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Aquasome: Unlocking Novel Drug Delivery System

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ABSTRACT:
Aquasomes are a class of self-assembled nanoparticles with a three-layered structure: a solid nanocrystalline core, a polyhydroxy oligomeric film, and adsorbed bioactive molecules. This design offers advantages over conventional drug delivery systems, particularly in preserving the conformational integrity of delicate biomolecules like peptides, proteins, hormones, and genes. The carbohydrate coating acts as a shield against denaturation and dehydration, crucial for maintaining biological activity., Aquasomes enable targeted delivery and sustained drug release, potentially reducing administration frequency and enhancing therapeutic efficacy. They also improve the solubility of poorly soluble drugs. The core materials, often biodegradable, are generally well-tolerated in the body. This review summarizes the structure, properties, preparation methods, characterization techniques, and applications of Aquasomes in drug delivery.

KEYWORDS:
Aquasomes, Nanoparticles, Drug Delivery, Self-assembly, Carbohydrate Coating, Biocompatibility, Targeted Delivery, Sustained Release.

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I. INTRODUCTION

Aquasomes, a self-assembled nanoparticulate drug delivery system, were first developed by Nir Kossovsky in 1995. They are a novel delivery system for poorly water-soluble drugs, offering improved safety and effectiveness.

Aquasomes are characterized by a unique three-layered structure that enhances the solubility and delivery of poorly soluble drugs. This structure comprises:

- Ceramic core: Providing structural stability and a high degree of order.
- Carbohydrate coating: A polyhydroxy oligomer layer coating the core, which creates a hydrophilic environment and protects the bioactive molecules from dehydration. This coating can be applied through various methods like co-polymerization, diffusion, or adsorption.
- Drug loading: Pharmacologically active molecules are incorporated into the carbohydrate layer through adsorption or other methods.

The water-like properties and surface chemistry of aquasomes contribute to their ability to preserve the conformational integrity and biochemical stability of bioactive molecules, including drugs, antigens, and proteins. This makes them an excellent choice for delivering conformationally sensitive molecules like peptides and proteins. The carbohydrate layer, often composed of disaccharides like trehalose, plays a crucial role in preventing denaturation and preserving the molecule's structure in dry or dehydrated states.

Compared to other nanoparticles, aquasomes distinguish themselves by their conformation and water-absorbent nature. This unique characteristic facilitates aqueous transport and enables the formation of non-covalent links with various molecules and macromolecules. This enhanced stability, particularly when compared to liposomes, creates a favorable environment for proteins and helps to prevent their denaturation. Aquasomes deliver their cargo through a combination of specific targeting, molecular shielding, and a sustained release process, which helps to maintain the drug's therapeutic activity and potentially increase the solubility of poorly water-soluble compounds. Aquasomes also help to avoid clearance by the reticuloendothelial system or degradation by other environmental challenges due to their size and structural stability.

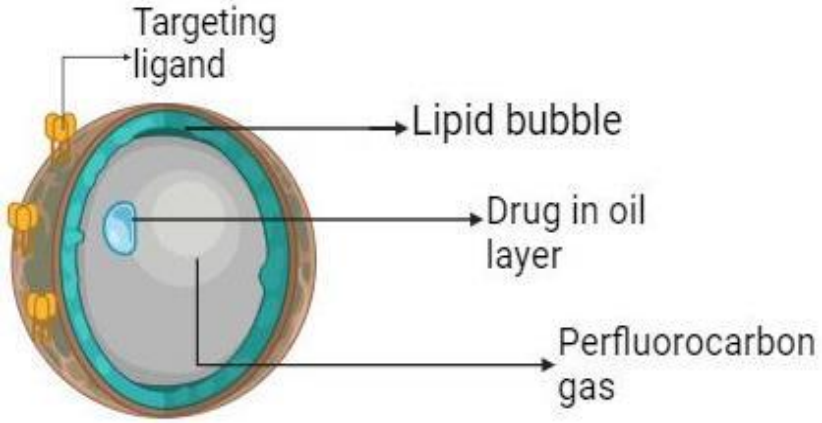

Fig No 1 : Structure of Aquasome

II. HISTORICAL DEVELOPMENT OF AQUASOME

Ancient Era:

In the Ancient era of medicine, in the "Charaka Samhita" one of the inorganic substances in the form of fine powder available, called Ayaskriti. The development of Bhasma is because of the variability in the size of particles. In ancient times, Bhasma (Ayurvedic) and kushtas (Unani) acted as nanoparticles, for their preparation, calcium salt or diamonds were used. Recently inorganic materials were utilized for preparing the core in aquasome. Some similarities found between aquasome and Bhasma such as nanometer size range, immune ability and low wettability.

Recent Era:

In the recent era, the nanostructured form of calcium phosphate and diamonds such as carbon are the most common materials used in synthesis of ceramic nanoparticles, which have a wide range of applicability, such as implantable devices, gene delivery, antimicrobial activity, and genomic and proteomics.The drug is adsorbed on the surface of ceramic nanoparticles and delivered the drug to the target in bone disorder. The surface functionalization of ceramic nanoparticles provides the delivery of genes and vaccines. Coating with carbohydrates shows good antibacterial properties.

