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NANOCAPSULES: A NOVEL DRUG DELIVERY SYSTEM

Mrs. Swathi.S, Mrs. Saranya.S, Dr. Prasobh.G. R

Sree Krishna College Of Pharmacy And Research Center, Parassala, Thiruvananthapuram.

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Abstract:

Nano capsules are vesicular system in which the drug is confined to a cavity consisting of an inner liquid core surrounding by a polymeric membrane. Nano capsule is a Nanoparticle that is spherical, hollow structure with a diameter less than 200nm in which desired substance may be placed. They can be filled with a solvent, either polar or non- polar. Nano capsules can be different from other Nanoparticles because they have well defined core and shell, whereas the latter do not. When it is made from polymers, Nano capsules can be referred as hollow polymer nanostructures. Polymers are large molecules composed of repeating chemical units. The smallest repeating unit is called a mer. The better distribution of bioactive compounds via targeted delivery via nano capsules presents various problems and potential for future study and development of novel improved therapeutics. They can be used in the delivery of active pharmaceutical ingredients. They provide the novel effective drug delivery systems in the upcoming future. The main goal of this review was to describe preparation techniques available for production of polymeric nanoparticles. The drug loaded nanosphere / nano capsules now can be produced by simple, safe, and reproductive technique available. Nano capsules are a contribution to the methodological development for formulation by various methods, mainly the interfacial polymerization and interfacial nano deposition.

Keywords: *Nanocapsules, Polymers, Nanoparticles, Drug, Polymerization.*

Corresponding author:

Mrs. Swathi.S,

***Student**, Sree Krishna College Of Pharmacy And Research Center, Parassala, Thiruvananthapuram.*

Email: swathisarath9558@gmail.com

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INTRODUCTION:

In ancient times, humans have widely used plant based natural products as medicines against various diseases. Modern medicines are derived from herbs based on traditional knowledge and practices. Nearly, 25% of the major pharmaceutical compounds and their derivatives are obtained from natural resources. The discovery of novel drugs was based on the natural compounds with different molecular backgrounds. Natural products exhibit remarkable characteristic features such as extraordinary chemical diversity, chemical and biological properties with wide macromolecular specificity and with less toxicity[1]. These lead to the discovery of novel drug delivery system.

Natural compounds are now being screened for treating several major diseases, including diabetes, cancer, cardiovascular, inflammatory, and microbial diseases, because natural drugs possess unique advantages, such as lower toxicity and side effects, low-price, and good therapeutic potential. Consequently, many natural compounds are not clearing the clinical trial phases because of these problems. Nanoparticle drug delivery systems are engineered technologies that use nanoparticles for the targeted delivery and controlled release of therapeutic agents. Some major advantages of nanoparticles are their high surface-area-to-volume ratio, chemical and geometric tunability, and they can interact with biomolecules to facilitate uptake across the cell membrane[2]. The surface area also has a large affinity for drugs and small molecules, like ligands or antibodies, for targeting and controlled release purposes. Nanoparticles refer to a family of materials both organic and inorganic.

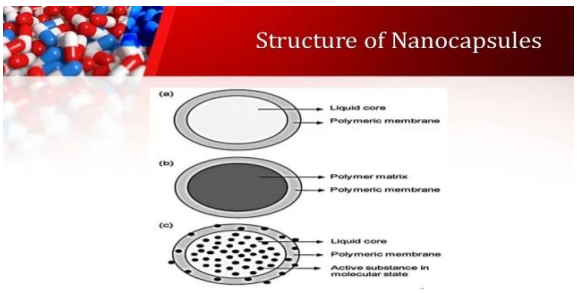


Figure (1): Structure of nanocapsules

Nano capsules are vesicular system in which the drug is confined to a cavity consisting of an inner liquid core surrounding by a polymeric membrane. The diameter of the drug particle should be in range of 250-500 nm. They are colloidal nano-bubbles in which the core (oily or aqueous) is surrounded by a polymeric membrane with specific properties as shown as figure (1).

It is characteristic class of nanoparticles, are made up of one or more active materials (core) and protective matrix (shell) in which the therapeutic substance may be confined[3]. Nano capsules have been developed as drug delivery system for several drugs by different routes of administration such as oral and parenteral with pH range of 3.0-7.5.

ADVANTAGES

- Sustained release, increasing drug selectively and effectiveness.
- Higher dose loading.
- Reduce irritation of drug at site of administration.
- Site specific action.
- Increase bioavailability of drug.

DISADVANTAGE

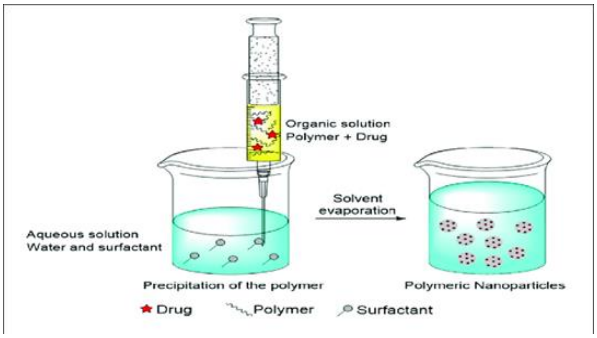
- Cytotoxicity.
- Pulmonary inflammation and pulmonary carcinogenicity.
- Alveolar inflammation.
- Limited targeting abilities.
- Extensive use of polyvinyl alcohol as a detergent issue with toxicity.

