Available Online through
www.ijpbs.com

International Journal of Pharmacy and Biological Sciences (eISSN: 2230-7605)
IJPBS |Volume 1| Issue 3 |JULY-SEPT |2011|183-197

COLLOIDOSOMES DRUG DELIVERY: A REVIEW

R. Parthibarajan[1]*, C. Rubina Reichel[2], N. L. Gowrishankar[2], D. Pranitha[2]

[1] Department of Pharmaceutics, Swami Vivekananda Institute of Pharmaceutical Sciences, Vangapally (P), Yadagirigutta (M), Nalgonda, Andhra Pradesh, India.

[2]Department of Pharmaceutics, Cherraan's College of Pharmacy, Telungupalayam Pirivu, Siruvani Main road, Coimbatore, Tamilnadu, India.

*Corresponding Author Email: parthi_pharma@yahoo.co.in

Review Article

RECEIVED ON 24-07-2011 **ACCEPTED ON 16-08-2011**

ABSTRACT

The purpose of writing this review on colloidosome drug delivery was to compile the focus on the types, properties, fabrication techniques, characterisation and stability of colloidosomes .The recent developments a number of lipid based systems like lipospheres, liposomes, niosomes, ethosomes, transferosomes were developed. This system also solves the problem of insolubility, instability, rapid degradation and widely used in specialized areas like protein delivery, gene delivery, targeting to brain, tumour targeting. In the series of vascular systems Colloidosome is the advanced tool in drug delivery. Vesicular drug delivery reduces the cost of therapy by improved bioavailability of medication, especially in case of poorly soluble drugs. Colloidosomes have a great, encapsulation efficacy with a wide control over size, permeability, mechanical strength and compatibility.

Keywords: *Colloidosomes, core materials, emulsion droplets, fused colloidal particles, microcapsules.*

Introduction

Vesicular delivery system provides an efficient method for delivery of drug directly to the site of infection, leading to reduction of drug toxicity with no adverse effects. Vesicular drug delivery reduces the cost of therapy by improved bioavailability of medication, especially in case of poorly soluble drugs. In the past few decades, consequently a number of lipid based systems like lipospheres[1], liposomes[2], niosomes, ethosomes, transferosomes were developed.[3] Such drug delivery systems are used for delay drug elimination of rapidly metabolizable drugs and function as sustained release systems. This system also solves the problem of insolubility, instability, rapid degradation and widely used in specialized areas like protein delivery, gene delivery, targeting to brain, tumor targeting.[4] Novel technology has shown great potential for improving the effectiveness and efficiency of delivery of nutraceuticals and bioactive compounds., In the series of vesicular system, colloidosomes are used as advanced tool for encapsulation of various materials such as drugs, dyes, cosmetics, biomaterials as filler in catalysis and waste removal.[5] The capsules are fabricated by the self – assembly of colloidal particles on to the interface of emulsion droplet. Colloidosomes are hollow, elastic shells whose permeability and elasticity can be controlled. The Colloidosomes is a novel class of microcapsules whose shell consists of coagulated or fused colloid particles at interface of emulsion droplet articles self assemble on the surface of droplets in order to minimize the total interfacial energy forming Colloidosomes. Hairy Colloidosomes[6] whose shell consists of micro rod particles are designed and fabricated novel Colloidosome capsules that consist of aqueous gel core and shells of polymeric micro rods. This has been achieved

by templating water-in-oil emulsions stabilized by rod like particles followed by gelling of the aqueous phase, dissolution of oil phase in ethanol and redispersion of obtained colloidosome microcapsules in water. Nonspherical capsules, therefore, can be used to store a larger amount of encapsulated materials compared to spherical capsules.

Fig: 1 scanning electron microscope image of a colloidosomes.

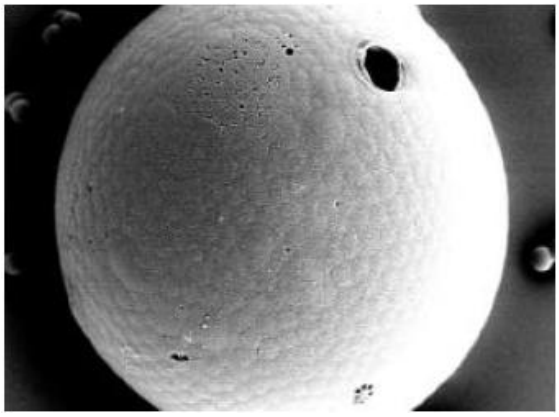
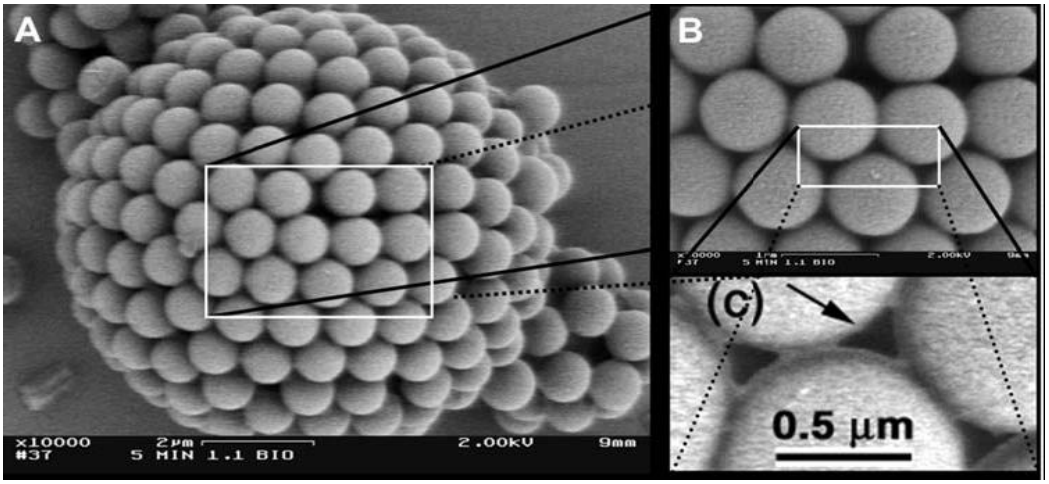


Fig: 2 scanning electron microscope image of a colloidosomes encapsulating oil in aqueous solution.



