

## MICROENCAPSULATION

Arnab Ghosh\*

India.

\*Corresponding Author: Arnab Ghosh

India.

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## ABSTRACT

Microencapsulation is a technique in which a substance is adjoining with another substance for the means of stabilizing the product, increasing the efficacy of the product, prolonging and delaying the action of the product. Depending on their core material (liquid, solid, dispersion) Microencapsulation techniques are varied. Concentration of coating material and solubility of coating material are maintaining the efficiency of encapsulation. The encapsulated products size varied in range 1 micron to 5000 microns. In modern days Microencapsulated product helps in target oriented drug therapy, food industry, agriculture, defence and so many vital places for solving humans problem areas. This article is about Microencapsulation techniques, fundamental consideration, recent developed techniques and its various applications and about some future thought of this technique.

**KEYWORD:** Microencapsulation, methodology, application.

## INTRODUCTION

Microencapsulation is a technique for applying relatively thin coating to particles of solids or droplets of liquids and dispersion. The term microencapsulation, in this work, encompasses the terms microcapsules, micro particles, microspheres, and microemulsions. Generally, the term microsphere is employed for a homogeneous structure made of one continuous phase, and the term

microcapsule is used for a reservoir-like structure with a well-defined core and envelope/coat.<sup>[1]</sup>

In that technique microencapsulation is done the particles which are ranging 1 micron to 5000 micron. The uniqueness of Microencapsulation is the smallness of the coated particles and their subsequent use and adaption to a wide variety of dosage forms and product application.

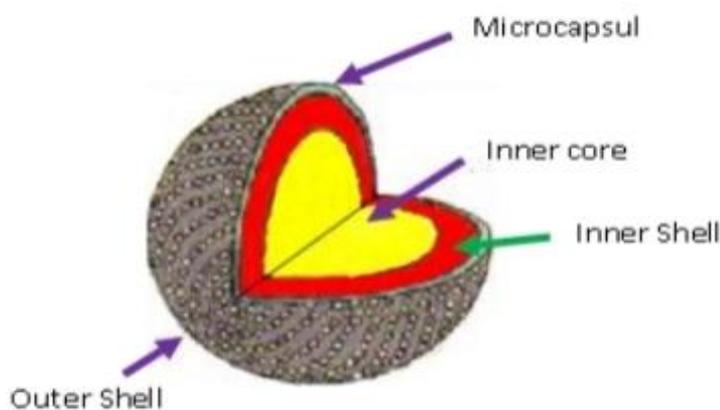
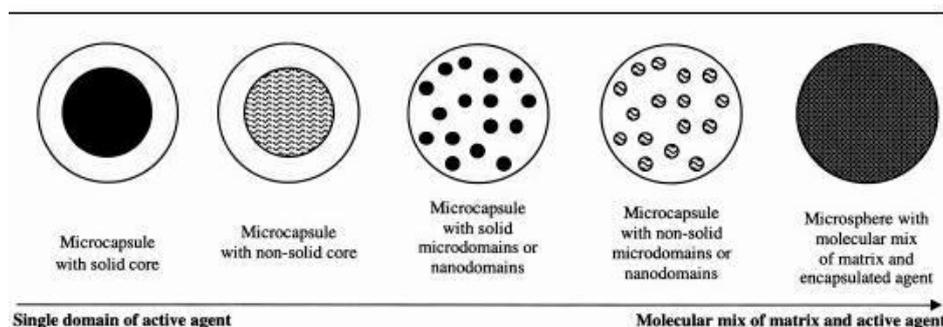


Figure 1: Structure of microcapsule.<sup>[2]</sup>

Microencapsulation is receiving considerable attention fundamentally, develop mentally, and commercially. This technology does not exclude problem, areas for instance, no single Microencapsulation process is adaptable to all core material candidates or product application. Difficulties, such as incomplete or

discontinuous coating, inadequate stability or shelf life of sensitive pharmaceutical, nonreproducible and unstable release characteristics of coated product and economic limitations are often encountered in the attempt to apply a particular Microencapsulation method to a specific task.



**Figure 2: Different structure of microspheres and microcapsules.**

It is typically assumed that a formulation represented as a microsphere is comprised of a fairly homogeneous mixture of polymer and active agent, whereas microcapsules have at least one discrete domain of active agent and sometimes more. Various microcapsules are shown in fig 2. Microcapsules becomes microparticles when the domain and subdomain of the microcapsules become progressively smaller.<sup>[6-8]</sup>

Microcapsules is outlined as a spherical particles that size is varied 50nm to 2nm containing a core substance .Microspheres are in strict sense, spherically empty particles. However, the terms microcapsules and microspheres are typically used synonymously. Because of engaging properties and wider applications of microcapsules and microspheres, a survey of the applications in controlled drug release formulations is appropriate.<sup>[6,9,10]</sup> “microspheres” specifically refers to spherical microparticles and therefore the subcategory of “micro-capsules” applies to microparticles that have a core enclosed by a material which is distinctly different from that of the core. The core is also solid, liquid, or even gas.<sup>[11]</sup>

Microencapsulation is completed for varied aspects like sustained or prolonged drug release, odour and taste

masking, changing liquid drug in a free flowing powder. Vaporization of the volatile drug (methyl salicylate, peppermint oil can be prevented by Microencapsulation), Bakan and Anderson reported that microencapsulated vitamin A palmitate had increased stability<sup>(3-4)</sup>, oxidation of vitamin c also can be stopped by Microencapsulation.<sup>[5,12]</sup>

**Formulation consideration:** The method of Microencapsulation involves several basic understanding of the overall properties of microcapsules just like the property of core and coating material, the stability and release characteristics of the coated material, and the Microencapsulation method.

**Core material:** core materials are the particular material that is to be coated. It is liquid or solid in nature. The liquid core can include dispersed and /or dissolve material whereas solid core is a mix of active constituent, stabilizer, diluents, excipients, and release rate retardant or accelerator. Various core material composition give definite flexibility and utilization of this characteristic typically permits design and development of the required microcapsules properties.<sup>[13]</sup>

**Table 1: Various types of core material.**

Core material	Characteristic property	Purpose of encapsulation	Final product form
Acetaminophen	Slightly water -soluble solid	Taste – masking	Tablet
Activated charcoal	Absorbent	Selective sorption	Dry powder
Aspirin	Slightly water soluble solid	Taste – masking , sustained release , reduce gastric irritation, separation of incompatibles	Tablet or capsule
Islet of Langerhans	Viable cells	Sustained normalization of diabetic condition	Injectable
Isosorbide dinitrate	Water soluble solid	Sustained release	Capsule
Menthol / Methyl salicylate camphor mixture	Volatile solution	Reduction of volatility, sustained release	Lotion
Potassium chloride	Highly water soluble solid	Reduce gastric irritation	Capsule
Vitamin A palmitate	Non-volatile liquid	Stabilize oxidation	Dry powder

**Coating material:** The choice of the suitable coating material dictates to a significant degree its results physical and chemical properties of the microcapsules. This material ought to be capable of forming a film that’s

cohesive with the core material. The coating material utilized in Microencapsulation process are easy and controlled, to some extent to in situ modification. As we can see colorant could also be added to achieve product

elegance or masking, or coating could also be plasticized or chemically altered through cross – linking, for an example, to achieve controlled dissolution or permeability.<sup>[9,14,15-17]</sup>

Generally hydrophilic polymers, hydro-phobic polymers or a mixture of each are used for the microencapsulation

process. The film thickness varied reckoning on the surface area of the material to be coated and different physical characteristics of the system. After isolating the microcapsules from liquid manufacturing vehicle and drying the material appears as a free flowing powder.<sup>[18,20]</sup>

**Table 2: Types of coating material.**

Water soluble resin	Water insoluble resin	Waxes and lipids	Enteric resins
Gelatin, Gum arabic, starch, polyvinylpyrrolidone, carboxymethylcellulose, Hydroxyethylcellulose, Methylcellulose, Arabinogalactan, polyvinyl alcohol, polyacrylic acid	Ethyl cellulose, polyethylene, polymethacrylate, Polyamide, poly, cellulose nitrate, silicone, poly	Paraffin, carnauba, spermaceti, Beewax, stearic acid, stearyl alcohol, Glyceryl stearates	Shellac, cellulose acetate phthalates, zein

**Methodology:** Various types of modern and old technologies are there for Microencapsulation. Processing depends on particles size and core material.

