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MICROENCAPSULATION: A REVIEW

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ABSTRACT

A technique called "microencapsulation" encases objects in microscopic particles and creates thin wall material coverings around them. These materials can be liquids or even solids. Tiny compounds containing an active component known as the core material that is embedded in a matrix structure or covered in a covering substance as microparticles or microencapsulated goods. The present review describes the encapsulation,it's components, methods of preparation, the physics of release via the capsule wall and microcapsule characterisation and the wide range of uses for microcapsules..It also discusses common microencapsulation methods, their advantages and disadvantages and their wider uses in the food, pharmaceutical, cosmetic and agricultural industries.

KEYWORDS: Microencapsulation techniques, Centrifugal extrusion, Polymerization, Coacervation.

INTRODUCTION

The use of microparticles in an international industry that is continuously growing in a number of fields, including environmental remediation, electronics, food and medicine. Because microparticles have a wide range of active chemicals that they can carry and protect.[1] The technology of microencapsulation is developing quickly. Applying a relatively thin coating to small solid particles or liquid droplets and dispersions is known as microencapsulation. Microencapsulation is willful when it comes to micro coating techniques, as the former entails coating particles that range in size from several tenths of a micron to 5000 microns.[2] In many consumer goods, microencapsulation is a quickly

developing technique that protects and delivers active chemicals to end-use applications.[3] Overall, medical technology has already been greatly impacted by the recent advancements in drug delivery, which have improved the pharmacokinetics of many medications and made it easier to administer many others.[4] A spherical substrate is coated with alternating layers of polyelectrolyte of opposing charge to create polyelectrolyte capsules.[5] The technique of enclosing functional components in one or more types of shell materials to create a capsule, usually a few microns in diameter, is known as microencapsulation of functional components. Uniformly coating the functional is the process of microencapsulation.[6] The process of microencapsulation involves isolating active substances (whether in a liquid, solid or gas state) to create spherical, micrometrically sized products, where the active material or core is protected from the environment by a membrane.[7] In several areas of daily life, controlling encapsulation and release are critical phenomena.[8] Their contents under particular circumstances and at regulated rates can be enclosed in various coat or shell materials, such as gelatine, polyesters, chitosans, sodium carboxymethyl cellulose, sodium alginate, ethylcellulose, hydroxyl propylmethyl cellulose, sodium alginate and PLGA.[9,10] A disadvantage of microcarriers over nanoparticles is that the former travel over a 100 nm range and are transported by the lymph into the interstitium, where they act locally.[11] There is currently a dearth of comprehensive study on targeting functions in probiotic microencapsulation, with most studies concentrating on techniques that can lessen microbial inactivation during processing. This suggests that studies on probiotic microcapsules' targeted delivery techniques will gain a lot of attention.[12]

MICROCAPSULE ESSENTIAL FEATURES[13]

Microcapsules' tiny size, which allows for an essential role surface area, is its most important feature. For example, it has been reported that a single millimeter of hollow microcapsules with a diameter of 0.1 mm has over 60 m of surface area. There is an inverse relationship between diameter and total surface area. Chemical interactions, light scattering, adsorption and desorption sites and other activities can all be facilitated by this enormous surface area. The writings of Gutcho12 and Arshady13 provide detailed explanations of the properties of microcapsules.

