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AQUASOMES: AN UPDATED REVIEW

Gurpreet Kumar*, Ritu Rani, Ajeet Pal Singh & Amar Pal Singh

Department of Pharmaceutics, St. Soldier Institute of Pharmacy, lidhran Campus, Behind NIT (R.E.C.), Jalandhar –Amritsar By Pass, Nh-1, Jalandhar -144011, Punjab, India.

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Abstract

Aquasomes are circular particles that serve as nano particulate carrier systems, consisting of a solid phase nanocrystalline core coated in an oligomeric film. These three-layered self-assembled structures, ranging from 60 to 300 nanometers in size, allow direct or indirect absorption of biochemically active molecules. Aquasomes can be loaded with large amounts of agents through entropic, van der Waals, and ionic forces due to their size and active surface area. They display colloidal physical characteristics in an aqueous medium and are effective in distributing insulin, hemoglobin, serratiopeptidase, and poorly water-soluble medications.eramic nanoparticles, also known as aquasomes, are spherical particles that self-assemble into nanoparticulate carriers, resembling water bodies. These self-assembled structures are effective in the distribution of hemoglobin, insulin, and enzymes like serratiopeptidase. In this abstract, we will cover a review on Aquasomes.

Keywords: Aquasomes, formulation, Preparation methods, Application.

***Corresponding Author**

Gurpreet Kumar

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Introduction

The term 'aquasome' is derived from two words: 'aqua' (water) and'somes' (body), and hence 'bodies of water'. The material is covered with polyhydroxy oligomers, which allow drug molecules or biochemically active compounds to adsorb [1]. Nanobiopharmaceutics entails the administration of biopharmaceutical products using various biomaterials [2]. Aquasomes, which were first developed by NirKossovsky [3], are the most recently developed drug delivery system for therapeutics because they have the ability to deliver active molecules such as proteins, peptides, hormones, antigens, genes, and drugs of various categories to specific sites [4].

Kossovsky proposed a method for creating nanoparticles containing Aquasomes, which have a particle size (less than 1000 nm) that is suited for parenteral delivery since it prevents bloodstream capillary constriction. Aquasomes are sometimes known as "bodies of water" [5, 6].

Carbohydrates serve a vital function as natural stabilizers, as evidenced by the fact that sucrose-rich solutions may stabilize fungal spores carrying alkaloid [7] and that particular disaccharides can inhibit desiccation-induced molecular denaturation. [8].

Advantages of Aquasomes [4, 23]

Aquasomes sustain the structural veracity of drug particles as well as their biochemical constancy.

Aquasomes display colloidal-like physical characteristics. Potential drug stability concerns can be handled.

Drug release from aquasomes may be regulated by modifying their surface using a mix of precise targeting, molecular shielding, and therapeutic controlled release.

Multi-layered aquasomes conjugated with antibiotics, nucleic acids, peptides, and other biomarkers can be employed in a variety of imaging studies.

Aquasome-based vaccines have several benefits as a vaccine delivery strategy because of their ability to stimulate both cellular and humoral immune responses [1].

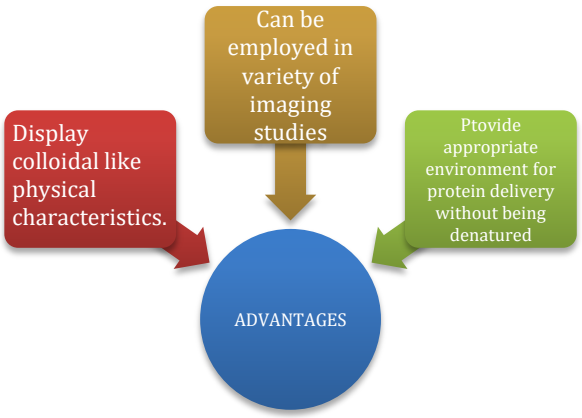

Figure 1: Advantages of Aquasomes

Properties [10, 11]

Aquasomes can successfully load huge quantities of agents employing ionic, non-covalent, van der Waals, and entropic forces due to their vast size and active surface.

Aquasomes' method of action is regulated by their surface chemical. Aquasomes use a mix of targeted distribution, molecular shielding, and a gradual and steady release mechanism to convey material.

Aquasomes are primarily examined using X-ray powder diffractometry, transmission electron microscopy, and scanning electron microscopy for structural analysis, morphological characteristics, drug loading efficiency, and in vivo performance [13].

Calcium phosphate is biodegradable in nature and may be broken down by monocytes and osteoclasts [13].