**Table 3: Microencapsulation process and their applicabilities.**

Microencapsulation process	Applicable core material	Approximate particle size (micron)
Air suspension	Solid	35-5000
Coacervation phase- separation	Solid and liquid	2-5000
Multiorifice centrifugation	Solid and liquid	1-5000
Pan coating	Solid	600-5000
Solvent evaporation	Solid and liquid	5-5000
Spray drying	Solid and liquid	600

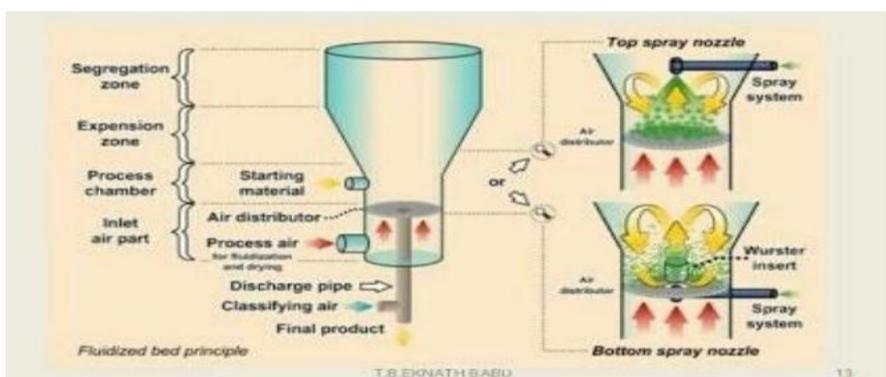
**Air suspension:** This method conjointly named as wurster method for its inventor Dale E. Wurster. This method essentially consists of the dispersing of solid, particulate core material during a supporting air stream and therefore the spray coating of the air suspended particles. The process involves inserting of solid, non volatile cores, within the bottom portion of the Fluid Bed Coater, bigger than 50 µm is size. The coating solution is sprayed and a non-turbulent, high rate stream of air is introduced up-stream that fluidizes the solid cores and carries them upwards. Most of the rising air (usually heated) flows within the cylinder, causing the particles to rise quickly.

coating material this process is repeated and cyclic process. Many hundred times throughout this process, reckoning on the aim of Microencapsulation the coating thickness is desired, or whether the core material particles are thoroughly encapsulated.

Some consideration might follow like density, surface area crystallinity and flowability of the core material. Coating material concentration. Coating material concentration and coating material application rate even be followed. Volume of air needed to support and fluidized the core material. Inlet and outlet operating temperature also be looked.

Then core material travel upward they mixed with coating material. Throughout every and each meet up with coating zone the core receives an increment of

By this method coating within the type of solvent solution aqueous solution, emulsion, dispersion.



**Figure 2: Air suspension process.**

Or hot melts in instrumentation move in capacities from 1 pound to 9990 pounds.

This method is convenient for solid core material encapsulation. Few cases liquids are often encapsulated by this method. with regards to particle size the air suspension technique is applicable for each Microencapsulation and macroencapsulation coating processes.<sup>[21-26]</sup>

**Multiorifice-centrifugal:** The southwest research institute has developed a mechanical process for manufacturing microcapsules that utilizes centrifugal forces to hurl a core material particle through an enveloping Microencapsulation membrane.

In this method liquid and solid (in solids, this solids are encapsulated that are dispersed in liquid). This method will procedure over 50 to 75 pounds of encapsulated products in an hour. The encapsulated product often provided as a suspension (slurry) within the hardening media or a dry powder.

In this method, a jet of core liquid is encircled by a sheath of wall solution or melt. Because the jet moves through the air it breaks, attributed to Rayleigh instability, into droplets of core, every coated with the wall solution. Since most of the droplets are within  $\pm 10\%$  of the mean diameter, they land in a very slim ring around the spray nozzle. Hence, if needed, the capsules are often hardened when formation by catching them in a ring-shaped hardening bath. This method is superb for forming particles 400-2000um(16-79mils) in diameter. Since the drops are fashioned by breakup of a liquid jet. This method is just appropriate for liquid or suspension (slurry) . A high production rate can be achieved, i.e., up to 22.5 kg (50 lb) of microcapsules are often produced per nozzle per hour per head.

Processing thought of this method

- A. Rotational speed of the cylinder
- B. The rate of flow of core and coating material
- C. Viscosity and surface tension of the core material<sup>[27,28]</sup>

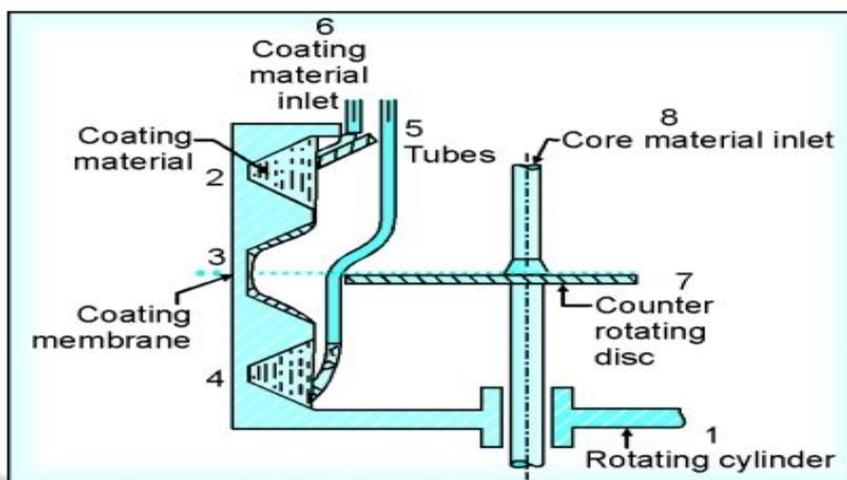


Figure 3: Multiorifice – centrifugal process.

**Spray Drying:** Spray drying methods have been used for several years as Microencapsulation technique. The principal of the spray drying is coating solidification, coating solidification in spray drying is accomplished by rapid evaporation of a solvent during which the coating material is dissolved.

Microencapsulation by Spray drying done by dispersing a core material in an exceedingly coating solution, in which the coating substance is dissolved and in which the core material is remain insoluble , and so, by atomizing the mixture into an air stream. The air heated provides the heat energy vaporization required to get rid of the solvent from the coating material, and form microencapsulated product.

The instrumentation which are principally used for spray drying is air heater, atomizer, main spray chamber, blower or fan, cyclone and product collector.

Process fundamentals are viscosity, uniformity and concentration of core and coating material, feed rate, technique of atomization , and also the drying rate which might be controlled by the inlet and outlet temperature and also air stream solvent concentration.