Latest Era:

The aquasome represents this era. It has a center ceramic core coated with polyhydroxy oligomer on to which bioactive materials or drugs are adsorbed. The aquasome works as a carrier for drugs, peptides and proteins because it has a carbohydrate coating, which protects it from dehydration and gives stabilization.
A recently emerging type of self-assembled nanoparticle is Aquasome, which is potential candidate for drug delivery. According to Nir Kossovsky, aquasome came into existence in 1995.

IDEAL PROPERTIES

- ✓ Aquasomes, characterized by their water-like properties, serves as a cornerstone in maintaining the structural integrity and biochemical stability of bioactive compounds.
- ✓ These remarkable attributes not only provide a stable foundation but also play a pivotal role in safeguarding the conformational integrity and biochemical stability of the encapsulated bioactive substances.
- ✓ Their unique size and intricately designed structure enable aquasomes to evade clearance by the reticuloendothelial system.
- ✓ It shields against degradation induced by environmental stresses.
- ✓ Functioning as a nanoparticle-based drug delivery system, aquasomes comprises of colloidal range biodegradable particles that exhibit enhanced accumulation in vital organs such as the liver and muscles.
- ✓ The nanoparticles possess an innate ability to attract and adhere drugs onto their surface without necessitating additional modifications.
- ✓ This inherent property facilitates smooth receptor recognition at the active site, thereby ensuring prompt pharmacological or biological activity upon delivery.
- ✓ Aquasome as a nano carrier system, it protects the drug, antigen, protein in pH condition and require low dose of drug.
- ✓ They have water-like properties preserving the bioactive molecules.

✓ Aquasome deliver contents through combination of specific targeting molecules in sustained release system.
✓ It has maintained pharmacological activity and preserve the molecule in dry solid state.
✓ Aquasome have a large size and larger active surface area, which provides loading enough active molecules.
✓ It does not require any further surface modification.
✓ They show their colloidal properties after dispersing in water.

ADVANTAGES

Aquasomes are specialized colloidal drug delivery systems with unique properties that offer several advantages in various applications. Some of the advantages of aquasomes are:

- **Encapsulation efficiency**

Aquasomes exhibit high encapsulation efficiency, allowing for the encapsulation of a variety of drugs, peptides, or bioactive molecules.

- **Improved bioavailability**

Aquasomes can enhance the bioavailability of poorly water-soluble drugs by improving their solubility and dissolution rate.

- **Targeted delivery**

Aquasomes can be designed for targeted drug delivery, ensuring the release of the encapsulated substance at a specific site or within a particular cell type.

- **Stability**

Aquasomes provide stability to labile drugs, proteins, or peptides, protecting them from degradation due to environmental factors or enzymatic activity.

- **Biocompatibility**

Aquasomes are often biocompatible and well-tolerated, making them suitable for biomedical applications.

- **Controlled release**

Aquasomes allow for controlled and sustained release of the encapsulated substance over time, providing a prolonged therapeutic effect.

- **Versatility**

Aquasomes can be modified for various applications, including drug delivery, cosmetics, and food industries, making them versatile carriers for different types of formulations.
Aquasomes demonstrate remarkable versatility in encapsulating a wide range of drug molecules, including hydrophobic drugs, proteins, peptides, and nucleic acids. This adaptability opens up new possibilities for delivering various therapeutics, revolutionizing treatments in diverse medical fields.

- **Reduced toxicity**

The use of aquasomes can help to reduce the toxicity associated with certain drugs by controlling their release and distribution in the body.

- **Ease of formulation**

Aquasomes can be easily formulated into different dosage forms, such as powders, capsules, or creams, providing flexibility in product development.

- **Enhanced stability of active ingredients**

Aquasomes can protect active ingredients from degradation, oxidation, or other chemical changes, enhancing the stability of the encapsulated substances.

- **Biodegradability**

Some formulations of aquasomes are designed to be biodegradable, minimizing their impact on the environment. The specific advantages of aquasomes may vary depending on the formulation, intended application, and the nature of the encapsulated substance.

Disadvantages of Aquasomes

- As per the method of preparation, its synthesis is a time-consuming process.
- For the drug loading into aquasome, it should be necessary to maintain the drug concentration, or else it gives a false result of drug loading.
- It exhibits poor absorption, as this may lead to an undesirable burst release in the body, posing potential toxicity.
- It causes leaching and aggregation on long-term storage.
- They are expensive.
- Their transfer efficiency is low

APPLICATIONS

Some of the applications of aquasome are:

