International Journal for Pharmaceutical Research Scholars (IJPRS)

V-6, I-1, 2017 ISSN No: 2277 - 7873

REVIEW ARTICLE

Microencapsulation in Pharmaceuticals: A Review

Md Younus Khan *[1], Abdul Mannan[2], Nazima Sultana[1], Mohd Sohail Ali[1], Amer Mahboob[1]

[1] *Deccan School of Pharmacy, Agapura, Hyderabad-500001.*

[2]*Professor, Deccan School of Pharmacy, Agapura, Hyderabad-500001, India.*

Manuscript No: IJPRS/V6/I1/00003, Received On: 12/01/2017, Accepted On: 21/01/2017

ABSTRACT

Microencapsulation is the way toward surrounding one substance inside another substance on a little scale, yielding microparticles ranging from one micron to a few hundred microns in size. The encapsulation efficiency of the microparticles relies on various components like convergence of the polymer, dissolvability of polymer in dissolvable, rate of dissolvable expulsion, solvency of natural dissolvable in water and so forth. Microencapsulation might be accomplished by a horde of systems. Substances might be microencapsulated with the goal that the core material be restricted to case dividers for a particular timeframe. On the other hand, core materials might be exemplified so that the core material will be discharged either bit by bit through the container dividers, known as controlled discharge or dispersion, or when outside conditions trigger the case dividers to break, soften, or disintegrate. This article is a survey of microencapsulation and materials required in it, morphology of microcapsules, microencapsulation advancements, reasons for microencapsulation, and advantages of microencapsulation, and the methods for evaluation.

KEYWORDS

Microencapsulation, Core and Coating Materials, Morphology, Method Of Preparation, and Evaluation

INTRODUCTION

Microencapsulation is a procedure in which minor particles or beads are encompassed by a covering to give little cases. In a moderately oversimplified shape, a microcapsule is a little circle with a uniform divider around it. The material inside the microcapsule is alluded to as the center, inward stage, or fill, while the divider is infrequently called a shell, covering, or film. Most microcapsules have distances across between a couple of micrometers and a couple of millimeters. The definition has been extended, and incorporates more substances. Each class of nourishment fixing has been exemplified; flavors are the most well-known.

***Address for Correspondence:**
Md Younus Khan,
Deccan School of Pharmacy,
Agapura, Hyderabad-500001, India.
E-Mail Id: khanilyas763@gmail.com

The system of microencapsulation relies on upon the physical and substance properties of the material to be embodied[1].

According to Simon Benita the Diameter and Type of capsules are[2]

Table 1: Diameter and Type of particle

Diameter	Type of particle
Less than 1 micron	Nanoparticle
3 to 800 micron	Microparticle
Larger than 1000 micron	Macroparticle

Advantages of Microencapsulation

- This procedure can be utilized for changing over fluid medications as a part of a free streaming powder.
- The medications, which are delicate to oxygen, dampness or light, can be settled by microencapsulation.
- Contrariness among the medications can be avoided by microencapsulation.
- Vaporization of numerous unstable medications e.g. methyl salicylate and peppermint oil can be avoided by microencapsulation.
- Many medications have been microencapsulated to diminish poisonous quality and GI bothering including ferrous sulfate and KCl.
- Adjustment in site of retention can likewise be accomplished by microencapsulation.
- Lethal chemicals, for example, bug sprays might be microencapsulated to decrease the likelihood of sharpening of factorial individual[3].

Disadvantages of Microencapsulation

- No single microencapsulation process is versatile to all core material candidate or item applications.
- Complicated process and requires talented work to oversee.
- Incomplete or intermittent covering.
- Non reproducible and insecure discharge attributes of coated products.
- Inadequate stability or time span of usability of touchy pharmaceuticals.
- Economic limitations[4].

Reasons for Microencapsulation

- The essential purpose behind microencapsulation is observed to be either for supported or delayed medication discharge.
- This system has been generally utilized for covering taste and scent of many medications to enhance tolerant consistence.
- This strategy can be utilized for changing over fluid medications as a part of a free streaming powder.
- The medications, which are touchy to oxygen, dampness or light, can be settled by microencapsulation.
- Incongruence among the medications can be anticipated by microencapsulation.
- Vaporization of numerous unpredictable medications e.g. methyl salicylate and peppermint oil can be anticipated by microencapsulation.
- Many medications have been microencapsulated to diminish poisonous quality and GI disturbance including ferrous sulphate and KCl.
- Change in site of assimilation can likewise be accomplished by microencapsulation.
- Dangerous chemicals, for example, bug sprays might be microencapsulated to diminish the likelihood of sharpening of factorial individual[5].

Materials Involved in Microencapsulation

Microencapsulation is the procedure by which singular particles or beads of strong or fluid material (core material) are encompassed or covered with a persistent film of polymeric material (the shell) to deliver cases in the micrometer to millimeter run, known as microcapsules.

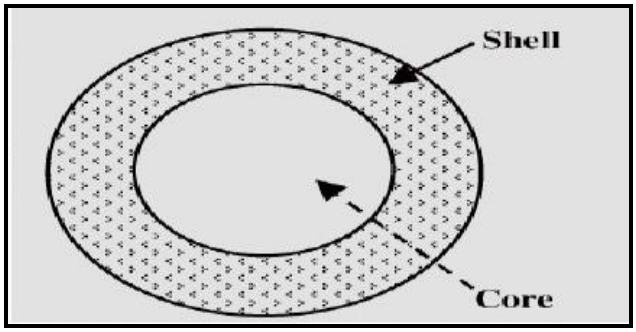


Figure 1: Microcapsule with core and shell

Core Materials

The core material, characterized as the particular material to be covered, can be fluid or strong in nature. The organization of the center material can be differed, as the fluid center can incorporate scattered and additionally disintegrated materials. The strong center be dynamic constituents, stabilizers, diluents, excipients, and discharge rate retardants or quickening agents. The capacity to fluctuate the center material structure gives clear adaptability and use of these qualities regularly permits solid outline and improvement of the wanted microcapsule properties[6].

Coating Materials

The choice of fitting covering material chooses the physical and substance properties of the resultant microcapsules/microspheres. While selecting a polymer the item necessities ie. Adjustment, diminished instability, discharge attributes, natural conditions, and so forth ought to be thought about. The polymer ought to be equipped for framing a film that is firm with the center material. It ought to be artificially perfect, non-responsive with the center material and give the fancied covering properties, for example, quality, adaptability, impermeability, optical properties and solidness.

Coating Material Properties

- Adjustment of core material.
- Idle toward dynamic fixings.
- Controlled discharge under particular conditions.
- Film-shaping, malleable, bland, stable.
- Non-hygroscopic, no high consistency, efficient.
- Dissolvable in a fluid media or dissolvable, or liquefying.
- The covering can be adaptable, weak, hard, thin and so forth.

