Review on Microencapsulation

Avhad Akash Sopan, Mr. Vikas B. Wamane, Ms. Dhawade A. A.
Pratibhatai Pawar College of Pharmacy, Wadala Mahadev, Shrirampur

Abstract: Microencapsulation is a proven method of enclosing or encasing one substance within another. substance that can be used to make pills of varying sizes, ranging from less than one micron to several hundred microns smaller One method that is considered relatively inexperienced is microencapsulation. The ability to encapsulate Microcapsules and microspheres depend on factors such as the solubility of the polymer in the solvent and the concentration. polymer, how well the herbal solvent dissolves in water, and how quickly the solvent is removed. Substances can be enclosed within a capsule.so that the central material is enclosed within tablet shells (coating material) for a specific period of time. This approach is used in amazing fields such as pharmaceuticals, agriculture, textiles, food, printing and defense. For protection, this approach introduced self-healing composites or chemical decontaminants. This article describes the evaluation of microencapsulation and related materials, microencapsulation technology, purpose of microencapsulation, microcapsule morphology, microcapsule methodology, release mechanism, and application areas of microencapsulated additives in building materials.

INTRODUCTION

A method called "microencapsulation" allows for the enclosing of solids, liquids, or even gasses in thin layers of wall fabric that generate microscopic detritus. The technique was first developed in the late 1930s as a cleaner substitute for carbon paper and carbon ribbons, which were being sought after by the business machinery sector. The development of several microencapsulated materials, including medications, was sparked by the breakthrough made in the 1950s with duplicate paper and ribbons that held dyes in tiny gelatin pills that were activated by a typewriter key or the pressure of a pen or pencil.A skillfully crafted controlled medication delivery system can In order to cause minimal toxicity and side effects, it is crucial to deliver the agent to the target tissue in the appropriate amount within the appropriate time frame. Turning in a medicinal material to the target website online in a sustained controlled launch approach involves a number of steps. The use of microspheres as medication delivery systems is one such method. Typically, microspheres are free-flowing powders made of proteins or synthetic polymers that are biodegradable and ideally have a particle length of much less than two hundred μm. A continuous film of polymeric fabric is used to encase or enclose minuscule droplets or fragments of liquid or stable fabric in a process known as microencapsulation. Bio is the component of microencapsulation.

Microsphers:
Stable particles, known as microspheres, have a matrix-like structure and range in diameter from 1 to 1000 μm. The medicine is either dissolved or uniformly distributed within the biodegradable polymer.

Microcapsule:
A microscopic pill that is launched while it breaks, melts, or dissolves and contains substance (such as an adhesive or medication).

Advantages:

1. Exorbitant production costs and output easy handling of powdered product, repeatability, and minimal operation.It is widely used in the synthesis and extraction of a wide variety of compounds with different polarity and short reaction times.
2. warmness obstruction remarkable center compound might be utilized strong item.
3. overseen send off of actives dissolvability of hydrophobic actives decrease absence of instability of compound.
4. low activity cost suitable for warmth sensitive actives.
5. price strong techniques no need for unnecessary temperature nor the utilization regular dissolvable for a specific pH circumstance for its elaboration.
6. right option for temperature delicate compound.

Disadvantages:

1. presently at this point not supported for thermolabile compound nonuniform trash can shape total.
2. unique from depending on texture steeply-estimated variable embodiment effectiveness utilization of normal dissolvable.
3. steeply-valued substances limited to low atomic weight can shape total .
4. scaling boundary (liquefying, atomiser air temperature and strain, cooling temperature, feed flow) fast send off of actives exceptional for hydrophobic compound nonuniform molecule variable exemplification proficiency.
5. unique measured and formed item issues with Thick arrangement.
6. slow technique styrofoam surface item cost.

Resons For Microencapsulation:

1. The first reason for microencapsulation is for supported or expanded send off of the medication
2. The strategy has been comprehensively utilized for covering the organoleptic houses like flavor And smell of numerous tablets and appropriately further develops Patient consistence for example Paracetamol, Nitrofurantoine for covering the sharp flavor.
3. Using microencapsulation techniques, the liquid tablets can be transformed into a powder that flows freely.
4. Microencapsulation can be used to include the tablets that are sensitive to light, moisture, and oxygen. For instance, nifedipine is incorporated from picture chart unsteadiness.
5. The microencapsulation method is also useful to avoid tablet incompatibility.
6. tablets which can be unsafe in nature can likewise also disintegrate at room temperature. Drugs like anti-inflamatory medicine and peppermint oil might be deflected By microencapsulation.
7. in poisonousness and GI irritation which incorporate with KCL and ferrous sulfate might be done By microencapsulation.
8. has also been recruited to change the web site online of ingestion. This product Has been valuable for the ones containers that have the harmfulness at decline pH.
9. and anderson referenced that microencapsulated diet a palmitate had upgraded dependability, as save you from oxidation.
10. Microencapsulation methodology has also been Utilized to assemble intrauterine preventative Gadget.

