MICROENCAPSULATION AND ITS TECHNIQUES

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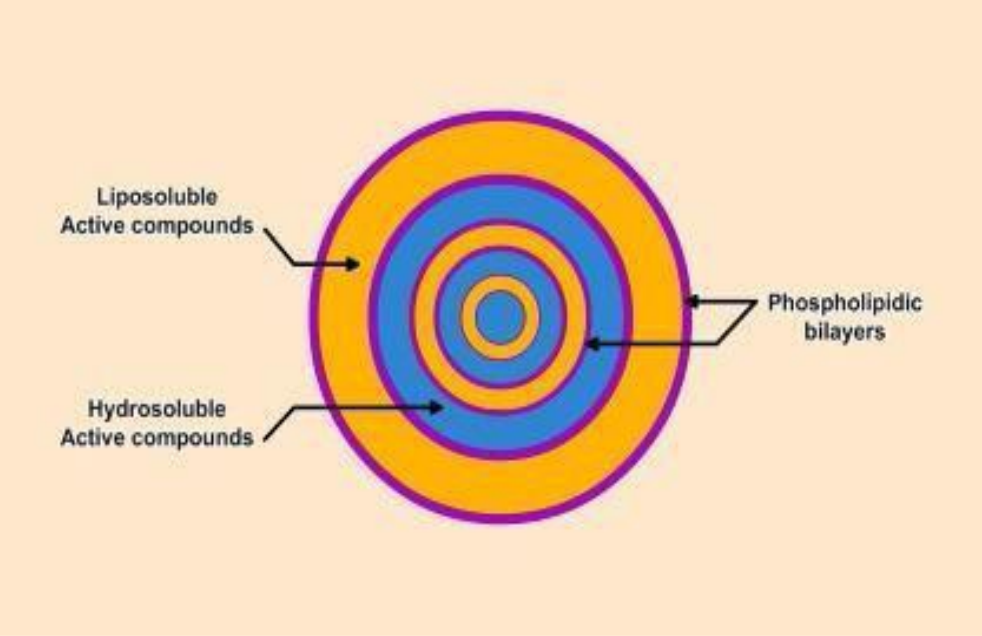
***Abstract*- Microencapsulation is essentially a method or procedure that creates microcapsules by applying thin coatings on small solid particles, liquid droplets, or dispersions in a repeatable manner. It is easily distinguished from other coating techniques by the size of the particles used, which vary in size from several tenths of a micron to 5000Âµ. Numerous methods of microencapsulation have been covered in the literature. Some are mechanical in nature and need specialized tools to create the necessary physical change in the system, while others are based on chemical processes and involve a chemical or phase shift. The process of microencapsulation offers solutions for a number of issues, including how to make prolonged-acting dosage forms, isolate incompatible materials, shield the chemicals from oxidation or moisture, and change a material's physical properties to make them easier to handle during formulation and production.**

***Keywords*: Microencapsulation, Pan coating , Coacervation phase seperation, Centrifugal extrusion process.**

INTRODUCTION:

Since its inception several years ago, microencapsulation has emerged as one of the most promising areas of medical use.Today, large pharmaceutical companies along with universities and research institutes are, like, super into studying microencapsulation. So, like, these Polymer chemical delivery system are focus on encapsulating big molecules such as peptides, proteins, and DNA/RNA for the purpose of using them as vaccinations or long-term vaccinations.
More importantly, some of these startups are all producing very cool drugs, many of these are still on the market today. (for example: Lupron Depot®, Zoladex®, Decapeptyl®, Eligard®, Enantone®, Trenantone®, Nutropin Depot®, Profact®). And then, to, like, add on, encapsulation to like, controlling the release of highly water-soluble chemicals has also received widespread attention.



Microencapsulation is basically like, it is a way in which small particles or droplets are surrounded by this chemical layer, resulting in small chemicals or droplets that have many advantages. So, more simply, a microcapsule is a small capsule surrounded by walls. The material inside the microcapsule is called the core, internal phase or filling, while the wall may be called the shell, layer or film.
Microcapsules were first discovered in 1931 by B Burg de Jon and Kan. By dealing with the preparations of gelatin spheres by using a coacervation process. In recent years, there is increasing interest in improving the quality of existing drugs by using developed drugs based on polymers that differ in permeability, dissolution rate, swelling and erodibility. It is generally believed that the diameter of microencapsulated particles(particles) is greater than 1 micron and can reach 1000 microns. Commercialized microparticles are 3–800 μm in diameter and have 10–90% w/w nuclei. Adhesives

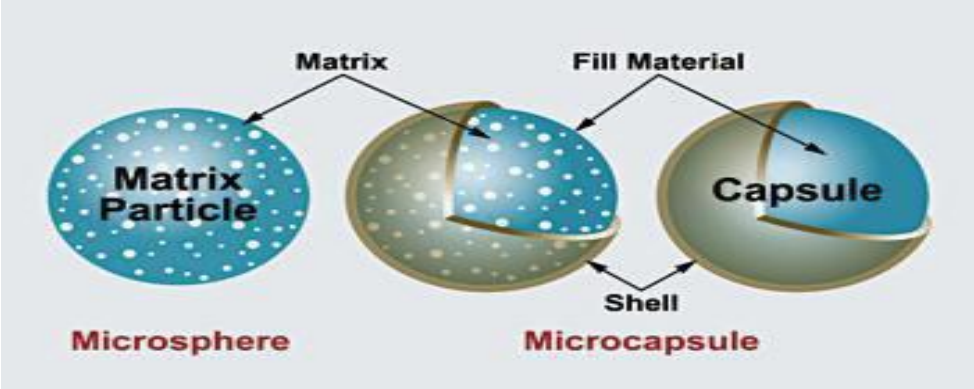
encapsulate many important materials, including agricultural chemicals, living cells, active enzymes, fragrances, fragrances and pharmaceuticals, and ink. A microcapsule is like a container; it's a type of system having of regular or sometimes even irregular shape which contains a well-defined nuclei, which could be solid, liquid, or even gaseous; And it has a shell made of one or more polymers with a continuous, porous or non-porous polymer phase. Microencapsulation provides a means to transform liquids into solids, alter colloidal and surface properties, protect the environment, and control product release or coating properties. Many tasks can be accomplished using macro compression technology; However, microencapsulation is characterized by the small size of the material layer that can be modified into different types of drugs, which is not technically possible.

Reasons for Microencapsulation:

- This device is widely used to mask the taste and smell of many drugs, s It can mask odors or smells, thus increasing the patient compliance such as paracetamol, nitrofurantoin.
- Thanks to microencapsulation technology liquid medicine can now be converted to a free-flowing powders.
- Residual drug can be protected with moisture-, light-, and oxygen-sensitive microcapsules, such as nifedipine, to prevent photoinstability and drug incompatibility.
- Microcapsules prevent allergens such as aspirin and peppermint oil from evaporating at room temperature.
- Microencapsulation can reduce the toxicity and gastrointestinal irritation of potassium chloride(KCL) and ferrous sulfate.
- Microcapsules are also used to change the site of absorption. This application is useful for chemicals with low p H toxicity.
- Bakan and Anderson stated that microencapsulated microencapsulated vitamin A palmitate increases stability by forbiding from disintegration.
- The microencapsulation method is also used for the preparation of in vivo anti-inflammatory drugs.

MATERIALS USED FOR MICROENCAPSULATION:

Preparation of microspheres should be based on procedures such as a simple understanding of the properties of microc apsules, such as the nature of the substrate and coating.

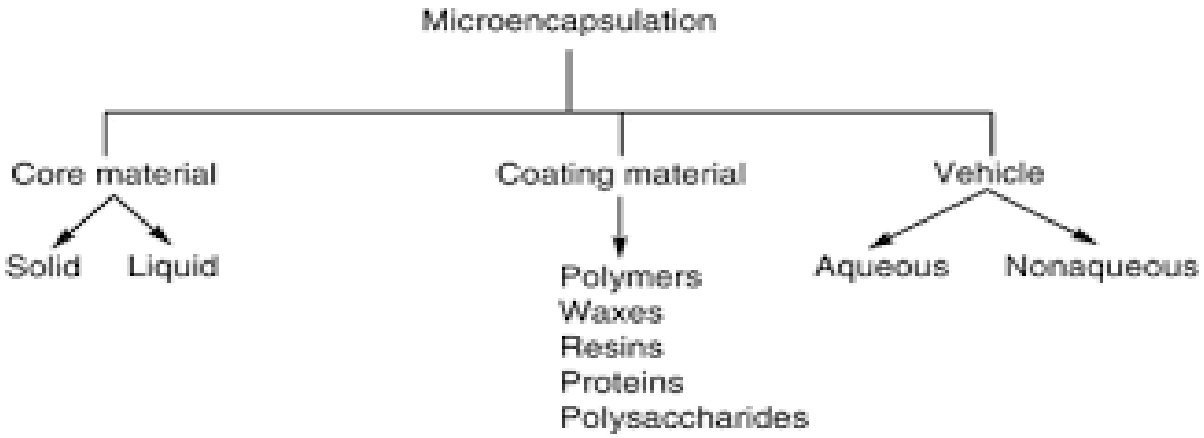


Core Material:

Substrate is defined as a special layer of material that can be liquid or solid in nature. The core material will change as the liquid core will contain solids and/or melts. The active core may be admixture of active constituents, stabilizers, diluents, receptors and blockers or acclerators. The ability to modify the base material provides unparalleled flexibility, and this tool can often be used to efficiently create and produce desired microencapsulated products.