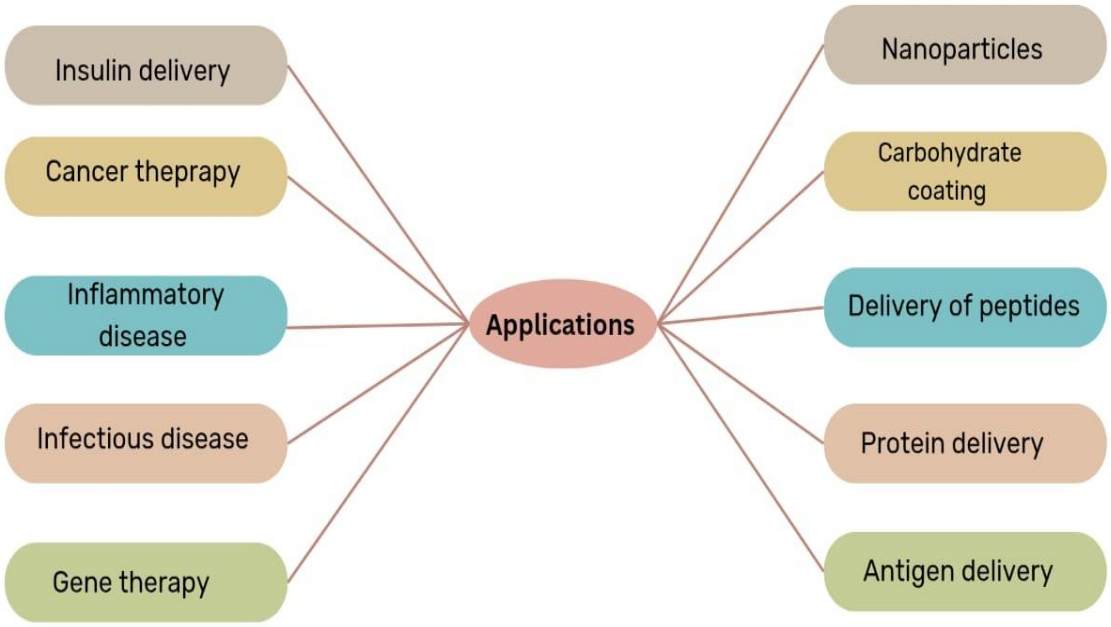

Fig No: 1.2 Applications of Aquasome

✓ **Nanoparticles**

Aquasomes can effectively encapsulate a wide range of substances through mechanisms such as ionic interactions, non-covalent bonds, van der Waals forces, and entropic effects. In the reaction process aided by sonication, nanocrystalline calcium phosphate ceramic core particles undergo self-assembly due to an elevation in surface-free energy.

This core material is commonly composed of calcium phosphate (CaHPO4). The nanocrystalline core particles made of calcium phosphate ceramic naturally come together and arrange themselves during the reaction process when exposed to sonication, primarily because the increased surface free energy promotes this self-assembly phenomenon.

✓ **Carbohydrate coating**

Aquasomes uphold the structural integrity of biochemically active compounds with the help of the assistance of ionic, non-covalent, and entropic forces. The ceramic core stability is ensured by a polysaccharide film. The water-like characteristics of aquasomes offer a foundation for maintaining the conformational integrity and biochemical stability of bioactive substances.

Carbohydrate is introduced into a core dispersion, and subsequent steps involve sonication, followed by lyophilization. The coating can also be achieved through adsorption via direct incubation or by adding a non-solvent.

✓ **Delivery of peptides**

The complexity inherent in the biochemical and structural makeup of protein and peptide-based pharmaceuticals poses significant challenges in formulating effective delivery strategies, setting them apart from conventional drugs.

✓ **Protein Delivery**

Protein delivery is essential to maintain the interaction with water for conformational stability and biological activity. At the active site, the water molecules affect the interaction between the substrate and proteins, which alters their mechanism of substrate binding and enzymatic activity.

✓ **Antigen Delivery**

Various adjuvants are available for the delivery of antigens to enhance antigen immunity. The aquasome can shield the functional group of antigens or change the conformation of the antigen.

✓ **Insulin delivery**

The core is prepared through the sonication technique by increasing the surface free energy of the core material and various types of disaccharides used like trehalose, pyridoxal-5-phosphate and cellobiose as covering materials which covered onto the core through different bonds and helps in adsorption of the drug to the aquasome. Once the core is prepared, then application of the disaccharide blend which covers the surface with a uniform layer.

Followed by drug introduction into the coated particles. Employing an adsorption method, the drug molecules are carefully absorbed onto the surface of the coated core material.

✓ **Cancer Therapy**

Aquasomes hold immense potential in targeted drug delivery for cancer treatment by modifying Aquasomes with specific antibodies or peptides, they can be designed to recognize and bind to tumor-specific antigens.

This promises targeting approach allows Aquasomes to selectively deliver anticancer drugs to tumor cells, minimizing damage to healthy tissues.

✓ **Inflammatory diseases**

Aquasomes can be modified to target inflamed tissues in conditions such as rheumatoid arthritis, inflammatory bowel disease, and atherosclerosis.

Targeted delivery of anti-inflammatory agents to these sites can help reduce inflammation and alleviate symptoms while reducing systemic side effects

✓ **Infectious diseases**

Targeted drug delivery with Aquasomes can be employed in combating infectious diseases by attaching ligands specific to pathogenic agents or infected cells.

Aquasomes can selectively deliver antimicrobial agents or antiviral drugs to the affected areas and enhance treatment efficacy.

✓ **Gene Delivery**

Aquasome can effectively target intracellular gene delivery. Some research findings describe the capabilities of aquasome for effective gene delivery. Gene delivery through aquasome has five layers, a ceramic central core, a film of polyhydroxy oligomeric layer, part of an applied gene, carbohydrate coating and protein of viral membrane that works as a layer of targeting. This shows that the aquasome preserves and ensures the genes. The aquasome has the potential for targeting or delivering genes or viral vectors.

III. COMPOSITION OF AQUASOME

The central core part of aquasome:

Aquasomes, revered for their remarkable systematic organization and consistency, embody a fusion of essential elements such as diamond flakes, brushite (calcium phosphate), and tin oxide.

These elements collectively epitomize qualities of being easily manufacture, cost-effective, biodegradable, and biocompatible, making aquasomes a coveted choice in the realm of ceramic materials. The inherent order and higher surface energy of aquasomes play a pivotal role in facilitating the effective binding of carbohydrates, as elucidated by research.