Core Material:

The center texture, portrayed in light of the fact that the remarkable texture to be covered, might be fluid or solid in nature. The creation of the center texture might be different on the grounds that the fluid center can comprise of scattered and additionally broke down material. The solid center might be total of enthusiastic constituents, stabilizers, diluents, excipients and discharge charge retardants or gas pedals. The ability to change the center substances structure bears the cost of distinct adaptability and utilization of this component frequently allows helpful design and improvement of The favored microcapsules properties.

Coating Material:

The covering fabric should have the option to framing a film this is firm with the middle material, synthetically very much coordinated and nonreactive with the middle material, Strength with focus material, Latent toward lively fixings, Controlled send off underneath exact circumstances, the covering might be adaptable, fragile, hard, thin and so forth., Cost-effectively and abundantly available. It also gives the favored covering properties, which include strength, adaptability, impermeability, optical properties, and strength. The covering substances used in microencapsulation strategies are managable, to a couple of degree, to in situ change. The decision of a given covering consistently might be helped through method of method for the assess of current writing and by means of method of method for the examine of free or fashioned films, despite the fact that reasonable utilization of free film records routinely is blocked for the ensuing reasons:

1. Project or loosened films coordinated with the guide of utilizing the normal, worn out projecting techniques yield motion pictures which can be obviously thicker than the ones delivered with the guide of utilizing the microencapsulation of little particles, thus the results got from the strong films will not be extrapolate to the thin microcapsule coatings.

2. The precise microencapsulation method used to deposit a coating produces precise and inherent homes that are difficult to replicate using current movie-casting techniques.
3. Coating homes can also be significantly affected by middle fabric's coating substrate. Consequently, the decision of a particular covering texture involves consideration of each conventional detached film realities and completed outcome.

Techniques to manufacture microcapsule:
Physical Method:
1. Pan Coating:
The most well-known modern method for encasing small, coated particles or tablets is the dish covering procedure, which is widely used in the pharmaceutical industry.
• The technique uses heated air in conjunction with a covering piece to move a sleeping cushion of trash in order to facilitate the dissolvable's disappearance.
• As the covering texture is applied gradually, the trash is tossed into a skillet or other container.

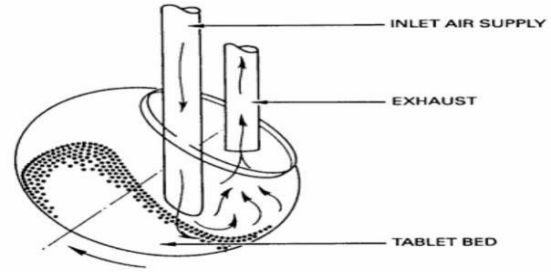

Fig.: Pan coating
• Relevant to garbage particles bigger than 600 microns in size;
• Covering is applied as an atomized shower or as a solution to the favored stable transitional material inside the covering skillet.
• Since the coatings are being applied inside the covering container, heat is much of the time applied over the covered materials to eliminate the covering dissolvable.
• In specific examples, the last dissolvable evacuation is finished in a drying stove.

Air Suspension Method:
The dispersion of the core materials in a supporting air stream and the spraying of coating material in the air suspended particles are the two steps in the air suspension process. Within the coating chamber, the particles are suspended in an upward direction by the moving air stream. The coating zone of the chamber, where a coating substance (polymer solution) is applied to the moving particles, is where the design of the coating chamber and its operational parameters should be considered in order to influence the flow of the particles. The coating material was continuously transferred to the core material as the moving particles passed through the coating zone. Depending on the required coating thickness and whether the core material particles are completely encased, the cyclic process is repeated a few times.based on the required coating thickness or the degree of full encapsulation of the core material particles. The stuff that is encapsulated is dried by air. The temperature of the supporting air stream has a direct impact on the rate of drying[1].The concentration of the coating material, or its melting point if it is in a solid state, as well as its solubility, surface area, density, melting point, volatility, application rate, temperature of the air stream, and the amount of air needed to fluidize the core material are some of the process variables that can have an impact on the process[2]

Fig. : Air Suspension method

Spray Draying:

When an active ingredient dissolves or suspends in a melt or polymer solution and gets trapped in the dried particle, spray drying functions as a microencapsulation process. The key benefits include the capacity to handle labile materials due to the dryer's short contact time and its cheap operation. The viscosity of the solutions to be sprayed in contemporary spray dryers can reach up to 300 mPa.

