# Review Article

## Microencapsulation

**Submitted to: Dr. Mahwash Aziz**

**Submitted by: Shazia Batool**

**Roll. No.: 106**

**Section: C**

## Abstract

Microencapsulation is the way toward encompassing or wrapping one substance inside another substance on a little scale, yielding capsules going from short of what one micron to a few hundred microns in size. The encapsulation proficiency of the microparticles or microcapsule relies on various factors like concentration of the polymer, solubility of polymer in solvent, rate of solvent removal, solubility of organic solvent in water and so forth. Microencapsulation techniques are partitioned into two fundamental groups, which are chemical and physical. Microencapsulation innovation is important to an extensive variety of industries, including pharmaceutical, food, biotechnological, agricultural, cosmetic and different industries. This is a review of microencapsulation and materials associated with it, morphology of microcapsules, reasons for microencapsulation, microencapsulation methods, and application fields, with unique accentuation on microencapsulated additives in building development materials.


## Introduction:

Microencapsulation is defined as the application of a thin polymeric coating to individual core materials (tiny particles or droplets of liquids and dispersions) that have an arbitrary particle size range from 5-5000 μm to give small capsules with many useful properties Capsule size greater than 1000 micrometer (1mm) are called macrocapsule and which are smaller than 1 micrometer are called nanocapsule (Das *et al*., 2011).

Microencapsulation is a technology that may be useful for generating small particles that aggregate into thin layers. The simplest of the microcapsules consist of a core surrounded by a wall or barrier of uniform or non-uniform thickness. The thickness of the coat ranges from several to hundreds of micrometers (0.2–500.0 mm) and protects against degradative chemical processes. Microencapsulation provides a physical barrier between the core components and the other components of the product (Achinna and kuna, 2010). The creation of microcapsules started in 1930s and blasted in 1970s. In simplest word, microcapsule is small sphere with a uniform wall all around it. The matter inside the microcapsule is called as the core, internal phase or wall, whereas the wall is sometimes called shell, coating, wall material or membrane (Sri *et al*., 2012).

The definition has been further elaborated and includes more foods. Each class of food ingredient has been encapsulated; flavors are the most common. The method of

microencapsulation depends on the physical and chemical properties of the material to be encapsulated (Sri *et al*, 2012).

The encapsulated particles produce their required effect when their core material is free. There are four typical procedures by which the core material is free from a microcapsule:

a. Mechanical rupture of the capsule wall
b. Dissolution of the wall
c. Melting of the wall
d. Diffusion through the wall.

There are some reasons for applying microencapsulation in food industry:

a. Reduce the core reactivity with environmental agents.
b. Decrease the transfer rate of the core material towards outside environment.
c. Promote easier handling of product.
d. Control the core material from releasing.
e. Poisonous chemicals such as insecticides may be microencapsulated to minimize the possibility of tender of industrial person.
f. This method can be used for converting liquid drugs in to a free-flowing powder (Shekhar *et al*, 2010).

## Development of microcapsules

### I. Core materials

The core material is defined as the specific material to be coated, it may be liquid or solid in nature. The proportion of the core material can be varied, as the liquid core can include dispersed or dissolved matter. The solid core can be active constituents, diluents, stabilizers, excipients and release-rate retardants or accelerators. The ability to change the core material proportion provides definite flexibility and utilization of these characteristics often allows adequate design and development of the desired microcapsule properties (Mishra *et al*, 2013).

### II. Coating Materials

The coating material should be capable of a coating that is cohesive with the core material, chemically compatible and nonreactive and provide the needed coating properties, such as strength, impermeability, flexibility, stability, and optical properties. The coating materials used in microencapsulation are enable to some extent, to in-situ modification (Mishra *et al*, 2013).

Coating Material Properties are:

- Stabilization of inner material.
- Inactive toward active ingredients.
- Restrained release under specific conditions.
- Film-forming, pliable, stable, tasteless.
- Non-hygroscopic, economical, no high viscosity.
- Easily soluble in an aqueous media or solvent.
- Coating can be flexible, brittle, thin, hard etc. (Mishra *et al*, 2013).

Examples of coating materials are:

### a. Synthetic polymers

(a) Non-biodegradable polymers e.g. Poly methyl methacrylate (PMMA), Glycidyl methacrylate Epoxy polymers, Acrolein.

(b) Biodegradable polymers e.g. Glycolides, Lactides& their co polymers.