POTENTIAL BENEFITS OF COLLOIDOSOMES

- **SIZE** – Allows flexibility in applications and choice of encapsulated materials
- **PERMEABILITY** -Allows selective and aimed release
- **MECHANICAL STRENGTH** –Allows yield stress to be adjusted to withstand varying of mechanical loads and to enable release by defined shear rates
- **COMPATIBILITY**-Allows encapsulation of fragile and sensitive ingredients such as biomolecities and cells.[7]

ADVANTAGES

Efficient encapsulation of active ingredients such as drugs , proteins , vitamins , flavors, gas bubbles or even living cells is becoming increasing the important for a wide variety of applications and technologies, ranging from functional foods to drug delivery to bio medical applications. Colloidosomes can address a wide verity of encapsulation needs

in addition to nutrient and for drug delivery. One important possibility is immune isolation of living cells by encapsulation in colloidosomes; they would provide a rigid scaffold that supports the living cell while simultaneously protecting it from the immune system and allowing free diffusion of gases and nutrients. Colloidosomes encapsulating cells could have advantages properties as bio reactors. Colloidosomes attractive candidates for encapsulation and delivery of food stuffs, fragrens and active ingredients. A super structure of Colloidosomes may form templates for tissue growth by providing a protected environment that has a useful three dimensional architecture and allows rapid permeation of small macromolecules. Success fill encapsulation of living fibro blast and maintained their viability for several hours using particle – coated water droplets in decaling oil. Colloidosomes can be fabricated as rigid porous super structures to enhance the viability of the cells.

LIMITATIONS

A major problem in the colloidosome manufacture is the poor yield of particles. If the shell locking is inefficient then the colloidosomes simply coalesce and fall apart on transfer into water. In addition a large proportion of the colloidosomes seem to be lost on the transfer from organic to water media.[8]

CORE MATERIAL

The core material can include a polymer gel. It consists of a cross linked network of long polymer molecules. This can provide physical strength, although the glass transition temperature. The gel can include water (i.e., a hydro gel) and/or organic liquids. Swelling and deswelling in water is a characteristic of a hydro gel. The gel can be formed as a particle, such as a spherical particle, an ovoid particle, a cylindrical particle, or some other three-dimensionally shaped particle. The gel particle can have at least one dimension that is microns to millimeters in size. The particle size of the core material is dependent on the intended application of the resultant colloidisomes. Generally, the core material diameter is in the range of about one or more microns to millimeters. Conventional methods of preparing a core particle include capillary-based micro fluidic techniques, precipitation polymerization techniques and inverse suspension polymerization techniques.[9] The gel possesses at least one property that exhibits an attractive interaction with the colloidal particles. For example, the gel can possess electrical charges, magnetic materials, and the like that are capable of attracting the colloidal particles toward the core. Magnetic material can be included in the gel that attracts colloidal particles to the core. For example, the gel can entrain certain magnetic materials (as solids or in solution) within the cross linked network that are attractive to magnetic metal particles that serve as the colloidal particles.

Factors affecting the property of the gel or core material

External stimulus, temperature, pH, electrical effects are affecting gel or core material.

COLLOIDAL PARTICLES

The colloidal particles can include a metal, a semiconductor, a polymer, an inorganic material, nanometer sized particles and micrometer sized particles. The colloidal particles have a particle size that is smaller than that of the core material. The colloidal particles possess an attractive interaction with the core material. For example, the colloidal particles possess electrical charges, magnetic properties, and the like that are attractive to the core material. The colloidal particles may

be negatively charged when the core material is positively charged. Types of colloidal particle are, 1) Semiconductor colloidal particles are silicon, germanium, gallium arsenide, and cadmium selenide. 2) Polymer colloidal particles are polystyrene, polymethyl methacrylate, poly (ε-caprolactone), poly (lactic acid), and poly (lactic acid-co-glycolic acid). 3) Inorganic colloidal particles are gold, silver, copper, cobalt, palladium, platinum, manganese-zinc, nickel-zinc, iron-platinum, silica, titania, iron oxide, zinc oxide, and nickel oxide. 4) Magnetic colloidal particles include gold, silver, copper, iron oxide, manganese-zinc, nickel-zinc, nickel oxide, cobalt, iron-platinum, $CoFe_2O_4$. The colloidal particles can possess magnetic properties that can be attracted to a gel having a magnetic material. For example, the gel can contain certain magnetic particles within the cross linked network and the colloidal particles can include a magnetic material. 5) The colloidal particles can possess additional properties, such as fluorescence that are suitable for certain chemical, biological. For example, the colloidal particles might be sensitive to certain diagnostic tools (e.g., MRI, ultrasound, x-ray, etc.) to determine the location of the colloidosomes, e.g., colloidisomes that encapsulate a drug or other therapeutic agent, in a human body.

Varity of techniques to address specific ENCAPSULATION

Coacervation or controlled gelation of polymers at the surface of water drops can be used to fabricate nano or micro porous capsules. Fluid extrusion methods can also be used to create the polymer coating. Coating immiscible templates by electrostatic deposition of alternating layers of charged polymers (or) particles can be used to fabricate nanoporous capsules. Micro fabrication technology can be used to create sub millimeter sized silicon capsules with precise nano meter-scale holes for selective permeability and slow release.