Shower drying and splash coagulating processes are comparative in that both include scattering the center material in a liquified covering substance and showering or presenting the center -covering blend into some ecological condition, by which, moderately fast cementing (and development) of the covering is affected. The essential contrast between the two techniques, is the means by which covering cementing is achieved. Covering hardening in the instance of splash drying is affected by quick vanishing of a dissolvable in which the covering material is broken down. Covering cementing in splash solidifying techniques, in any case, is achieved by thermally coagulating a liquid covering material or by cementing a broke down covering by presenting the covering - center material combination into a nonsolvent. Evacuation of the nonsolvent or dissolvable from the covered item is then achieved by sorption, extraction, or vanishing procedures. By and by, microencapsulation by splash drying is directed by scattering a center material in a covering arrangement, in which the covering substance is disintegrated and in which the center material is insoluble, and afterward by atomizing the combination into air stream. The air, typically warmed, supplies the inactive intensity of vaporization expected to eliminate the dissolvable from the covering material, in this manner shaping the microencapsulated item. The gear parts of a standard splash dryer incorporate an air radiator, atomizer, primary splash chamber, blower or fan, typhoon and item gatherer. Microencapsulation by splash hardening can be achieved with splash drying gear when the defensive covering is applied as a dissolve. General cycle factors and conditions are very like those as of now portrayed, then again, actually the center material is scattered in a covering material dissolve instead of a covering arrangement. Covering hardening (and microencapsulation) is achieved by splashing the hot combination into a cool air stream. Waxes, unsaturated fats and alcohols, polymers and sugars, which are solids at room temperature however meltable at sensible temperatures, are pertinent to splash solidifying methods. Ordinarily, the molecule size of splash solidified items can be precisely controlled when shower drying gear is utilized, and has been viewed as a component of the feed rate, the atomizing wheel speed, scattering of feed material thickness, and factors[3]

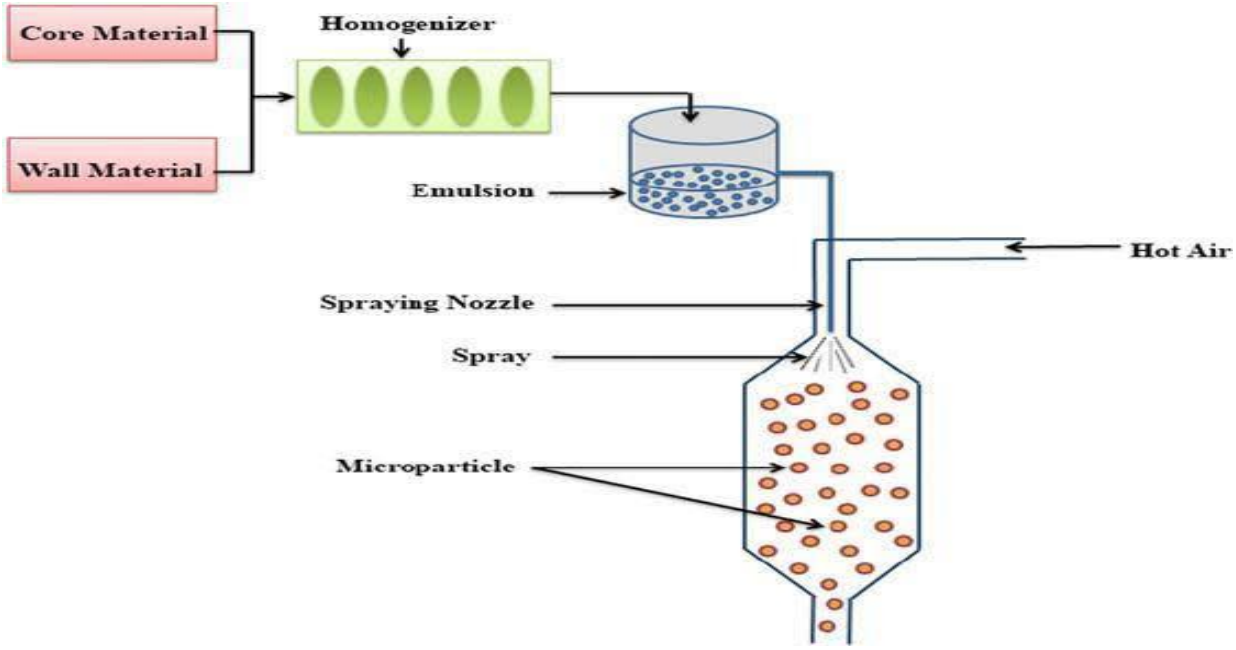

Fig. : Spray Draying

Centrifugal Extrusion:

coating substances are co-extruded thru the concentric orifices of the nozzles as a fluid rod of the center sheathed in coating cloth.Centrifugal pressure impels the rod outward, inflicting Any other encapsulating technique that a few manufacturers have looked into and used is centrifugal extrusion. Many coating structures approved for use in food were developed to encapsulate products that included vitamins, spices, and flavorings. These wall materials include gum acacia, starches, cellulose derivatives, sodium alginate, carrageenan, lipids, fatty acids, waxes, and polyethylene glycol. Centrifugal extrusion is a method of liquid coextrusion that involves the use of nozzles and a concentric orifice located at the pinnacle, or outer circle, of a revolving cylinder. One by one, coating and center ingredients are injected through a concentric feed tube in the encapsulating cylinder or head to the several nozzles that are positioned at the tool's exterior floor. Coating cloth flows as the center cloth goes through the middle tube. Clothes for coating pass via the outer tube. The apex of the tool revolves around its vertical axis as a result of the tool's attachment to a revolving shaft. The center and coating materials are co-extruded through the nozzles' concentric orifices as the pinnacle rotates, forming a fluid rod of the center covered with coating fabric.Pressure from centrifugation forces the rod outward, causingit to hinder into little particles. By the development of floor pressure, the covering material encompasses the middle fabric, accordingly. The microcapsules are gathered on a moving bedding of fine-grained starch,which pads their impact and assimilates bothersome covering dampness. Particles delivered strategy have a measurement beginning from 100 and fifty to 2000 mm