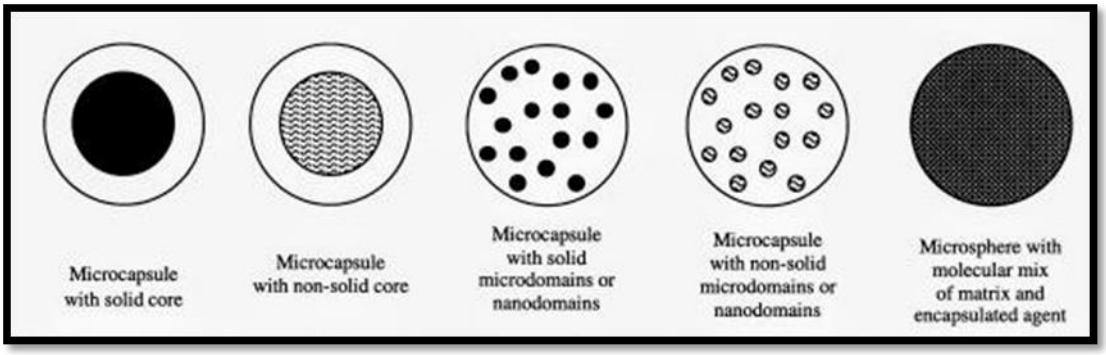

Fig 1: Different structures of microcapsules and microsphere.[14]

ADVANTAGES[15]

1. Modified and targeted medication release and administration, including site-specific.
2. Selection of dose form for the preferred drug delivery method (parenteral injections, oral tablets).
3. More predictable pharmacokinetics with less variation within or between subjects.
4. A more uniform dispersion within the physiological milieu.
5. Consistent fixed-dose medication combinations reduced dose-dumping and dosage titration
6. Patient centricity through improved adherence and compliance (e.g., patients with dysphagia).
7. Individual treatment, such as for elderly or pediatric patients.
8. Increasing the pharmaceutical formulations' stability.
9. Separating the components to improve compatibility.
10. New items that have a longer lifespan thanks to patent protection.

DISADVANTAGES[1]

1. Not advised for chemicals that are thermolabile aggregates can be formed by nonuniform particles.
2. Various shapes based on the materials pricey efficiency of variable encapsulation application of organic solvents.
3. Issues with viscous solutions for products of various sizes and shapes.
4. The cost of the slow-process styrofoam texturing product.
5. Pricey supplies only low-molecular-weight substances able to create aggregates.

REASON OF MICROENCAPSULATION

- It is frequently utilized to improve stability and offer a prolonged, continuous release of the substance.
- This method is mostly used to hide the taste of different drugs and to increase patient compliance and odor.[16]
- Enhanced organoleptic qualities of the product that is encapsulated.[17]
- For turning liquid medications into a powder that flows freely.
- Help lessen the medications' toxicity, gastrointestinal distress and numerous other serious adverse effects.
- Microencapsulation can be used to change the absorption site.[18]

MORPHOLOGY OF MICROENCAPSULATION[13]

The morphology of microcapsules is primarily determined by the core material and the shell deposition process. In addition to these three basic morphologies, microcapsules can also be mononuclear (core-shell) with multiple shells or form clusters of microcapsules. Polynuclear (capsules have multiple cores enclosed within the shell) or matrix encapsulation (in which the core material is distributed uniformly into the shell).

MICROCAPSULE STRUCTURE[3]

The majority of microcapsules are tiny spheres with dimensions varying from a few micrometers to a few millimeters. Nevertheless, a lot of these microcapsules don't look anything like these straightforward spheres. In actuality, the materials and techniques used to prepare the microparticles affect both their size and shape. The different types of microcapsules and microspheres are produced from a wide range of wall materials like monomers and/or polymers. Depending on the physico-chemical properties of the core, the wall composition and the microencapsulation technique used, different types of particles can be obtained a simple sphere surrounded by a coating of uniform thicknesses.

MECHANISM OF DRUG RELEASE FROM MICROENCAPSULATION

Monolithic diffusion-controlled system

In this case, a rate-controlling membrane encloses the active drug, which diffuses through it. Once the delivery is finished, the membrane erodes. In this instance, matrix breakdown had no effect on drug release.[20]

Dissolution

When the polymer coat is soluble in the dissolution fluid, the rate at which the drug is released is determined by the rate at which the coat dissolves. It also relies on the thickness of the coating substance and how soluble it is in the dissolving fluid. Either the coat dissolves or the capsule wall melts, releasing the medication.[18]

Degradation-controlled monolithic system

The medication is dispersed throughout the core after dissolving in the matrix. When the matrix breaks down, the medicine that is affixed to it is released. When compared to matrix breakdown, drug diffusion is sluggish.[18]