This characteristic not only shows its functional efficacy but also highlights its suitability for diverse applications, particularly in the formulation of aquasomes. In the formulation process, polymers emerge as indispensable components, with options like albumin, gelatin, or acrylate being commonly employed.

These polymers not only contribute to the structural integrity of aquasomes but also enhance their functional properties, further expanding their potential applications and utility in various domains.

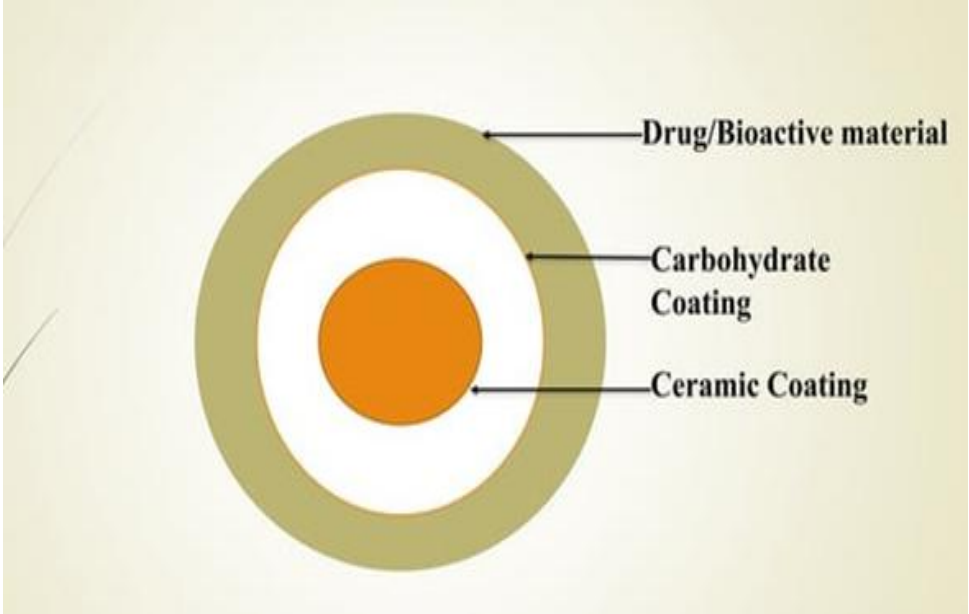

Fig No: 2.1 Composition of Aquasome

Coating material

Cellobiose, a key player in the intricate world of polysaccharides. It emerges from the partial degradation of cellulose, a structural component abundant in plant cell walls. This process involves the linkage of glucopyranosyl units, culminating in the formation of cellobiose-a disaccharide pivotal not only in biological processes but also in pharmaceutical applications.

Its role as a protective agent for drug molecules against dehydration aligns with that of trehalose, another notable disaccharide composed of alpha-D-glucopyranosyl units. Trehalose, renowned for its prowess in stress resilience across diverse organisms, surpasses cellobiose in effectiveness, marking it as a superior choice for pharmaceutical formulations requiring stability under desiccation stress.

The versatility of trehalose extends across various kingdoms of life, demonstrating its efficacy in preserving cell integrity and functionality in fungi, bacteria, insects, yeast, and specific plant species. Particularly during desiccation, trehalose assumes a pivotal role in maintaining cellular structures, safeguarding natural attributes such as taste, color, and texture by preserving essential biomolecules like proteins and membranes.

The significance of disaccharides like sucrose and trehalose lies in their ability to interact with polar protein residues, effectively replacing water molecules and ensuring the structural integrity of biological components even in the absence of aqueous environments. This phenomenon is crucial in lyophilization.

Experimental evidence, notably from studies involving calcium-carrying microsomes extracted from rabbit and lobster muscles, underscores the protective role of sugars like trehalose. Findings reveal that trehalose supplementation preserves the shape and function of biological components post lyophilization, as evidenced by maintained calcium absorption and ATPase activity. The coating mechanism serves to enhance stability and prolong the shelf-life of pharmaceutical products, ensuring their efficacy and safety.

Bioactive molecules

Pharmaceuticals that disrupt the film through non-covalent and ionic interactions have demonstrated considerable promise as potential options for aquasomes.

FORMULATION TECHNIQUES OF AQUASOMES

The overall technique is the production of an inorganic core, which is then covered with Lactose to generate a polyhydroxylated core, which is then loaded with model medication. The aquasomes are made in three steps:

1. PREPARATION OF THE CORE
2. COATING OF THE CORE
3. IMMOBILISATION OF THE DRUG MOLECULE

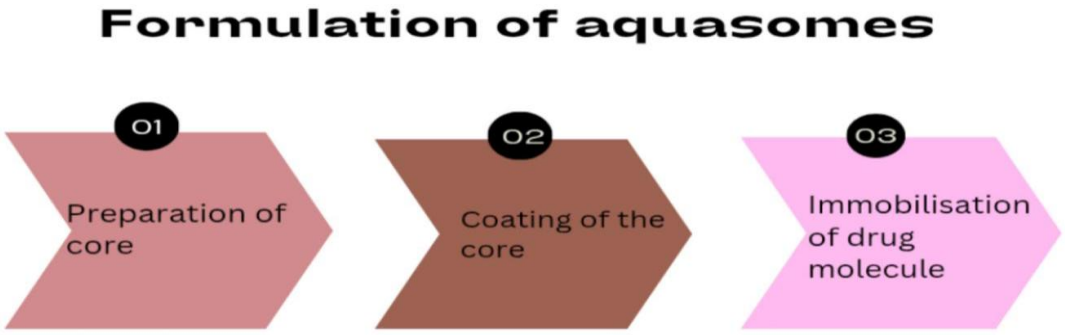

Fig No: 2.2 Formulation of Aquasome

- **Preparation of the Core:**

The manufacturing of the ceramic core is the initial stage in aquasome preparation. The method for preparing ceramic cores is determined by the materials used for the core. Colloidal precipitation and sonication reversed magnetron sputtering, plasma condensation, and other methods can be utilized to make these ceramic cores. Ceramic materials were commonly chosen for the core since they are the most structurally regular materials known. The great degree of order in ceramics assures that any surface alteration will have only a limited influence on the nature of the atoms underneath the surface layer, preserving the bulk

qualities of the ceramic.The elevated degree of order guarantees that the surfaces have a high amount of surface energy, which facilitates the binding of polyhydroxy oligomeric surface films. Diamond and calcium phosphate are the most often utilized ceramic cores.

- **Carbohydrate coating:**

The second stage includes covering the surface of ceramic cores with carbohydrates. The carbohydrate covering adsorbs epitaxial on the surface of the nanocrystalline ceramic cores by some processes. To induce the mostly irreversible adsorption of carbohydrates onto the ceramic surfaces, the techniques typically include adding polyhydroxy oligomer to a dispersion of painstakingly cleaned ceramics in ultra-pure water, sonication, and then lyophilization. Stir cell ultra-filtration removes excess and quickly desorbing carbohydrates. Cellobiose, citrate, pyridoxal-5-phosphate, sucrose, and trehalose are popular coating ingredients.

- **Immobilization of Drugs:**

Surface-modified nano-crystalline cores serve as the solid phase for nondenaturing self-assembly of a wide spectrum of biochemically active molecules. incomplete adsorption can be used to load the medication.

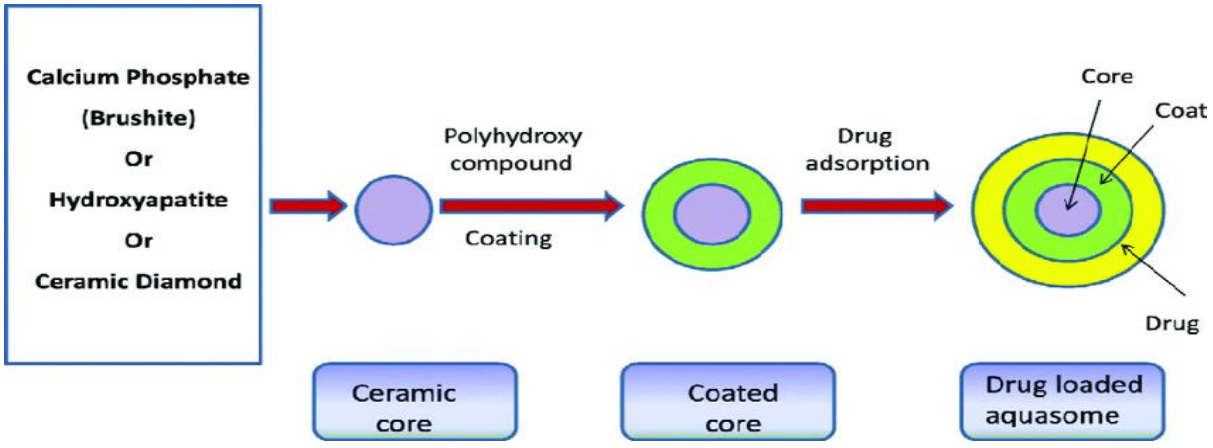

Fig No:2.3 Synthesis of Aquasome

THE ROUTE OF ADMINISTRATION OF AQUASOME

Various routes are used to deliver an aquasome to work as a carrier such as topical route, parenteral route, oral route.

❖ **Topical Route**

Aquasome are self-assembled three-layered nanoparticles which act as bodies of water. Their stable conformation and water-absorbent properties permits the aquasome to cross the aqueous layer of the skin and bind with molecules present in the skin as well as improve the permeability of bioactive substances.

❖ **Parenteral Route**

It is the easiest route which provides higher bioavailability with reduced side effects. An Aquasome with a small particle size of less than 1000 nm is applicable for parenteral delivery because this size of aquasome prevents the obstruction to blood capillaries. Various proteins and peptides are delivered through aquasome via this route.

❖ **Oral Route**

Measurement of drug loading and release. The oral route is the most common, easy and conventional route for delivering various therapeutic molecules. Unique structure of aquasome offers hydrophilic properties along with the facility of non-covalent linking of numerous molecules and prevents them from denaturation. It has been reported that enzymes serratiopeptidase and bromelain are delivered through aquasome via the oral route

EQUIPMENTS USED IN THE SYNTHESIS

Equipment's used in the synthesis of aquasomes are as follows:

Equipment for Coating

❖ Stirred Cell Ultrafiltration:

It is a laboratory-scale membrane filtration technique used primarily for the concentration, purification, and desalting of macromolecules (like proteins, nucleic acids, or nanoparticles
from solution. It is used to remove excess and desorbing carbohydrates quickly during the coating process.