Examples of Coating Materials

- **Water soluble resins** – Gelatin, Gum Arabic, Starch, Polyvinylpyrrolidone, Carboxymethylcellulose, Hydroxy ethylcellulose, Methylcellulose, Arabinogalactan, Polyvinyl alcohol, Polyacrylic acid.
- **Water insoluble resins** – Ethylcellulose, Polyethylene, Polymethacrylate, Polyamide (Nylon), Poly (Ethylene Vinyl acetate), cellulose nitrate, Silicones, Poly lactideco glycolide.
- **Waxes and lipids** – Paraffin, Carnauba, Spermaceti, Beeswax, Stearic acid, Stearyl alcohol, Glyceryl stearates.
- **Enteric resins** – Shellac, Cellulose acetate phthalate, Zein[7].

Morphology of Microcapsules

The morphology of microcapsules depends basically on the center material and the statement procedure of the shell.

Mononuclear: microcapsules contain the shell around the center.

Polynuclear: cases have many centers encased inside the shell.

Matrix encapsulation: In which the center material is appropriated homogeneously into the shell material.

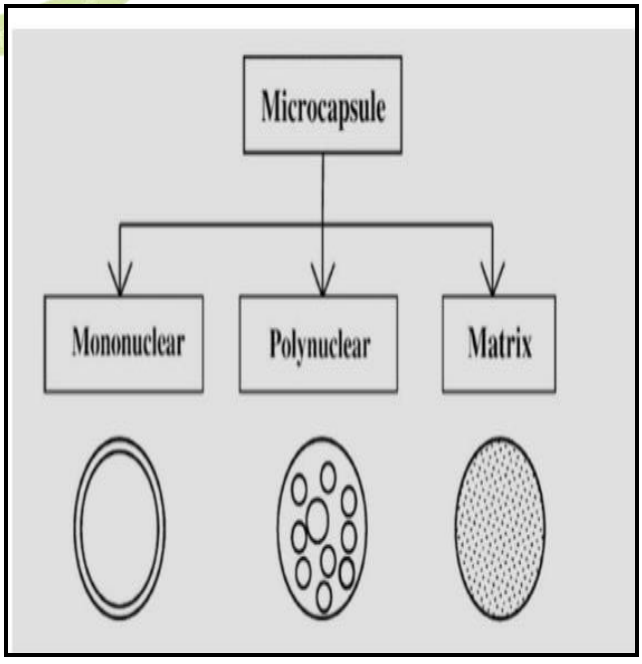
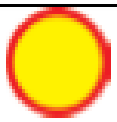


Figure 2: Morphology of Microcapsules[8]

Table 3: Terminology of microencapsulation products[9]

Terminology of microencapsulation products

Terminology	Description	Size range	Schematic illustration
Microcapsules (narrow sense of Meaning	Products of coating liquid nuclei with solid walls.	μ m	
Nanocapsules	Same structure as microcapsules, but smaller.	nm	
Microspheres or Microparticles	The cores and walls are both solid. Often, there is no clear distinction between them: the thick solid wall functions as a porous matrix where active substances are embedded.	μm	
Nanospheres or Nanoparticles	Same structure as microspheres, but smaller.	nm	

Methods for Preparation

Preparation of microspheres ought to fulfill certain criteria: The capacity to join sensibly high convergences of the medication.

1. Stability of the readiness after blend with a clinically worthy time span of usability.
2. Controlled molecule size and dispersability in watery vehicles for infusion.
3. Release of dynamic reagent with a decent control over a wide time scale.
4. Biocompatibility with a controllable biodegradability and
5. Susceptibility to concoction alteration[10].

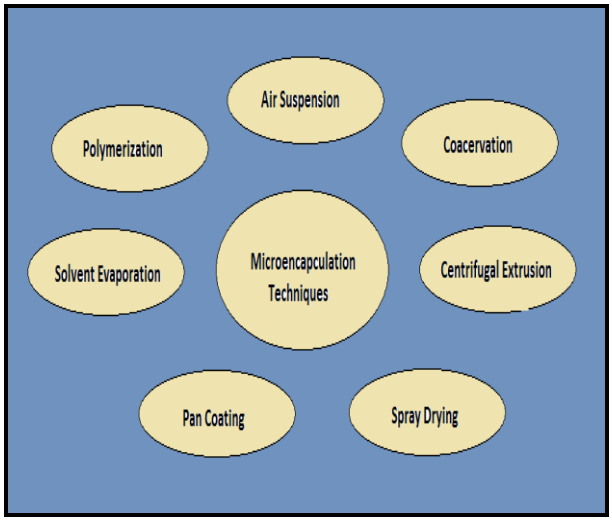


Figure 3: Microencapsulation techniques

Microencapsulation Methods

Physical Methods

- ✓ Air suspension
- ✓ Coacervation phase separation
- ✓ Multiorifice-centrifugal process
- ✓ Spray drying and congealing
- ✓ Pan coating

Chemical Methods

- ✓ Solvent evaporation techniques
- ✓ Polymerization

Physical Methods

Air Suspension

Microencapsulation via air suspension procedure comprise of the scattering of strong, particulate centre materials in a supporting air stream and the shower covering reporting in real time suspended particles. Inside the covering chamber, particles are suspended on an upward moving air stream. The plan of the chamber and its working parameters impact a recycling stream of the particles through the covering zone bit of the chamber, where a covering material, generally a polymer arrangement, is shower connected to the moving particles. Amid every go through the covering zone, the centre material gets an addition of covering material.

The cyclic procedure is rehashed, maybe a few hundred times amid handling, contingent upon the motivation behind microencapsulation the covering thickness desired or whether the core material particles are thoroughly encapsulated. The supporting air stream also serves to dry the product while it is being encapsulated. Drying rates are directly related to the volume temperature of the supporting air stream.[11]

Application of Air Suspension

- Coletta and Rubin depicted covering of headache medicine gems of different work sizes with blends of ethyl cellulose and methylcellulose showered from methylene chloride: isopropyl alcohol (1:1) solution utilizing Wurster air suspension mechanical assembly.

Caldwell and Rosen utilized an air suspension coater to successfully apply dexamphetamine sulfate onto sugar pellets utilizing arrangement of gelatin as a part of hydroalcholic dissolvable as adhesive. At that point covered with different materials, including beeswax glyceryl monostearate and distearate to get lipid coated microcapsules with supported discharge properties.