Method/Composition of Preparation of Aquasomes [14, 4]

In principle, an inorganic core is created, which is subsequently covered with Lactose to generate a polyhydroxylated core, which is then filled with model pharmaceutical. Aquasomes are prepared in three phases based on the self-assembly idea. i.e.

1) Core preparation
2) Core coating
3) The drug molecule is immobilized.

1.) Preparation of the core: The core material serves as the foundation or base of the entire construction. The core should have a high degree of stability, structural consistency, and a higher surface energy for effective coating material binding. Brushite (Calcium Phosphate), Ceramic Diamond (nano-crystalline carbon-ceramic), polymers (gelatin, albumin, and acrylates), and tin oxides are the most often utilized compounds for core preparation [1, 26].

Co-precipitation technique by sonication

In sonication at 4°C for 2 hours, a solution of disodium hydrogen phosphate (Na2HPO4, 0.75 M) is gradually added to a solution of calcium chloride (CaCl2, 0.25 M). To get core particles with diameters smaller than 0.2 m, the precipitate is redispersed with bi-distilled water and filtered through a 0.2 m Millipore filter [1].

Figure 2: Aquasomal core formation.

Coating of core: Polyhydroxyoligomeric compounds are commonly employed as coating materials. Cellobiose, sucrose, lactose monohydrate, trehalose, citrate, chitosan, and pyridoxal-5-phosphate are some of the favored coating materials.Ceramic cores are covered with carbohydrate (polyhydroxyl oligomer) in the second stage [3]. Immobilization of drug molecule

Adsorption is used to load the medicine onto the coated particles in the final stage. To do this, a solution of known drug concentration is produced in an appropriate pH buffer, and coated particles are disseminated in it.

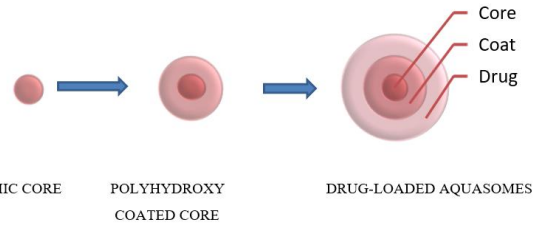

FIGURE 3: Steps involved in the formulation of aquasome.

Aquasome Characterization and Evaluation

The most significant properties of aquasomes are their structural and morphological properties, particle size scattering, and drug loading capabilities.

Characterization of ceramic core

Size distribution

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) are commonly employed for morphological description and scale sharing research [15, 16].

Structural analysis

FT-IR spectroscopy can be utilized for structural investigation. The potassium bromide sample disc technique may be used to analyse both the core and the coated core by recording their IR spectra in the wave number range 4000-400 cm-1 and comparing the

identified distinctive peaks with reference peaks [17, 18, 1].

Crystallinity

To assess if the ready ceramic core is crystalline or amorphous, X-ray diffraction can be employed. The X-ray diffraction form of the sample is compared to a standard diffractogram, and observations are made based on the results [18, 19].

Characterization of coatedcore

Carbohydrate coating

The concanavalin A-induced aggregation method (which calculates the amount of sugar coated over the core) or the anthrone method (which calculates the amount of sugar coated above the core) can also be used to determine how much sugar is smeared on the ceramic heart (calculates the amount of boundless sugar or remaining sugar left after coating). Sugar adsorption over the breast can even be validated using zeta potential calculations. [17, 18, 19].

Glass transition temperature

DSC methods have been used extensively to investigate the glass transition temperatures of carbohydrates and proteins [19].

Identification of drug-loaded Aquasomes. The drug filling may be assessed by incubating the simple aquasome preparation (i.e., without medicine) in a well-known attention of the drug solution for 24 hours at 4°C [16].

Characterization of drug-loaded aquasomes Drug loading :The drug loading may be evaluated by incubating the basic aquasomes formulation (which contains no medication) for 24 hours in a known concentration of drug solution. The solution was then centrifuged for 1 hour at low temperature in a chilled centrifuge using high-speed centrifugation [13].

Entrapment efficiency and drug loading The percentage of the actual mass of drug entrapped in the carrier relative to the original amount of loaded drug is referred to as entrapment efficiency [1,13].

$$\% \text{ Entrapment efficiency} = \frac{\text{Actual drug loaded}}{\text{Theoretical drug loaded}} \times 100$$

$$\% \text{ Drug loading} = \frac{\text{Weight of total added drug} - \text{Weight of unentrapped drug}}{\text{Weight of aquasomes}} \times 100$$

In vitro drug release studies

The in vitro release kinetics of the loaded drug were estimated by hatching a known amount of drug-burdened Aquasomes in an adequate pH buffer at 37°C with uninterrupted stirring to investigate the drug discharge pattern from the Aquasomes.