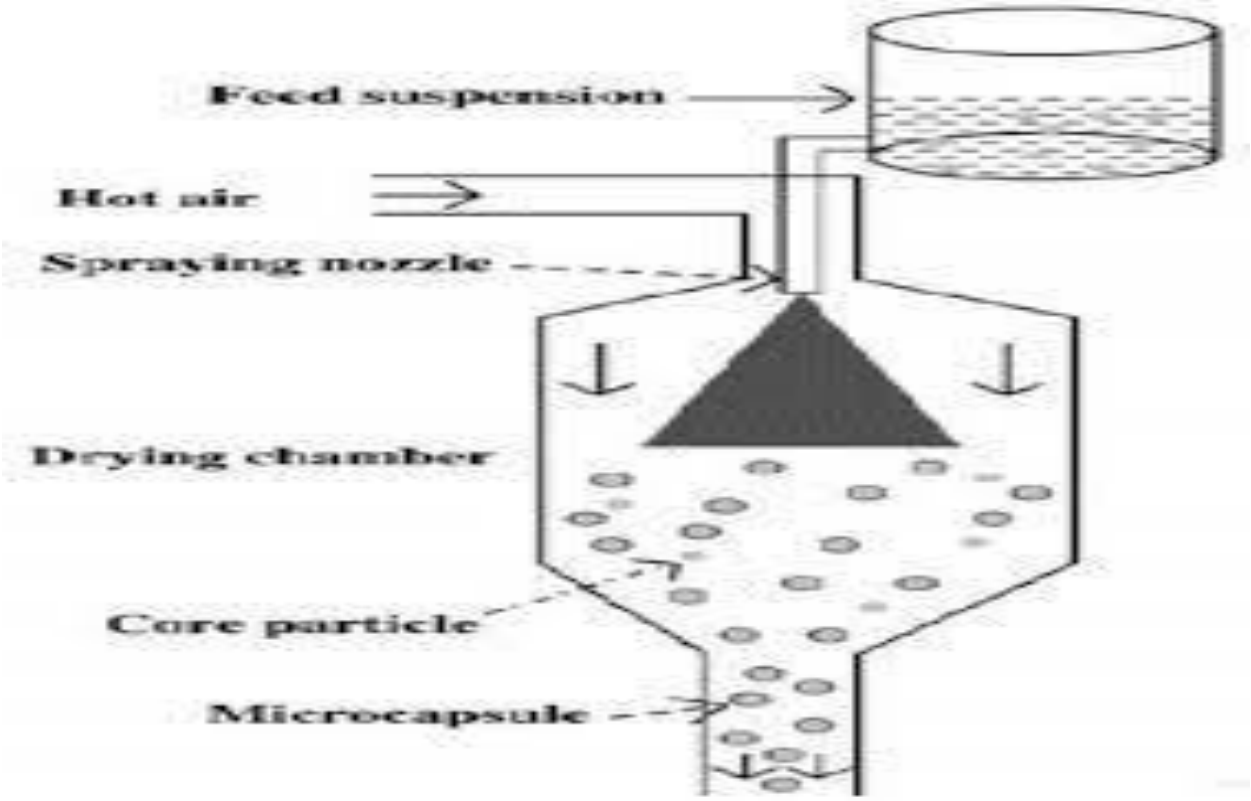

Fig: Centrifugal extrusion

Physico-chemical Method:

1.Coacervation:

Coacervation, consistently called "segment partition," is thought about as a genuine microencapsulation strategy, because of the reality the center texture is totally ensnared through method of method for the framework. This technique incorporates the precipitation or detachment of a colloidal segment from a fluid segment both, simple and confounded techniques of coacervation might be utilized. In simple coacervation, a nonsolvent or a more noteworthy water-solublepolymer is utilized. The polymer seeks

the dissolvability for gelatin protein answer through method of method for hydrophobic cooperation. In muddled coacervation, the tablet is molded through the ionic exchange of oppositely charged polymers, typically the excellent costs on protein atoms and anionic macromolecules comprising of gelatin and gum arabic The convoluted coacervate is delivered while going against the norm costs are killed with each other Coacervation involves the detachment of a fluid portion of covering texture from a polymeric response saw through the covering of that section as a uniform layer round suspended focus particles. The covering is then hardened. By and large, the group kind coacervation approaches incorporates 3 stages and are achieved beneathneath constant disturbance.

1.Formation of a three-immiscible chemical segment kinetics.

2.Deposition of the coating

3.Solidification of the coating

Numerous coating materials were assessed for coacervation microencapsulation; however, the gelatin/gum Acacia device is the most thoroughly researched and comprehended coating device. Nonetheless, several coating structures such as gliadin, chitosan, carrageenan, polyvinyl alcohol, B lactoglobulin/gum Acacia, gliadin/heparin/gelatin, carrageenan, soy protein, and guar gum/dextran are also suitable for coacervation microencapsulation. In recent years, new coacervation strategies have also emerged that can address many of the problems that arise during a typical gelatin/gum acacia complex coacervation process, particularly when handling the encapsulation of heat-sensitive food ingredients like hazardous flavor oils.