Fig No: 2.4 Stirred Cell Ultrafiltration

❖ Lyophilizer (Freeze Dryer):

A lyophilizer, also known as a **freeze dryer**, is a device used to perform **lyophilization** (freeze drying) a dehydration process. It is used for drying the coated nanoparticles after the carbohydrate coating process.

Fig No; 2.5 Lyophilizer

Reaction Vessels:

❖ General Flasks and Beakers:

Standard laboratory glassware like flasks and beakers are used for preparing solutions and carrying out reactions like precipitation.

❖ Sonication Bath:

Used for dispersing and reducing particle size during core synthesis.

Fig No: 2.6 Sonication Bath

❖ Centrifuge:

Employed to separate and purify the core material after synthesis.

Fig No: 2.7 Centrifuge

Specialized Reactors:
For techniques like magnetron sputtering, specialized reactors are used to control the sputtering process and deposition of the core material

Instruments
Aquasome synthesis utilizes various instruments for core material characterization, coating, and drug loading. Key equipment's are,
• Transmission Electron Microscope (TEM)
• Scanning Electron Microscope (SEM)
• X-ray Diffraction (XRD)
• Fourier Transform Infrared (FTIR)
• Zeta Sizer
• **Transmission Electron microscope (TEM)**
It is crucial for characterizing aquasomes, particularly for assessing their size, morphology, and internal structure. TEM with negative staining can reveal internal details of the aquasome structure, including the arrangement of the ceramic core, carbohydrate coating, and drug molecules.

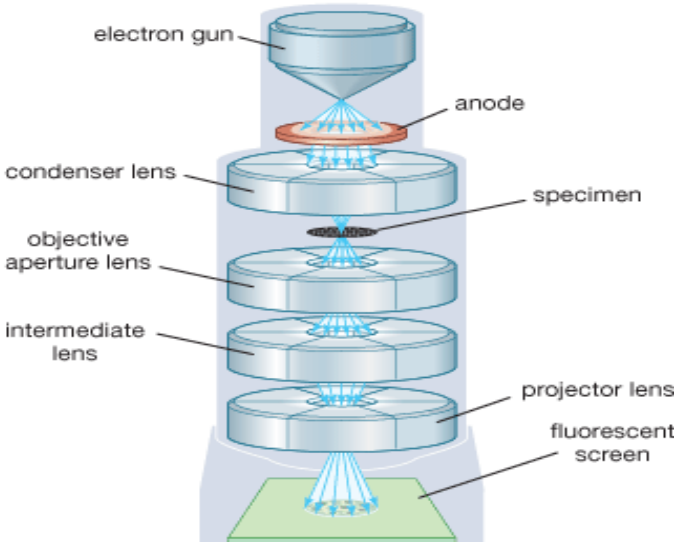

Fig No 2.8 Transmission Electron Microscopy

• **Scanning electron microscope (SEM)**
This is also having the same properties of TEM.
Also helps in accessing size, morphology, and internal structure, particle size etc.

• **X-ray Diffraction (XRD)**
Employed to analyze the crystallinity and phase composition of the core material.
X-ray diffraction patterns reveal whether the aquasome's core is crystalline or amorphous. Crystalline materials produce sharp, well-defined peaks in the diffractogram, while amorphous materials exhibit broader, less defined peaks.

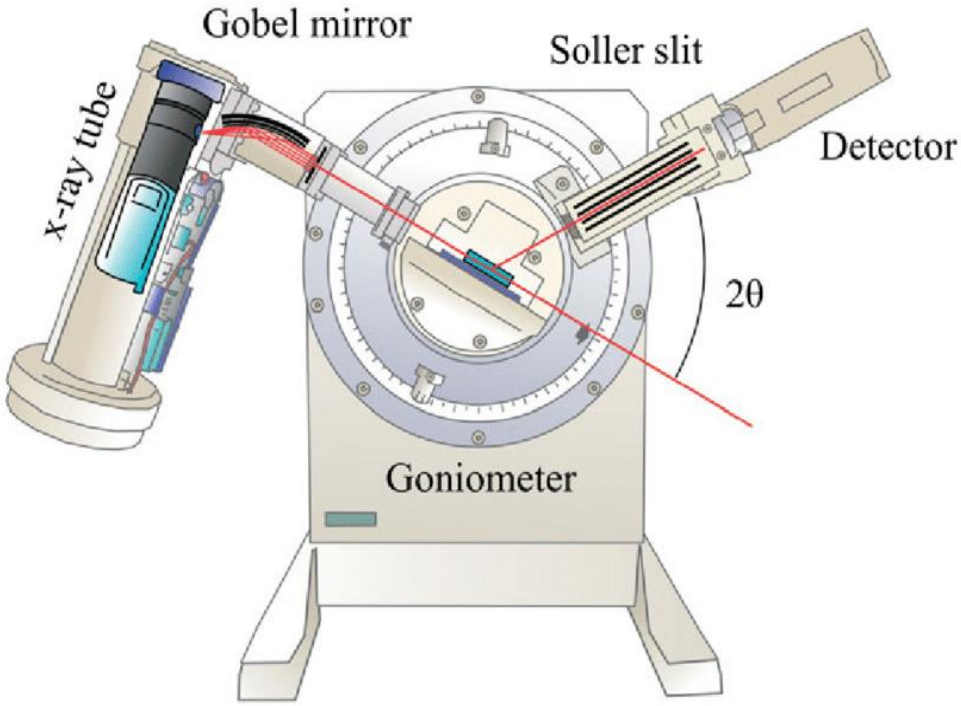

Fig No 2.9 X-ray Diffraction

• **Fourier Transform Infrared Spectroscopy (FTIR)**:
Used to analyze the chemical structure of the coating material.