Erosion

Some coatings can be designed to gradually break down over time, releasing the drug contained in the particle. Monomer accumulation in the release media happens at the same time as polymer erosion or polymer loss. The matrix becomes plasticized and the polymer begins to dissolve when water seeps into the carrier and alters its microstructure.[13]

Core materials

The particular substance to be coated is known as the core material, and it might be either liquid or solid. Since the liquid core may contain dissolved or scattered elements, the core material's composition can be changed. Active ingredients, stabilizers, diluents, excipients and release-rate accelerators or retardants make up the solid core. Variability in the composition of the core material offers definite flexibility and the effective design and development of the desired microcapsule features is frequently made possible by the usage of these properties.[20]

Materials for coatings

The coating material should be able to form a cohesive film with the core material, be nonreactive and chemically compatible with the core material and offer the desired coating properties, including stability, strength, flexibility, impermeability and optical qualities.[21] It need to be compatible with chemicals. It must to be capable of creating a film. It should not have a high viscosity, be pilable, tasteless, stable, non-hygroscopic and economical.[16]

A NUMBER OF CHARACTERISTICS AFFECTS ENCAPSULATION EFFICIENCY[13]

1. Viscosity of the dispersed phase.
2. Volume fraction of the dispersed phase to continuous phase.
3. Quantity of drug in dispersed phase.
4. Concentration of surfactant.
5. Operating parameters.
6. Agitation rate.
7. Temperature.
8. Pressure.
9. Reactor and agitator geometry.

METHOD OF MICROENCAPSULATION PREPARATION

Physical techniques Coatings for air suspension

Initially introduced by professor Dale Erwin Wurster at the university of Wisconsin in 1959, air suspension coating provides greater control and adaptability than pan coating. This method involves dispersing the solid middle material into the supporting air and lining the suspended debris with polymers in an unstable solvent, resulting in a very thin film of polymer on top. Hundreds of repetitions of this air-suspension process are necessary to attain the necessary coating thickness and other parameters. The air movement that aids the debris also makes it easier for them to dry and the drying charge is directly related to the air movement's temperature, which can also be altered to affect the coating's properties.[13]

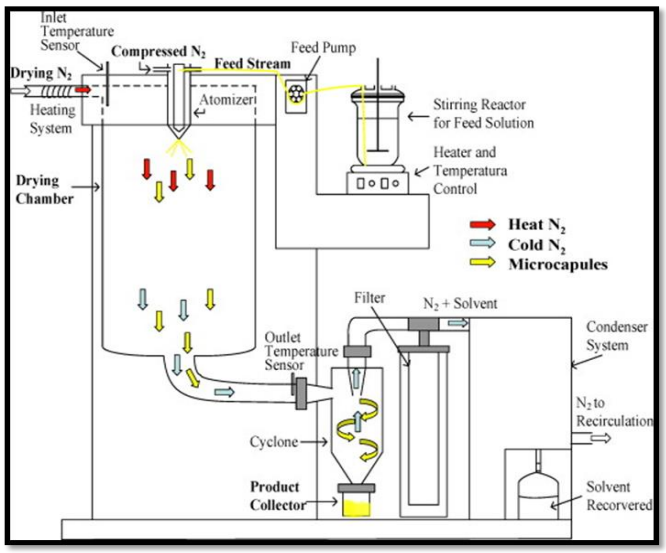

Fig. 2: Fluidized bed used by.[13]

Pan coating

One of the first industrial processes for creating tiny, coated particles or tablets is pan coating, which is extensively employed in the pharmaceutical sector. While the coating substance is applied gradually, the particles are agitated in a pan or equivalent apparatus. One of the first commercial processes for creating tiny, coated particles or tablets is the pan coating method, which is extensively employed in the pharmaceutical sector. While the coating substance is applied gradually, the particles are agitated in a pan or equivalent apparatus. Solid particles larger than 600 microns are typically thought to be necessary for an efficient coating in microencapsulation and the technique has been widely used to create controlled release beads. Medications are typically covered with protective layers of different polymers after being applied on a variety of spherical substrates, such as nonpareil sugar seeds.[22]