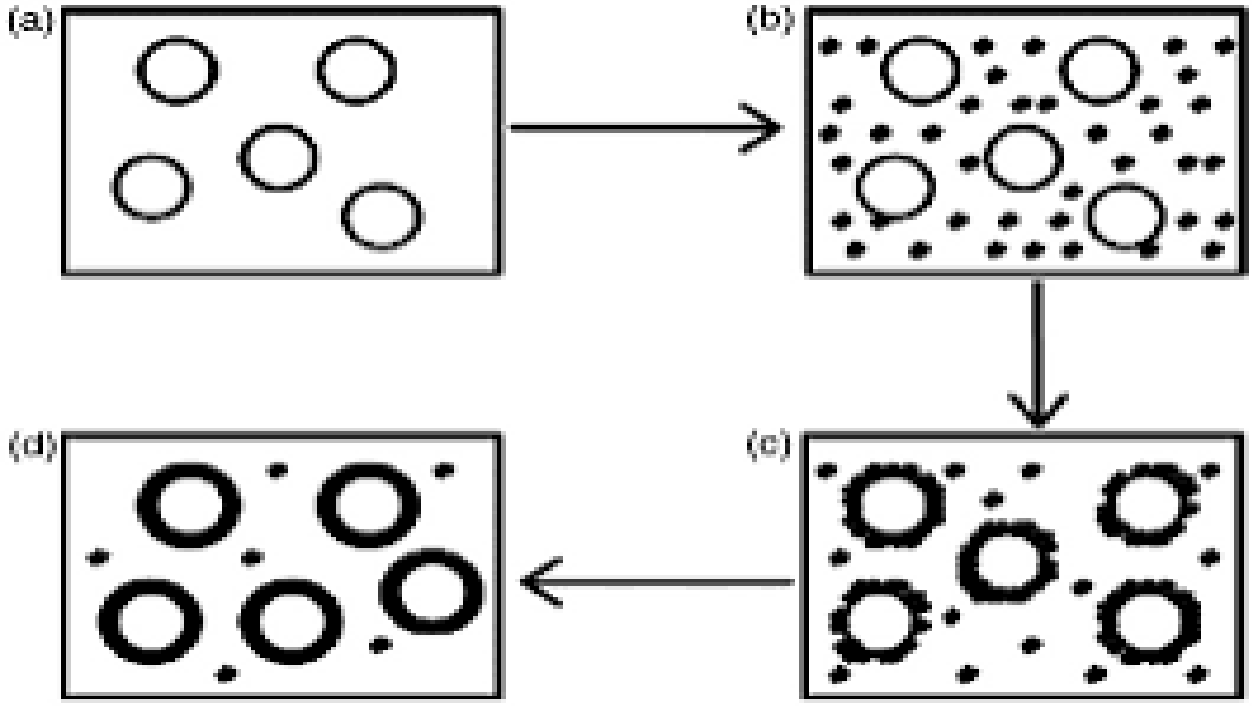

Fig. Coacervation

Chemical Method:

Polymerization:

A.Interfacial Polymerization:

The two reactants in a polycondensation come together at an interface and react quickly in interfacial polymerization. The classical Schotten-Baumann reaction between an acid chloride and a substance having an active hydrogen atom, such as an alcohol or amine, polyesters, polyurea, or polyurethane, forms the basis of this procedure. At the interface, thin, flexible barriers quickly form in the correct circumstances. An amine and a polyfunctional isocyanate are added to an aqueous solution made by emulsifying a pesticide and a diacid chloride in water. In order to counteract the acid produced during the reaction, base is present. Condensed polymer walls appear instantly at the emulsion droplet contact.