CLASSIFICATION OF COLLOIDOSOMES: [3]

The colloidosomes are classified on the basis of emulsion used.[10] They are classified as Water-in-oil emulsion based colloidosomes, Oil-in-water emulsion based colloidosomes, Water-oil-water emulsion based colloidosomes, The colloidosomes are classified on the basis of nature of colloids. They are classified as Aqueous or oily gel core colloidosomes, Hairy colloidosomes, Nanoparticle colloidosomes, Layer by layer colloidosomes Non-spherical colloidosomes

METHOD OF PREPARATION

PREPARATION OF EMULSION BASED COLLOIDOSOMES

Water-in-oil emulsion based colloidosomes

Aqueous solution is emulsified in oil in presence of colloidal particles to produce water-in-oil emulsion. Particles are adsorbing onto the surface of the droplets to reduce the surface energy. These particles are subsequently locked together by addition of polycations, by Vander Waals forces or by sintering the particles. These colloidal particles help in producing water-in-oil stabilized emulsion[11]. Then water-in-oil based colloidal dispersion is obtained. The two different ways to transfer them into water is suggested. They are centrifugation approach and filtration approach. In centrifugation approach, the obtained colloidosomal dispersion is diluted with non aqueous phase (ethanol, dodecane) and then allowed to centrifuge to separate them from the supernatant. The obtained water core colloidosomes are washed with ethanol and water and redispersed in water. The second transfer approach is to filter the oil suspension on the hydrophobic milipore membranes. At the end of filtration, a small

amount of water containing a small proportion of ethanol is added to top of the membrane, removing the oil interface and resuspending the colloidosomes in water. This water core colloidosomes (W/O emulsion based) seem to be a suitable encapsulating agent for the drugs, dye, fragrances because of their mechanical resistance of their shell, the tunable porosity and the easy mass transfer potential due to absence of chemical barrier.[12]

Oil-in-water emulsion based colloidosomes

In such type, oil is emulsified in aqueous solution containing particles in presence of a surfactant to produce oil-in-water emulsion. This colloidal particle in presence of surfactant is used to stabilize the oil/water interface. This introduces an electrostatic driving force to take the colloidal particles to the emulsion interface. Then Oil-in-water emulsion based colloidosomal dispersion is obtained. The obtained colloidosomal dispersion added to non aqueous phase (ethanol) and allowed to centrifuge to separate them from the supernatant. The obtained oil core colloidosomes are washed with ethanol and finally redispersed in water.

Water-oil-water emulsion based colloidosomes :

Pendant drop of an aqueous suspension of latex particles is formed in an oil phase. A closely packed particle monolayer adsorbed on the drop surface by multiple infusion and withdrawal of the particle suspension through the capillary in the oil phase. Finally, the pendant water drop in oil, densely coated with adsorbed particles, is transferred through a planar oil-water interface (free of particles) to form a giant pendant colloidosome, which consists of a spherical water/oil/water film supported by latex particles possibly bridging both surfaces.[13] Nanoparticle colloidosomes with selective permeability are generated by using water-in-oil-in-water (W/O/W) double emulsions as templates.[14]

PREPARATION OF COLLOIDOSOMES BASIS OF NATURE OF COLLOIDS

1) Aqueous or oily gel core colloidosomes [15]

The basics of the method are illustrated in Fig. 3 and involve the following three stages: (i) A hot aqueous solution of agarose is emulsified in oil in the presence of solid particles to produce water-in-oil emulsion stabilized by the solid particles and the system is cooled to set the agarose gel. (ii) The obtained suspension of aqueous gel microcapsules is diluted with ethanol and centrifuged to separate them from the supernatant. (iii) The microcapsules are washed with ethanol and water and redispersed in water. This technique allowed us to prepare giant colloidosome microcapsules of diameters varying between several tens to several hundreds of micrometers. The average size of the colloidosomes can be varied by changing the size of the solid particles.