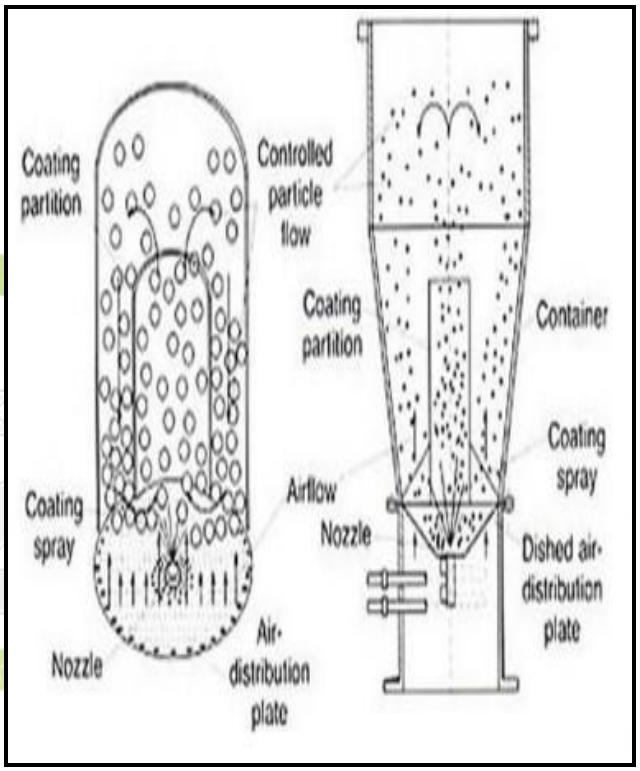


Figure 4: Air Suspension Technique

Coacervation Phase Separation

Coacervation is a colloid marvel. In the event that one begins with an answer of a colloid in a fitting dissolvable, then as indicated by the way of the colloid, different changes can achieve a decrease of the solvency of the colloid. As an after effect of this diminishment a substantial part of the colloid can be isolated out into another stage. The first one stage framework gets to be two stages. One is rich and the other is poor in colloid fixation. The colloid-rich stage in a scattered state shows up as indistinct fluid beads called coacervate drops. After standing these blend into one clear homogenous colloid-rich

fluid layer, known as the coacervate layer which can be kept in order to deliver the divider material of the resultant containers.

This procedure of microencapsulation is by and large alluded to The National Cash Register (NCR) Corporation and the licenses of B.K. Green.[11]

This procedure comprises of three Steps:

- ✓ Formation of three immiscible stages; a fluid assembling stage, a center material stage and a covering material stage
- ✓ Deposition of the fluid polymer covering on the center material
- ✓ Rigidizing of the covering material

Step-1: The initial step of coacervation stage partition includes the development of three immiscible substance stages: a fluid vehicle stage, a covering material stage and a center material stage. The three stages are framed by scattering the center material in an answer of covering polymer, the vehicle stage is utilized as a dissolvable for polymer. The covering material stage comprises of a polymer in a fluid stage, is framed by utilizing one of the of stage detachment coacervation strategy, i.e. .by changing the temperature of the polymer arrangement, by including an answer, or by inciting a polymer-polymer association.

Step-2: It includes the testimony of the fluid polymer covering upon the center material. This is finished by controlled blending of fluid covering material and the center material in the assembling vehicle. The fluid covering polymer saved on the center material if the polymer is adsorbed at the interface shaped between the center material and fluid stage. The diminishment in the aggregate free interfacial vitality of the framework advance the affidavit of the covering material, brought by the lessening of the covering material surface region amid blend of the fluid polymer beads.

Step-3: In the last stride rigidizing of the covering material done by the warm, cross connecting desolvation procedures, to frames a self-supporting microcapsule.[11]

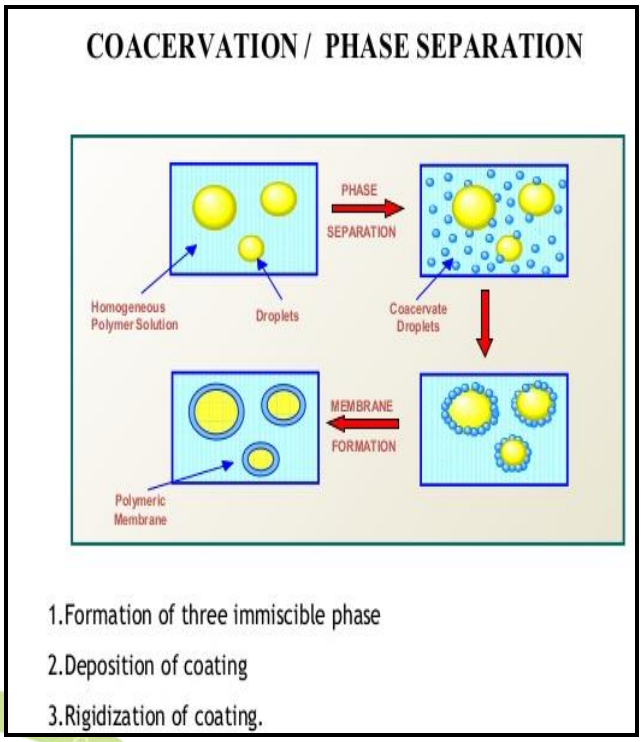


Figure 5: Coacervation Process

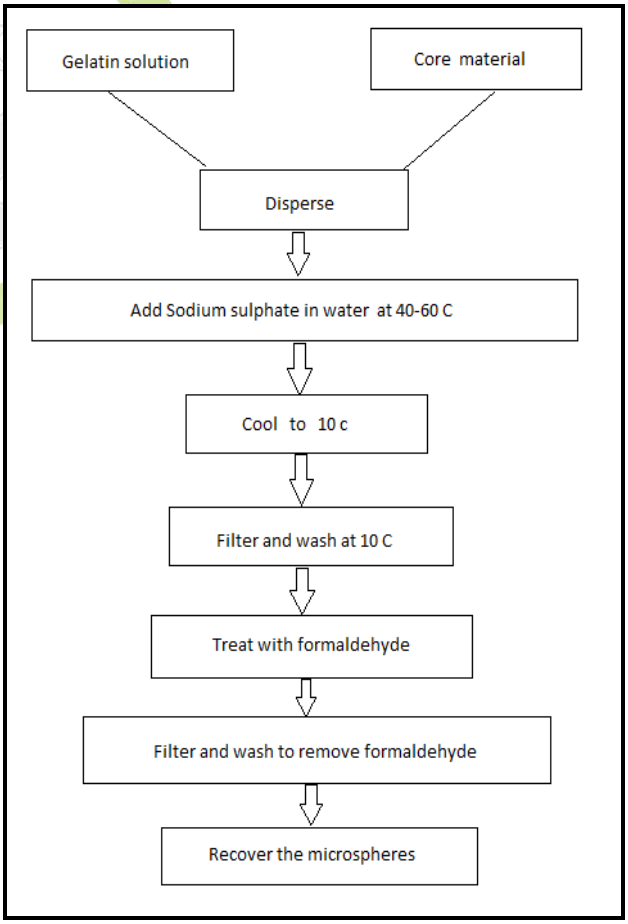


Figure 6: Simple Coacervation Process[12]