In this method microcapsules approached within the size vary of 5 to 600 micron in an exceedingly spherical structure. Several coating material will be applied to liquid and solid core material by spray drying coating solution containing the dispersed core material.

This method is for Microencapsulation of free flowing powder and liquid flavour yielding dry to be used for food and pharmaceuticals.<sup>[29-31]</sup>



Figure 4: spray drying machine.

**Pan coating:** This is often associate wide used method in pharmaceutical industry for encapsulation. Solid particles larger than 600 microns are in size are usually considered as essential for effective coating. This methodology is employed to prepare of controlled

release beads. Medicine drug are typically coated onto numerous spherical substrates like nonpareil sugar seeds, and then coated with protecting layers of various polymers.

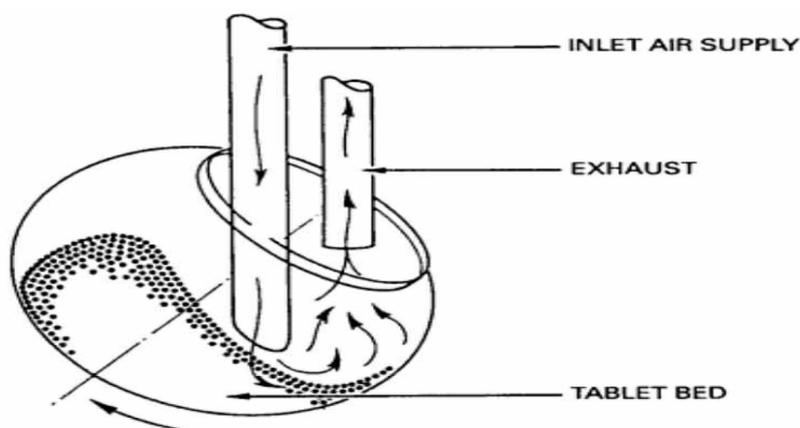


Figure 5: Pan coating.

Basically, the coating is applied as a solution, or as an atomized spray, to the desired solid core material within the coating pan , Heat air is passed over the coated materials to get rid of the coating solvent because the coating are being applied within the coating pans.<sup>[32-34]</sup>

Some limitations are improper maintenance between inlet and exhaust air can cause dust and solvents to leak into general Coating area, produce hazard. The mixing efficiency can be poor with several dead spots existing among the bed of product being coated.

**Coacervation – phase separation:** This methodology is attributed to the National Cash Register(NCR) corporation and the patent B.K. Green et al.

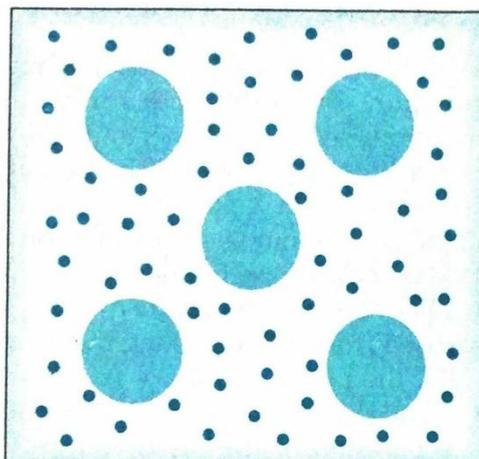
Coacervation is a colloid phenomenon. If one starts with a solution of a colloid in an appropriate solvent, then

according to the nature Of the colloid, numerous changes can bring about a reduction of the solubility of the colloid. Resulting of this reduction a bigger part of the colloid may be separated out into a new phase. The original one phase system divided into two phases. One is rich and another is Poor in colloid concentration. The colloid-rich phase in a dispersed state appears as amorphous liquid droplets called coacervate Droplets.

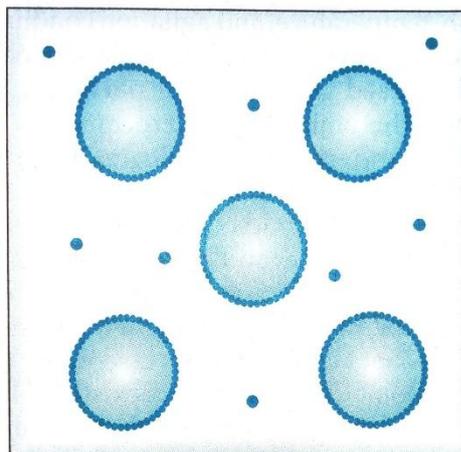
Coacervation is induced in various techniques like Temperature change , incompatible polymer addition, non solvent addition, salt addition,

This method have three steps like

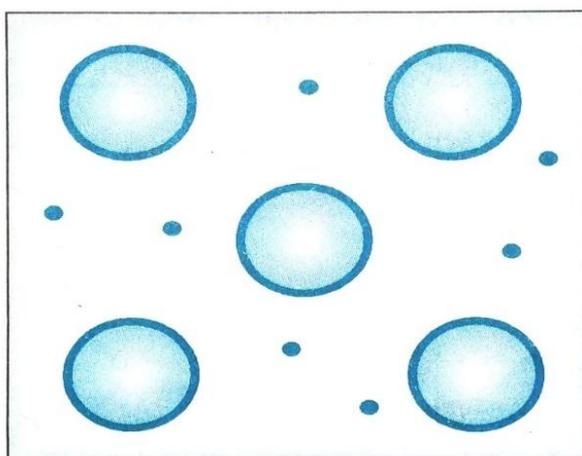
1. Step 1: Formation of 3 immiscible chemical phases
2. Step 2: Deposition of the coating
3. Step 3: Rigidization of the coating



Step 1: core and liquid coating in manufacturing.  
Figure 6(A).



Step 2: Deposition of liquid coating material  
Figure 6(B)



Step 3: completed capsule in manufacturing vehicle  
Figure 6(C)  
Figure: 6(A), 6(B), 6(C) Steps for Microencapsulation.

**Step 1:** Formation of three immiscible chemical phases like a core material phase, a coating material phase, and a liquid manufacturing vehicle phase. To organize these phases core material is dispersed in a solution of coating polymer. The solvent for the polymer is that the liquid manufacturing vehicle phase. By utilizing one of the method of phase separation – coacervation coating material phase is formed.

**Step 2:** Deposition of the coating is that the step of depositing the liquid polymer coating upon the core material. It is done by controlled, physical mixture of the coating material and also the core material in the processing vehicle. If the polymer is absorbed at the interface formed between the core material and the liquid vehicle phase deposition of the liquid polymer coating around the core material happens.

**Step 3:** The rigidizing of the coating is particularly involved in thermal, cross linking, or desolvation technique. And makes a self supporting microcapsules.<sup>[35-36]</sup>

There have some techniques of coacervation process,

**1. By thermal change:** In this phase separation is occurs when dissolved polymer form immiscible liquid droplets by change in temperature. Once the temperature lower one phase becomes polymer poor (vehicle phase) and another phase becomes polymer rich (coating material phase). At this stage if a core material is remain under Proper agitation condition, the liquid polymer droplets coalesce around the dispersed core Particles and form the embryonic microcapsules.<sup>[21]</sup>

**Example:** core material: Ascorbic acid, coating material: Ethyl cellulose, core and coating ratio: 2:1  
Solvent: cyclohexane, phase separation technique: thermal change.

At high temperature ethyl cellulose dissolved on cyclohexane, then when temperature decrease dissolved ethyl cellulose separate out and deposited in core material.