Fundamental considerations: Knowledge of the possibilities offered by microencapsulation requires an elementary comprehension of the general characteristics of the microcapsule, including the material and coating qualities, the data layer stability and release characteristics, and the microencapsulation procedure.

FUNDAMENTAL CONSIDERATION:



Release mechanisms:

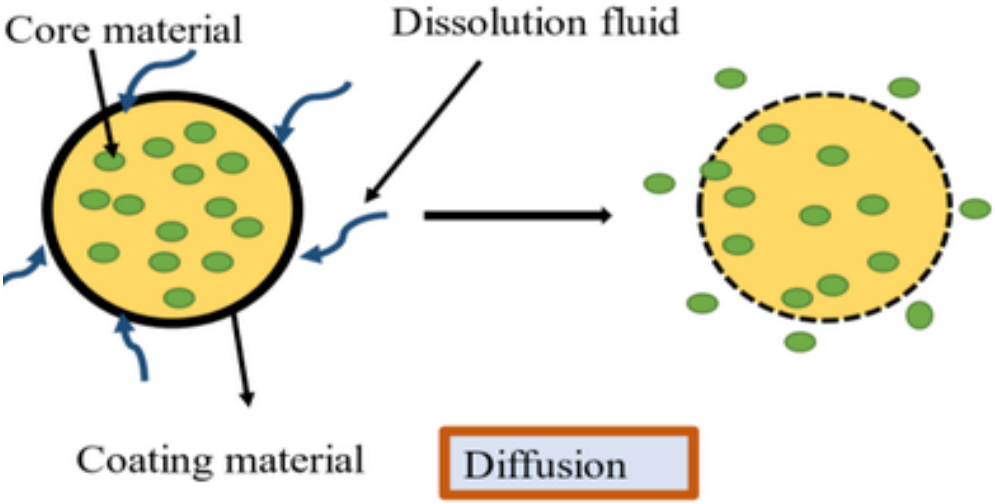
The drug release mechanism of microspheres is as follows:

1.Disintegration Controlled Monolithic System: -

The matrix is uniformly mixed with the solution. The matrix is broken down and the drug is released, which is how it adheres to the matrix. Matrix degradation occurs faster than drug diffusion.

2. Diffusion controlled monolithic system:

In this case, the polymer matrix breaks down either before or at the same time as the active chemicals are released through diffusion. The degree to which the polymer breaks down via homogeneous or heterogeneous pathways affects the release rate as well.



3. Diffusion controlled reservoir system:

Here, the API is enclosed in the networkactive agent, the agent is dispersed and the membrane is separated only after distribution is complete. In this case, matrix degradation does not affect drug release.

4. Erosion:

Coating erosion due to pH and enzymatic hydrolysis results in the release of chemicals from some coating materials s uch as glyceryl monostearate, beeswax, and sterile alcohol.

Coating materials:

The coating material must be able to form a thin film that adheres on the substrate; It must be chemical, not nuclear material. It offers essential functions like stability, strength, flexibility, sealing, and optical strength. Changes in fields can cause some sensitivity in the data layer employed in the microencapsulation process. Analyzing available information and searching for free movies or advertisements often helps to choose a particular tec hnique, but the use of free movie files is often affected by:

(1) Cast films or white films produced by the casting process produce thicker films than films formed by microencapsulation of tiny particles; therefore, the results obtained from the cast film cannot be extrapolated to the microcapsule process alone.

(2) Special microencapsulation technology uses specialized equipment and provides special and unique properties that are difficult to express through technology alone.

(3) The substrate of the main product has a decisive influence on the performance of the layer. The selection of special coating materials therefore involves taking into account classic white film materials and their application results.
(4) The coating material must be able to form an adhesive bond with the main substance.
(5) It ought to be chemically compatible with the substrate and non-reactive.
(6) It must meet the necessary criteria such as flexibility, strength, sealing, optical strength and stability.

Coating material properties:
(1) Stabilization of important products.
(2) Do not mix with active ingredients.
(3) Regulate release under certain conditions.
(4) The production of the film is simple, odorless and stable.
(3) Regulate release under certain conditions.
(4) The production of the film is simple, odorless and stable.
(5) No moisture, no viscosity and cheap price.
(6) Soluble in medium or heavy water.
(7) The layer is gentle, brittle, tough or skinny.

Examples of coating materials:

✓ **Water Soluble resins** – Gelatin, Gum Arabic, Starch, Polyvinylpyrrolidone, Carboxymethylcellulose, Arabinogalactone, Hydroxy-ethylcellulose, Polyacrylic acid.

✓ **Water insoluble resins** – Ethyl cellulose, Polyethylene, Polymethacrylate, Polyamide (Nylon), Poly (Ethylene Vinyl acetate), cellulose nitrate, Silicones, Poly lactidecoglycolide.

✓ **Lipids and waxes**– Paraffin, Carnaubawax, Spermaceti, Beeswax, Stearic acid, Stearyl alcohol, Glyceryl stearate.

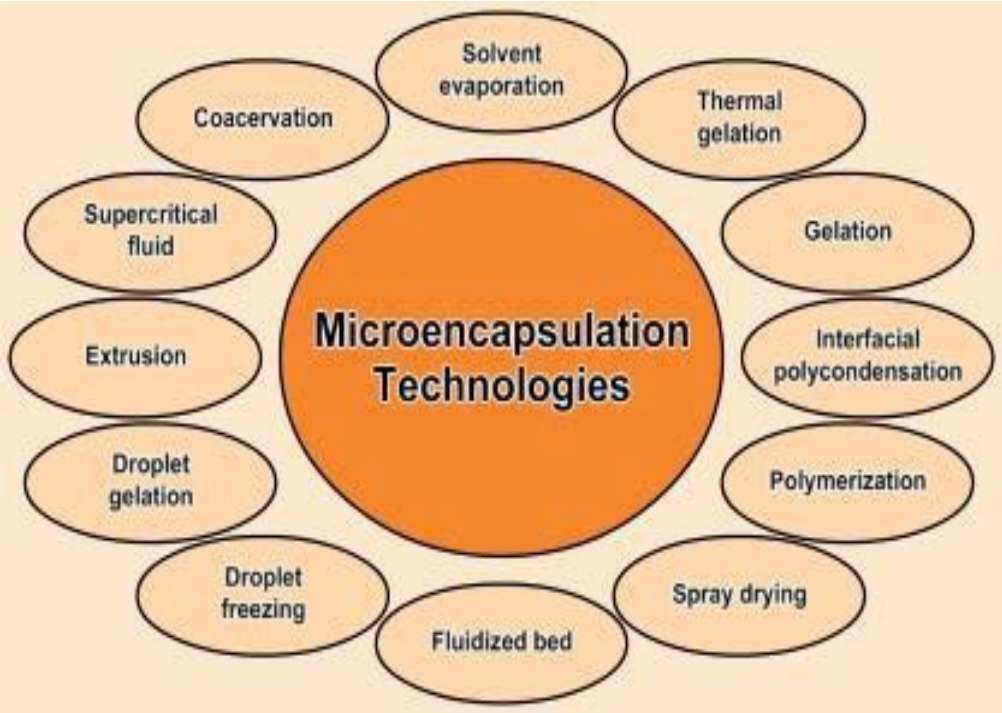
✓ **Enteric resins** – Shellac, Cellulose acetate, phthalate, Zein.