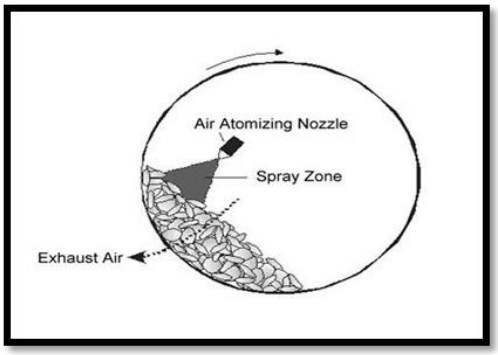

Fig. 3: Representation of a typical pan coating process.[23]

Centrifugal extrusion

This method works best with liquids or slurries. A revolving extrusion head with concentric nozzles is used in this method to encapsulate. A sheath of solution envelops the central liquid jet. The air breaks into core droplets, each coated with wall solution, as the jet passes through. The molten wall is hardened and the solvent may evaporate from the wall solution while the droplets are fluidized or in flight. The droplets settle as a narrow ring around the spray nozzle because their mean diameter is within ±10%. Therefore, capsules can be held in a ring-shaped hardening bath to harden them after formation. Particles between 400 and 2000 µm can be formed using this method.[18]

Spray drying[16]

Both of these procedures entail scattering the core material into the liquid coating substance and spraying or injecting it into the core coating mixture, which affects the coating's ability to solidify quickly. The process used to achieve coating solidification is the primary distinction

between these two approaches. Rapid evaporation of the solvent in which the coating material is dissolved during spray drying affects the solidification of the coating. In contrast, the spray congealing approach involves either putting the core material into a non-solvent or thermally congealing a molten coating material to achieve coating solidification. Sorption extraction or evaporation procedures can be used to remove solvent or non-solvent from the coated product. Flavors, lipids and carotenoids are a few examples of food additives that can be microencapsulated by spray drying. Researchers has lately concentrated on gums, proteins and carbohydrates because a single encapsulating agent cannot retain all the desired wall material qualities. The choice of atomizer is one of the most crucial steps in the spray drying process, since it has a big impact on the final formulation's size distribution of dried particles. Formulations made with spray drying and spray congealing are displayed.

Airflow

Co-current

The drying air and particles move in the same direction through the drying chamber. Because the product temperatures when they are discharged from the dryer are lower than the exhaust air temperature, this mode is ideal for drying heat-sensitive materials. When employing a rotating atomizer, the air disperser creates a high degree of air rotation, which maintains constant temperatures throughout the drying chamber. However, tower or filter material style spray dryers sometimes use a separate non-rotating airflow technique using atomizers in the nozzles and attain similar results.[13]

Counter current

Particles and drying air flow in opposing directions through the drying chamber. Products that need some degree of heat treatment during drying can use this setting. Typically, the temperature of the powder exiting the dryer is higher than the temperature of the exhaust air.[22]

Mixed-flow

Particles flow through the drying chamber in two stages: co-current and counter-current. This mode is effective for heat-sensitive products with air inlet and outlet at the top of the drying chamber, where the atomizer sprays droplets downward towards an integrated fluid bed or for heat-stable products whose coarse powder requirements necessitate the use of nozzle atomizers that spray upward into an incoming airflow.[13] For example, a study on the spray-encapsulation of lycopene.[22]