**2. By incompatible polymer addition:** This method is done by addition of incompatible polymer to the existing solution of polymer. At a certain concentration

of polymer, dissolved form of polymer get separated out from of liquid polymer droplet. And encapsulation occurred.<sup>[21]</sup>

**Example:** core material: methyl blue HCL, coating material: Ethyl cellulose, solvent: Toluene, phase separation technique: By addition of incompatible polymer polybutadiene. (It is incompatible with Ethyl cellulose)

**3. By non-solvent addition:** In this type of phase separation is done by Liquid addition which is non solvent in given polymer. The resulting liquid polymer which is immiscible effect on Microencapsulation of an immiscible core material<sup>(21)</sup>

**Example:** Core Material: Methylscopolamine, Coating material: Cellulose acetate butyrate, solvent: Methyl Ethyl ketone, core and coating ratio: 2:1,

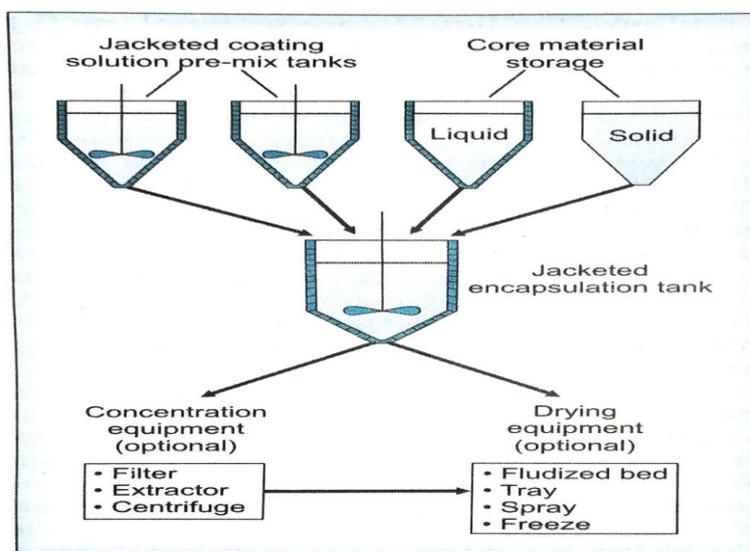
**4. By Salt addition:** To the aqueous solution of certain water soluble polymers, soluble inorganic salts are added to cause phase separation.<sup>[21]</sup>

**Example:** Core material: Vitamin A , coating material: Gelatin, solvent: Water and oil, Phase separation: Adding 20% solution of sodium sulfate.

**5. By polymer- polymer interaction:** In this process phase separation is done by interaction of oppositely charge poly electrolyte this result form a complex which have low solubility in solvent. It involves neutralization of charges on the colloid and depends primarily on pH of the solution.<sup>[21]</sup> It has 5 steps:

1. Preparation of hydrophilic colloid solution
2. Addition of second hydrophilic colloid solution of opposite charge to induce coacervation at a particular pH
3. Deposition pf polymeric complex around the drug particles.
4. Gelation of coacervate
5. Hardening of microcapsules

**Example:** Core material: Methylsaliysalate, Coating material: Acacia and Gelatin (2% each. pH- 4.5) Solvent: water. Phase separation: By complex formation



**Figure 7: Typical phase – separation / coacervation process.**

**Solvent evaporation:** The method is executed in a liquid manufacturing vehicle. The coating of microcapsules is dissolved in a very volatile solvent that's incompatible with the liquid manufacturing vehicle part. A core material to be microencapsulated is dissolved or dispersed in coating polymer solution. With agitation, the core coating material mixture is spread among the liquid manufacturing vehicle part to induce the suitable size microcapsules. For evaporation of the solvent for the polymer the mixture is heated.

In some cases wherever core material is spread among the polymer solution, polymer shrinks around the core. And in some cases wherever core material is dissolved within the coating polymer solution, microcapsules shaped as Matrix kind. Once all the solvent for polymer evaporated reduced the liquid vehicle temperature to ambient temperature with continuing agitation.

Throughout this stage the microcapsules could also be utilized in suspension form, coated on to substrates or isolated powder.

Process variation are evaporation rate of the solvent for the coating polymer, temperature cycle, and agitation rates.

Important factors are vehicle part and solvent for the polymer coating because these choices highly influenced microcapsule properties.

This technique used wide for various of liquid and solid core Materials. And these core Materials is either water soluble or water insoluble material.<sup>[37-39]</sup>

**Polymerization:** During this variety of Microencapsulation method used to form protecting microcapsules coating in situ. The method involves the

reaction of monomeric units located at the interface existing between continuous phase in which the core material is dispersed and a core material substance. The continuous or core material supporting part is sometimes a liquid or gas and for that polymerization happens at a liquid-liquid, liquid-gas, solid-liquid, or solid-gas interface.

**1. In-situ polymerization:** During this kind, direct polymerization of a single monomer is carried out on the particle surface. As in polyethylene while cellulose fibre is encapsulated immersed in dry Toluene. Usual deposition rates regarding 0.5µm/min. Coating thickness ranges 0.2-75µm. The coating is uniform, even over sharp projections.<sup>[40]</sup>

**2. Interfacial polymer:** During this method, the most elementary is that the classical schotten Baumann reaction, between an acid chloride and a compound contains an active hydrogen atom, like an amine or alcohol, polyesters, polyurea, polyurethane. Thin flexible wall form at right condition at interface. A solution of diacid chloride and pesticides are emulsifying in water and a aqueous solution which contained an amine and a polyfunctional isocyanate added. To neutralize the acid base is present during this reaction. Instantaneously condensed polymer wall form at the interface of the emulsion droplet.<sup>[41]</sup>

**3. Matrix polymer:** A core material is imbedded in a very polymeric matrix throughout formation of the particles. An easy technique of this kind is spray-drying, During which the particle is made by evaporation of the solvent from the matrix material. However, the solidifying of the matrix can also be caused by a chemical action.<sup>[42]</sup>

**Recent advances in Microencapsulation process:**

Some new advances of Microencapsulation processes are

**1. Fluidized bed spray coating:** Core particles Microencapsulation will be fluidized by a gas mat be accomplished by spraying a coating agent throughout the surface of the particles. By congealing of a molten material wall is made. Then by evaporation of a solvent or chemical reactions of the surface they create a coating solution. Then the solvent is removed and coating thickness simply maintained by quantity of wall Material applied.<sup>[43]</sup>

In the encapsulation of solid particles fluidized bed spray coating is employed. And if the liquids will be frozen in particulate form then liquid may even be encapsulated, and which is coated at a temperature that is below their freezing point.

Fluidized bed spray technique employed in slow release fertilizer, coating of iron particles, Seeds, salts, clays

**2. De – agglomerating jet spray coating:** For satisfying the necessity of particular problem number of modification of conventional fluidized bed Microencapsulation are developed. De-agglomerating jet unit Was created to coat core particles of little size that tend to Agglomerate in a conventional fluidized bed, by application Of a speed burners (high velocity gas jet) and a conical conduit in a fluidized Bed to de-agglomerate

the partly coated particles before Additional coating material is applied from the coating spray Nozzle.<sup>[43]</sup>

The solid particles that are down within the size vary 10\_g are encapsulated during this technique. Liquid core material doesn't encapsulated during this method or the solid particles that are larger than 300-gm in size.

Inorganic salts, pigment plastics, resin catalyst are encapsulated in this method.