### b. Natural polymers

(a) Proteins: albumin, collagen and gelatin.

(b) Carbohydrates: carrageenan, starch, chitosan, agarose.

(c) Chemically modified carbohydrates: poly starch, poly dextran.

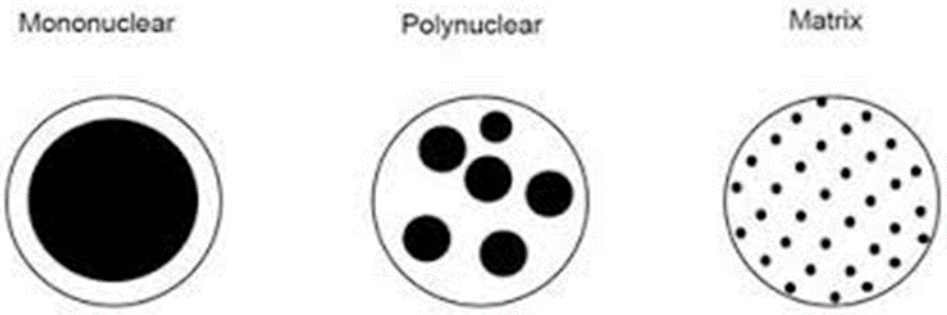
## Morphology of microcapsules:

The morphology of microcapsules relies mainly on the core material and the deposition process of the shell.

1- **Mononuclear** (core-shell) microcapsules include the shell around the core.

2- **Polynuclear** capsules have many cores in hold within the shell.
3- **Matrix encapsulation** in which the core material is distributed uniformly into the shell material.

In addition to these three morphologies, microcapsules can also be mononuclear with many shells, or they may form clusters of microcapsules.




**Equipment and processing of microencapsulation:** The equipment needed to produce microencapsulation differs from complex to simple processing equipment. Microcapsules as whole materials are available in either dry powder or in dispersed form. Microcapsules can be processed into end product by using common equipment such as V-blender, granulator, tablet machine, homogenizer, and hard gelatin, capsule filling machine, and kneader or coating equipment. Selection of processing equipment depends on the end product form desired and on the properties of the microcapsule (Das *et al*., 2011).

## Methodology for microencapsulation:

Many techniques are available for the encapsulation of core material. Basically, microencapsulation methods are divided into two groups, namely chemical and physical techniques, which are further subdivided into physico-chemical and physico-mechanical techniques. The microencapsulation methods which will be discussed are polymerization, interfacial polycondensation, solvent evaporation, coacervation, supercritical fluid precipitation, air suspension, spray-drying, pan coating, congealing, and multiorifice-centrifugal techniques (Shekhar *et al*., 2010).

### I. Chemical methods:

### Polymerization

### a. Interfacial polymer

In this method, the two reactants in polycondensation gather at an interface and react quickly. The fundamental of this method is the classic Schotten Baumann reaction between acid chloride and a compound containing an active hydrogen atom, such as an alcohol or amine, polyesters, polyurea, polyurethane. Under well conditions, thin flexible walls form rapidly at the interface. A solution of pesticide and diacidchloride are emulsified in water and an aqueous solution containing an amine and a polyfunctional isocyanate is added. Base is required to neutralize the acid formed during reaction. Condensed polymer walls form immediately at the interface of the emulsion droplets (Shekhar *et al*., 2010).

### b. In-situ polymerization

In some microencapsulation processes, the direct polymerization of one monomer is carried out on the particle surface e.g. Cellulose fibers are encapsulated in polyethylene while immersed in dry toluene. Usually a deposition rate is about 0.5μm/min. Coating thickness varies from 0.2 to 75μm. The coating is even over sharp projections (Shekhar *et al*., 2010).

### c. Matrix polymer

In this process, a core material is encapsulating in a polymeric matrix during formation of the particles. An example of this type is spray-drying, in which the particle is formed by evaporation of the solvent from the matrix matter. However, the solidification of the matrix can do by a chemical change. Using this procedure, prepares microcapsules containing protein by embodied the protein in the aqueous di-amine phase (Shekhar *et al*., 2010).