The materials used for coating in microencapsulation are classified as:

i. Cellulose: Eor example- Ethyl-Cellulose, Nitro-Cellulose, Carboxy-Methylcellulose, Cellulose-acetate phthalate and Cellulose -cetate butyrate phthalate.
ii. Condensation polymers: Eor example - Nylon, Teflon, Poly-methane, Poly-carbonate, Amino resins, Alkyl resins and Silicone resins.
iii. Curable polymers:, Eor example- Epoxy-resins, Nitro paraffin and Nitrated polystyrene.
iv. Proteins: Eor example- Collagen, Gelatin, Casein, Fibrinogen, Haemoglobin and Poly-amino acids.
v. Waxes: Eor example- Wax, Paraffin, Rosin shellac, Tristerium, Monoglyceride, Bees-wax, Oils, Fats and Hardened oils.
vi. Homopolymer: Eor example- Poly-vinyl chloride, Polyethylene, Polystyrene, Poly-vinyl acetate and Poly-vinyl alcohol.
vii. Vegetable Gums: Eor example- Gum Arabic, Agar, Sodium-alginate, and Carrageenan and Dextran-sulphate
viii. Copolymers: Eor example- Maleic-anhydride copolymer with Ethylene or Vinyl methyl ether, Acrylic acid copolymers and Methacrylic acid co-polymers.
ix. Curable polymers: Eor example- Epoxy- resins, Nitro paraffin and Nitrated polystyrene.

Methods of microencapsulation are:

1. Air suspension technique.
2. Coacervation phase separation technique.
3. Centrifugal Extrusion process.
4. Spray drying and congealing process.
5. Pan coating technique.
6. Solvent evaporation process.
7. Polymerization technique.



1. Air suspension technique.

In air suspension technique the layers of products obtained from assembly or insulation offers increased control and flexibility. Particles get coated and then removed as they move upward in the perforated panels provide them with support flow with specially designed internal and external cavities and round and hollow ends. Move upwards from the outer ring to fluidize the particles. Most risers communicate with (usually heated) air in a keg, causing the product to rise rapidly. As the noise of the conversation faded away, they returned to the bed outside and moved to start the cycle again. Material passes through the inner cylinder many times within minutes.Prepared suspensions provide various candidate coatings for microencapsulation.

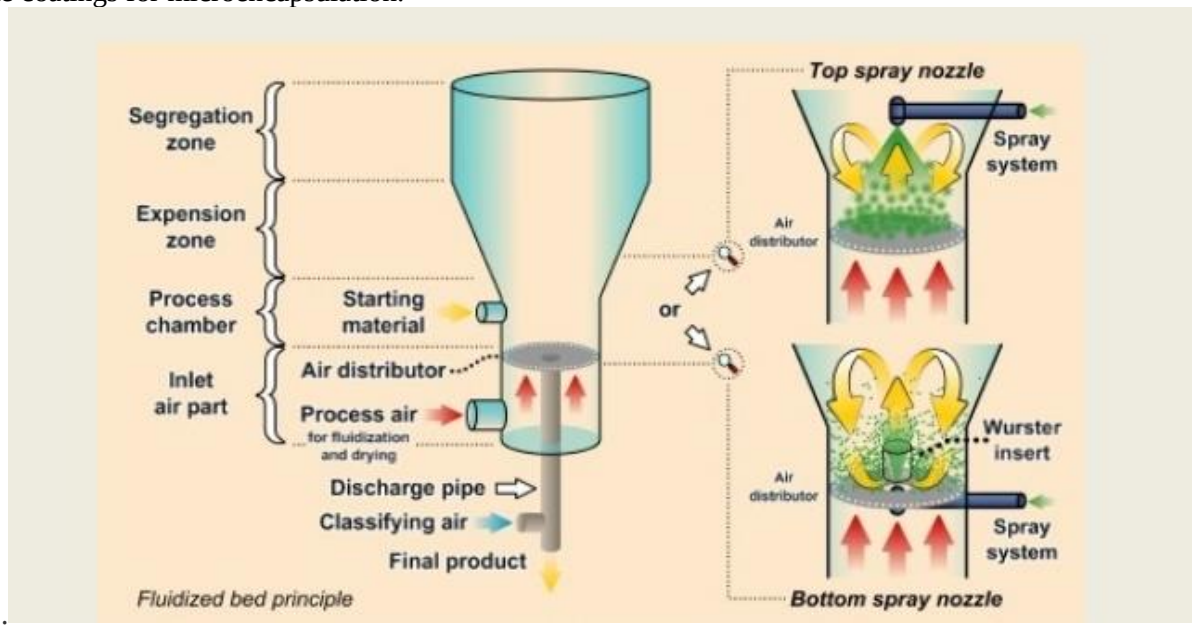


Figure: Air suspension.

The process leads to the application of coating, liquid preparation, emulsions, crushed or thermally softened glass fra me in soluble process from 1 lb to 990 lb capacity. Significant materials containing micron or submicron particles can be processed by subtraction, the particles are typically agglomerated into a larger size.

2. Coacervation phase separation

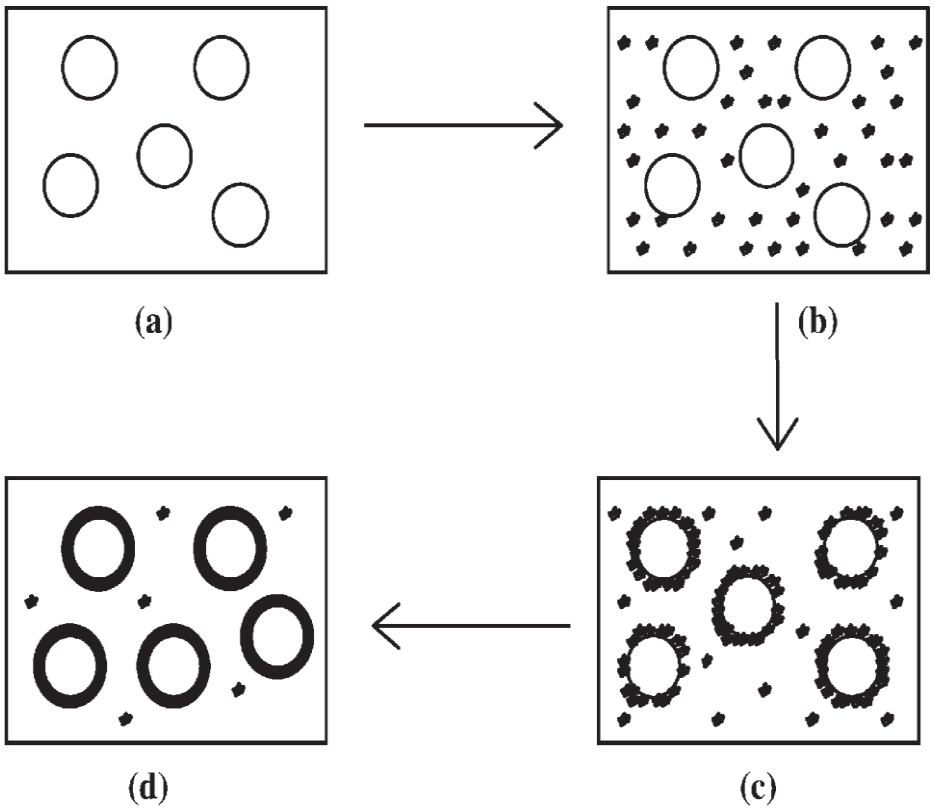
This procedure involves three steps performed through continuous agitation.

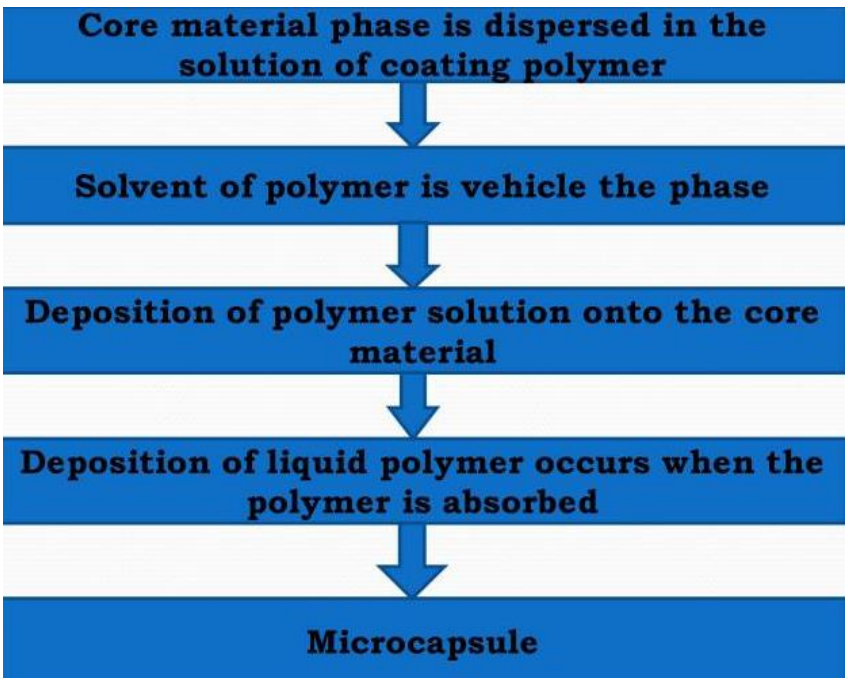
a) **Formation of three non-mixing chemical phases:**