**3. Melt prilling fluidized bed:** During this technique wall Material must have to be solid particle type because it will fluidized by gas. The core material is Heated and is within liquid form for atomizing from a nozzle to Yield droplets of the appropriate size. The droplets of core Material fall into the fluidized bed and are continuously Cooled and coated with the wall material particles. The heat generated from the core droplets is transferred to the wall Material particles caused them to melt or soften, adhere to the core Surface, and flow along to create a coherent capsule wall Structure. A mixture of capsules and bed material is removed From the fluidizing column in and also the capsules are separated by Screening. The excess bed material is returned to the system The method has been created continuous by providing Continuous capsule removal and bed material make-up.

Liquid and solid each are encapsulated during this methodology.

Slow release glycerine capsule, and biologically active encapsulated product are created during this method.<sup>[43]</sup>

**4. Using ultrasonic atomizer based on interfacial solvent exchange:** During this technique reservoir-type microcapsules are occurred employing a twin micro dispenser system that is involved two ink jet nozzles. Series of drops of polymer solution and aqueous Drug solution are separately produced using ink-jet nozzles, And then they are induced to collide within the air. Followed the collision the two liquid phases are separated as a core and a membrane within the merged micro-drops because of the surface tension difference of the two liquids.

Its shows successful utilization of Microencapsulation of therapeutic protein.<sup>[44]</sup>

**Mechanism and kinetics of drug release:** Primarily drugs release of Microcapsules include diffusion, dissolution, osmosis, etc.

**1. Diffusion:** During this method dissolution fluid penetrate the shell, dissolved the core and leaked out through the interstitial channel and pores. And also the overall release depends on the rate of dissolution fluid that penetrate the wall of microcapsules, the rate at that the drug dissolved within the dissolution fluid, the rate at which the dissolved drug leak out and disperse from the surface. The mechanism of such release followed by the Higuchi's equation, that is  $Q = [D/J (2A - \epsilon CS) CS t]^{1/2}$ . Where the letter Q is presented as the total quantity of the drug release per unit area of exposed surface in time, the letter D is presented as the diffusion coefficient of the solute within the solution; The letter A is presented as the total quantity of drug per unit volume; CS is

presented the solubility of drug in permeating dissolution fluid;  $\epsilon$  is that the porosity of the wall of microcapsule;  $J$  is that the tortuosity of the capillary system in the wall. The above equation can be simplified to  $Q = vt$  where,  $v$  is that the apparent release rate.<sup>[14,74-78]</sup>

**2. Dissolution:** Polymer coat dissolution rate determines the discharge of the drug from microcapsules once the coat is soluble within dissolution fluid. Thickness of the coat and its solubility in the dissolution fluid influence the discharge rate of the drug.<sup>[79]</sup>

**3. Osmosis:** The polymer which is coat of microcapsule dealed as semi permeable membrane and permits the creation of an osmotic pressure difference between the inside and the outside of the microcapsule and drives drug solution out of the microcapsule through small pores in the coat.<sup>[80]</sup>

**Application:** Microencapsulation techniques are utilised in various fields. In prolonged release drug dose form and production of Microencapsulated capsule, tablets or parented dosage form.<sup>[46]</sup> And this is Often helpful on enteric coated drug dose form ,so that it will be absorbed in intestine not in stomach.<sup>[47]</sup> This technique additionally useful in bitter taste masking.<sup>[48,49]</sup> It provides protection the products from environmental hazards like humidity, oxygen, heat. As Microencapsulation doesn't provide excellent barrier for material it can be degraded in oxygen, moisture and heat protection at a limited could be provided.<sup>[50,51]</sup> It shows a decent results to decrease volatility. And encapsulated volatile substance could stored for long time substantial evaporation.<sup>[48]</sup> Microencapsulation utilizes to reduce potential danger of harmful or noxious product. The toxicity happens once fumigant, herbicide, insecticides, and pesticides are handled.<sup>[51]</sup> Hygroscopic properties even be reduced of many core material in this method.<sup>[52]</sup> And microencapsulated drug have shown results in reductions of stomachic irritation and used for making intrauterine contraceptive devices,<sup>[52,53,54]</sup> And even Microencapsulation product used in

**1. Agriculture:** currently microencapsulated products are significantly employed in crop protection. insect pheromones are getting viable as a biorational alternative to conventional hard. Specifically, sex-attractant pheromones will cut back insect populations by disrupting their mating process. As little quantities of specific pheromones are spread during their mating season. Raising the background level of pheromones to the point where its hide the pheromones plume release by its feminine mate. Polymer microcapsules, Gelatin, polyurea, and gum arabic presents efficient delivery vehicle to deliver the pheromones by spraying the capsule dispersion. And encapsulation protect the pheromones from oxidation and light through storage and release<sup>[55-58]</sup>

**2. Food industry:** microencapsulated products helps in healthier method of living that helps in growing awareness of human being for what they eat and what benefits of that certain products for maintenance their good health. Illness prevention by diet is unique offering

of innovative thus its referred as "Functional Food". However simply adding ingredients to food products to boost nutritional value can compromise their taste, colour, texture and aroma. Sometimes they slowly degrade and lose their activity, or become hazardous by oxidation reactions. Elements that are present in food systems can even react with this ingredients and becomes risky and may limit bioavailability. Microencapsulation is employed to get rid of this problems in food industry. It provides appealing aroma release, viable texture blending, odour colour and taste masking, This technology helps food companies to incorporate oils , vitamin, minerals flavour. Microencapsulation can simply food manufacturing method by converting liquid to solid powder. Decreasing production prices by permitting batch processing using low cost, powder handling equipment. Microencapsulation conjointly stabilize the shelf life of food products.<sup>[59-64]</sup>

**3. Pharmaceuticals:** Microencapsulation have major value on pharmaceuticals. Like medical specialty for controlled and sustained drug delivery. Potential applications of this drug delivery systems are gene therapy, cancer treatment, tumors, diabetes, treatment of aids, protein such as insulin, growth hormone, erythropoietin, are examples of drugs that may benefit from this new kind of oral delivery. The delivery of corrective gene sequences within the form of plasmid DNA might offer convenient therapy for a variety of genetic diseases such as cystic fibrosis and hemophilia. The spheres are built to stay tightly to and even penetrate linings within the gastrointestinal track before transferring their contents over time into circulatory system.

Throughout this novel drug delivery systems, Lupin has launched in the market first Cephalexin (Ceff-ER) and Cefadroxil (Odoxil OD) antibiotic tablets that are used to prevention of bacterial infections. Zorprin CR, the aspirin controlled release version are used to get rid from arthritis symptoms and prevent from abnormal heart rhythm. Niaspan CR tablet is employed to regulate cholesterol levels and thus reducing the danger for a heart attack. Glucotrol (Glipizide SR) is an anti diabetic medicine utilizes to manage high blood pressure.<sup>[65-71]</sup>

**4. Energy generation:** Gaseous deuterium is loaded in hollow plastic microspheres for manufacturing electrical energy by nuclear fusion. The capsules are multilayered. The inner layer, that compresses the fuel, could be a polystyrene shell about 3 mm thick. Next could be a layer of poly(vinyl alcohol) about 3 mm thick, that retards diffusion of deuterium out of the capsule. The outer layer (the ablator) is concerning 50 mm thick and consists of a highly cross-linked polymer made up of 2-butene. By the surface of microcapsule shell energy from high powered laser beams is absorbed throughout this fusion experiment. The reaction force accelerate the rest of the shell inward , because the outside of the shell burn off, compression and heating deuterium inside. This leads to high densities and temperature within the centre of the capsule resulting in the fusion of deuterium nuclei

to give tritium, helium and other particles releasing an huge quantity of energy. This mechanism is named as inertial confinement fusion (ICF). Since 1980, ICF targets made of organic microcapsules.<sup>[72]</sup>