PREPARATION OF NANOCAPSULES

- ✓ Polymerization method
- ✓ Layer by layer method
- ✓ Nanoprecipitation

Nanoprecipitation method:

It is the process of preparing involves preformed polymer of organic solution and the presence or absence of surfactant the organic solvent is allowed to diffuse generally using polymer Poly-Lactic Acid.



Figure(2): Nanoprecipitation

Polymerization method:

The monomers are polymerized in an aqueous solution to form nanoparticles followed by placing the drug

either by dissolving in the medium of polymerization or by the adsorption of nanoparticles[4]. The method for purifying the nanoparticle suspension, removes various and stabilizers and surfactants employed for polymerization is Ultracentrifugation method. The nanoparticles are then resuspended in an isotonic surfactant medium.

Layer-by-Layer Method

The layer-by-layer method makes used of polycations such as polylysine, chitosan, gelatin B, poly (allylamine) (PAA) poly (ethyleneimine) (PEI), antidextran and protamine sulphate.

The following polyanions are used:

- poly (styrene sulfonate) (PSS),
- sodium alginate,
- poly (acrylic acid),
- dextran sulphate,

CHARACTERIZIATION ON NANOCAPSULES:

Particle size

Particle size and size distribution plays a crucial role in nano capsule systems, and it establishes the in vivo distribution, bioavailability, toxicity, and the targeting capacity of nanoparticulate systems[5].

Determination Of the Ph of Nano capsules

Nano capsules formula pH was measured using a digital pH meter at room temperature.

Mean Nano capsules

The mean particle size of nano capsules prepared from performed polymers are in general between 250-500 nm.

Determination Of Drug Content

Drug content was determined by dissolving 1 ml of prepared nano capsules in 20 ml of acetonitrile.

Particle size distribution and particle charge /zetapotential

Particle size distribution is an important aspect during the formation of nano systems.

CHARACTERIZATION TECHNIQUES:

Characterization of nano capsules is difficult due to its small size and complex formation. Some of the techniques include Gel permeation Chromatography (GPC), Transmission Electron microscopy (TEM), Scanning Force Microscopy (SFM) and Scanning electron microscopy (SEM). But these techniques do not provide a clear picture of the Nano capsules shell. The characteristics of interest of Nano capsules are morphology, size and size distribution, density, and zeta potential[7]. The characterization of Nano particles deals with a branch called nanometrology.

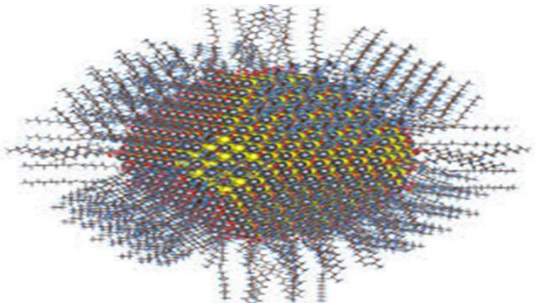
Methods of Characterization of Nanoparticles

Microscopic Methods:

Electron microscopy and scanning probe microscopy are the preferred method to detect the Characterization of Nano capsules.

Surface Chemistry and Charge:

For nanoparticles a higher proportion of atoms are on their surfaces relative to micron-scale particles, and surface atoms are in direct contact with solvents and influence their interactions with other molecules.



Figure(3): surface of nanocapsule

Determination of The Ph of Nano capsule:

Nano capsules formulation pH was measured using a digital pH meter at room temperature. Nano capsules dispersion pH values fall within a range of 3.0-7.5.

EVALUATION STUDIES

X-Ray Diffraction

(XRD) studies Phase analysis of the products is performed by powder XRD on a Rigaku D/max-2000 diffractometer with graphite monochromatized CuKα (λ = 0.154 056 nm) at a voltage of 50 kV and a current of 250 mA. The XRD pattern shows the phase composition of prepared products.

Electron Microscopy (SEM)

The architecture of the hierarchical branching aggregates, characterized from nano capsules, may be of flocculent structure, small clusters, big clusters, and big branches step by step at different scales, which confirms the self-similar attributes of the structure. It is characterized by a Philips XL-30 scanning electron microscope (SEM) which shows at a high magnification the clear morphology of small clusters. The clusters are composed of flocculent structure formed by the small particles adhered together.

Differential Scanning Calorimetry (DSC)

DSC analysis is conducted in both open samples (no lid) and closed samples (pan capped possessing a small

hole in the center). Both methods have similar thermal behavior as per the observations reported.