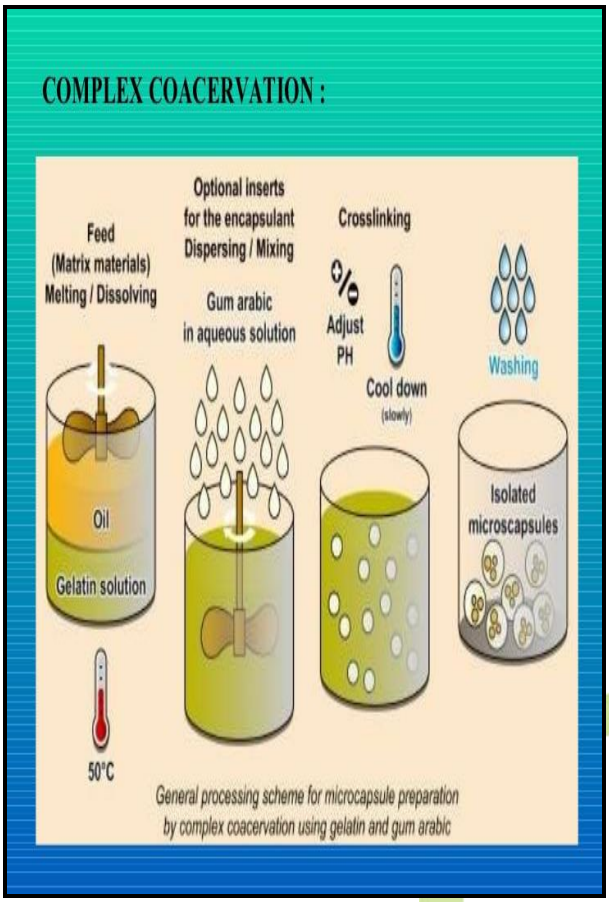


Figure 7: Complex Coacervation Process

Centrifugal Extrusion

Liquids are typified utilizing a pivoting expulsion head containing concentric spouts. In this procedure, a fly of center fluid is encompassed by a sheath of divider arrangement or dissolve. As the stream travels through the air it breaks, attributable to Rayleigh unsteadiness, into beads of center, each covered with the divider arrangement. While the beads are in flight, a liquid divider might be solidified or a dissolvable might be vanished from the divider arrangement. Since the vast majority of the beads are inside ± 10% of the mean width, they arrive in a restricted ring around the splash spout. Henceforth, if necessary, the containers can be solidified after arrangement by getting them in a ring-formed solidifying shower. This procedure is great for framing particles 400–2,000 μm (16-79 mils) in distance across. Since the drops are framed by the separation of a fluid fly, the procedure is appropriate for fluid or slurry. A high creation rate can be accomplished, i.e., up to 22.5 kg (50 lb) of microcapsules can be delivered per spout every hour per head. Heads containing 16 spouts are accessible.[13]

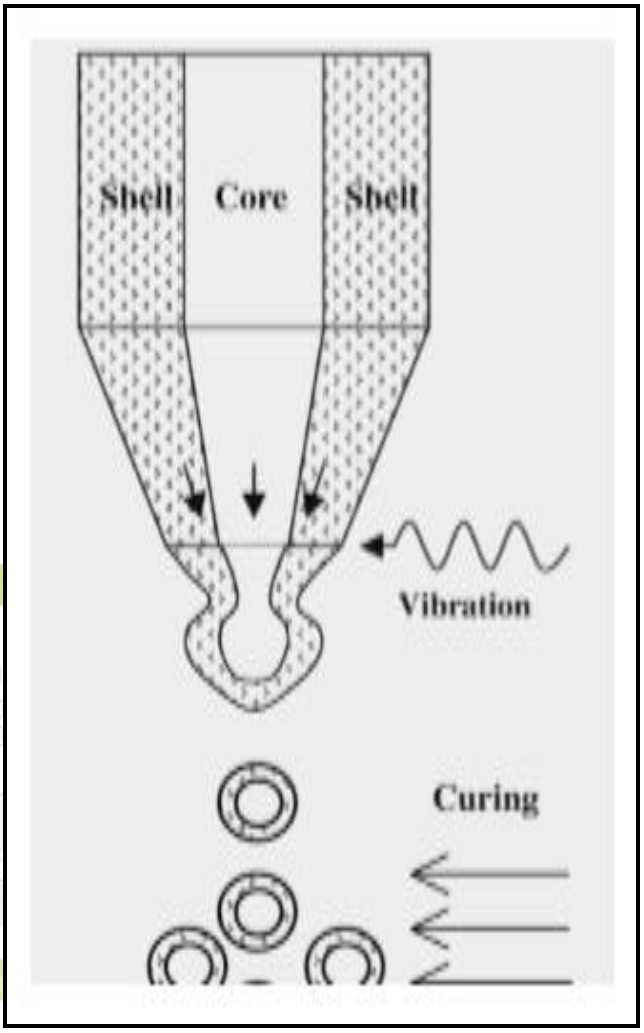


Figure 8: Centrifugal Extraction[14]

Advantages

- They don't require any numbers, or many moving parts.
- This makes them simple to create with a wide range of materials.
- It likewise permits them to move at high speeds with insignificant upkeep.
- Their yield is relentless and reliable.
- The vast majority of all, they are little contrasted with different sorts of pumps that make a similar yield.

Disadvantages

- They utilize turn rather than suction to move water, and in this manner have no suction control.
- This implies a diffusive pump must be put submerged, or prepared, before it will move water.

Pan Coating

The Pan Coating process, broadly utilized as a part of the pharmaceutical business, is among the most seasoned modern methods for framing little, covered particles or tablets. The particles are tumbled in a dish or other gadget while the covering material is connected gradually. The dish covering process, generally utilized as a part of the pharmaceutical business, is among the most established mechanical methods for shaping little, covered particles or tablets. The particles are tumbled in a skillet or other gadget while the covering material is connected gradually regarding microencapsulation, strong particles more noteworthy than 600 microns in size are for the most part viewed as fundamental for viable covering, and the procedure has been widely utilized for the readiness of controlled – discharge dots. Medicaments are normally covered onto different round substrates, for example, quintessence sugar seeds, and after that covered with defensive layers of different polymers. In practice, the covering is connected as an answer, or as an atomized shower, to the craved strong core material in the covering dish. More often than not, to evacuate the covering dissolvable, warm air is disregarded the covered materials as the coatings are being connected in the covering skillet. At times, last dissolvable evacuation is proficient in a drying stove[15].