**5. Defence:** Microencapsulation is additionally used for designing special fabrics for military personnel, for their increased chemical protection against chemical war. To form this sort of product special reactive microcapsules are used that can be applied on fabric or garments to provide reactive sites to neutralize chemical reagents. This involves microencapsulation of conventional decontamination chemicals that are currently effective for deactivation of toxic mustard blistering agents (H agents) and toxic nerve agents known conventionally as G agents, for example isopropylmethyl phosphonofluoridate (GB, sarin) and also the V agents, and formulation of the microcapsules in a resin finish that can be uniformly applied to fabric substrates. The preferred microcapsules containing a decontaminating agent were obtained by organic phase separation with ethyl cellulose microcapsules containing a solid decontamination agent consisting of sym-bis (N-chloro-2,4,6-trichlorophenyl) urea and ZnO. With an acrylic binder emulsion the microcapsules were bonded. The very thin walls (1 to 10 microns) of microcapsules permits for rapid agent permeation for optimum decontamination and therefore protect the wearer from toxic chemical agents.<sup>[73]</sup>

Apart from this Microencapsulation technique conjointly used for cosmetic and photography. Chitin and chitosan have fungistatic properties. Chitosan is simply the natural cationic gum that become Viscous on being neutral with acid. These are employed in cream preparation and lotion preparation. Due to its resistance to abrasion, its optical characteristics, and film forming ability chitosan have application in photography. Silver complexes are not appreciably retained by chitosan and thus can easily be penetrated from one layer to another of a film by diffusion.<sup>[45]</sup>

**6. Catalysis:** Transition metal primarily based catalytic processes are of significant importance to pharmaceutical, agrochemical and fine chemical industries. A enormous proportion of such catalytic metal species are usually high priced and toxic, thereby creating operational handling typically hazardous. Microencapsulation has recently been recognized as a helpful different strategy to enable safe handling, easy recovery, reuse and disposal at an appropriate economic cost. Polyurea microcapsules due to their insolubility in aqueous and organic solvents, and resistance towards degradation have been useful for encapsulation of various catalysts. Metal species like palladium (II) acetate and osmium tetroxide are encapsulated in polyurea microcapsules and used successfully as recoverable and reusable catalysts without significant leaching and loss of activity. It is thought that the urea functionality, which forms the backbone of the polymer, ligates and retains the metal species within the polymeric matrix. Futuristic trend is towards incorporation of other chelating and ligating functional groups within the

polyurea framework to study rate enhancement in such reactions, and trying other polymers for encapsulation.<sup>[85,86]</sup>

**7. Soil inoculation:** Rhizobium bacteria that improves nitrate adsorption and conversion. However cells are washed out by rain thus inoculation is often unsuccessful. By cell encapsulation processes, it is possible to maintain continuous inoculation and higher cell concentration. Nutraceuticals (e.g. probiotics, vitamins...) improving of their efficiency and stability by protective and giving targeting release of the active materials.

**Future outlook:** As detailed in this paper the utilisation of Microencapsulation have growing day by day. The process of Microencapsulation employed in designing therapeutic formulation of microbial cells, mammalian cell, drugs and other molecular pharmaceuticals. Microencapsulation that appears promising, with the use of this technology in developing disease model like the model for tumors in pharmaceutical formulations.<sup>[81-83]</sup> In the other hand Microencapsulation technique have developed in food industry. It keeps on creating novel parts for use like helpful fixings, additives, colorants, and seasons in sustenance items utilizing microencapsulation systems.<sup>[84]</sup> And Microencapsulation of oil ingredients Like omega 3 with sugar beet pectin could provide an alternative more traditional encapsulating agents like milk protein and gum arabic. It conjointly helpful in nanotechnology and preparation of nanoparticles. It is upgrading and being easily handled technology in future days.

## CONCLUSION

Microencapsulation technique has developed in 1970. From 1970 Microencapsulation technique have incremented it's process and utilization. Now many researchers and scientists have developed it and it's become facile now. And it engaged with human being closely. Microcapsule and microsphere are introduced as identical vehicle system for many pharmaceutical products. Microencapsulation techniques are not only used for controlled drug delivery systems but also it has contribution in targeted drug delivery systems. With this technique a microencapsulated drug can targeted specific site of the body part. It also gives protection of liable product before and after administration. It has also contribution in food industry as we can consume intoxic substance for maintaining healthy life.

Still Microencapsulation technique faces some challenges for its cheap processing fundamental. As it is a helpful technology in human life so we need depth look into it. So it becomes more facile for human.

## REFERENCES

1. [C Wischke and S. P. Schwendenan, "Principles of encapsulating hydrophobic drugs in PLA/PLGA microparticles international journal of pharmaceuticals, 2008; 364(2): 298-327.