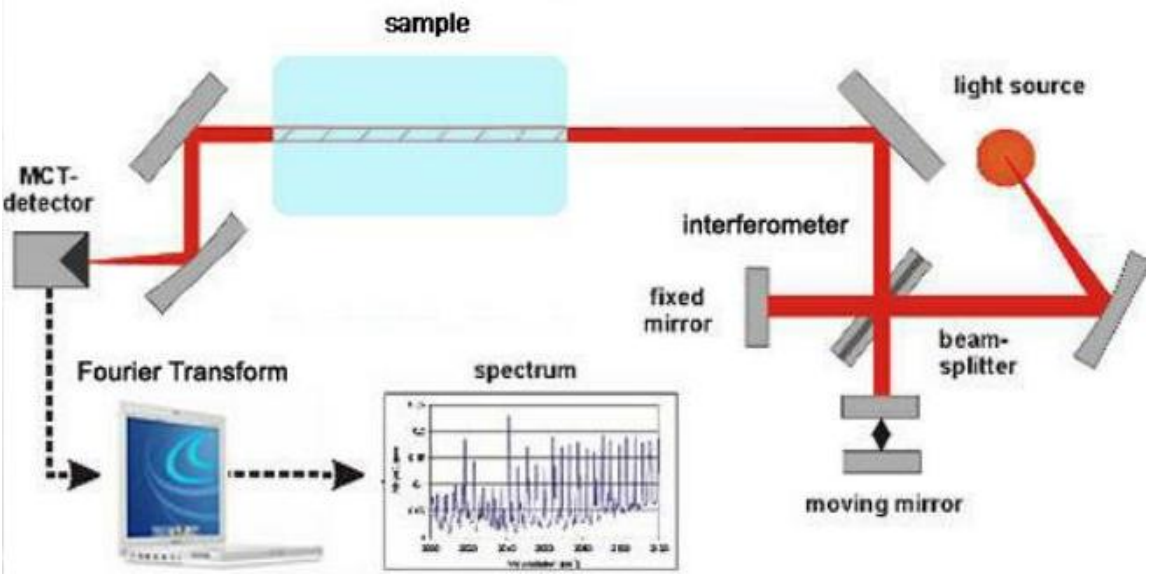

Fig No: 2.10 Fourier Transform Infrared Spectroscopy

• **Zeta Sizer**
Used to determine the zeta potential, which indicates the stability of the aquasomes.

Fig No:2.11 Zeta Sizer

EVALUATION OF AQUASOMES

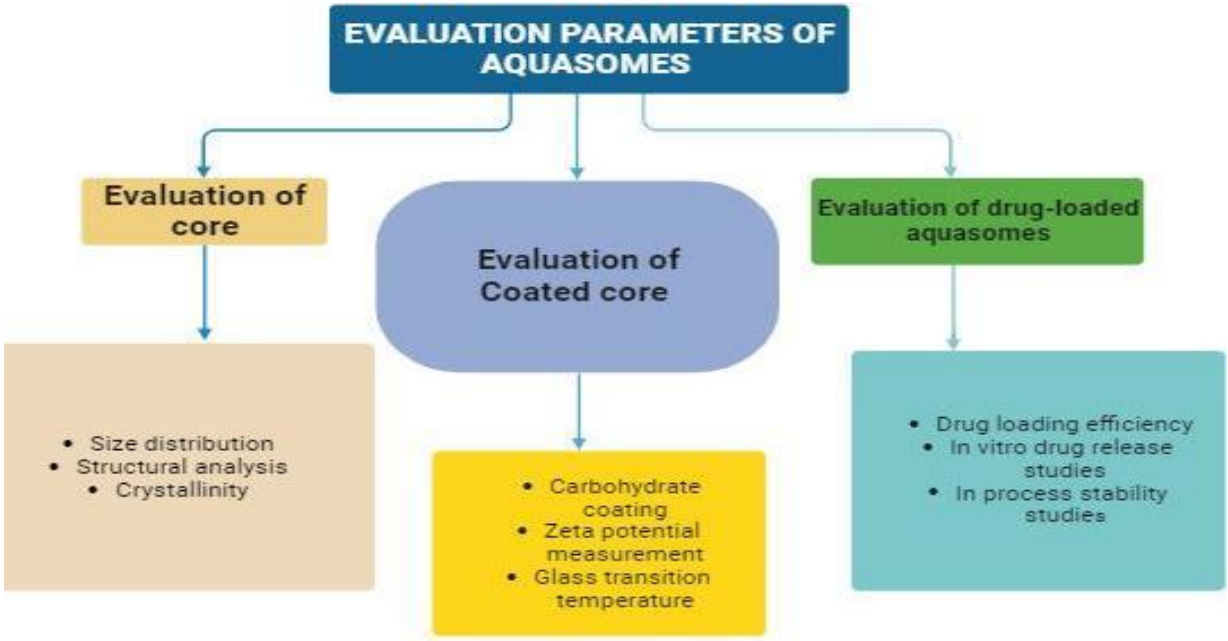

Fig No: 3.1 Evaluation parameters of Aquasomes

Evaluation of core

Size distribution:

The morphological examination of prepared systems is performed using a transmission electron microscope following the negative staining of phosphotungstic acid solution. The mean particle size and size distribution are determined by a photon correlation spectroscopy using a Automizer II C apparatus and SEM. Aquasomes are mainly characterized for structural analyses, particle size, and morphology.