FORMATION OF NANOCAPSULES

1.Formation by interfacial polymerization polyalkylcyanoacrylate nano capsules:

In this case, the capsule wall is formed by polymerization at the interface between the two liquid phases of an emulsion the active ingredient and either the organic phase or the aqueous phase is formed, depending on the nature of the original emulsion.

If the preparation is based on suspensions, the analogous interfacial polymerization approach leads to a capsule with a solid core which must be removed under drastic chemical or physical conditions.

2.Formation by interfacial deposition polyelectrolyte nano capsules:

The basic idea of this method is again to use an interface as a template for the formation of a spherical polymer membrane.

In case of larger active ingredients, e.g., enzymes, a crystal of the substrate may be used as a template by itself as has been successfully demonstrated on catalase.

In addition, for direct encapsulation of a crystal of the active ingredient, the encapsulation efficiency is extremely high and suitable for technical applications.

IMPORTANT CAPSULE PROPERTIES

Capsule radius

Generally, the radius of nano capsules is too small to be directly accessible by a light microscopic measurement.

A dark-field light microscope, equipped with a video camera and an automatic image analysis system allows for efficient particle tracking of capsules with radii between 50 and 500 nm.

Capsule surface

The outer capsule surface represents a very important feature of a capsule system as it is directly linked to the immunological response in a living organism.

Capsule decomposition

The processes leading to capsule decomposition may be manifold. They include chemical decomposition by the hydrolytic degradation of the polymer, by oxidation or by enzymatic action in a living organism as well as physical decomposition caused by shear forces, heat, or sonic disruption. In all cases, the capsule decomposition finally leads to the release of the capsule contents.

NANOCAPSULES FOR DRUG DLIVERY

Nano capsules, which measure 1 thousandth of a millimeter, can be coated with an antibody on the surface, which assists in directing them from the blood stream to an induced tumor. After reaching to the tumor, an instant blast occurs that makes the capsules to open and discharge their therapeutic contents. On the surface of the polymer, there are tiny gold particles in the range of 6 nm i.e., 6 millionth of a millimeter which stick across and are specific to the laser light and lead the capsules to position their drug load capacity at the desired time[8]. The rupturing of the capsule can be seen when near infrared light hits the gold spots, and they melt instantaneously without harming the content.

Nano capsules for oral delivery of peptides and proteins

Nano capsules are used as carriers for oral administration of peptides and proteins, particularly biodegradable poly (isobutyl cyanoacrylate) nano capsules. However, the development of suitable carriers remains as a challenging technique due to the characteristic bioavailability of these molecules. They are restricted due to the gastrointestinal barriers of the epithelium and by their degradation of digestive enzymes[9]. By the technique of encapsulation which provides the bioactive molecules from enzymatic and hydrolytic degradation.

Treatment of hormone dependent breast cancer

The study of specific siRNAs encapsulated in nano capsules can be used to target estrogen receptor alpha (ERα). The intravenous injection of these nano capsules into estradiol stimulated MCF-7 cell xenografts led to a significant decrease in tumor growth and a decrease in ERα expression in tumor cells. This indicates that a novel strategy, based on ERα−siRNA delivery, could be developed for the treatment of hormone dependent breast cancer.

Nuclear nano capsules treatment for cancer by using radioactive materials.

The radioactive compound Astatine, like radium and uranium, emit high velocity alpha particles by the procedure of re-elections and, which is about 4,000 times faster than the beta decay of the emitted electrons, and is most used to treat cancer[10].

APPLICATION OF NANOCAPSULES

They have the potential applications in various fields like agrochemicals, cosmetics products, genetic

engineering techniques, wastewater treatments, cleaning products, and componential adhesive applications. They also find applicability in encapsulating the enzymes, organic or inorganic catalysts, oils, adhesives, surface polymers, inorganic micro-particles and Nanoparticles, latex particles, or even biological cells.

CONCLUSION:

The better distribution of bioactive compounds via targeted delivery via nano capsules presents various problems and potential for future study and development of novel improved therapeutics. They can be used in the delivery of active pharmaceutical ingredients (APIs). They provide the novel effective drug delivery systems in the upcoming future. The main goal of this review was to describe preparation techniques available for production of polymeric nanoparticles. The drug loaded nanosphere / nano capsules now can be produced by simple, safe, and reproductive technique available.

Nano capsules preparation method has been marked by three aspects.

- Need for less toxic reagents.
- Simplification at the procedure to allow economic scale up.
- Optimization to improve yield and entrapment efficiency.

Nanoencapsulation is an attractive strategy for the vectorization of a variety of active substances. Although with different objectives, research has been focused on antineoplastics, anti-inflammatories, immunosuppressants, antigens, hormones, antivirals, antibacterials, antifungals, diuretics, anti-pneumocystics and vitamins, among others. There is no ideal method because each one has its advantages and limitations. In drug delivery system, they are confined to suit the complexity of the application as they intend to produce contents in response to a specific bimolecular triggering action mechanism. In conclusion, they can be used in the delivery of active pharmaceutical ingredients (APIs).

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