## II. Physical methods:

## a. Coacervation

Coacervation describes the basic procedure of capsule wall formation. The procedure was developed by Barrett K. Green of the National Cash Register Corporation (NCR) in the 1940s and 1950s. Coacervation is a colloid procedure which is conduct under continuous agitation to encapsulate liquids and solids. Coacervation are of two sorts, to be specific straightforward and complex coacervation. The procedure of microcapsule formation for two coacervation techniques is same, apart from the way in which the phase separation is taken place. In

straightforward coacervation a one colloidal solute is involved although in complex coacervation needs two or more colloidal solutes in the continuous phase of the fluid system (Shekhar *et al*., 2010).

A simple coacervation method utilizes gelatin. Simple coacervation happen when a strongly hydrophilic substance, such as ammonium sulphate, sodium sulphate or alcohol is added to a colloidal solution (e.g. gelatin) and two phases, one of which contain colloidal droplets, are produced. If the colloidal solution contains substances (e.g. solid particles or liquid droplets) insoluble with the system before coacervation then these substances may become encapsulated by the colloidal droplets. Gelatin and cellulose derivatives are mostly used polymers in simple coacervation, but different other polymers have been used to produce microcapsule in pharmaceutical products. Simple coacervation with cellulose derivatives has been used for microencapsulating of different drugs, such as Ibuprofen, indomethacin and theophylline (Shekhar *et al*., 2010).

In complex coacervation the contrary charged polyelectrolytes interact to form a complex of decreased solubility, same in the case of microencapsulation by coacervation method trigger by polymer-polymer interactions, where two contrary charged polymers (e.g. gum acacia and gelatin) interact under the correct pH, temperature, and concentrations to induce separation of the polymer rich complex coacervate phase. The basic benefit of complex coacervation method is that any core material which dispersed in a liquid phase can potentially be coated. This is a significant benefit over interfacial polymerization, which is restricted only to liquefiable material (Shekhar *et al*., 2010).

## b. Air suspension

Air suspension device consists of various parts such as control panel, air distribution plate, coating chamber, nozzle for applying film coatings. Within the coating chamber of air suspension device particles are suspended over moving air stream. In the coating area, coating matter is applied by spraying to the moving core fragment. The structure and operating parameters of the chamber affect the recirculating flow of the core fragment through the coating area. The core matter receives an amplification of coating material, basically a polymer solution during each pass through the coating area. The cyclic procedure is repeated up to desired coating

thickness is obtained. The air flow helps to dry the product during encapsulation process (Shekhar *et al*., 2010).

This method is generally applied for encapsulation of the solid core materials. (Das *et al*., 2011). Core materials composed of micron or submicron particles, which are effectively encapsulated by this method, while cluster of the particles to some larger size is normally achieved (Shekhar *et al*., 2010).

### c. Pan coating:

The pan coating method, widely used in the pharmaceutical sector, which is the oldest industrial method for forming small, coated particles. The particles are tousled in a pan while the coating matter is applied slowly. For microencapsulation, solid particles greater than 600 μm in size are generally considered necessary for effective coating. The coating is applied in a solution form or an atomized spray is used to the desired solid core material in the coating pan. Generally, to remove the coating solvent, warm air is passed through the coated matter which has being applied in the coating pans. In some situations, final solvent removal is performed in drying oven (Mishra *et al*., 2013).

Pan coating is useful for making small, coated particles or tablets. The disadvantage of this method is that it needed large particles on the demands of several millimeters to several centimeters in size (Das *et al*., 2011).

### d. Spray drying:

Spray drying is a basic method by which a liquid product is atomized in a hot gas current to immediately obtain a powder. The gas usually used is air or sometime an inert gas as nitrogen. The initial liquid feeding the sprayer can be a solution, a suspension or an emulsion. Spray-drying which is produces mainly depends on the starting feed material and operating conditions, a large size particle (2-3 mm) or a very fine powder (1050 lm). Spray drying act as a microencapsulation method at the point when a functioning material is broken up or suspended in a dissolve or polymer arrangement and ends up caught in the dried molecule. The fundamental focal points are the capacity to deal with thermo labile materials considering the short contact time in the dryer, likewise, the task is conservative. In present day spray dryers, the thickness of

the solution for be splashed can be as high as 300 mPa.s (mili Pascal second). Spray drying, and spray coagulating forms are comparable in that both include scattering of the center material in a condensed covering substance and spraying or bringing the center covering blend into some natural condition, whereby, generally quick hardening and arrangement of the covering is influenced. The important contrast between the two techniques is the methods by which coating hardening is accomplished. Coating hardening in the case of spray drying is affected by rapid evaporation of a solvent in which the coating matter is mixed. Coating hardening in spray congealing is accomplished by thermally coagulating a molten coating material or by hardening a dissolved coating by introducing the coating - core material mixture into a nonsolvent. Evacuation of the nonsolvent or solvent from the covered item is then proficient by sorption, extraction, or dissipation techniques (Mishra *et al*., 2013).