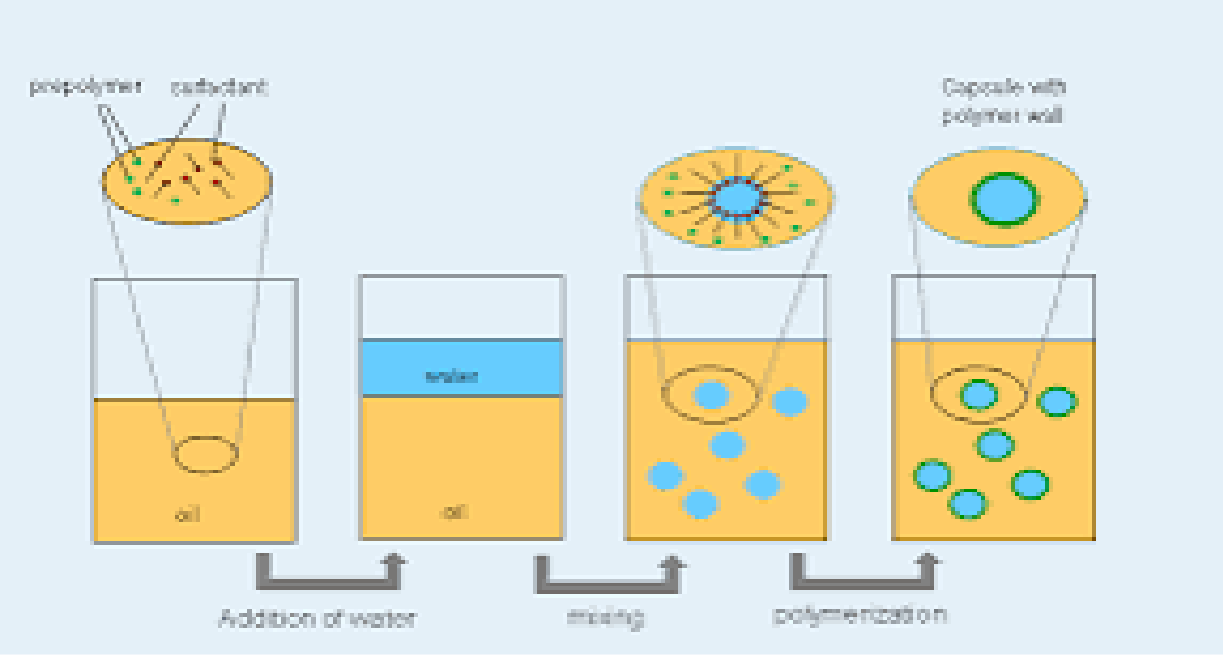

Fig. Interfacial Polymerization

B. In-Situ Polymerization :

Like IFP the pill shell arrangement happens due to polymerization of monomers brought to The embodiment reactor. In this technique no receptive retailers are brought to the center material. Polymerization happens totally inside side the persistent fragment and at the constant section side of the connection point formed with the guide of utilizing the scattered center material and constant fragment. At first a low sub-atomic weight prepolymer will be formed, as time is going at the prepolymer fills In size. It stores at the floor of the scattered center material there with the guide of utilizing areas of strength for delivering shell.

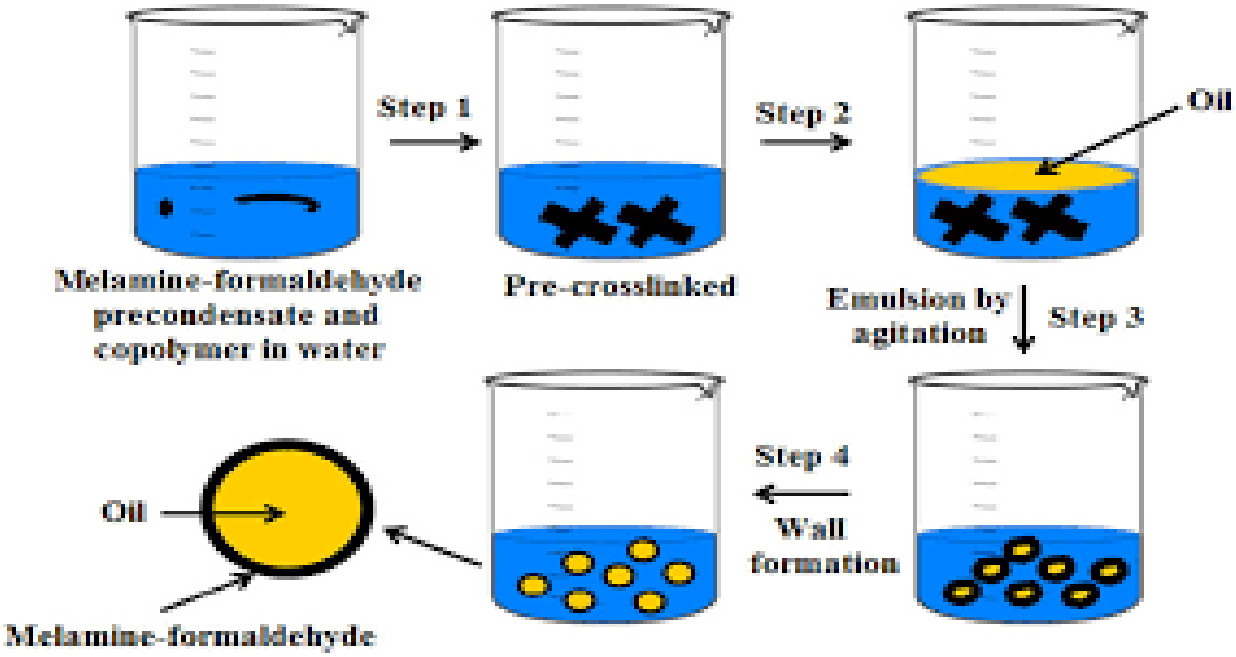

Fig. In-Situ Polymerization

C. Matrix Polymer:
In various cycles, a center material is imbedded in a polymeric network during development of the particles. A basic strategy for this sort is splash drying, in which the molecule is shaped by dissipation of the dissolvable from the framework material. Nonetheless, the cementing of the framework likewise can be brought about by a compound change.
Utilizing this peculiarity, Chang gets ready microcapsules containing protein arrangements by consolidating the protein in the watery diamine stage. Chang has shown the permselectivity, by their capacity to change blood urea over completely to alkali, the protein staying inside the microcapsules when integrated inside an extracorporeal shunt framework. Various gatherings are using polymerization strategies to achieve microencapsulation. Models are the Public Lead Organization, Eurand America[4] .