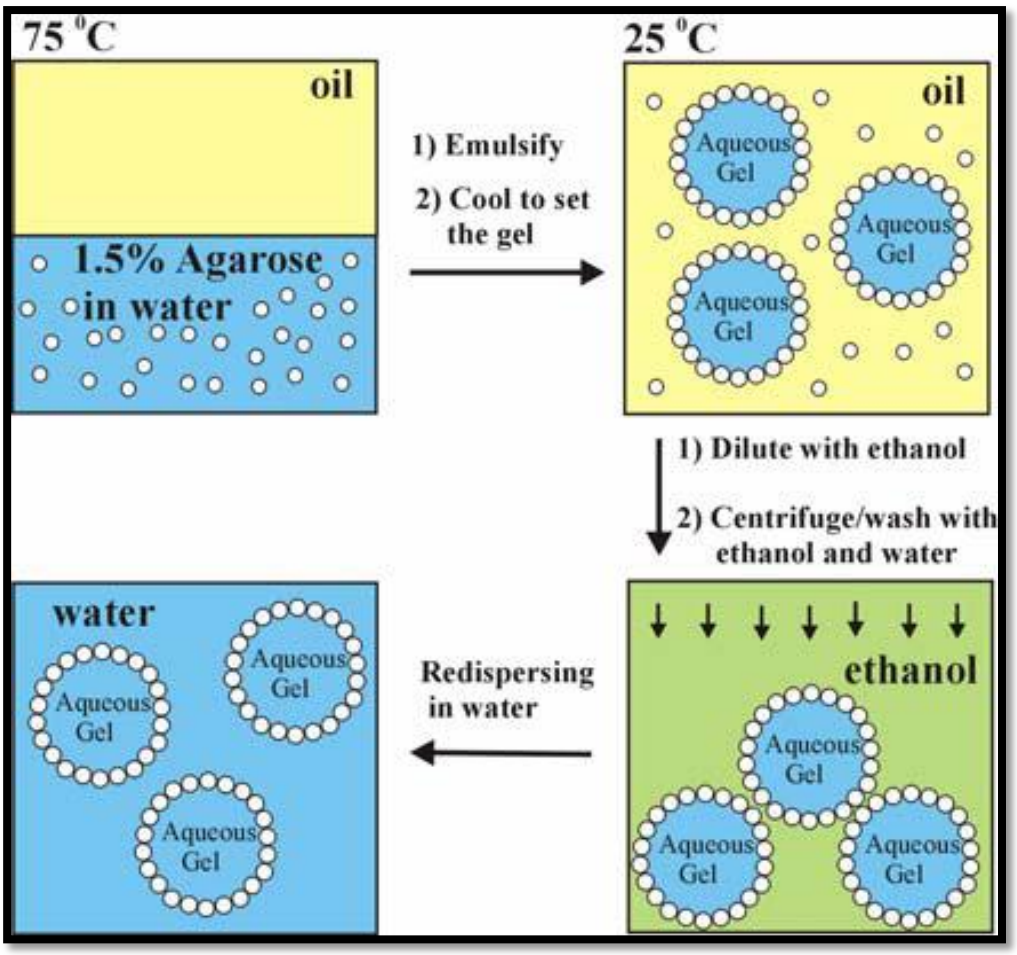


Fig: 3 Schematics of the method for preparation of the gel core colloidosomes

Hairy colloidosomes

The basics of the method are illustrated in Fig. 4 and involve the following three stages: i) Hot aqueous solution of agarose is emulsified in oil in the presence of rod like polymeric particles to produce a stable water-in-oil emulsion stabilized by the solid particles, and the system is cooled off to set the agarose gel. ii) The obtained suspension of aqueous gel microcapsules is diluted with ethanol and centrifuged to separate them from the supernatant. iii) The microcapsules are washed with ethanol and water and redispersed into water. This technique allows preparation of colloidosome microcapsules of diameters varying between several tens to several hundreds of micrometers. The function of the gel cores is to support the particle shell and to give the microcapsules enough stiffness to be separated from the oil phase by centrifugation.

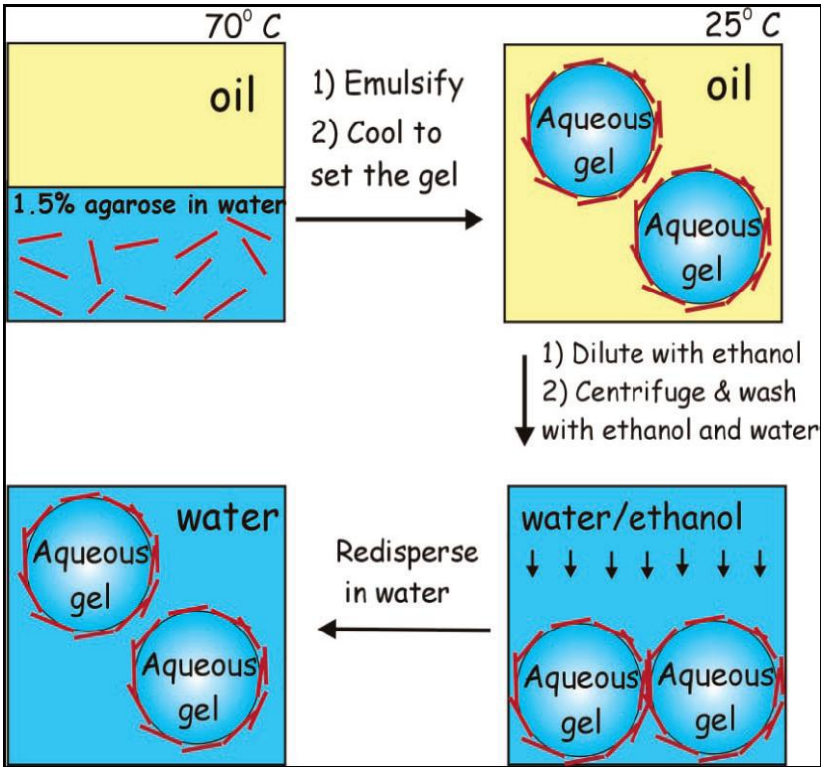


Fig: 4 Schematics of the method for preparation of the gelled colloidosomes of polymeric micro rods.

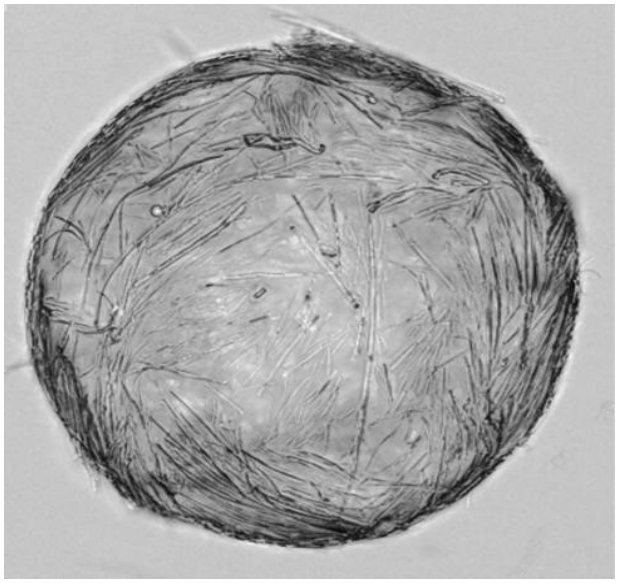


Fig: 5 "Hairy" colloidosome microcapsules produced by transferring the micro rod-coated agarose beads in water.