The chemical composition and the crystalline structure of all samples were obtained through X-ray powder diffractometry.

Evaluation of Coated core

The coated core plays a vital role in maintaining the structural integrity of aquasomes and in facilitating effective drug adsorption. The evaluation of the coated core focuses on analyzing the uniformity, chemical characteristics, surface properties, and compatibility with the bioactive molecule.

Below are the key parameters and methods used in its evaluation:

❖ Carbohydrate coating:

Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) are used to visually examine the surface of the coated core.These methods help determine the uniformity, smoothness, and thickness of the coating layer. Proper coating ensures a stable surface for adsorption of the bioactive molecule and prevents core degradation.

❖ Zeta Potential:

Zeta potential is also measured to determine the surface charge, which affects colloidal stability and drug-binding efficiency. A sufficient zeta potential (positive or negative) is necessary to prevent aggregation and ensure dispersion in biological fluids.

❖ Glass transition temperature:

Differential Scanning Calorimetry (DSC) studies have been widely used to study glass transition temperature of carbohydrates and proteins. Asian Journal of Pharmaceutics - April-June 2012 99 Narang: Aquasomes glass to rubber state can be measured using a DSC analyser as a change in temperature upon melting of glass.

In-process stability studies using sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) can be performed to determine the stability and the integrity of protein during the formulation of the aquasomes. (Heparin coated nanoparticles coupled with haemoglobin)

Evaluation of drug-loaded Aquasome

❖ In vitro drug release studies:

The in vitro release kinetics of the loaded drug is determined to study the release pattern of drug from the aquasomes by incubating a known quantity of drug loaded aquasomes in a buffer of suitable pH at 37°C with continuous stirring. Samples are withdrawn periodically and centrifuged at high speed for certain lengths of time. Equal volumes of medium must be replaced after each withdrawal. The supernatants are then analysed for the amount of drug released by any suitable method.

❖ Drug loading efficiency:

This test is done to ensure the amount of drug which is bound on the surface of aquasomes. Spectrophotometric analysis of hydrophobic drugs like indomethacin and piroxicam are done by using 0.1 N methanolic hydrochloric acid solutions.

❖ In process stability studies

In process stability studies is crucial to ensure the quality and efficacy of aquasomes. It evaluates

✓ Vesicle Size and Distribution: Monitoring changes in vesicle size and distribution during processing and storage.

✓ Entrapment Efficiency: Evaluating the retention of the active ingredient within the aquasome vesicles.

✓ Zeta Potential: Assessing the electrostatic charge on the surface of aquasome vesicles.

✓ Physical Stability: Evaluating the physical stability of aquasomes, including aggregation, sedimentation, or leakage.

The methods used are,

✓ Dynamic Light Scattering (DLS): Measuring vesicle size and distribution.

✓ High-Performance Liquid Chromatography (HPLC): Determining entrapment efficiency and drug content.

✓ Zeta Potential Analyzer: Measuring zeta potential.

✓ Microscopy: Visualizing aquasome morphology and aggregation.

Other Evaluation parameters

❖ The Hb loading capacity:

It is estimated by the difference between the control sample (HbA solution) and the free haemoglobin contained in all fractions without nanoparticles. The spectrophotometric measurements of haemoglobin are done according to Drabkin's method.

❖ The antigen-loading efficiency for the aquasomes:

The formulation's loading efficiency can be determined as reported in literature. Accurately weight antigen-loaded aquasome formulations were suspended in Triton X-100 and incubated in a wrist shaker for 1 h. Then, samples are centrifuged at and absorbance is determined using Micro BCA methods with set a blank of unloaded aquasomes formulation. Antigen loading is expressed as per unit weight of aquasomes particles (g of antigen/mg of sample).

❖ Effect of cellobiose and trehalose on antigen:

DSC analysis of aquasome formulations is done by DSC analyser having a sample cell (containing formulation) and a reference cell (filled with buffer only).

IV. CONCLUSION

Aquasome is a new emerging nanoparticle with a self-assembling three-layered structure with a ceramic core and a carbohydrate coating that has the potential as a carrier in pharmaceutical fields for delivering drugs, insulin, haemoglobin, genes, enzymes, proteins and peptides. They can protect the structural and functional integrity of proteins and improve effects and immunological effects with conformational stability. It also affords the loading of hydrophilic and lipophilic drugs and raises the biological activity of drugs. The unique carbohydrate coating on the aquasome preserves the bioactive molecules from enzymatic degradation and their pharmacological activity without changes in their structural conformation and serves them stability in

the biological system. Therefore, all these properties and potential for delivery emerge as new and alternative approaches for delivering bioactive materials. This review addresses the information about aquasome and its potential use in pharmaceutical science. However, in the aquasome, some problems need to be addressed, such as control over the loading of bioactive materials to reduce the batch variation. The preparation method of aquasome should be simple and cost-effective. In aquasome, their target effectiveness needs to be enhanced. Here are various aspects of aquasome, such as pharmacokinetics parameters, toxicological effect, clinical trials and immunological effect, which are necessary for their development in the pharmaceutical field.

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