Characterization of microcapsules:
1.Particle size and shape:
Scanning electron microscopy (SEM), or traditional mild microscopy, is the most common method for observing microcapsules. The study of the microcapsule's shape and form makes use of each of these methods. Provides greater resolution than mild microscopy. In addition to allowing for the investigation of double-walled systems, it investigates the surfaces of microspheres. Non-destructive visualization, also known as confocal laser scanning microscopy (CLSM), is a technique that provides results not only about systems and surfaces but also about internal particles[5].

2)Fourier transform-infrared spectroscopy (FTIR):
It is utilized to investigate the interaction between polymer and drug system and the degradation of provider system polymeric matrix.

3)Carr's index and hausner's ratio:
The state of repose was chosen in accordance with the constant funnel and cone method. The hausner's ratio or carr's index, as well as the poured or trapped bulk densities of the pattern's known weight, were used to calculate the combined microcapsule bulk density with the help of a measuring cylinder.
Carr's Index = [Tapped Density-Bulk Density/Tapped Density] ×100
Hausner's ratio (HR)=ρT/ρB wherein ρT is tapped density and ρB is Bulk density[6].

4)Bulk density:
Weigh the appropriate microcapsules, then move to a 100 ml cylinder to clearly see volumes between 50 and 100 ml.
Bulk Density (ρρ)= [Weight of Microcapsules(g) (M) / Bulk Volume (ml)(V)]
Where, M = mass of the powder,
Vo = quantity of the powder.

5)Isoelectric factor:
The device known as micro electrophoresis is used to measure the degree of electrophoretic mobility of microspheres, allowing for the simple calculation of the isoelectric factor. The floor contained charge, ionisable behavior, or ion absorption nature of microcapsules are related to the mobility.

6)Contact angle:
To determine the wetting assets of the microcapsule, the attitude of contact is calculated. We can easily identify the hydrophilicity and hydrophobicity of microcapsules with the aid of this method. This is measured at the solid, air, or water floor by placing a droplet within a circular mobile phone that is connected above the objective of an inverted microscope. It is measured at 200 degrees Celsius within a minute of the microcapsules breaking down.

DIFFERENT PROPERTIES OF THE CAPSULES:
1)Particle size and morphology of microcapsules:
The molecule length of the microcapsules depends upon at the stand-out techniques which can be utilized to supply the microcapsules. The variant of the particle sizes based on the unique strategies employed is shown in Table 3. The inner and outer shapes of the drugs are referred to as the morphology of the microcapsules, and their morphology largely depends on the working conditions and wall materials used to supply the microcapsules.

2)Porosity:
One of the most important properties of the microcapsules, shaped in any way, is their porosity, which is responsible for their inclusion in a particular food matrix. Furthermore, the assets are heavily dependent onpiece of the wall texture of the

microcapsule and the technique that is utilized to supply the microcapsule. If you want to direct the mass switch between the surroundings and the middle, the wall matrix that holds it is designed in one of these ways.

3)Surface hydrophobicity:
A molecule's surface hydrophobicity can be described as its physical property of repelling water. This is a resources which is fundamentally principally based absolutely at the center material to be embodied and the wall material[7]. conducted a study in this regard. SPI and pectin were used to make microcapsules that contained casein hydrolysate. The results showed that the microcapsule's hydrophobicity decreased as the awareness of casein hydrolysate increased.

4)Flow properties:
The microencapsulated powders' float residences include compressibility, bulk density, tapped density, and porosity. It is essential to conduct an analysis of the drugs' bulk density and tapped density in order to maximize the powder's potential during the packaging, storage, and distribution processes.

5)Flowability:
The percentage compressibility or Carr's Index and the Hausner Ratio (HR) are the parameters that are used to determine the flowability of microencapsulated powder shapes[8]. Similar methods were used to determine the flowability of lycopene microcapsules[9]. The better expense of HR ascribed to the truth that the powder changed into durable, demonstrating unreasonable powder consistency and changed into limited to free-stream.

6)Micromechanical properties:
The microcapsules' mechanical cause is determined by their micromechanical homes. It is absolutely necessary to examine the mechanical properties of the microcapsules as soon as they are produced. This allows you to ensure that the release of the middle material occurs at a specific point and time, not earlier or later. All the more basically in bunches of dinners applications, a totally movable sort of mechanical power is favored withinside the microcapsules.

7)Thermal properties:
The thermal properties of microcapsules are one of the most important properties to study because they can be used to determine their garage balance in addition to their discharge rates. A technique known as differential scanning colorimetry (DSC) can be used to receive these. There are separate holders for the pattern and a reference inside the instrument in this method. Heaters are gifts that can either keep the colorimeter at a specific temperature or raise the temperature at a precise rate.