This process consists of three stages: the liquid stage, the main product stage and the outer layer, which will form the cargo. The primary product is distributed within the layer of polymer solution, with the polymer solvent being a liquid that forms the carrier phase. The coating process is a liquid form of immiscible polymer produced by a separation combination process by adjusting the temperature of the polymer, adding salt or solvent, or inducing polymer-polymer interactions.

b) Deposition of the coating:

The liquid polymer process is used for important materials by controlling the physical composition of the product. Wh en the polymer is soaked up at the boundary between the base material and the liquid layer, the coating is deposited on the base material. This absorption is necessary for successful coating. The decrease in total free interfacial energy of energy promotes the coating and material elongates, decreasing its surface area as the liquid polymer coalesces.





c) Rigidity enhancement of the coating:

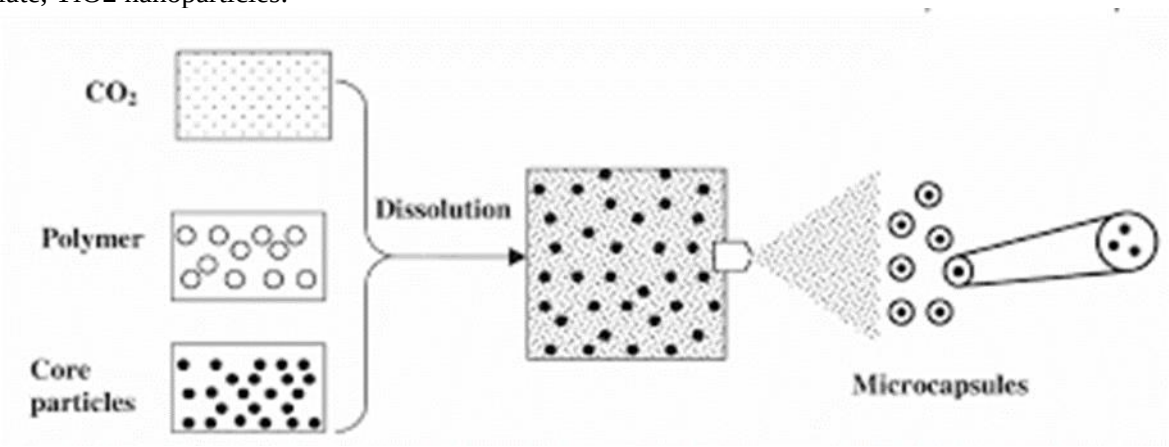
This process involves solidifying the coating typically through thermal and cross-linking methods to create stable microcapsules are:

The most common uses are as follows:

- Rapid expansion of supercritical solution (RESS).
- Gas anti-solvent (GAS) method.
- Particles from gas-saturated solution (PGSS).

Rapid growth of supercritical solution

After the pressure is controlled throughout the process, the supercritical fluid, which holds the active material and shell material, is sprayed through small nozzles at atmospheric pressure. The material shell melts rapidly due to shock and forms a layer around the material (core). The disadvantage of this method is that it requires high resolution of the shell material and gradient operation in supercritical fluid. Supercritical fluids such as CO2 generally dissolve only a few polymers with low adhesion density (polydimethylsiloxane, polymethacrylate, etc.). The use of cosolvents can increase the solubility of polymers.Although the solubility of the supercritical fluid increases when non-solvents are used, the shell material does not dissolve at atmospheric pressure. In recent applications, ethanol has been utilized as an inadequate solvent for polymer shells, including polyethylene-glycol, Poly(styrene)-b-(polymethyl methacrylate)-co-(methacrylate) copolymer microencapsulation with Polystyrene-block-poly(methyl methacrylate) and polymethyl methacrylate, TiO2 nanoparticles.



Gas anti solvent (GAS) method

Another name for this process is supercritical fluid antisolvent (SAS). In this method, a solution of shell material and active ingredients is mixed with supercritical fluid and then pressurized. The solution's volume increases, leading to supersaturation and the precipitation of the liquid. Therefore, the substance should be dissolved in the liquid solvent instead of in a combination of heavy and supercritical fluid. However, liquid solvents and supercritical fluids require mixing. Because water has low solubility in supercritical fluids, this technique is unsuitable for encapsulating water-soluble components. Additionally, submicron particles can be created using this approach.

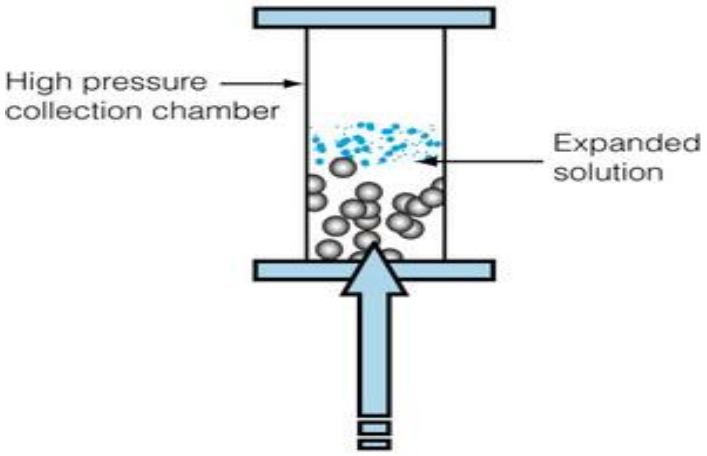


Figure: Gas anti-solvent method.

Particles containing Gas Saturated Solutions (PGSS)

The process is finished when the shell and core are submerged under pressure in a supercritical fluid. This process causes the crust to expand as supercritical fluid enters it. When the mixture is heated on glass, the polymer liquefies. Once the pressure is removed, let the crust settle on top of the ingredients. The material used in the shell and core of this process does not dissolve in the supercritical fluid. The pharmaceutical industry frequently uses preformed microparticles to use supercritical fluid to capture active ingredients under pressure.

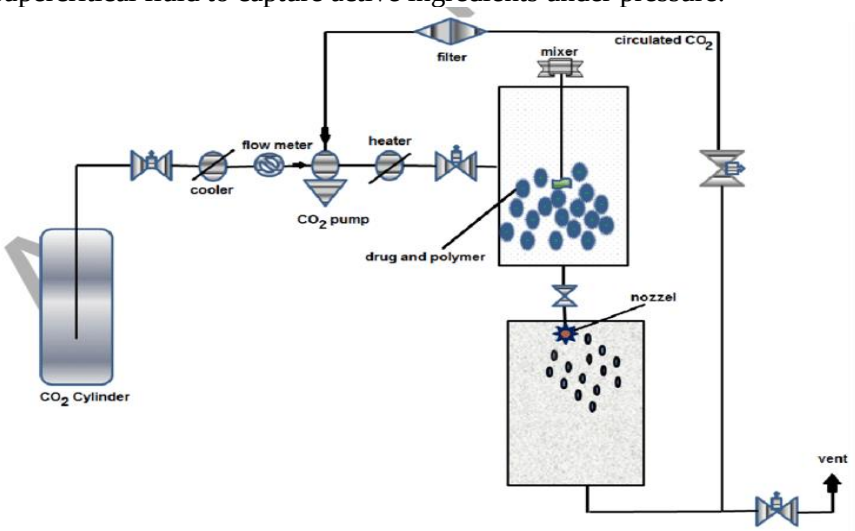
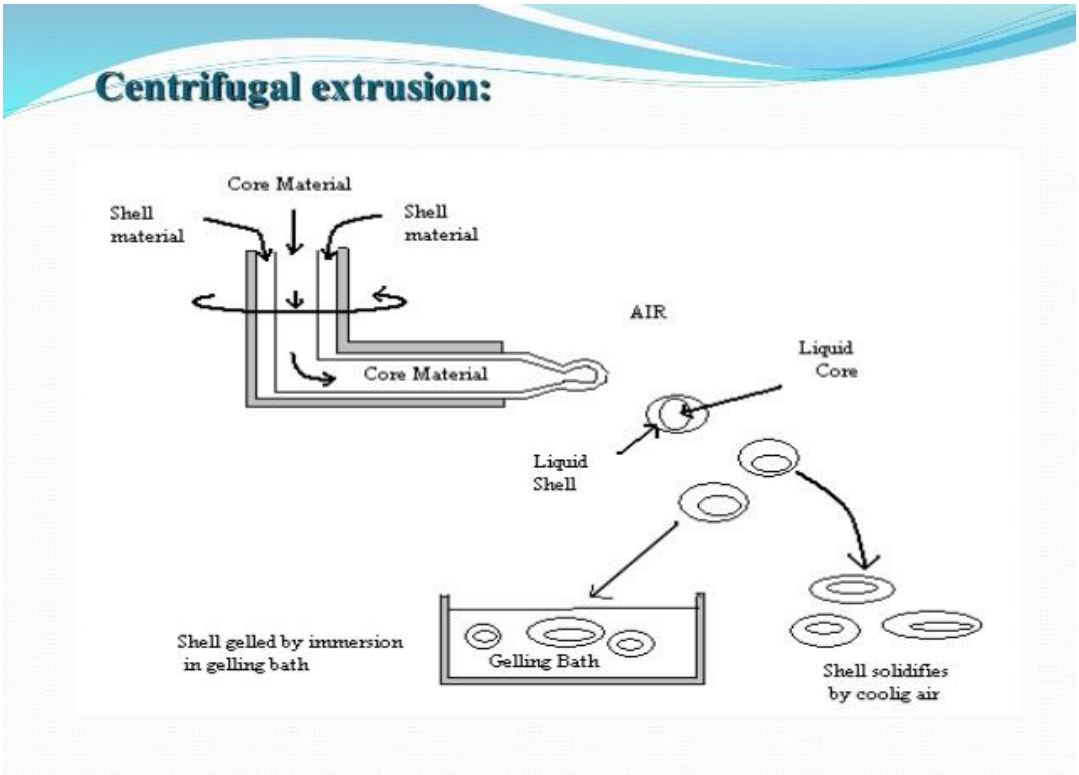