Advantages

1. It is used for coating the core material by using pans
2. It is used for solid particles for coating.

Disadvantages

1. It is a expensive process.
2. It requires skill persons.

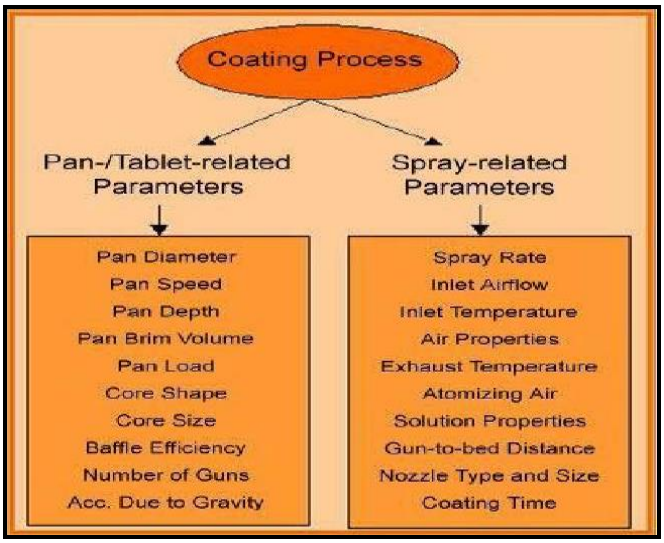


Figure 9: Representation of typical Pan Coating

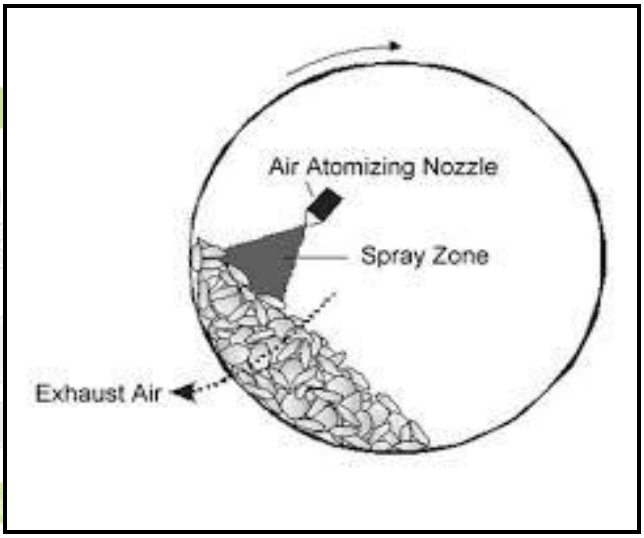


Figure 10: List of variables affecting pan coating

Application of Pan coating

- Lowy 14 skillet covered adjusted granules containing nitro glycerine with different cellulose subsidiaries, for example, methylcellulose, ethyl cellulose, or cellulose acetic acid derivation utilizing beeswax or castor oil as a plasticizer.
- Rosen and Swintoskey 15 reported pan covering of trimeperazine that contain taking after step:

1. 35S-marked trimeperazine tartarte, a hostile to puritic agent mixed with powdered starch and sugar

2. This is a plied on sugar pellet utilizing hydroalcholic gelatine adhesive as a part of covering pan
3. Dried, screened and after that covered with arrangement of 11%w/w glyceryl monostearate, 11% w/w glyceryl monostearate &3% w/w white beeswax in CCl_4,come about microcapsules demonstrated managed discharge in human subjects after oral organization.

Spray–drying

Spray drying serves as a microencapsulation system when a dynamic material is broken down or suspended in a dissolve or polymer arrangement and gets to be caught in the dried molecule. The primary focal points is the capacity to handle labile materials in view of the short contact time in the dryer, moreover, the operation is prudent. In present day splash dryers the consistency of the answers for be showered can be as high as 300 m Pa.s.

Spray drying and spray congealing procedures are comparable in that both include scattering the center material in a melted covering substance and showering or bringing the center covering blend into some natural condition, whereby, generally quick cementing (and arrangement) of the covering is influenced. The chief contrast between the two strategies is the methods by which covering hardening is proficient. Covering cementing on account of splash drying is affected by quick vanishing of a dissolvable in which the covering material is broken up. Covering hardening in splash coagulating techniques, in any case, is expert by thermally hardening a liquid covering material or by setting a broke down covering by presenting the covering - center material blend into a non-dissolvable. Expulsion of the non-dissolvable or dissolvable from the covered item is then expert by sorption, extraction, or dissipation strategies.

Microencapsulation by spray drying is directed by scattering a center material in a covering arrangement, in which the covering substance is broken down and in which the center material is insoluble, and afterward by atomizing the blend into air stream.[16]

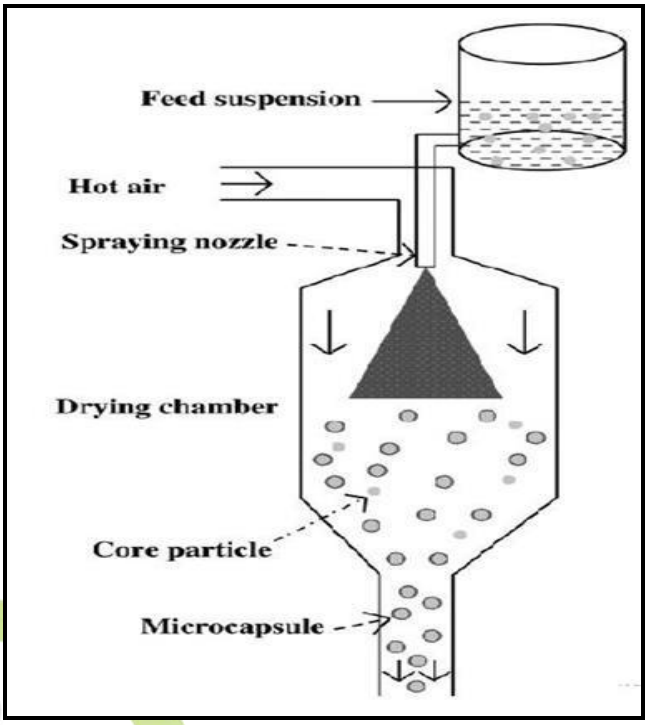


Figure 11: Spray dryer

Advantages

- ✓ Quick, single stage operation, can be utilized for warmth sensitive substance

Disadvantages

- ✓ Permeable covering, not appropriate for taste and smell veiling and for controlled discharge formulation ,high cost of creation

Application of Spray Drying

- ✓ Marottaetal in patent doled out to National Starch and Chemical Corp speech, utilized a fluid arrangement of corrosive esterdextrins to exemplify emulsified scattering lemon oil by spray drying.
- ✓ Sager , inpatent appointed to Beecham Group ltd., Great Britain , depicted shower drying of penicillin as takes after:

1. For instance of process, high moved ampicillin trihydrate suspended in weaken arrangement of sodium carboxy methylcellulose.
2. Control of frothing by expansion of ethanol

3. Filtration
4. Shower dried at 160^0C and outlet temperature is 84^0C
5. Item under 75 micron are reused

Application Spray Congealing

- Robinson and Swintosky microencapsulated particles of sulfaethylthiadiazole by blending them with molten hydrogenated castor oil at 110 ^{0}C; then suspension was spray congealed into air cooled chamber utilizing radiating wheel atomizer.
- Koffdis persed thiamine monohydrate into a liquid mixture of mono-and diglycerides of palmitic and stearic corrosive at 74^0C splash solidified into encompassing air at 20^0C. Normal particle size is around 60 micron and the procedure was accounted for to be suitable for the embodiment of vitamin of B gathering for tasking reasons

Solvent Evaporation

This technique has been used by companies including the NCR Company, Gavaert Photo Production NV, and Fuji Photo Film Co., Ltd. to produce microcapsules. The processes are carried out in a liquid manufacturing vehicle. The microcapsule coating is dissolved in a volatile solvent, which is immiscible with the liquid manufacturing vehicle phase. A core material to be microencapsulated is dissolved or dispersed in the coating polymer solution. With agitation, the core coating material mixture is dispersed in the liquid manufacturing vehicle phase to obtain the appropriate size microcapsule. The mixture is then heated (if necessary) to evaporate the solvent for the polymer. In the case in which the core material is dispersed in the polymer solution, polymer shrinks around the core. In the case in which core material is dissolved in the coating polymer solution, a matrix - type microcapsule is formed. Once all the solvent for the polymer is evaporated, the liquid vehicle temperature is reduced to ambient temperature (if required) with continued agitation. At this stage, the microcapsules can be used in suspension form, coated on to substrates or isolated as powders in which center material is broken down in the covering polymer arrangement, a lattice - sort microcapsule is framed. When all the dissolvable for the polymer is dissipated, the fluid vehicle temperature is decreased to encompassing temperature (if required) with proceeded with unsettling. At this stage, the microcapsules can be utilized as a part of suspension frame, covered on to substrates or segregated as powders.