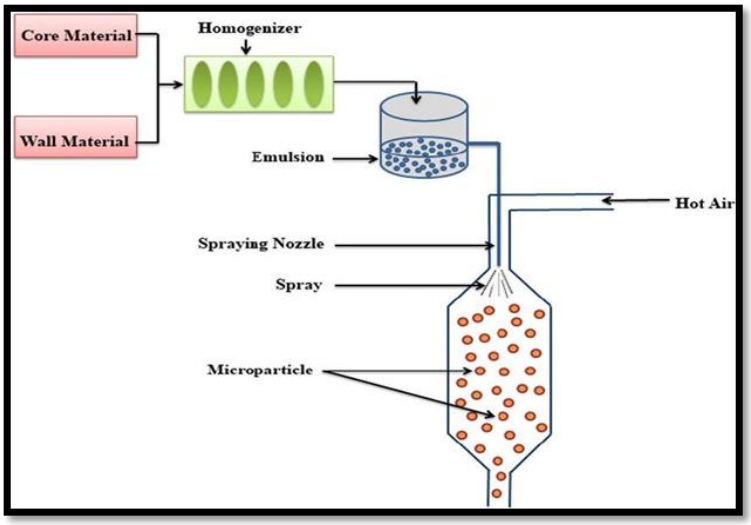

Fig. 4: Schematic representation of the microencapsulation process by spray-drying.[24]

CHEMICAL PROCESS

Solvent Evaporation

A liquid manufacturing vehicle is used for the actions. A volatile solvent that is incompatible with the liquid production vehicle phase dissolves the microcapsule coating. The coating polymer solution dissolves or disperses the core substance to be microencapsulated. To create the right size microcapsule, the core coating material combination is agitated and dispersed throughout the liquid manufacturing vehicle phase. The solvent for the polymer is then evaporated by heating the combination, if required. The polymer shrinks around the core when the core material is dispersed throughout the polymer solution.

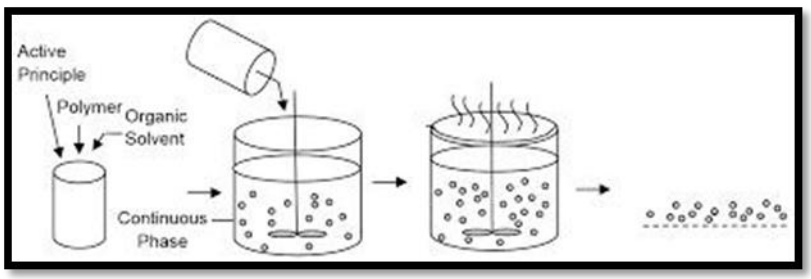

Fig. 5: Solvent evaporation method.[25]

Polymerization

A notably novel method of microencapsulation shapes protective microcapsules in situ by employing polymerization techniques. The methods include the reaction of monomeric units placed on the interface between a non-stop section where the center cloth is distributed and a core cloth substance. The polymerization response occurs at a liquid-liquid, liquid-fueloline,

solid-liquid, or solid-fueloline interface because the non-stop or center cloth aiding portion is typically a liquid or fueloline.[26]

Interfacial polymer

Various polymerization processes and sphere construction are used in chemical procedures. This suggests that monomers or pre-polymers will be the first components in these cases. Oil-in-water or water-in-oil emulsions can be produced from microcapsules created using the interfacial polymerization method, also referred to as the polycondensation method. Almost instantly, a "primary membrane" is created when two monomers that are dissolved in incompatible phases contact at the interface and react. The polymeric shell then restricts the diffusion of monomers, which lowers the reaction rate. Enough time is needed to guarantee full wall development.[27]

In-situ polymerization

A single monomer is directly polymerized on the particle surface in a few microencapsulation procedures. One method involves encasing cellulose fibers in polyethylene and submerging them in dry toluene. The typical rate of deposition is 0.5µm/min. The coating is between 0.2 and 75µm thick. Even on acute projections, the coating is uniform.[22]

Matrix polymer

During the particle's production, a core material is introduced into a polymeric matrix using a number of techniques. By letting the solvent evaporate from the matrix material, this kind of basic process known as spray-drying creates the particle. But a chemical shift could also be the cause of the matrix's solidification. Chang uses this process to make protein solutions in microcapsules by incorporating the protein into the aqueous diamine phase. By demonstrating the conversion of blood urea to ammonia, Chang has demonstrated permselectivity. This enzyme remains in the microcapsules when integrated into an extracorporeal shunt system.[13]

THE APPLICATIONS OF MICROENCAPSULATION

Food

The components of a traditional drug delivery system react, gradually deteriorate, lose their effectiveness or become toxic due to oxidation processes, which also reduces bioavailability. Therefore, by offering texture, color, blending, odor and taste masking, and an enticing aroma release, microencapsulation can overcome all of these difficulties. Liquids can be

inexpensively turned into solid powder using microencapsulation, which also prolongs the shelf life of active substances.[18]