8)Solubility:
The purpose of the microcapsules' soluble test is essentially to determine their behavior in water or any other medium—that is, whether or not the middle material is released into that medium. The type of wall fabric used for encapsulation and the manufacturing method of microcapsules both contribute to the microcapsules' soluble properties.

9)Surface tension:
The characteristics of a fluid floor that function as a stretched elastic membrane constitute surface anxiety. The strong powers or the interfacial powers at the liquid film are responsible for this peculiarity[10,11]. The measurements of static and dynamic floor tensions of microcapsules containing casein hydrolysate inside SPI and pectin for dedication of pattern adsorption on the air-water interface were carried out because the interfacial forces govern phenomena like the wetting of solids by means of liquids.

10)Heat and light stability:
There are extraordinary compounds like vitamins, pigments, and others in food products, which is extremely sensitive to the rigorous processing conditions used in the food industry, such as pasteurization, sterilization, baking, and so forth. In order to prevent their degradation and, consequently, losses within the foods, these compounds must be included. In this manner, microencapsulation fills in as one of the five star systems for the wellbeing of such mixtures[12]. used casein micelles to encapsulate beta-carotene to protect it from degradation during various processing conditions.

APPLICATIONS[13,14]:
1. Cell immobilization: Human tissue is continuously fermented in plant cell cultures to create bio-artificial organs.
2. Production of beverages.

3. Keeping molecules safe from other substances.
4. Delivery of drugs: Systems of controlled release.
5. Safety and quality in the food, farming, and environmental sectors.
6. Inoculation of soil.
7. Finishing techniques for fabrics.
8. Safeguarding liquid crystals.

CONCLUSION

The term "microencapsulation" refers to the process of enclosing an active component within a capsule that is between one micron and several millimeters in size. Until the proper moment, the capsule shields the active substance from its surroundings. Subsequently, the material finds a way out of the capsule wall by a variety of channels, including as diffusion, dissolution, melting, or rupture. Microencapsulation is a science and an art. There is no one right method to do things, and every application presents a different set of difficulties. These puzzles require knowledge, expertise, and technological proficiency in a wide range of domains.

REFERENCE

[1] Bakan JA. 1991. Microencapsulation. In: Lachman L, Lieberman HA, Kanig JL, editors. The theory and practice of industrial pharmacy. 3rd ed. Ch. 13, Part III. 1991, Varghese Publishing House, Bombay 412-28.

[2] Bansode SS, Banarjee SK, Gaikwad DD, Jadhav SL. Microencapsulation: a review. Inter J Pharm Sci Review and Research. 2010;1:38–43.

[3] Leon, L., Herbert A. L., Joseph, L. K; "The Theory And Practice Of Industrial Pharmacy", 3rd edition, 1990, Varghese Publishing House,412, 428.

[4] Jackson, L. S., Lee., K., (1991-01-01), "Microencapsulation and the food industry" (htm) Lebennsmittel-Wissenschaft Techonologie. Rerrived on 1991-02-02.

[5] Singh, M., Dua, J.S., Menra, M., Soni, M. and Prasad, D.N., 2016. Microencapsulation and its various aspects: A review. Int. J. Adv. Res, 4(6), pp.2094-2108.

[6] Paulo, F. and Santos, L., 2017. Design of experiments for microencapsulation applications: A review. Materials Science and Engineering: C, 77, pp.1327-1340.

[7] Paulo, F. and Santos, L., 2017. Design of experiments for microencapsulation applications: A review. Materials Science and Engineering: C, 77, pp.1327-1340.

[8] Desai, K.G.H. and Jin Park, H., 2005. Recent developments in microencapsulation of food ingredients. Drying technology, 23(7), pp.1361-1394.

[9] Gupta, A.K. and Dey, B.K., 2012. Microencapsulation for controlled drug delivery: a comprehensive review. Sunsari technical college journal, 1(1), pp.48-54.

[10] Khandbahale, S.V., 2020. Microencapsulation-A novel approach in drug delivery: a review. Asian Journal of Research in Pharmaceutical Science, 10(1), pp.39-50.

[11] Jyothi, S.S., Seethadevi, A., Prabha, K.S., Muthuprasanna, P. and Pavitra, P., 2012. Microencapsulation: a review. Int. J. Pharm. Biol. Sci, 3, pp.509-531.

[12] D.K., Jain, A.K. and Jain, P.K., 2013. A review on various techniques of microencapsulation. Int J Pharm Chem Sci, 2(2), pp.962-968.

[13] Alfonso, R. G., "Remington: The Science of Practice Of Pharmacy", Vol-2, Lippincott Willarms And Wilkins, 890-891.

[14] Nelson, G., "International Journal of Pharma." 2002, 242(1-2): 55-62.

[15] http//www.jiwaji.edu/pdf/ecourse/pharmaceutical/Microencapsulation-MPH%20201T.pdf

[16] https://www.chips.ac.in/pages/downloads/PPTs/Pceutics/MICROENCAPSULATION.

[17] https://old.amu.ac.in/emp/studym/1333.pdf