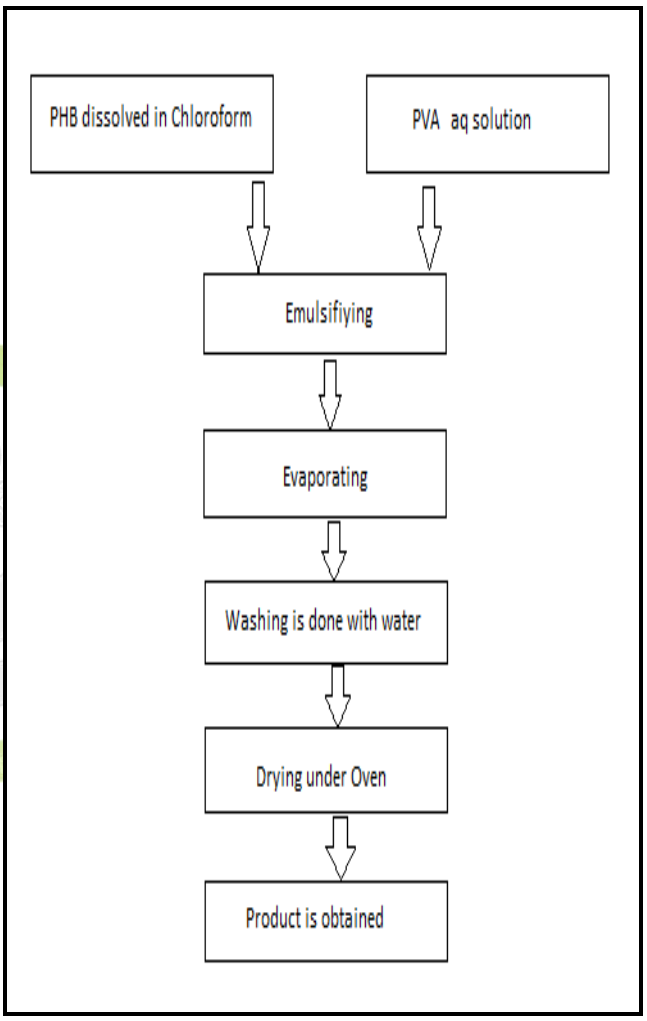


Figure 12: Solvent evaporation

The dissolvable dissipation system to deliver microcapsules is appropriate to a wide assortment of fluid and strong center materials. The center materials might be either water solvent or water insoluble materials. An assortment of film shaping polymers can be utilized as coatings. Illustration: Evaluation of sucrose esters as option surfactants in microencapsulation of proteins by the dissolvable dissipation technique.[17]

Advantages

1. It is used for both small scale and large scale industries.
2. Its construction is simple and it is operated easily.
3. It requires low maintenance.

Disadvantages

1. Its heat economy is less
2. It is not suitable for heat sensitive materials.
3. When concentration is increased heat transfer rate drastically decreases.

Polymerization

In this procedure the case shell will be shaped at or on the surface of the bead or molecule by polymerization of the responsive monomers. The substances utilized are multifunctional monomers. For the most part utilized monomers incorporate multifunctional isocyanates and multifunctional corrosive chlorides. These will be utilized either independently or as a part of blend. The multifunctional monomer broke up in fluid center material and it will be scattered in watery stage containing scattering specialist. A coreactant multifunctional amine will be added to the blend. This out comes in quick polymerization at interface and era of container shell happens. A poly urea shell will be framed when isocyanate responds with amine, polynylon or polyamide shell will be shaped when corrosive chloride responds with amine. At the point when isocyanate responds with hydroxyl containing monomer produces polyurethane shell. Like IFP the case shell development happens in light of polymerization monomers added to the exemplification reactor. In this procedure no responsive operators are added to the center material, polymerization happens solely in the persistent stage and on the constant stage side of the interface shaped by the scattered center material and consistent stage.

At first a low sub-atomic weight prepolymer will be framed, over the long haul the prepolymer develops in size, it stores on the surface of the scattered center material there by creating strong case shell.

Case: embodiment of different water immiscible fluids with shells shaped by the response at acidic pH of urea with formaldehyde in watery media[18].

Interfacial Polymerization

In Interfacial polymerization, the two reactants in a polycondensation meet at an interface and respond quickly. The premise of this technique is the traditional Schotten Baumann response between a corrosive chloride and a compound containing a dynamic hydrogen iota, for example, an amine or liquor, polyesters, polyurea, polyurethane. Under the correct conditions, thin adaptable dividers frame quickly at the interface. An answer of the pesticide and a diacid chloride are emulsified in water and a watery arrangement containing an amine and a polyfunctional isocyanate is included. Base is available to kill the corrosive shaped amid the response. Consolidated polymer dividers shape immediately at the interface of the emulsion beads[19].

In-situ Polymerization

In a couple microencapsulation forms, the immediate polymerization of a solitary monomer is done on the molecule surface. In one process, E.g. Cellulose filaments are epitomized in polyethylene while inundated in dry toluene. Regular testimony rates are around 0.5µm/min. Covering thickness ranges 0.2-75µm. The covering is uniform, even over sharp projections[21].

Applications of Microencapsulation

Pharmaceutics: One of the significant applications zones of epitome method is pharmaceutical/ biomedical for controlled/maintained medication conveyance. Potential uses of this medication conveyance framework are substitution of helpful operators (not taken orally today like insulin), quality treatment and being used of immunizations for treating AIDS, tumours, growth and diabetes.

Table 4: Comparison between Interfacial polymerization and In-situ polymerization[20]

Interfacial polymerization	In-situ polymerization
The multifunctional monomer broke down in fluid core material which will be then scattered in water stage containing scattering operator	In this procedure no receptive specialists are added to the core material
A co reactant multifunctional amine will be added to the blend	Polymerisation happens only in the continuous stage and on the continuous stage side of the interface framed by the scattered core material and continuous stage
This in fast polymerization at interface and era of container shell happens	At first a low atomic weight prepolymer will be framed, over the long haul the prepolymer develops in size
Polynylon or polyamide shell will be shaped when corrosive chloride responds with amine	It stores on the surface of the scattered core material accordingly creating strong container shell
A polyurea shell will be shaped when isocyanide responds with amine	

Table 5: Application of Microencapsulation[24]

S.No	Method	Particle Size	Applicable For	Time Required	Cost Factor	Production Scale
1	Air Suspension	35-5000	Solids	High	High	Pilot Scale
2	Coacervation	2-5000	Solids & Liquids	Less	Less	Lab Scale
3	Centrifugal Extrusion	1-5000	Solids & Liquids	High	High	Pilot Scale
4	Spray Drying	600	Solids & Liquids	High	High	Pilot Scale
5	Pan Coating	600-5000	Solids	High	High	Pilot Scale
6	Solvent Evaporation	5-5000	Solids & Liquids	Less	Less	Lab Scale

Protein, for example, insulin, development hormone and erythropoietin (used to treat pallor) are case of medications that would profit by this new type of oral conveyance[22].