2. [Microencapsulation and its various aspects “international journal of advanced research”.]
3. [A review on Microencapsulation “international journal of pharmaceutical sciences research and review, 2010; 5(2): 102.]
4. [James S, Encyclopedia of Pharmaceutical Technology, 3<sup>rd</sup> edition, 1325-1333.]
5. [Microencapsulation: its application in nutrition, “proceedings of the nutrition society, 2001; 60: 475-479.]
6. [Chien YW. Novel drug delivery systems: Fundamentals, developmental concepts, and biomedical assessments. New York: Marcel Dekker, 1982.]
7. [Conick JR, Walker WR, Geynes WR. Sustained release of mycoherbicides from granular formulations. 10<sup>th</sup> International symposium on controlled release bioactive materials. San Francisco, 1983; 283.]
8. [Costa P, Lobo JMS. Modeling and comparison of di- solution profiles. Eur J Pharm Sci., 2001; 13: 123-133.]
9. [Birnbaum DT, Brannon-Peppas L. Microparticle drug delivery systems. In: Brown DM, editor. Drug delivery systems in cancer therapy. Totowa: Humana Press Inc, 2003; 117-136.]
10. [Chaumeil JC, Chemtob C, Ndongo M. Tablets of metronidazole microcapsules: release characterization. Int J Pharm Sci., 1986; 29: 83-92.]
11. [Berkland C, Kipper MJ, Narasimhan B, Kim KY, Pack DW. Microsphere size, precipitation kinetics and drug distribution control drug release from biodegradable polyanhydride microspheres. J Control Rel., 2004; 94: 129-141.]
12. [Microencapsulation : a promising technique for controlled drug delivery. “ Research of pharmaceutical sciences, October 2010; 5(2): 65-77.]
13. [Leon L, Herbert AL, Joseph LK. The Theory And Practice of Industrial Pharmacy. Varghese Publishing House, 1990; 412-428.]
14. [Brazel SC, Peppas NA. Modeling of drug release from swellable polymers. Eur J Pharm Biopharm, 2000; 49: 47-48.]
15. [Ike O, Shimizu Y, Wada R, Hyon SH, Ikada Y. Controlled cisplatin delivery system using poly(d,l-lactic acid). Biomaterials, 1992; 13: 230-234.]
16. [Itoi K, Tabata CY, Ike O, Shimizu Y, Kuwabara M, Kyo M, et al. In vivo suppressive effects of copoly(glycolic/l-lactic acid) microspheres containing CDDP on murine tumor cells. J Control Rel., 1996; 42: 175-184.]
17. [Spentehauer G, Vert M, Benoit JP, Chabot F, Veillard M. Biodegradable cisplatin microspheres prepared by the solvent evaporation method: Morphology and release characteristics. J Control Rel., 1988; 7: 217-229.]
18. [Spentehauer G, Veillard M, Benoit JP. Formation and characterization of cisplatin loaded poly (d,lactide) microspheres for chemoembolization. J Pharm Sci., 1986; 75: 750-755.]
19. [Ciftci K, Hincal AA, Kas HS, Ercan TM, Sungur A, Guven O, et al. Solid tumor chemotherapy and in vivo distribution of fluorouracil following administration in poly(l-lactic acid) microspheres. Pharm Dev Technol, 1997; 2: 151-160.]
20. [Akbuga J, Bergisadi N. 5-fluorouracil-loaded chitosan microspheres:preparation and release characteristics. J Microencapsulation, 1996; 13: 161-168.]
21. [Leon L., Lieberman H.A., Kanig J.L. The Theory And Practice Of Industrial Pharmacy, 1991; 3: 412-28.]
22. [Lachman/ Liebermann’s “the theory and practice of industrial pharmacy” fourth edition, 579-596.]
23. [Bansode S.S., Banarjee S.K., Gaikwad D.D., et al. Microencapsulation: A Review. International Journal of Pharmaceutical Sciences Review and Research, 2010; 1(2): 38.]
24. [Aulton M.E. Pharmaceutics The Science Of Dosage Form Design. Churchill Livingstone, 2: 82-83.]
25. [H.C., Loyd V., Allen Jr, et al. Ansel’s pharmaceutical dosage form & drug delivery system, 8: 265.]
26. [Deasy P. Microencapsulation of drug by pan and air suspension techniques. Critical Review Ther. Drug Carrier Syst, 1995; 8: 39-89.]
27. [George RS, John TG, Donald EJ. Controlled Release of Quinidine Sulfate Microcapsules, ACS Symposium Series, 1976; 33.]
28. [Bansode SS, Banarjee SK, Gaikwad DD, Jadhav SL, Thorat RM. Microencapsulation: A review. International J of Pharmaceutical Sciences Review and Research, 2010; 1: 38-43.]
29. [Leon L., Lieberman H.A., Kanig J.L. The Theory And Practice Of Industrial Pharmacy, 1991; 3: 412-28.]
30. [Re MI. Microencapsulation by spray drying. Drying Technology: An International Journal, 1998; 16: 1195-236.]
31. [Sheu TY. Microencapsulation by Spray Drying Ethyl Caprylate in Whey Protein and Carbohydrate Wall Systems. Journal of Food Science, 1995; 60: 98-103.]
32. [Kasturagi Y, Sugiura YC, Lee K, Otsugi, Kurihara, Selective inhibition of bitter taste of various drugs by Lipoprotein, Pharmaceutical Research, 1995; 12: 658- 662.]
33. [Alagusundaram.M, Madhu Sudana chetty, C.Umashankari. Microspheres as a Novel drug delivery system – A review. International J of chem. Tech, 2009: 526-534.]
34. [Jackson, L. S., Lee., K., (1991-01-01), “ Microencapsulation and the food industry ”(htm) Lebensmittel-Wissenschaft Technologies. Rerrived On, 1991-02-02.]
35. [Weil G, Knoch A, Laicher A. Simple coacervation of Hydroxyl propyl methylcellulose phthalate:

- Microencapsulation of ibuprofen, *International J of Pharm*, 1995; 124: 97-105.]
36. [Guo, JH. Bioadhesive polymer buccal patches for buprenorphine controlled delivery: formulation in vitro adhesive and release properties. *Drug Dev.Ind.pharm*, 1994; 20: 315-325.]
  37. [Obeidat WM, Price JC, Evaluation of enteric matrix microspheres prepared by emulsion-solvent Evaporation using scanning electron microscopy, *Journal of Microencapsulation, Micro and Nano Carriers*, 2004; 21: 47 – 57.]
  38. [Boza Y, Barbin D, Scamparini ARP. Survival Of *Beijerinckia* sp. Microencapsulated i. Carbohydrates by Spray-drying. *Journal of Microencapsulation*, 2004; 21: 15-24.]
  39. [Anil KN, Harjinder S. Recent advances in Microencapsulation of probiotics for industrial Applications and targeted delivery, *Trends in Food Science & Technology*, 2007; 18: 240-251.]
  40. [Nikhil K Sachan. Controlled drug delivery through microencapsulation. Assam India, Dibrugarh University, 2005; 1-3.]
  41. [Nagai T, Machida Y, Suzuki Y, Ikura H. Method & preparation for administration to the mucosa & preparation for administration to the Mucosa of the oral or nasal cavity US patent NO.4226848, 1980.]
  42. [Nack H, Microencapsulation techniques, application and problems. *J.Soc.Cosmetic Chemists*, 1970; 21: 85-98]
  43. [Berman N. Microencapsulation techniqs Applications s Bermun N and Problems *Journal of the wickets of Cimetic Chemi*, 1921; 59.]
  44. [Yoon Y, Kinam P. A new microencapsulation method Using an ultrasonic atomizer based on interfacial solvent Exchange, *Journal of Controlled Release*, 2004; 10: 379- 388.]
  45. [Majeti N.V, Ravi Kumar, A review of chitin and chitosan applications, *Reactive and Functional Polymers*, 2000; 46: 1-27.]
  46. [Benita S, Donbrow M. Effect of polyisobutylene on ethyl cellulose-walled microcapsules: wall structure and thickness of salicylamide and theophylline microcapsules. *J Pharm Sci.*, 1982; 71: 205-210.]
  47. [Felt O, Buri P, Gurny R. Chitosan: a unique polysaccharide for drug delivery. *Drug Dev Ind Pharm*, 1998; 24: 979-993.]
  48. [Chaumeil JC, Chemtob C, Ndongo M. Tablets of metronidazole microcapsules: release characterization. *Int J Pharm Sci*. 1986; 29: 83-92.]
  49. [Fukushima S, Kishimoto S, Takeuchi Y, Fukushima M. Preparation and evaluation of o/w type emulsions containing antitumor prostaglandin. *Adv Drug Delivery Rev.*, 2000; 45: 65-75.]
  50. [Arshady R. Preparation of biodegradable microspheres and microcapsules: polylactides and related polyesters. *J Control Rel*, 1991; 17: 1-22.]
  51. [Carrasquillo KG, Stanley AM, Aponte-Carro JC, De Jesus P, Costantino HR, Bosques CJ. Non-aqueous encapsulation of excipient-stabilized spray-freeze dried BSA into poly(lactide-co-glycolide) micro-spheres results in release of native protein. *J Control Rel*, 2001; 76: 199-208.]
  52. [Jiang W, Schwendeman SP. Stabilization of a model formalinized protein antigen encapsulated in poly(lactide-co-glycolide)-based microspheres. *J Pharm Sci.*, 2001; 90: 1558-1569.]
  53. [Deasy PB. Microencapsulation and related drug processes. New York: Marcel Dekker, 1984.]
  54. [Hemant KSY, Singh MN, Shivakumar HG. Chitosan/ Sodium tripolyphosphate cross linked microspheres for the treatment of gastric ulcer. *Der Pharmacia Lettre*, 2010; 2: 106-113.]
  55. [Scher, H. B.; Rodson, M & Lee, K. S. Microencapsulation of pesticides by interfacial polymerization utilizing isocyanate or aminoplast chemistry. *Pestic. Sci.*, 1998; 54: 394-400.]
  56. [Scher, H. B.; Groenwold, B. E., Pereira, F. & Purnell, T. J. Microencapsulated thiocarbamate herbicides. In *Proc. Brit. Crop. Prot. Conf. Weeds*, 1980; 185-91.]
  57. [Bingham, G.; Gunning, R.V.; Gorman, K.; Field, L.M & Moores, G.D. Temporal synergism by microencapsulation of piperonyl butoxide and cypermethrin overcomes insecticide resistance in crop pests. *Pest Mgmt. Science*, 2007; 63: 276-81.]
  58. [Ilichev, A.L.; Stelinski, L.L.; Williams, D.G. & Gut, L.J. Sprayable microencapsulated sex pheromone formulation for mating disruption of oriental fruit moth (Lepidoptera: Tortricidae) in Australian peach and pear orchards. *J.Econ. Entomol.*, 2006; 99(6): 2048-054.]
  59. [Kirby, C. J.; Whittle, C. J.; Rigby, N.; Coxon, D. T. & Law, B. A. Stabilization of ascorbic acid by microencapsulation in liposomes. *Int. J. Food Sci. Technol.*, 1991; 26: 437-49.]
  60. [Pothakamury, U. R. & Barbosa-Canovas, G. V. Fundamental aspects of controlled release in Foods. *Trends Food Sci. Technol.*, 1995; 6: 397-406.]
  61. [Wagner, L. A. & Warthesen, J. J. Stability of spray dried encapsulated carrot carotenes. *J. Food Sci.*, 1995; 60: 1048-053.]
  62. [Schrooyen, P. M. M.; Meer, R. V. D. & Kruif, C. G. D. Microencapsulation: Its application in nutrition. *Proc. Nutr. Soc.*, 2001; 60: 475-79.]
  63. [Gibbs, B. F.; Kermasha, S.; Alli, I. & Mulligan, C. N. Encapsulation in the food industry: A Review. *Int. J. Food Sci. Nutr.*, 1999; 50: 213-24.]
  64. [Vasistha, N. Microencapsulation: delivering a market advantage-food ingredients-cover story [assessed on 2 June 2008] website: <http://findarticles.com/p/articles/>]
  65. [Naha, P.C.; Kanchan, V.; Manna, P.K. & Panda, A.K. Improved bioavailability of orally delivered insulin using Eudragit-L 30D coated PLGA microparticles. *J. Microencap.*, 2008; 25(4): 248-56.]
  66. [Kim, C. H.; Kwon, J. H. & Choi, S. H. Mi Tech Company Limited, Seoul, Korea. Controlled Release preparation of Insulin and its method. US Patent 7,087,246 B2, 8 Aug 2006; 22.]