Beverages

Functional products, which also reflect a clear trend in the creation of nutritious food, are the market sector with the quickest rate of growth and the largest market share. Probiotics and prebiotics are popular because they are important parts of a balanced diet. Prebiotics are indigestible food ingredients that help one or a small number of good bacteria in the intestine grow and function. The goal of curcumin and catechin microcapsules composed of water-in-oil-in-water emulsions is to prevent their degradation in beverage systems. The spray-drying method is used to encapsulate maltodextrin with lemon oil. Lemon oil is a popular choice for seasoning food and beverages because of its rich, pleasant aroma. Anthocyanin is one type of water-soluble pigment that is frequently employed as a food and beverage coloring agent. However, anthocyanins are unstable pigments that can break down into colorless substances based on a variety of conditions, including pH, temperature, light, oxygen and the dietary matrix. Thus, the application of microencapsulation increases the stability of this molecule.[13]

Agriculture

The area of crop protection is home to one of the most important packages of microencapsulated goods (87–93). Insect pheromones are becoming a viable biorational substitute for conventional harsh pesticides. In particular, by interfering with the mating process, sexattractant pheromones can reduce insect populations. As a result, throughout the mating season, trace amounts of a species' specific pheromone are distributed, increasing the pheromone's heritage degree to the point where it obscures the pheromone plume.[26]

AMONG THE OFTEN UTILIZED APPLICATION ARE[13]

1. Exports of carbon-free paper.
2. Scratching and sniffing.
3. Taste and scent.
4. There are medical uses for microencapsulation.
5. Microencapsulation: commonplace (vitamin and mineral (iron) encapsulation).
6. Microencapsulation is an additional technique to reduce any risks related to handling toxic or hazardous compounds. The use of toxins, herbicides, fumigants and insecticides has successfully decreased toxicity after microencapsulation.
7. Formulation (medicines in injectable and oral form).

8. Drug flavor masking (improving the microencapsulation process and obscuring the taste of tinidazole).
9. Protection.
10. Practicality.
11. Reactant exclusion.
12. Better microcapsule surface usability.
13. To lessen toxicity.
14. To try to reduce volatility.
15. Reducing uncertainty.
16. Reducing fire hazards. Ways of long-term release. Given that microencapsulation is the most effective A prescription must be written for the drug that is being microencapsulated before it may be prepared into pills, capsules or other parenteral administration methods.
17. Separating volatile materials to get rid of incompatibilities.
18. Creating a solid out of a liquid.
19. Preserving the environment by stabilizing items that are vulnerable to the.
20. To reduce inflammation of the stomach and GI tract.
21. Medication targeting.
22. A summary of the consumer goods, cosmetics and meat sectors.
23. Techniques for encapsulating agricultural products.
24. It was also suggested that a microencapsulation-based intrauterine contraception technique be developed.
25. To expand space capacity, a variety of uses are required

- To improve the stability of the emulsion.
- To make the flow easier.
- To eliminate any unpleasant taste or odor and adjust the solubility of chemical reactants at various levels while taking a drug.

- To raise the dosage of a drug because the contents may gradually leak out of the capsule because it is not completely cracked.
- To shield the medication from environmental degradation.

CONCLUSION

Microencapsulation is a technique for producing new, precious materials as well as a means of maintaining the quality of fragile products. The most extensively used technique for shielding and concealing, slowing down the rate of dissolution, simplifying handling and

spatially focusing active compounds is the use of microencapsulation. The method of placing an active ingredient in a capsule that microencapsulation is the term for materials that vary in size from a single micron to many millimeters. Until the appropriate over time, the capsule protects the active ingredient from the environment. After then, the material melts, dissolves, diffuses or breaks through the wall of the capsule. Microencapsulation technique is beneficial for enteric coated dosage form so drug is easily absorbed in intestine as compared to the stomach.

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