Figure 3: PGSS.

Centrifugal extrusion

To encapsulate the liquid, a revolving extrusion head with concentric nozzles is utilized. In this process, a wall solution or molten sheath is formed around the plane of the core liquid. Rayleigh instability causes the jet to break up into small droplets, each covered by a wall of solution, as it propagates through the air.One possibility is that the solvent evaporates from the chemical wall or the molten wall solidifies when the droplets fly away. The droplets fall in a narrow ring around the nozzle, with most being within ±10% of the average diameter. Therefore, once the capsules are formed, they can be hardened if necessary by immersion in a ring hardening bath.This method is best for fabricating parts with diameters of 400-2,000 μm (16-79 mil). This technique is only suitable for liquid or slurry materials because droplets are formed by the breakup of the liquid plane. Each nozzles can be produced upto each nozzle, 22.5 kg (50 lb) of microcapsules every hour, which is very beneficial. Sixteen nozzle sprinkler heads are available.



4. Congealing and Spray drying

A microencapsulation process called spray drying involves dissolving or suspending an energetic component in a polymer or softener solution and then trapping it inside the dried particle. The main benefits include the dryer's ability to handle labile materials due to its short touch time and reasonably priced operation. In contemporary dryers, spray viscosity can get up to 300 mPas. The parent material is distributed in a liquefied coating and the coating process is sprayed or absorbed into the environment, which impacts quick strengthening (and creation) of the layer. These processes are comparable for both spray drying and spray coagulation. The primary distinction between the two approaches is how the solidification layer is finished. The primary distinction between the two approaches is how the solidification layer is completed. The coating's curing process is correlated with the solvent's quick evaporation during spray drying. However, in order to purify the melt process, the coating layer must be added to the nontoxic layer or the molten layer must be heat treated in the spraying process. Adsorption,extraction or evaporation methods are used when the solvent or solvent is removed from the coated product.

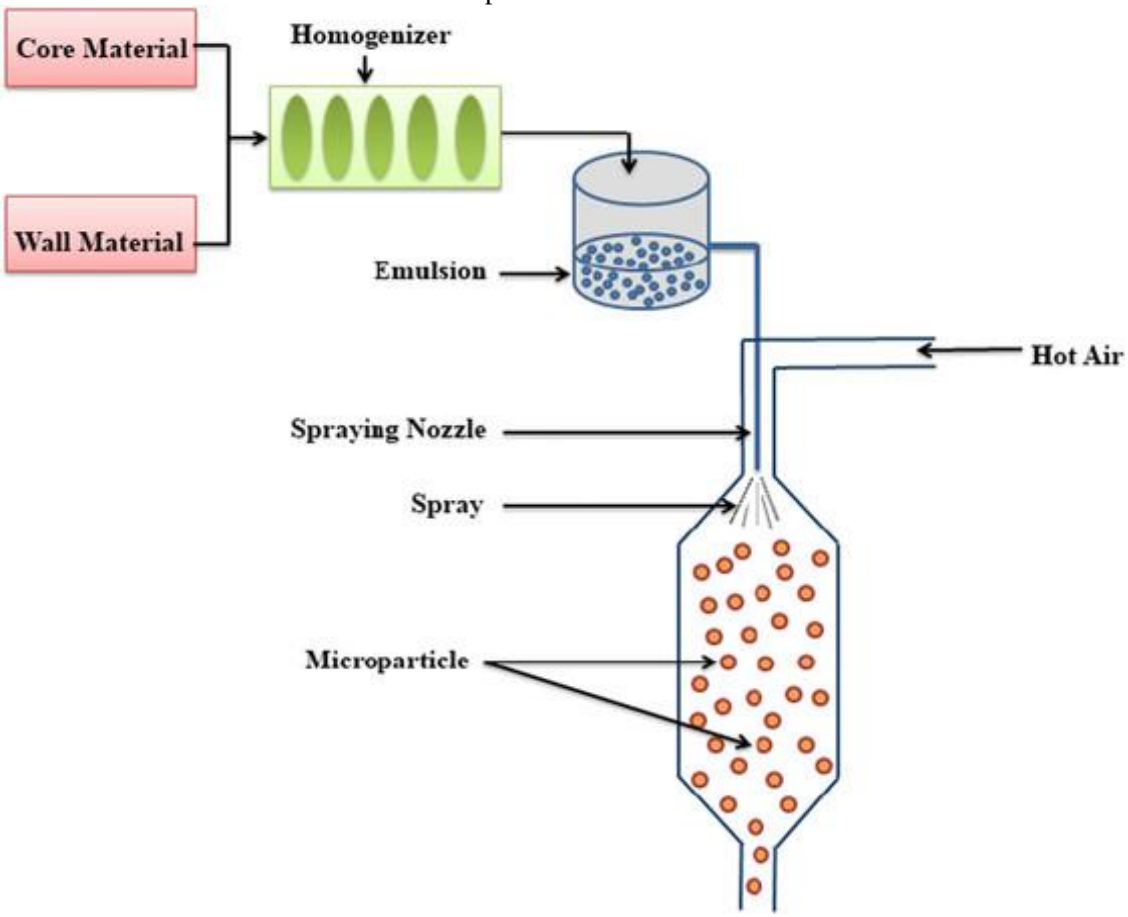


Figure: Spray drier

Following the atomization of the mixture into the air stream, which dissolves the coating while leaving the parent insoluble substance, the real microencapsulation process through drying will have an impact on the parent material. Hot air is typically used to produce the latent heat of evaporation needed to extract the solvent from the coating material and create the microencapsulated item. The parts of the dryer include the cyclone separator, packing, blower or fan, primary spray chamber, atomizer, and heater. When the melt-form protective layer is applied, microencapsulation can be achieved by spray condensation using spray drying equipment. Except that the source material dissolves into a molten layer rather than a layer, the transformation process and conditions are the same as those described above. Spray the hot mixture into a stream of cold air to perform the process, also known as microencapsulation. Wax, fatty acids, alcohols, polymers, and sugar are among the materials that are solid at ambient temperature but melt when using spray condensation technology. Generally, when spray drying is used, the small particles of coagulated spray can be accurately controlled, and it has been shown that they have good feed, atomizer wheel speed, feed viscosity distribution and exchange performance.

5. Pan coating

One of the most advanced processes for making small coated granules or tablets is the coating pan, which is widely us ed in the pharmaceutical industry. When the pellets are filled into the pot or other equipment, handle the coating mater ial slowly.

One of the most advanced processes for making small coated granules or tablets is the coating pan, which is widely used in the pharmaceutical industry. Larger particles over 600 microns are typically thought to be appropriate for effective coating, and this technique is widely used in the preparation of controlledrelease microbeads. Swirling the granules in a pot or other container while slowly applying the coating causes microencapsulation.