## e. Solvent evaporation

The solvent dissipation procedure to create microspheres is appropriate to a wide assortment of fluid and solid center materials. The emulsion solvent dissipating procedure was completely created at the end of the 1970s. At first the covering material is broken down in a volatile solvent which is immiscible with the fluid assembling vehicle stage. Then the core matter is dispersed in the coating polymer solution. The core covering material blend is then scattered in the fluid assembling vehicle stage with constant unsettling to acquire the desired size microcapsule. At the point when the required emulsion droplet size is framed, the blending rate is diminished and dissipation of the solvent for the polymer is done under atmospheric or lessened pressure at a suitable temperature (Das *et al*., 2011).

## f. Extrusion:

Extrusion microencapsulation has been used for the encapsulation of volatile and unstable flavors in glassy carbohydrate matrices. The main advantage of this procedure is that it imparted very long shelf life to normally oxidation-prone flavor compounds, e.g. citrus oils, because atmospheric gases diffuse gradually through the hydrophilic glassy matrix, in this way giving a relatively impermeable obstruction against oxygen. Time spans of usability of up to 5 years have been accounted for extruded flavors oils, contrasted with ordinarily 1 year for spray dried flavors and a few months for encapsulated citrus oils. Carbohydrate matrices in the glassy forms have

very good protection properties and extrusion is an easy process enabling the encapsulation of flavors in such matrices. This method generally used for encapsulating nutraceuticals. These methods could, generally use glassy carbohydrates as shell material, e.g. fluidize bed coating, while extrusion remains the most preferable method for such shell materials (Achinna and Kuna, 2010).

## Applications of microencapsulation:

### 1. In pharmaceutical industry

A large application of microencapsulation in pharmaceutical area is controlled or sustained drug delivery. Many pharmaceutical microencapsulated items are currently on the market, such as:

| **Drugs** | **Purpose of Encapsulation** |
|---|---|
| Paracetamol | Taste masking |
| Aspirin | sustained release, taste masking, reduced in gastric irritation, |
| Menthol | Reduction in volatility, Sustained release |
| Vit.A Palmitate | Stabilization to oxidation |
| Potassium Chloride | Reduction in gastric irritation |
| Nifedipine | Prevention from photo instability |
| Urease | Perm selectivity (restriction of permeation of macromolecules across a glomerular capillary wall based on molecular size, charge, and physical configuration.) of enzyme, substrate and reaction |
| Progesterone | Sustained release |
| Cells of Islet of Langerhans | Sustained normalization of diabetic condition |
| Isosorbide Dinitrate | Sustained release |

(Mishra *et al*., 2013).

### 2. In food industry:

Presently food industry utilizes increasingly sanitized regular engineered delicate substances and there is an increased need to secure them. Purchasers are more aware with respect to what they eat and what benefits certain ingredients has keeping up great well-being. Functional food

ingredients such as, flavors antioxidants or vitamins etc. are sensitive to environmental stress during processing, storage and utilization of the food product. Sometimes these food ingredients gradually debase and lose their bioactivity during digestion. A large portion of the "functional foods" are expanded with ingredients to enhance healthful esteem can bargain their taste, texture, aroma and color. Microencapsulation is a helpful procedure to safeguard the useful properties of these ingredients and to control their discharge at both the opportune place and the perfect time. Spray drying procedures is generally utilized in food industry to diminish water content and along these lines guarantee a microbiological stability of items. Spray drying methods has been for quite a long time to encapsulate food ingredients, for example, flavors, carotenoids, and lipids (Das *et al*., 2011).

The food industry is consequently tested to create conveyance frameworks for consolidating nutraceutical compounds into food without decreasing their bioavailability. Microencapsulation innovation is utilized to encapsulate liquid flavor compounds in a bearer grid to give dry free-streaming materials secured against degradative response and the loss of flavors during food processing (Das *et al*., 2011).