Nano Particle Colloidosomes [16]

Nano particles colloidosomes prepared by using water in oil in water double emulsion as

template provides a robust and monodisperse semi-permeable nanoparticles colloidosomes with precisely tuned structure and composition. Monodisperse water in oil in water double emulsions with core/shell geometry are generated using glass capillary micro fluidic devices. Hydrophobic silica nanoparticles dispersed in the continuous phase (water in oil emulsion).These particles self-assemble at the interface between the two immiscible liquid phases and form a colloidal shell/oil shell, to stabilize the droplets and ultimately become the colloidosome shells upon removal of the oil solvent. Then they were transferred to an aqueous phase either by centrifugation or repeated washings, to create efficient colloidosomes with particles ranging from 5nm to several microns in diameter. Size and dimensions of colloidosomes controlled by the independently controlling the flow rates of each fluid phase.

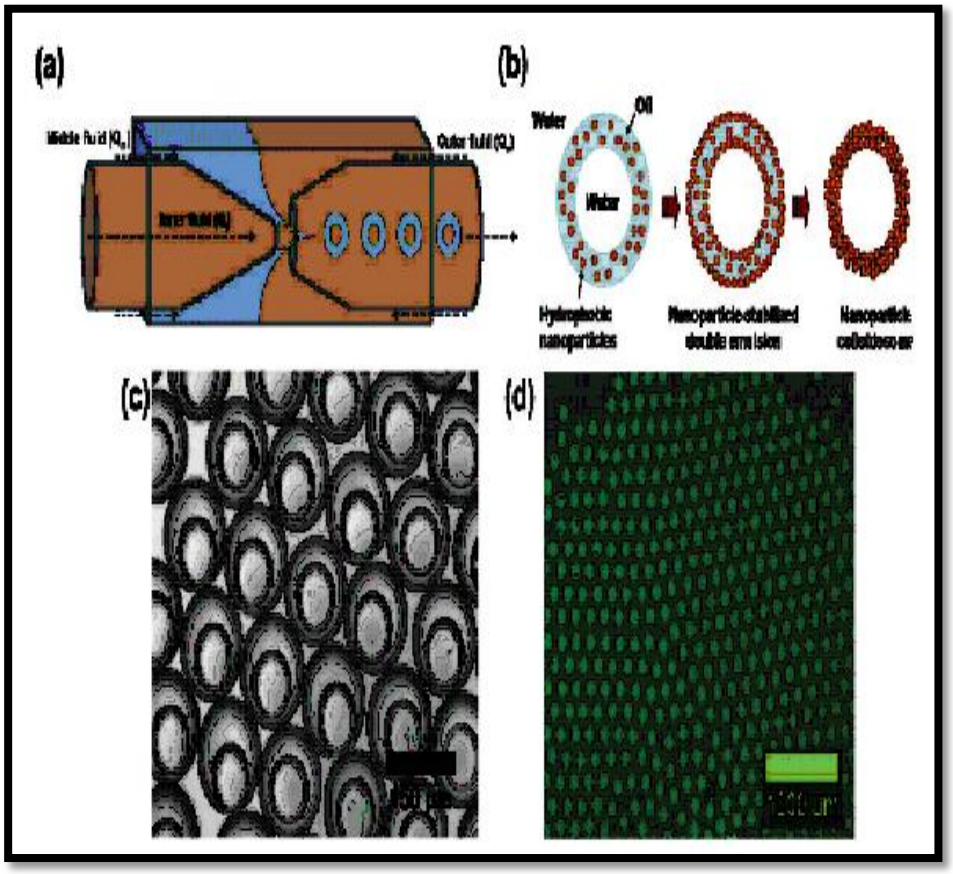


Fig: 6 Schematics of the method for formation of nano particle colloidosomes

A. micro capillary device for double emulsion generation

B. formation of nano particle colloidosomes

C. optical microscope image of double emulsion.

D. fluorescence microscope image of double emulsion

Layer by Layer Colloidosomes[17]

The process used to encapsulate enzymes by using biocrystals as templates for

the deposition of polymer multilayers, subsequent enzyme solubilization and release, and the formation of hollow polymer capsules .Polyelectrolyte layers are deposited stepwise onto the crystals by making use of the surface charge reversal that occurs upon adsorption of each layer. Each polyelectrolyte layer deposited bears an opposite charge to that already adsorbed, unadsorbed polyelectrolyte is removed by repeated centrifugation/wash redispersion cycles before the next layer is deposited. Solubilization of the enzyme inside the polymer capsule by exposure to solutions of pH>6 or acidic solution pH<4 results in a morphology change of the polymer capsule. Release of the enzyme by rupturing the polymer capsule, achieved by exposure to solution of pH >11. Exposure of the encapsulated enzyme to an oxidizing solution results in decomposition of the enzyme which then is expelled from the interior through the polymer walls, leaving behind hollow polymer capsule that originally encapsulate the enzyme.

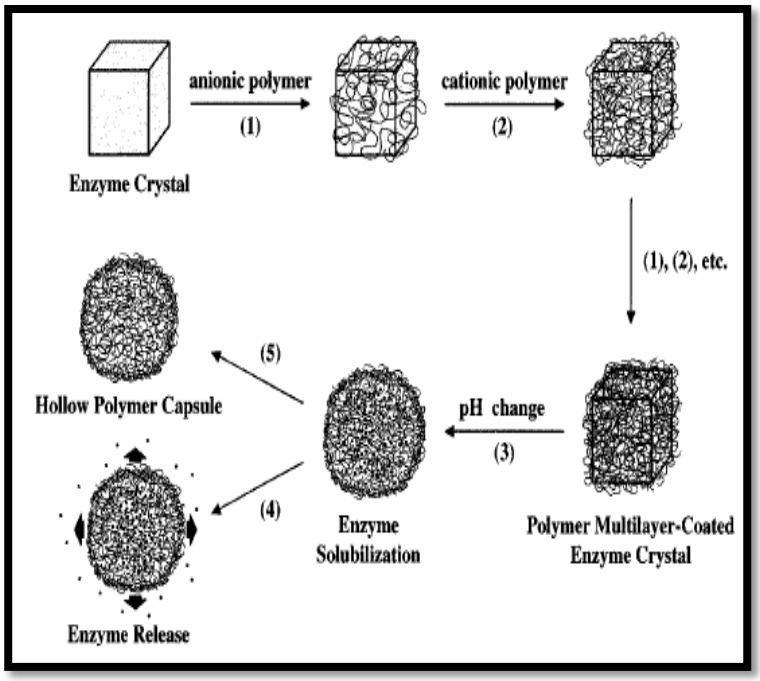


Fig: 7 Schematics of the method for formation of layer by layer colloidosomes.