67. [Jones, D.H.; Farrar, G.H. & Stephen, J.C. Microbiological Research Authority (GB). Method of making microencapsulated DNA for vaccination and Gene Therapy. US Patent 6,270,795, 7 Aug 2001; 23.]
68. [Ross, C. J. D.; Ralph, M. & Chang, P. L. Somatic gene therapy for a neurodegenerative disease using microencapsulated recombinant cells. *Exp. Neurol.*, 2000; 166(2): 276-86.]
69. [McMahon, J.; Schmid, S.; Weislow, O.; Stinson, S.; Camalier, R.; Gulakowski, R.; Shoemaker, R.; Kiser, R.; Harrison, S.; Mayo, J & Boyd, M. Feasibility of cellular microencapsulation technology for evaluation of anti-human immunodeficiency virus in vivo. *J. Nat. Cancer Inst.*, 1990; 82(22): 1761-765.]
70. [Kim, H.K. & Park, T.W. Microencapsulation of human growth hormone within biodegradable polyester microspheres: Protein aggregation stability and incomplete release mechanism. *Biotechnol. Bioeng.*, 1999; 65(6): 659-67.]
71. [Human growth hormone aggregates within poly(D, L-lactic-co-glycolic acid) microparticles for sustained release. *Int. J. Pharmaceutics.*, 2001; 229(1-2): 107-16.]
72. [Mishra, K. K.; Khardekar, R. K.; Singh, R. & Pant, H.C. Fabrication of polystyrene hollow microspheres as laser fusion targets by optimized density matched emulsion technique and characterization. *Pramana, Journal of Physics.*, 2002; 59(1): 113-31.]
73. [Cowsar, D. R. The United States of America as represented by the Secretary of the Army, Washington, D. C. Novel Fabric containing microcapsules of chemical decontaminants encapsulated within semipermeable polymers. US Patent, May 1980; 4,201,822. 6. 6.]
74. [Berkland C, Kipper MJ, Narasimhan B, Kim KY, Pack DW. Microsphere size, precipitation kinetics and drug distribution control drug release from biodegradable polyanhydride microspheres. *J Control Rel*, 2004; 94: 129-141.]
75. [Conick JR, Walker WR, Geynes WR. Sustained release of mycoherbicides from granular formulations. 10<sup>th</sup> International symposium on controlled release bioactive materials. San Francisco, 1983; 283.]
76. [Lin YH, Vasavada RC. Studies on microencapsulation of 5-fluorouracil with poly(ortho ester) polymers. *J Microencapsule*, 2000; 17: 1-11.]
77. [Haznedar S, Dortue B. Preparation and in vitro evaluation of eudragit microspheres containing acetazolamide. *Int J Pharm*, 2004; 269: 131-140.]
78. [Deng JS, Li L, Tian Y, Ginsburg E, Widman M, Myers A. In vitro characterization of polyorthoester microparticles containing bupivacaine. *Pharm Dev Technol*, 2003; 8: 31-38.]
79. [Wang C, Ge Q, Ting D, Nguyen D, Shen HR, Chen J, et al. Molecularly engineered poly(ortho ester) microspheres for enhanced delivery of DNA vaccines. *Nat Mater*, 2004; 3: 190-196.]
80. [Chien YW. Novel drug delivery systems: Fundamentals, developmental concepts, and biomedical assessments. New York: Marcel Dekker, 1982.]
81. [L. Pamera S. J. Kontides and VT Karathanos, "Microencapsulation of curcumin in cats of Saccharina vind Food Chemistry, 2011; 125: 92-902]
82. [G Shi Lao, H. Ya. H. Klang, H. Yang, and R. "Stabilization and encapsulation of phosensitise wwwwal wahin year cell tatalurnal of Pharmacies, 2008; 3(1-2): 9]
83. [M. Z. M. DE Cheng, 1 1. W et al. Momencapsulated umir assay evaluation of the male mouse model of pancreatic case World.]
84. [Santiago G, Castro R. Novel technologies for the encapsulation of bioactive food compounds. *Current Opinions in Food Science*, 2016; 7: 78-85.]
85. [Ley, S.V.; Ramarao, C.; Lee, A.L.; Ostergaard, N.; Smith, S.C. & Shirley, I.M. Microencapsulation of osmium tetroxide in polyurea. *Organic letters*, 2003; 5(2): 185-87.]
86. [Ley, S. V.; Ramarao, C.; Gordon, R. S.; Holmes, A.B.; Morrison, A. J.; McConvey, I. F.; Shirley, I. M.; Smith, S. C. & Smith, M. D. Polyurea encapsulated palladium (II) acetate: a robust and recyclable catalyst for use in conventional and supercritical media. *Chem. Commun.*, 2002; 1134-35.]