## 3. In agricultural industry:

A standout amongst the most vital uses of microencapsulated items in pesticide industry is to enhance taking care of wellbeing of the pesticides by peril and exposure decrease. Pesticide is generally utilized all through the world in the territory of yield protection. Aldicarb is a carbamate pesticide, profoundly dangerous to mammals. With the end goal to beat these issues, microspheres of aldicarb by utilizing carboxymethyl cellulose (CMC) as the biodegradable help material cross-connected with aluminum chloride (Das *et al*., 2011).

## 4. In biotechnological industry:

Attractive supports have discovered application in progressively assorted areas of biotechnology, including purification of proteins, cell sorting and isolation, viruses and nucleic acids,

biosensors, and enzymes immobilization. Artificial cell microencapsulation innovation holds bioactive materials inside the capsules has indicated guarantee in the treatment of various sicknesses. Microsphere-based measures speak to another age of diagnostics in this field and give generous quantitative and quantitative data from gene expression profiling (Das *et al*., 2011).

## 5. In cosmetic industry:

In the field of Cosmetics microencapsulation innovation has been utilized for making items like antiperspirants, shampoos, and sprays, to enhance their steadiness or bioavailability. The particulate conveyance frameworks utilized in cosmetics incorporate microparticulate, permeable polymeric frameworks, nanoparticulate, and cyclodextrin complexes. For the most part, microparticles are utilized in beauty care products to keep away from incongruence of substance, lessen scent of actives and for security of substances inclined to oxidation or activity by atmospheric moisture. Nylon microspheres are being utilized in cosmetic make-up and healthy skin items due to the feel and skin bond they give. The utilization of vitamin E, a natural antioxidant, in healthy skin items shields tissue from the impacts of UV radiation, postpones the photoaging procedure and displays moisturizing properties. Alencastre et al., arranged Carboxymethylcellulose (CMC)/chitosan microparticles containing vitamin E by a complex coacervation technique and assessed their potential use as a topical conveyance framework (Das *et al*., 2011).

## Future prospects of microencapsulation:

a. Microencapsulation, as its name proposes, is the making of a small capsule (or, practically speaking, heaps of tiny capsules), typically only microns in diameter, containing a specific material. Practically speaking, microencapsulation involves putting a round shell made out of an engineered or natural polymer totally around another chemical. That shell delays or moderates the arrival of the core material. At the point when the polymer shell breaks down or is burst by pressure, the material it encapsulates is discharged (Sri *et al*., 2012).

b. Microencapsulation isn't new. It has been around for quite a long time as spray drying, spray chilling, freeze drying and coacervation. In any case, researchers trust that the part has enhanced quickly. The microencapsulation area is in this way quick building up itself at the cutting edge of food and beverage flavor advancement. The utilization of nanotechnology, which includes the examination and utilization of materials at sizes of millionths of a millimeter, could progressively be utilized in the creation and improvement of flavors and flavor frameworks in future (Sri *et al*., 2012).
c. Microencapsulated flavors are opening new food advancement potential outcomes at no other time endeavored "The Franken food that enhances you" in UK's. Of these, encapsulation advances assume a tremendous job in their picture of the future food.
d. Additionally, research of microencapsulation, to test the oxidative dependability of the microcapsules after some time and also for flavor maintenance for aroma mixes.
e. Future prospects of microencapsulation of islets of Langerhans utilized sodium alginate and poly-l-lysine (PLL) to frame the capsules.
f. Microencapsulation of oil ingredients, similar to omega-3, with sugar beet pectin could give an option in contrast to more customary encapsulating agents like gum Arabic and milk proteins (Sri *et al*., 2012).
g. Notwithstanding the familiar uses noted above, microcapsules have discovered uses in the pharmaceutical, cosmetic, farming, and food industries and have been utilized to encapsulate oils, alcohols, aqueous solution and different solids (Sri *et al*., 2012).

## Conclusion:

Microencapsulation implies packaging an active ingredient inside a capsule extending in size from one micron to a few millimeters. The capsule shields the active ingredients from its encompassing condition until a fitting time. At that point, the material escapes through the capsule wall by different means, including burst, melting, dissolution or diffusion. Microencapsulation is both a science and an art. There's no real way to do it, and each new application gives a new challenge. Solving these enigmas requires experience, ability and the authority of a wide range of technologies.

The challenges are to choose the proper microencapsulation techniques and encapsulating material. In spite of the extensive variety of encapsulated items that have been produced, manufactured, and effectively marketed in the pharmaceutical and cosmetic industries,

microencapsulation has discovered a nearly significantly smaller market in the food industry.

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