Non-spherical colloidosomes

The generation of nonspherical colloidosomes with multiple compartments. We use glass capillary micro fluidics to prepare W/O/W double emulsions with different morphologies. These double emulsions have a different number of internal aqueous drops in the oil drop. Hydrophobic SiO_2 nanoparticles, suspended in the oil phase, and poly vinyl alcohol (PVA), dissolved in the continuous aqueous phase, stabilize the double emulsions. The nanoparticles in the oil phase eventually become the shell of colloidosomes upon the removal of the oil. During the oil removal, the internal W/O interface retains their spherical shapes whereas the outer O/W interface deforms; this process leads to the generation of nonspherical colloidosomes with multiple compartments.

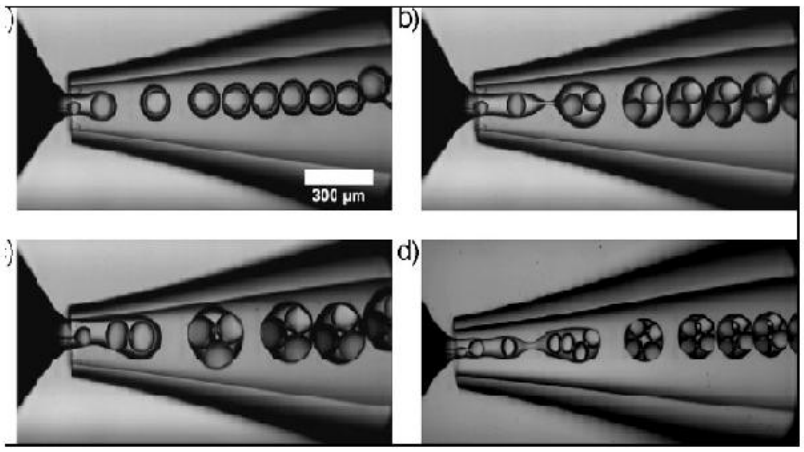


Fig: 8 Generation of double emulsion with varying no .of internal drops

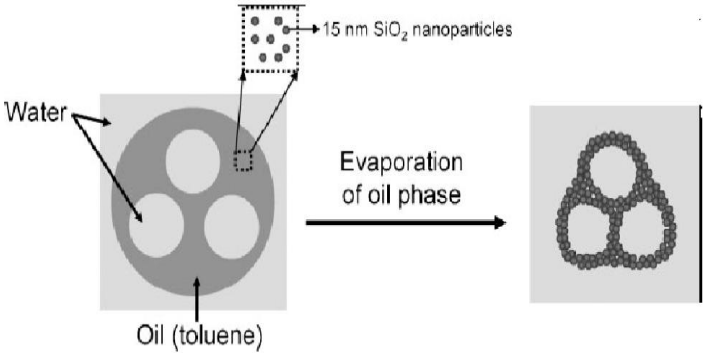


Fig: 9 Generation of nonspherical colloidosome from W/O/W double emulsions with multiple internal aqueous drops. Oil phase comprises toluene and 15-nm hydrophobic silica nanoparticles.

FACTORS AFFECTING COLLOIDOSOMES FORMATION

Several factors that might be expected to affect the formation of stable colloidosomes.

Particle size

System consisting of a mixture of small and large spherical colloidal particles with opposite electrical charges. Small particles will be attracted to the surface of large particle due to electrostatic attraction. When concentration of small particles is insufficient to saturate the surface of one large particle, which tends to occur "bridging flocculation''. When concentration small particles exceeds some critical volume, that may generate a sufficiently high depletion attraction between the colloidosomes to promote their flocculation.

.Critical Saturation Concentration

Simple geometric consideration can be used to calculate the volume fraction of small mono disperses and in compressible particles required to saturate the surface of a single layer of particles. [18]

Critical depletion concentration:

Once surfaces of the large particles have become completely saturated with small particles, then any additional small particles added to the system will remain free in the continuous phase, therefore they will generate a depletion attraction between the large particles if this depletion attraction is strong enough to overcome any repulsion interaction, then the large particles will tends to flocculated[19].
The small particles added to the system are adsorbed to the surface of the large particles, and then the overall concentration of small particles required promoting depletion flocculation.

Critical adsorption concentration

Critical adsorption concentration is the another important factor that influences the stability of colloidosomes against aggregation during formation is the time taken for the surface of the large particle to be saturated with small particle relative to the time i.e. surface to be 90% saturated with spherical particles, known as characteristic "adsorption time ".Dominant mechanism for collisions of large particles, known as "**Brownian motion**"[20]. We would expect the adsorption time to be faster than collision time between large particles and therefore little aggregation to occurs. Hence critical adsorption will increase as concentration of large particles (ØL) increases.

Effect of co solvents

Co solvent (ethanol) introduced into the colloidal suspension, to improve the packing of colloidal particles at water – oil interface. Ethanol induces colloidal particle aggregation and coalescence[21] due to plasticization by ethanol.[22] Critical ethanol concentration is found to be around 25 wt % for a 11.25wt % colloidal suspension.