Microencapsulation frames minor fluid filled, biodegradable small scale inflatables containing different medication arrangements that can give better medication conveyance and new restorative medicines for strong tumors and safe contaminations. Microcapsules containing antitumour medicines and visualization markers, the treatment can be guided ideal to the tumor, which has a few advantages over systemic treatment, for example, chemotherapy. The microcapsule additionally contain a difference operator that empowers C-T, X-beam or ultrasound imaging to screen the dispersion inside the tissues to guarantee that the whole tumor is dealt with when the microcapsules. Microencapsulation electrostatic handling framework 2 test, or MEPS-2,led by dennis morrison at NASA johnson space centre ,was performed on the station in 2002 and included inventive epitome of a few distinctive against malignancy drugs, magnetic activating particles and embodiment of hereditarily engineered DNA.

With more than 60years of exemplification innovative work understanding, southwest research institute(SwRI) is the field and have aptitude in various specialized fields, for example, pharmaceuticals, sustenance and nutrition, polymer and material science and process designing, SwRIs epitome masters take care of item stability, release and application issues in an extensive variety of businesses. SwRI has led more than 1,000 embodiment investigate programs for business and government customers[22].

There are many reasons why tranquilizes and related chemicals have been microencapsulated. The innovation has been utilized generally as a part of the outline of controlled discharge and maintained discharge dose shapes[23].

- To cover the intense taste of medications like Paracetamol, Nitrofurantoin and so forth. Many medications have been microencapsulated to diminish gastric and other G.I. tract aggravations. Supported discharge Aspirin arrangements have been accounted for to bring about fundamentally less G.I. seeping than customary arrangements.
- A fluid can be changed over to a pseudo-strong for simple taking care of and capacity. eg. Eprazinone.
- Hygroscopic properties of center materials might be decreased by microencapsulation eg. Sodium chloride.
- Carbon tetra chlorides and various different substances have been microencapsulated to lessen their scent and instability.
- Microencapsulation has been utilized to give insurance to the center materials against climatic impacts, e.g. vitamin A palmitate.
- Separation of contradictory substance has been accomplished by epitome.
- Cell immobilization: In plant cell societies, Human tissue is transformed into bio-fake organs, in constant maturation forms.
- Beverage generation.
- Protection of particles from different mixes.
- Drug conveyance: Controlled discharge conveyance frameworks.
- Quality and security in nourishment, rural and natural divisions.
- Soil immunization.
- In materials: method for granting wraps up. Protection of fluid precious stones[23].

Evaluation of Microencapsulation

Particle Size Distribution

Particle size analysis of the microcapsules is done by sieve analysis method using Indian Standard Sieves i.e., 16, 20, 30, 40, 60 and #80.The amount retained on various sieves is weighed .From the obtained data, weight percent and average size can be calculated[25].

Figure 14: Standard sieve

Shape and Surface Morphology

The shape and surface morphology of the microcapsules is considered by utilizing checking electron magnifying instrument. Microcapsules are mounted straightforwardly onto the Scanning Electron Microscope test stub utilizing twofold sided staying tape and is covered with gold film i.e., thickness 200 nm under lessened weight i.e., 0.001 mm of Hg[26].

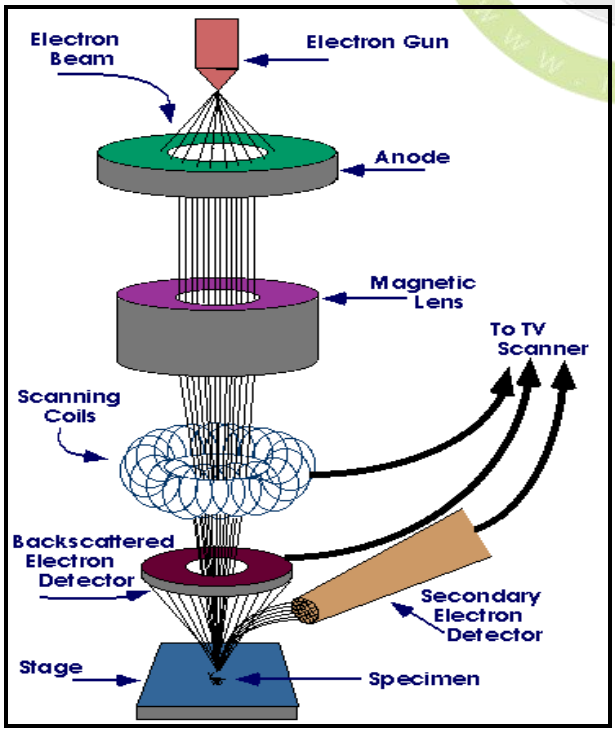


Figure 15: Scanning electron microscope

Carr's Index & Hausner's Ratio

The static point of rest was measured by settled pipe and detached cone strategy. The mass thickness of the blended microcapsules was computed in deciding the Hausner's proportion and Carr's file from the pored and tapped mass densities of a known weight of the example utilizing a measuring barrel[27]. The accompanying equations were utilized for as certaining carr's record:

Carr's Index = [Tapped Density-Bulk Density/Tapped Density] ×100

The Hausner proportion of the microcpsules fabricated utilizing diverse definitions was registered by taking after relationship:

HR=ρT/ρB

where ρT is tapped density and ρB is bulk density.

Bulk Density

Accurately weighed microcapsules (Wm) were moved into a 100ml graduated barrel to get the clear volumes (V) of somewhere around 50 and 100 ml. The mass thickness was figured in gram per milliliter by the accompanying equation:

Bulk Density (ρρ) = [Weight of Microcapsules (g) (M) / Bulk Volume (ml) (V)]

Whereas, M = mass of the powder, Vo = volume of the powder

Figure 16: Bulk density Apparatus

Angle of Repose

A pipe was settled on and remains in such a way the highest point of the pipe was at a stature of 6cm from the surface. The microcapsules were passed from the channel so they shape a heap. The tallness and the span of the load were measured and the point of rest was figured utilizing the condition[28]

$$\mathbf{Tan\ \theta = h/r}$$

Where h is the height of the heap and r is the radius of the heap

Figure 17: Angle of repose

Thickness of Coating

Thickness of aceclofenac microcapsules can be determined by using method of Luu. et. al using equation[29]

$$h = r\,(1-p)\,d1 / 3[pd2 + (1-p)\,d1]$$

Whereas: h = wall thickness of microcapsules,

r = arithmetic mean radius,

d1 = density of core material,

d2 = density of coating material,

p = proportion of medicament in microcapsules.

