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# NANOSPONGES: A REVIEW ON NOVEL APPROACH

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## ABSTRACT:

Nanosponges, the tiny, porous structures, have emerged as a revolutionary technology with diverse applications in various fields ranging from medicine to environmental remedies. This review provides a comprehensive overview of nanosponges, detailing their synthesis, properties, and multifaceted applications. We searched the structure of nanosponges, their unique characteristics, and the mechanisms underlying their exceptional performance. Furthermore, we explore the current state-of-the-art research and future prospects of nanosponges, highlighting their potential to address complex challenges and ease the progress for innovative solutions.

**KEYWORDS**: Nanosponges, Targeted drug delivery system (TDDS), Hydrophilic and Lipophilic drug, cyclodextrin drug

## INTRODUCTION:

Tiny particles containing small cavities of few nanometres are known as Nanosponges. Nanosponges represent a fascinating class of nanomaterials characterized by their porous structure and ratio of area is to volume is very high. They have ability that carries hydrophilic and lipophilic drug particles. These are best to improve stability of water insoluble drug. These are polyester (i.e. biodegradable) network which can degrade naturally and break down in body slowly. Inspired by natural sponges, these synthetic counterparts exhibit remarkable properties that make them highly desirable for a myriad of applications. Nanosponges are stable at 300˚C and very strong as compared to micro sponges which are fragile and stable till 130 ˚C. They are non-toxic, insoluble in water as well as organic solvents, porous, free flowing, spherical which are cost effective, self-sterile. The ability to tailor their composition and structure at the nanoscale allows for precise control over their properties, enabling customization for specific purposes.

## SYNTHESIS OF NANOSPONGES:

The synthesis of nanosponges encompasses a variety of approaches, each tailored to produce structures with distinct properties and functionalities. Common methods include template-assisted synthesis, self-assembly techniques, and polymerization in the presence of pyrogens. Template-assisted synthesis involves the use of technique for creating porous structures in polymer membrane such as nanoparticles or micelles, around which the nanosponges material is deposited. Autonomous assembly methods leverage the spontaneous organization of molecules or nanoparticles into desired structures, while polymerization in the presence of pyrogens enables the formation of porous networks within polymers. These versatile synthesis methods allow for the creation of nanosponges with precise control over pore size, morphology, and surface chemistry.

## PROPERTIES OF NANOSPONGES:

Nanosponges possess a unique set of properties that distinguish them from other nanomaterials. Their ratio of area is to volume is very high, interconnected pore structure, and tunable porosity make them ideal candidates for various applications. The porous nature of nanosponges facilitates high loading capacities for guest molecules, such as drugs or environmental contaminants, while their large surface area enhances interactions with surrounding molecules. Additionally, nanosponges exhibit excellent stability, biocompatibility, and stimuli-responsive behavior, further expanding their utility in diverse fields.

## APPLICATIONS OF NANOSPONGES:

The versatility of nanosponges has led to their widespread adoption in a multitude of applications. In the biomedical field, nanosponges show promise for drug delivery, where they can encapsulate and deliver therapeutics with enhanced efficacy and reduced side effects. Furthermore, nanosponges have been explored for tissue engineering, biosensing, and wound healing applications. In environmental remediation, nanosponges are employed for the removal of pollutants from water and air, owing to their high adsorption capacities and selectivity. Moreover, nanosponges find applications in catalysis, energy storage, and antimicrobial coatings, showcasing their broad range of functionalities.

## METHODS FOR NANOSPONGES:

### 1. Template-Assisted Synthesis:

Template-assisted synthesis involves the use of sacrificial templates around which the nanosponges are deposited. These templates can be in the form of nanoparticles, micelles, or other colloidal structures. The nanosponges are then cross-linked or polymerized around the templates, which are subsequently removed to create pores within the nanosponges structure.

### 2. Emulsion Polymerization:

Emulsion polymerization is a technique used to prepare nanosponges by dispersing monomer droplets in an aqueous phase containing surfactants or stabilizers. Polymerization is then initiated to form a polymer network within the droplets, leading to the formation of nanosponges. The size and morphology of the nanosponges can be controlled by adjusting various parameters such as monomer concentration, surfactant type, and reaction conditions.

### 3. Solvent Evaporation:

Solvent evaporation methods involve the dissolution of polymer precursors in a volatile solvent followed by the controlled evaporation of the solvent to induce the formation of porous structures. Nanosponges prepared using solvent evaporation methods typically exhibit interconnected pores and high surface area. This method offers simplicity and versatility in terms of choice of polymers and solvents.

### 4. Supercritical Fluid Technology:

Supercritical fluid technology utilizes supercritical fluids, such as carbon dioxide, as solvents to prepare nanosponges. Under supercritical conditions, the solvent exhibits unique properties that enable efficient penetration into polymer matrices, leading to the formation of highly porous structures. This method offers precise control over pore size and morphology and is particularly suitable for the preparation of nanosponges with uniform pore distribution.

### 5. Electrospinning:

Electrospinning is a versatile technique used to prepare nanosponges in the form of nanofibers or nanofibrous mats. In this method, a polymer solution is electrostatically charged and extruded through a spinneret to form fine fibers. The fibers are then collected on a substrate to create a nanosponge scaffold with interconnected pores. Electrospinning offers excellent control over fiber morphology and pore structure and is widely used in tissue engineering and drug delivery applications.

### 6. Self-Assembly:

Self-assembly techniques involve the spontaneous organization of molecules or nanoparticles into desired structures, including nanosponges. By carefully selecting building blocks with complementary interactions, such as hydrogen bonding or hydrophobic interactions, nanosponges can be formed through self-assembly processes. This method offers simplicity and scalability and can be used to prepare nanosponges with tailored properties for various applications.

### 7. Microfluidics:

Microfluidics-based methods utilize microscale fluidic devices to control the mixing and reaction of precursor materials for nanosponge synthesis. By precisely controlling flow rates, concentrations, and reaction conditions within microchannels, nanosponges with uniform size and morphology can be produced. Microfluidics offers advantages such as high throughput, rapid mixing, and precise control over reaction parameters, making it suitable for the fabrication of nanosponges with specific properties.

## FUTURE PERSPECTIVES:

As research in nanosponges continues to advance, the future holds immense potential for further innovation and discovery. Emerging trends such as the development of smart nanosponges capable of responding to external stimuli, as well as the integration of nanosponges into hybrid materials for enhanced performance, are poised to drive the field forward. Moreover, the exploration of novel synthesis strategies and the investigation of biocompatible and sustainable materials for nanosponge fabrication present exciting avenues for exploration. By harnessing the unique properties of nanosponges, researchers can unlock new possibilities for addressing pressing challenges and shaping the future of science and technology.

## CONCLUSION:

In conclusion, nanosponges represent a remarkable achievement in the realm of nanotechnology, offering a wealth of opportunities for innovation and discovery. Their porous structure, tailored properties, and versatile applications make them invaluable assets across various fields. As our understanding of nanosponges continues to evolve, so too will their impact on society, driving progress and catalyzing advancements in science and technology. With ongoing research efforts and interdisciplinary collaborations, the potential of nanosponges to revolutionize diverse sectors remains boundless, heralding a new era of possibilities in the nanoscale world.

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