Effect of surfactants

Surfactant is efficient to produce high yield of colloidosomes. For the better drive of the particles to the edge of the water droplets, surfactant is added to oil phase prior to introducing the colloidal suspension. Surfactant can limit the potential application of the colloidosomes. Non ionic surfactant with a hydrophobic tail and a polar head, which can stabilize water –oil droplets .Cationic surfactant could also have been appropriate, since the colloidal particles are negatively charged.

Effect of sintering time

Sintering time greatly affects the stability of the colloidosomes. By increasing the sintering time, the stability of the shell will be significantly higher, which yields higher colloidosomes.

Effect of electrolyte

The presence of an electrolyte in a particle – stabilized emulsion can induce particle aggregation at the water-oil interface and the resulting can remain stable.

Effect of volume fraction of water

With increase in the volume fraction of water, the shape and stability of colloidosomes altered.[23]Volume of fraction of water ø'=0.1 produced an emulsion template of higher stability.

CHARACTERIZATION OF COLLOIDOSOMES

The characterization of colloidosomes including particle size measurement, zeta potential measurement, gravitational separation, small droplet concentration, optical microscopy, surface area are as follows:

Particle size analysis:

The particle size distribution of the emulsions is measured using a laser diffraction particle size

analyzer. This instrument measures the angular dependence of the intensity of light scattered from a stirred dilute emulsion. To avoid multiple scattering effects the emulsions were diluted with buffer prior to making the light-scattering measurements. The emulsions were stirred continuously throughout the measurements to ensure the samples were homogenous. Dilution and stirring are likely to disrupt any flocculated droplets or break up any free oil into droplets, hence particle size data on highly flocculated or coalesced samples should be treated with caution. A refractive index ratio of 1.08 is used by the instrument to calculate the particle size distributions. The size of the latex particles was measured by dynamic light scattering and by differential scanning calorimetry.

Zeta potential measurements

Emulsions are diluted using a buffer solution prior to analysis to avoid multiple scattering effects. Diluted emulsions are injected directly into the measurement chamber of a particle electrophoresis instrument. The zeta (ζ) - potential was then determined by measuring the direction and velocity of droplet movement in a well-defined electric field. The zeta potential measurements are reported as the mean and standard deviation of two separate injections, with five readings made per injection. The zeta potential measurements are used to monitor the adsorption of colloidal molecules onto the surfaces of large emulsion-coated droplet.

Gravitational separation

Emulsions is poured into glass tubes (100 mm height, 16 mm internal diameter), covered and stored at room temperature for 24 h before the heights of any separated layers were measured manually using a ruler. Different kinds of layers are observed depending on emulsion type, e.g., a clear oil layer at the top, an opaque emulsion layer in the middle and/or a transparent serum layer at the bottom. The serum layer to be the sum of the turbid and transparent layers. The total height of the emulsion (HE) and the height of the serum layer (HS) are measured. The extent of creaming is characterized by a creaming index =100X (HS/HE). The creaming index provided indirect information about the extent of droplet aggregation in an emulsion.

Free small droplet concentration

The concentration of small droplets that is not adsorbing to the surfaces of the large droplets is determined by using a gravitational separation and turbidity method. The composite emulsions is allowed to stand at room temperature for 24 h, which meant that any large droplets creamed to the surface while the small droplets remained in the lower layer. A sample of the lower phase containing the free small droplets was then collected and the turbidity measured.

Optical microscopy

The microstructure of selected emulsions is determined using optical microscopy. Emulsions were gently agitated in a glass test tube before analysis to ensure that they were homogeneous. A drop of emulsion was then placed on a microscope slide, covered by a cover-slip and observed at a magnification of 40X using an optical microscope.

APPLICATIONS OF COLLOIDOSOMES

Colloidosomes have widely used as encapsulating agent with endless application in biomedical, pharmaceutical and cosmetic industries with strong interest in encapsulation and controlled release in the field of drug delivery, cosmetic delivery, food delivery, LCD display devices, polymer blends, paints, catalytic material or even living cells. The functional biopolymers (colloidal particles) can

further act as a targeting agent, wherein the functional biopolymer acts to direct the colloidosomes to a desired location. Accordingly, the resulting colloidosomes can provide an integrated mechanism for targeted delivery of the colloidosomes and potentiates controlled release of the encapsulated material, and biocompatibility with the subject. Colloidosome is prepared in the expanded gel state. By entraining the drug in the particle core and permits the drug release by particle expansion upon cooling. A similar effect may be achieved by altering the pH. It exhibited 80% decrease in volume when actuated; thus, they can be of immense potential in applications that require targeted pulsed-release of active materials. Colloidosomes may be used for following range of therapeutic and pharmaceutical applications:[24]

- Colloidosomes as drug/protein delivery carrier
- Colloidosomes for controlled and sustained drug release
- Colloidosomes for enhanced drug solubilization
- Colloidosomes for altered pharmacokinetics and biodistribution
- Colloidosomes in tumor therapy
- Colloidosomes in antimicrobial, antifungal, antiviral therapy
- Colloidosomes in cosmetics and dermatology
- Colloidosomes in ocular drug delivery
- Colloidosomes in brain delivery
- Colloidosomes in DNA delivery
- Colloidosomes in enzyme immobilization

CONCLUSION

Colloidosomes that consist of large droplets surrounded by a layer of small droplets can be produced by mixing coarse and fine emulsions that containing oppositely charged droplets together. The capsules are fabricated by the self- assembly of colloidal particles onto the interface of emulsion droplets. After the particles are locked together to form elastic to elastic shells, the emulsion droplets are transferred to a fresh continuous phase fluid that is the same as that inside the droplets. The resultant structures are called colloidosomes are hollow, elastic shells whose permeability and elasticity can be precisely controlled. It has wide range of applications in products that are consumed by humans, ex- beverages, food, pharmaceuticals, flavors, fragrances, cosmetics industries. It may be possible to reduce their susceptibility to gravitational separation to control their stability to environmental stresses, to develop novel controlled or triggered release system, to compartmentalize active agents or to control certain chemical reactions. The choice of different colloidal particles allows for additional flexibility. A variety of release strategies may be feasible, either through control of their permeability for slow but sustained release, or through control of their rupture stress for shear-induced breakup. This flexibility will allow a wide range of potential applications to be explored.