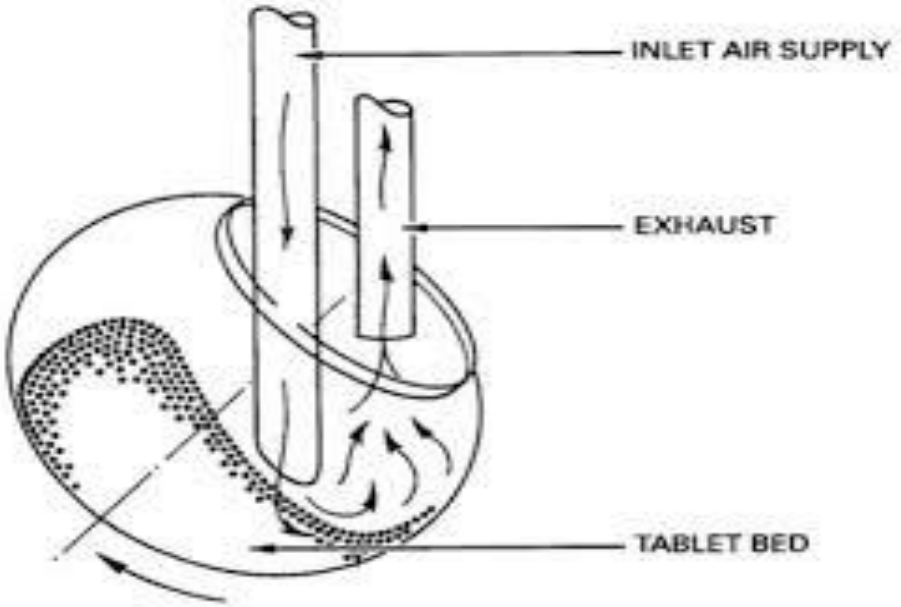
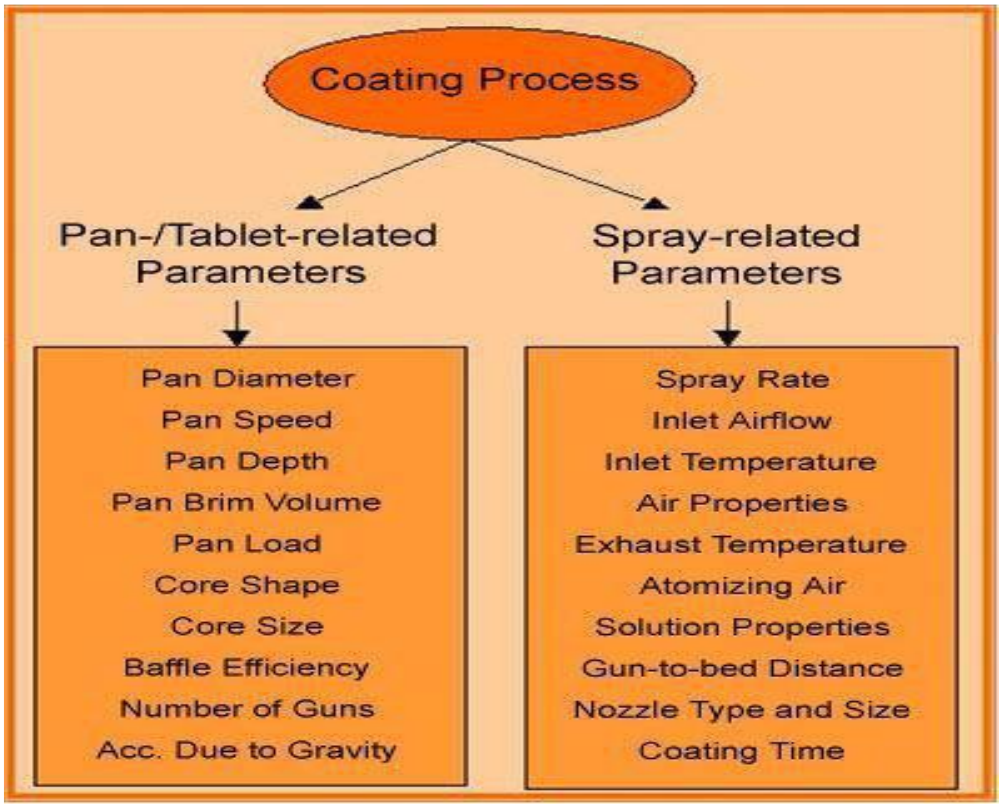


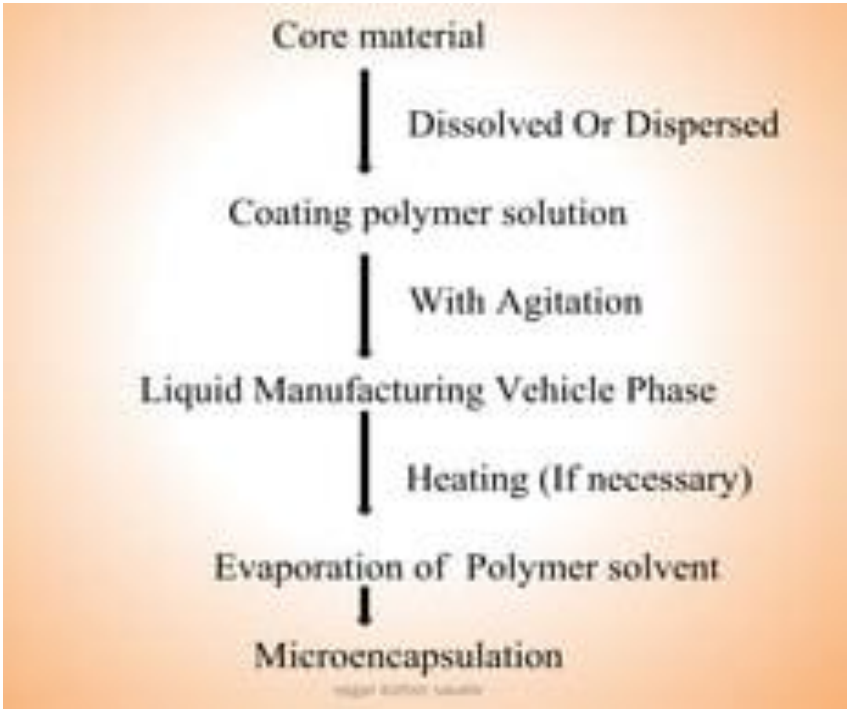
Figure: Coating pan

Generally, the drug is coated on various spherical substrates such as unique sugar seeds and then coated with different polymer layers for protection.Generally, the coating is sprayed as an atomized spray or solution onto the desired mate rial in the coating pan. When coating is used in a plating pan, hot air is usually flown through the coated material to re move the heavy coating. Sometimes the final solvent.



6. Solvent Evaporation Techniques

To create an O/W emulsion, two immiscible liquids are combined, which is used as a tool for solvent evaporation technology. Volatile solvents that are immiscible with the liquid vehicle are used in this process to dissolve the microcapsule layer (polymer).The polymer solution is mixed with the active ingredient to form microcapsules. The mixture of coating material and core is mixed and blended together in a liquid forming process to produce microc apsules of the correct size. The system was stirred continuously until the solvent separated into the aqueous phase and evaporated, removing the aqueous phase. Variables associated with the manufacturing process, polymer solvent evapo ration rate, temperature cycling, and agitation speed are some of the factors that can affect the microencapsulation pro cess.



The selection of the carrier phase and solvent for the polymer layer is crucial for creating microcapsules using solvent evaporation techniques, because they have a significant impact on the product and solvent recovery process of the final product. This method of making microcapsules works in both liquids and solids. Use water-soluble or insoluble materials as important materials. Coating materials include various film-forming polymers.