The required amount of aquasomal powder was poured into the hard gelatin capsules, and dissolution was performed using a USP type 1 dissolving device (basket type) at 37.5oC in an appropriate buffer at a suitable rpm for a particular time duration. Samples were taken at various time intervals, the sink condition was maintained, and absorbance at an appropriate wavelength was assessed using a UV-Visible spectrophotometer [13].

Drug release kinetics: To comprehend the linear connection, that is, kinetic principles, the drug release kinetics is produced by plotting many data gathered from in vitro drug release experiments in numerous kinetics models. MS Excel statistical tools are used to handle the data for regression analysis [23].

In-process stability studies

SDS-PAGE (sodium dodecyl sulphate polyacrylamide gel electrophoresis) can be used to test the protein's stability and integrity throughout the Aquasomes synthesis process [18].

Application

Aquasomes as substitutes for red blood cells, with hemoglobin immobilized on the oligomer surface due to the conformational sensitivity of haemoglobin's oxygen release. This minimizes toxicity by obtaining an 80% haemoglobin concentration and supplying blood in a nonlinear manner akin to regular blood cells [20].

Aquasomes, a five-layered composition made up of a ceramic core, polyoxyoligomeric film, therapeutic gene section, extra carbohydrate film, and a targeting layer of conformationally conserved viral membrane protein, have been employed successfully for targeted intracellular gene therapy [20]

In order to elicit appropriate antibodies, aquasomes utilized as vaccines for viral antigen delivery, such as Epstein-Barr and Immune Deficiency Virus, must be triggered by conformationally specific target molecules [18].

Aquasomes for pharmaceutical administration, such as insulin, were developed because drug action is conformationally specific. Bioactivity was maintained and activity enhanced by 60% as compared to i.v. treatment, with no verified toxicity.[22] Using simple adsorption, the medication was later adsorbed onto this coated core. In vitro tests demonstrated that the insulin-loaded aquasome performed considerably better than insulin solution [1, 25]

Lipophilic drug delivery via aquasomes in the oral cavity Vengala et al. developed aquasomes for the administration of the poorly soluble medication pimozide. A variety of procedures were used to produce the core, with the coprecipitation approach by sonication being the most effective [1, 24].

Delivery of protein and peptides. The surface modification of aquasomes with polyhydroxy oligomers results in the formation of a glassy molecular stabilizing coating that adsorbs therapeutic proteins while causing little structural denaturation. As a result, because there is no swelling or porosity change with pH or temperature change, these particles give full aqueous nature protection to the adsorbed pharmaceuticals against the denaturing effects of external pH and temperature [13].

Challenges

Aquasomes have the potential to revolutionize the future of protein/peptide delivery and other pharmaceutically active substances. However, several obstacles have arisen

in the successful formulation and distribution. Aquasomes must be examined in a variety of areas, including their irreconcilable response to various sterilizing treatments and their shelf-life in conformity with ICH requirements. Other issues include the feasibility of large-scale production and the possibility for commercialization. The overall high cost of the components, as well as the lengthy production procedure, have yet to be overcome. Some of the critical portions that have still to be thoroughly examined include reproducibility following characterization of essential aspects such as in vitro and in vivo investigations and their safety characteristics [1, 24].

Conclusion

Aquasomes are one of the most important fundamental and novel drug carriers. However, further study is needed in pharmacokinetics, toxicology, and animal trials to prove their efficacy, safety, clinical value, and commercialization. Aquasomes represent a significant challenge in drug delivery systems for proteins and peptides, and have a bright future as a medication and bioactive delivery mechanism. It has been discovered that it can preserve and safeguard the structural integrity and conformation of physiologically active compounds. The structural stability and overall integrity are provided by the crystalline ceramic core. Because the carbohydrate coating preserves the structural integrity of bioactive molecules, it has been proposed that aquasomes offer promise as a carrier system for the transport of peptides, proteins, hormones, antigens, genes, and hydrophobic medicines to particular regions. Despite various problems, such as time consumption, sophisticated processes, safety, and expensive research costs, aquasome may emerge as an alternative vesicular carrier in the future. Still, further research into aquasomes' pharmacokinetics, toxicity, and animal tests are required to prove their efficacy and safety, demonstrate their therapeutic value, and commercialize them.

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Conflicts of Interests

There are no conflicts of interest.

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Authors Contributions

All the authors have contributed equally.

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