REFERANCE

1. Rawat, M. and S. Saraf,. Liposphere: Emerging carriers in the delivery of proteins and peptides. Int. J. Pharm. Sci. Nanotechnol., 1: 207-214, 2008.
2. Chanchal, D. and S. Swarnlata, Novel approaches in herbal cosmetics. J. Cosmet. Dermatol. 7: 89-95, 2008.
3. Elsayed, M.M.A., O.Y. Abdullah, V.F. Nagar and N.M. Khalafallah, Deformable liposome and ethosome: Mechanism of

enhanced skin delivery. Int. J. Pharm., 322: 60-66, 2006.
4. Biju, S.S., S. Talegaonkar, P.R. Mishra and R.K. Khar, Vesicular system: An overview. Ind. J. Pharm. Sci., 68: 141-153, 2006.
5. Ofoegbu, O.,. Force measurements on nanorods-enriched sintered colloidosomes. Gordon Mckay Laboratories: Harvard University Summer, pp: 2-9 . http://eduprograms.seas.harvard.edu/reu03_papers/Ofoegbu.O.FinReport03.pdf, 2003.
6. Paul F. Noble, Olivier J. Cayre, Rossitza G. Alargova, Orlin D. Velev, and Vesselin N. Paunov,Fabrication of "Hairy" Colloidosomes with Shells of Polymeric Microrods. *Chemical Engineering, North Carolina State University, Raleigh, North Carolina 27695-7905.* , 2004
7. Dinsmore, A.D., M.F. Hsu, M.G. Nikolaides, M. Marquez, A.R. Bausch and D.A. Weitz, 2002. Colloidosomes: Selectively permeable capsules composed of colloidal particles. Science, 298: 1006-1009, 2002.
8. Laib, S. and A.F. Routh, 2008. Fabrication of colloidosomes at low temperature for the encapsulation of thermally sensitive compounds. J. Colloid Interface. Sci., 317: 121-129, 2008.
9. *Angew. Chem. Int. Ed.,* Vol. 46, pp. 1819-1822 (2007) and Utada et al., *Science,* Vol. 308, pp. 537-541 (2005).
10. Gibbs, B.F., S. Kermasha, I. Alli and C.N. Mulligan, 1999. Encapsulation in the food industry: A review. Int. J. Food Sci. Nutr, 50: 213-224, 1999.
11. Cayre, O.J., P.F. Noble and V.N. Paunov, Fabrication of novel colloidosome microcapsules with gelled aqueous cores. J. Mater. Chem., 14: 3351-3355, 2004.
12. Velev, O.D., K. Furusawa and K. Nagayama, 1996. Assembly of latex particles by using emulsion droplets as templates. 1. Microstructured hollow spheres. Langmuir, 12: 2374-2384, 1997.
13. Ashby, N.P., B.P. Binks and V.N. Paunov, Bridging interaction between a water drop stabilized by solid particles and a planar oil/water interface. Chem. Comm., 21: 436-437, 2004.
14. Lee, D. and D.A. Weitz, Double emulsion-templated nanoparticle colloidosomes with selective permeability. Adv. Mater., 20: 3498-3503, 2008.
15. Olivier J. Cayre, Paul F. Noble and Vaseline N. Paunov Fabrication of novel colloid some microcapsules with gelled aqueous coresJ. Ma t e r. C h em. , 2 0 0 4, 1 4, 3 3 5 1 – 33.
16. Dayton Lee and David A.Weitz, double emulsion – templated nano particle colloidosomes with selective permeability .Indian science 2008, 20,3498-3503.
17. Caruso et al., Langmuir,. Layer-by-Layer (LbL) Encapsulation .16 (2000) 1485.
18. Yates, P.D., G.V. Franks, S. Biggs and G.J. Jameson, Heteroaggregation with nanoparticles: Effect of particle size ratio on optimum particle dose. Colloids Surf. A: Physicochem. Eng. Aspects, 255: 85-90, 2005.
19. McClements, D.J., Food Emulsions: Principles, Practice and Techniques. 2nd Edn. CRC Press, USA. pp: 632, 2000.
20. Walstra, P., Physical Chemistry of Foods. 1st Edn. Marcel Decker, New York, 2003.
21. Laib, S. and A.F. Routh,. Fabrication of colloidosomes at low temperature for the encapsulation of thermally sensitive compounds. J. Colloid Interface. Sci., 317: 121-129, 2008
22. Gu, Y.S., E.A. Decker and D.J. McClements, Formation of colloidosomes by adsorption of small charged oil droplets onto the surface of large oppositely charged oil droplets. Food Hydrocolloids, 21: 516-526, 2007.
23. Liu, H., C. Wang, Q. Gao, X. Liu and Z. Tong, Fabrication of novel core-shell hybrid

alginate hydro gel beads. Int. J. Pharm., 351: 104-112, 2008.
24. Vyas, S.P. and R.K. Khar, 2002. Targeted and Controlled Drug Delivery- Novel Carrier Systems. 1st Edn. CBS Publisher, New Delhi.

*Address for the Correspondence:
R.PARTHIBARAJAN, M.Pharm.,
Department of Phrmaceutics,
Swami Vivekananda Institute of pharmaceutical Sciences,
Vangapally(P)
Yadagirigutta(M)
Nalkonda(D)
E.mail: parthi_pharma@yahoo.co.in