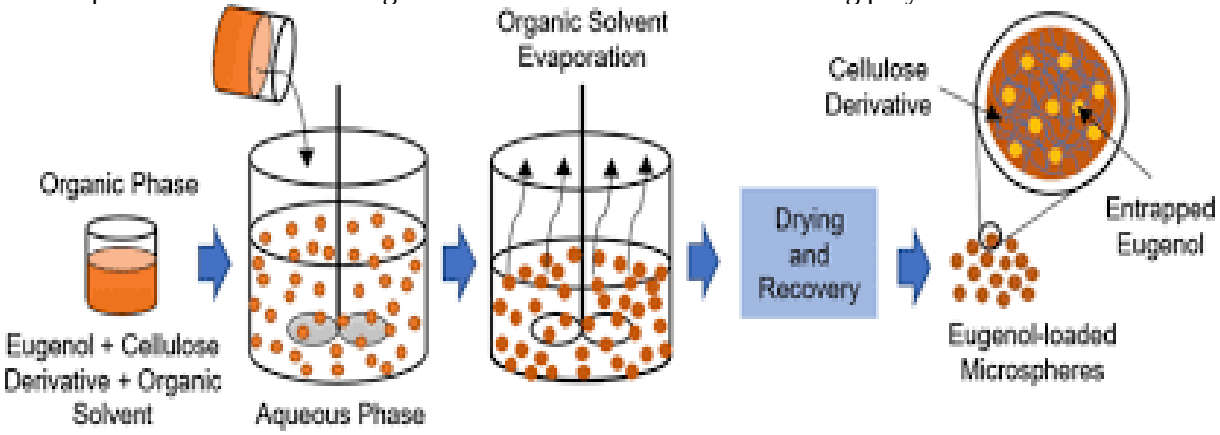
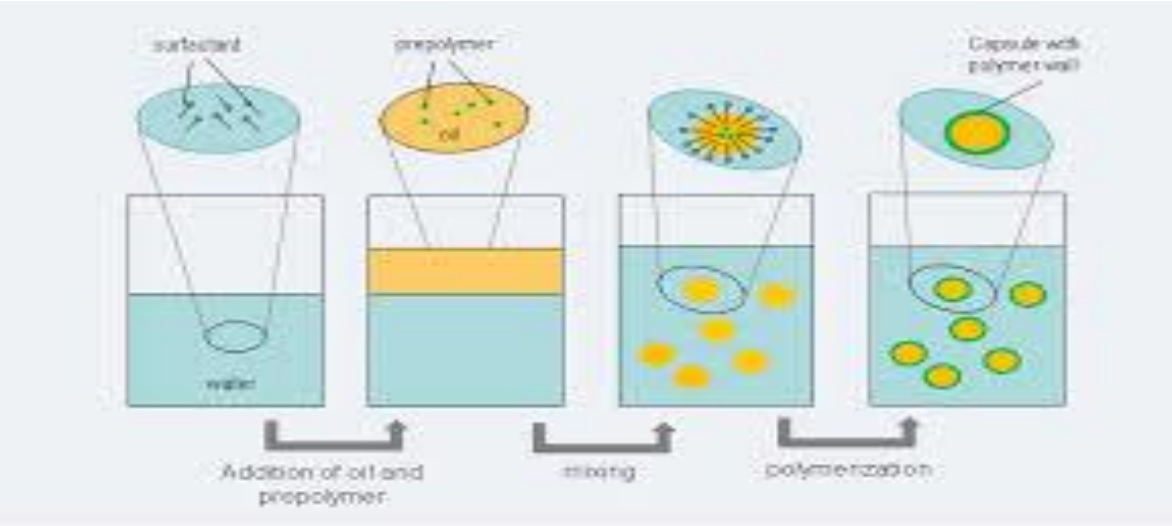


Figure: Solvent evaporation method.

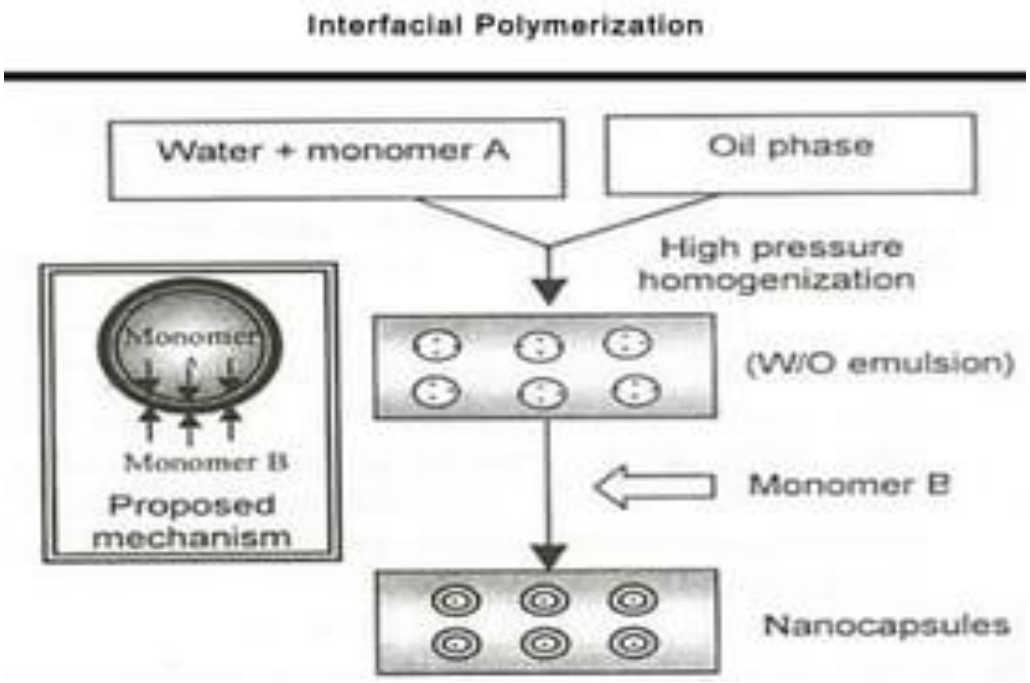
7. Polymerization

a) Interfacial polymer

When two reactants congregate at the interface during condensation polymerization, they react quickly during interfacial polymerization. The classical Schotten Baumann reaction between acid chlorides and molecules (polyesters, polyureas, polyurethanes, alcohols, or amines) containing hydrogen atoms is the basis for this technique. In actuality, it changes quickly at the interface because of the thin walls.



The aqueous solution including amine and polyfunctional isocyanate is added after the insecticide and dichloride have been emulsified in water. The presence of a base helps stabilize the acid produced by the reaction. A condensed polymer wall immediately forms at the emulsion droplet interface.



b) In-situ polymerization

Some microencapsulation technologies involve polymerizing single monomers directly on the surface. One method is to soak cellulose fibers in dry toluene and wrap them in polyethylene. Typically, the rate of deposition is approximately 0.5µm/min. Range of layer thickness: 0.2-75µm. The uniformity of finish extends to angular projections.

