivo* efficacy:** Techniques like cell culture assays and animal studies are used to evaluate nanosponge efficacy.

   Overall, the evaluation parameters for nanosponges provide a comprehensive framework for assessing their quality, safety, and efficacy. By carefully evaluating these parameters, researchers and manufacturers can develop high- quality nanosponges that meet the required standards for therapeuticapplications.

Applications

1. **Drug delivery:** Nanosponges can be used to deliver drugs in a controlled and targeted manner.
2. **Cancer treatment:** Nanosponges can be used to deliver chemotherapy drugs directly to cancer cells.
3. **Wound Healing:** Nanosponges can be used to deliver growth factors and other molecules to promote wound healing.
4. **Cosmetics:** Nanosponges can be used in skincare products to deliver active ingredients and improve skin health.

CONCLUSION

Nanosponge gels have been found as the important drug delivery system in the field of pharmacy. It is one of the best conveyor in the localized delivery of drugs to the site of action. Nanosponge gels offers a favourable replacement to current treatments for Rheumatoid Arthritis. By adjusting the polymer to crosslinking ratio one can control the particle size and release rate. The nano-sized spheres entraps a wide range of chemicals before being mixed into a prepared product. The method of preparation of nanosponges helps in entrapping the substance, resulting in fewer side- effects, high stability and formulation flexibility. It improves the elegance. Nanosponges can be effectively incorporated into topical delivery systems for dosage form retention on skin; thereby improving patient compliance and provides site specific drug delivery system and prolongs dosage intervals.

Conflict of Interest

The authors declare no conflict of interest.

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