Practical Yield

It is calculated by using formula:

% yield = weight of the microcapsules/ Theoretical weight of drug and polymer ×100

Atomic Force Microscopy

It is a digital instrument used to study the surface morphology of the microspheres.[30]

Figure 18: Atomic Force microscope

CONCLUSION

Microencapsulation means packaging an active ingredient inside a capsule ranging in size from one micron to several millimeters. The capsule protects the active ingredient from its surrounding environment until an appropriate time. Then, the material escapes through the capsule wall by various means, including rupture, dissolution, melting or diffusion. Microencapsulation is both an art and a science. The microencapsulation technique offers a variety of opportunities such as protection and masking, reduced dissolution rate, facilitation of handling, and spatial targeting of the active ingredient. This approach facilitates accurate delivery of small quantities of potent drugs. In future by combining various other approaches, microencapsulation technique will find the vital place in novel drug delivery system. And they are characterised by using the methods which are in the evaluation part.

REFERENCES

1. Jackson, L. S., & Lee, K. (1991). Microencapsulation and the food industry. *Lebensmittel-Wissenschaft+ Technologie*, *24*(4), 289-297.
2. Lachman, L., Lieberman, H. A., & Kanig, J. L. (1986). *The theory and practice of industrial pharmacy*. Lea & Febiger., bobbay, 3rd edition, P.P.412-429.
3. Berger, H. L. (1998). *Ultrasonic liquid atomization: theory and application*. Partridge Hill Publishers.
4. Lachman, L., Lieberman, H. A., & Kanig, J. L. (1986). *The theory and practice of industrial pharmacy*. Lea & Febiger.
5. Swarbrick, J. (2002). *Encyclopedia of Pharmaceu cal Technology* (pp. 2053-2056). New York: Marcel Deker. Vol-1325-1333.
6. Blanco, M. D., & Alonso, M. J. (1997). Development and characterization of protein-loaded poly (lactide-co-glycolide) nanospheres. *European Journal of Pharmaceutics and Biopharmaceutics*, *43*(3), 287-294.
7. Fabregas, J. L., & Garcia, N. (1995). "In Vitro" Studies on Buccoadhesive Tablet Formulations of Hydrocortisone Hemi-succinate. *Drug Development and Industrial Pharmacy*, *21*(14), 1689-1696.
8. Morphology of microencapsulation by Samiksha sawant www.slideshare.net/samikshasawant146/microencapsulation-54347409
9. Boh, B. (1996). *Microencapsulation technology applications: with special reference to biotechnology: developing support for introducing knowledge intensive technologies*.
10. Lachman, L., Lieberman, H. A., & Kanig, J. L. (1986). *The theory and practice of industrial pharmacy*. Lea & Febiger. 3, 414-415.
11. O'Donnell, P. B., & McGinity, J. W. (1997). Preparation of microspheres by the solvent evaporation technique. *Advanced Drug Delivery Reviews*, *28*(1), 25-42.
12. Torres, D., Seijo, B., García-Encina, G., Alonso, M., & Vila-Jato, J. L. (1990). Microencapsulation of ion-exchange resins by interfacial nylon polymerization. *International Journal of Pharmaceutics*, *59*(1), 9-17.
13. Bansode, S. S., Banarjee, S. K., Gaikwad, D. D., Jadhav, S. L., & Thorat, R. M. (2010). Microencapsulation: a review. *International Journal of Pharmaceutical Sciences Review and Research*, *1*(2), 38-43.
14. J.T. Goodwin, G.R. Somerville, Chemtech: 623–626, (1974).
15. Bodmier, R., & Hermann, J. (1997). Encyclopedia of Pharmaceutical Techonology. Vol. 16. *Waxes. New York: Marcel Deckker, Inc*, 335-61.
16. Khawla, A. (1996). Abu izza, Lucila Garcia-Contreras, Robert Lu D. Selection of better methed for the preparation of microspheres by applying hierarchy process. *Journal of Pharmaceutical Sciences*, *85*, 144-149.
17. Li, S. P., Kowarski, C. R., Feld, K. M., & Grim, W. M. (1988). Recent advances in microencapsulation technology and equipment. *Drug Development and Industrial Pharmacy*, *14*(2-3), 353-376.
18. Lu, W., & Park, T. G. (1995). Protein release from poly (lactic-co-glycolic acid) microspheres: protein stability problems. *PDA Journal of Pharmaceutical Science and Technology*, *49*(1), 13-19.
19. Nagai, T., Machida, Y., Suzuki, Y., & Ikura, H. (1980). *U.S. Patent No. 4,226,848*. Washington, DC: U.S. Patent and Trademark Office.
20. Jyothi Sri. (2012). Microencapsulation: A Review. International Journal of Pharma and Bio Sciences, 3(01).
21. Sachan, N. K., Singh, B., & Rao, K. R. (2006). Controlled drug delivery through

microencapsulation. *Malaysian Journal of Pharmaceutical Sciences*, *4*(1), 65-81

22. Bansode, S. S., Banarjee, S. K., Gaikwad, D. D., Jadhav, S. L., & Thorat, R. M. (2010). Microencapsulation: a review. *International Journal of Pharmaceutical Sciences Review and Research*, *1*(2), 38-43.
23. O'Donnell, P. B., & McGinity, J. W. (1997). Preparation of microspheres by the solvent evaporation technique. *Advanced Drug Delivery Reviews*, *28*(1), 25-42.
24. Venkatesan, P., Muralidharan, C., Manavalan, R., & Valliappan, K. (2009). Selection of better method for the preparation of microspheres by applying Analytic Hierarchy Process. *Journal of Pharmaceutical Sciences and Research*, *1*(3), 64-78.
25. Prakash, K., Raju, P. N., Shanta, K. K., & Lakshmi, M. N. (2007). Preparation and characterization of lamivudine microcapsules using various cellulose polymers *Tropical Journal of Pharmaceutical Research*, *6*(4), 841-847.
26. Chowdary, K. P., & Rao, Y. S. (2003). Design and in vitro and in vivo evaluation of mucoadhesive microcapsules of glipizide for oral controlled release: a technical note. *AAPS PharmSciTech*, *4*(3), 87-92.
27. Hausner, H. H. (1967). *Friction conditions in a mass of metal powder*. Polytechnic Inst. of Brooklyn. Univ. of California, Los Angeles.
28. Michael, E. A. (2002). Pharmaceutics: The science of dosage form design. *London, UK: Churchill Livingstone*, 197-210.
29. Si-Nang, L., Carlier, P. F., Delort, P., Gazzola, J., & Lafont, D. (1973). Determination of coating thickness of microcapsules and influence upon diffusion. *Journal of Pharmaceutical Sciences*, *62*(3), 452-455.
30. Method of Evaluation Microencapsulation by Sagar kishor www.slideshare.net/sagarsavale1/microencapsulation-62714987