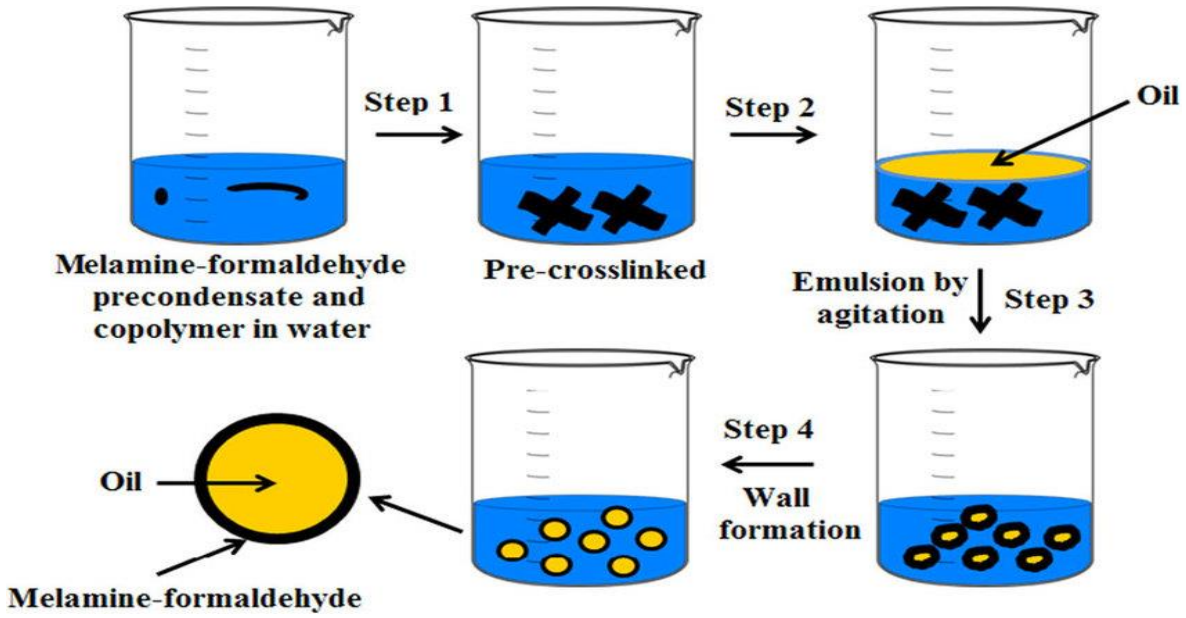


Figure: in-situ polymerization

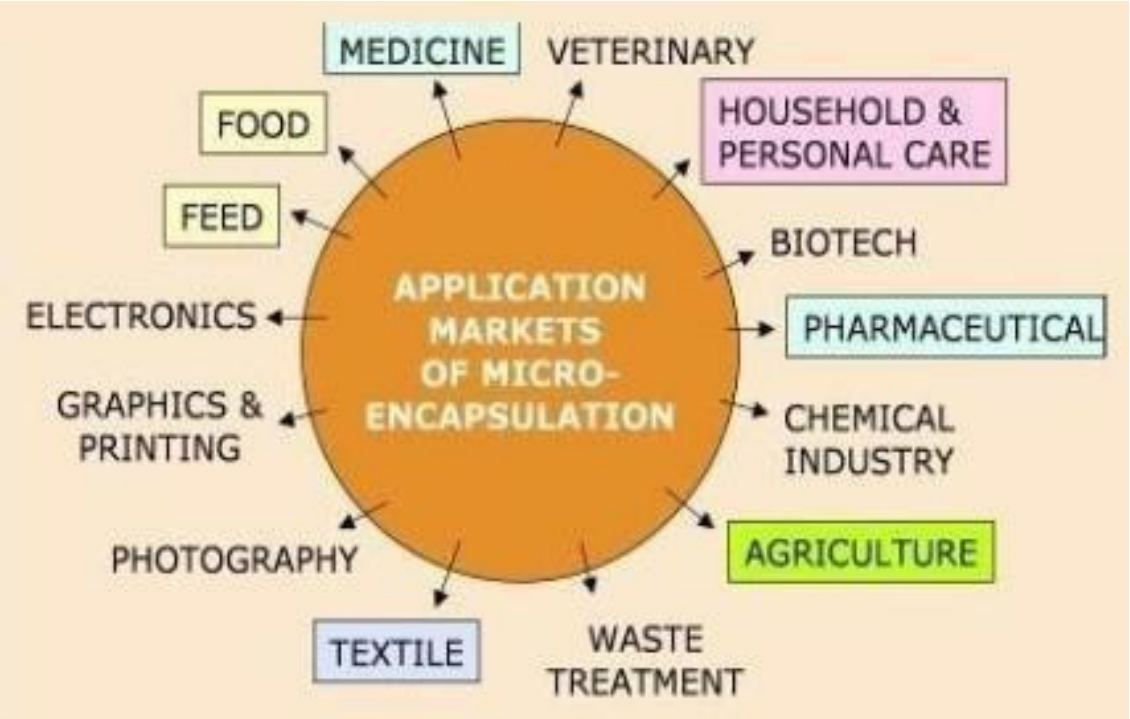
c) Matrix polymer

During particle formation, the parent material will be embedded in the polymer matrix through various processes. Eva porating the solvent from the matrix material forms the result in a straightforward process called spray drying. However, chemical changes may also be responsible for the solidification of the matrix.

Application of microencapsulation

Medicines and related drugs are microencapsulated for various reasons. This technology is widely used to produce lar ge quantities of paper with controlled release and control.

- ✓ Cover the smell of nitrofurantoin, paracetamol and other medications.
- ✓ Many drugs are packaged in microcapsules to reduce stomach ulcers and other stomach disorders. Your wife. S ustained-
  release aspirin has been reported to reduce food intake. Bleeding occurs more frequently than in previous plans.
- ✓ Liquids such as Erprazinone can be made into dummy materials for easy use and storage.
- ✓ Hygroscopic microencapsulation can reduce the activity of important materials such as sodium chloride
- ✓ Carbon tetrachloride and many other chemicals are microencapsulated to reduce their odor and volatility.
- ✓ Microencapsulated vitamin A to avoid the effects of weather protects important information such as palmitic acid.
- ✓ Encapsulation can intelligently separate the substances which are not compatible.
- ✓ Cell Immobility: Human tissue undergoes continual fermentation in plant cell culture to become a bioartificial organ.
- ✓ For production of drinks.
- ✓ Protects the molecules from the effect of other substances.



Characterization of microcapsule

An important phenomenon that helps create suitable vehicles for the transport of proteins, drugs or antigens is the beh avior of the transporters. The microstructure of these microspheres is different. The stability and release of the carrier are determined by the microstructures.

Sieve analysis

A mechanical sieve (Sieving instrument, Retsch, Germany) was used to determine the separation of microspheres into fractions of different sizes. Five fine wire meshes (20, 30, 45, 60 and 80 mesh) were placed by reducing the opening size. On top of the highest sieve, five grams of drug-loaded microspheres are present. After the sieve was shaken for about ten minutes, the material on the sieve was weighed.

Morphology of microsphere

The morphology of the microspheres was examined with an electron microscope (Philips XL 30 SEM, Eindhoven, and The Netherlands).

Doublesided tape was used to attach the microspheres to a copper cylinder with a diameter and height of 10 mm. Samples were coated using ion sputtering equipment (JFC-1100E, Jeol, Japan) at a current of 10 mA for four minutes.

Atomic force microscopy (AFM)

The surface morphology of the microspheres was examined using digital multimode atomic force microscopy. Use do uble-sided tape to adhere the sample to the metal plate and examine it in a climate-controlled, vibration free machine.

Particles size

Determining the size after being ultrasonically dispersed for three minutes in two to three milliliters of distilled water with 0.1% (w/w) Tween 20, about thirty milligrams of microparticles were moved to a tiny recirculator running at sixty milliliters per second. The Malvern Mastersizer X (Malvern Instruments, UK) can be used for laser diffraction to determine size.

Polymer's solvent solubility.

One powerful measure of solvency is a solution's turbidity. Polymer solubility in a variety of organic solvents can be ascertained using cloud point.

The polymer solutions' viscosity

A U-tube viscometer is used to evaluate the viscosity (absolute), viscosity (kinematics), and intrinsic viscosity of the polymer solvent in different solvents.The formula for the viscosity of the U-tube viscometer at 400C is as follows: The viscometer at 25°C / 0.10°C is used to measure the viscosity of the U-tube viscometer. The solvent should be allowed to stand at room temperature for 24 hours before testing to guarantee the completion of the polymer.

Determination of the Density.

An instrument called a multivolume pycnometer can be used to determine the microspheres' thickness. Insert the measuring tool into the beaker's multi-volume pycnometer. In the chamber, helium is added at a steady weight and allowed to expand. This extension was achieved by reducing the weight of the interior. Two consecutive readings of

different indicator weights are famous. Two weight measurements yield the volume and thickness of the microsphere carrier.

Bulk density

After weighing, the resulting microspheres were placed in a graduated glass cylinder, 10 mL.

An automated apparatus (Quantach, Rome, FL, USA) was used to tap the cylinder until the microsphere bed volume remained constant and the volume was estimated using the weight of the microspheres divided by the ultimate bed volume of microspheres.

Capture efficiency

Microspheres that are washed and allowed to break down can be used to calculate the capture or percentage of microspheres. The lysate is then tested for active ingredients according to monograph guidelines. Formula: Returns the percentage of package efficiency.

Ratio of entrapment = Real content / Theoretical content x 100

The angle of contact

To find out how much moisture is in the cargo, the angle needs to be measured. It establishes if microspheres are hydrophilic or hydrophobic. Adsorbed materials have an impact on this special thermodynamic property. At the interface of a substance, air, and water, the contact angle is determined. The angle of advance and return of the contact is measured by placing the drop in the circle of the hand placed over the target of the reverse measuring machine. Contact angles were measured at 200° within one minute after microsphere deposition. Measurements of the permeability and release characteristics of pharmaceuticals via membranes require experimental approaches. Numerous in vitro and in vivo methods have been documented for this objective. research on the release of drugs in vitro, drug creation, etc. In fields, it serves as a process for quality control. Accurate and repeatable data from physicochemically and hydrodynamically defined circumstances are required. Many in vitro release methods have been created for oral formulations due to the influence of circumstances and the difficulty of reproducing in vivo conditions; nevertheless, the in vitro model method has not yet been produced. Depending on the type of paper and its intended function, various workers employ different materials in different settings.

Beaker method

The dose form is manufactured to adhere to the beaker's bottom, protecting the medium, and is thoroughly mixed using an over-head stirrer. The literature indicates that the stirrer speed varies between 60 and 300 rpm, while the medium volume employed in the research varies between 50 and 500 ml.

Dissolution apparatus

Using a typical USP or BP dissolving device with two rotating elements (paddle type and basket type), in vitro release data were analyzed. The study's average dissolution was between 100 and 500 cc, while the rotation speed was between 50 and 100 rpm.

Figure: Dissolution apparatus.

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