Microencapsulated Fragrances: A Review

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***Abstract*: Microencapsulation technology allows a compound to be encapsulated inside a tiny low sphere brought up as microcapsule, having a mean diameter as small as 1mm to several hundred micrometers. Encapsulation provides an efficient method to protect flavor compound. The ingredient to convert liquid components into solid particle to supply how of controlled release. Microencapsulation is also a process of building a functional barrier between the core and wall material to avoid chemical, physical reaction to keep up the biological, functional and physcio-chemical properties of core material. A technique of encapsulating an amphiphilic flavor or fragrance compound into a microcapsule having a hydrogel shell and an oil core. Encapsulation entraps or coats a flavor with material and processes it to create a protective matrix or shell that completely surrounds a flavor. Encapsulation of flavor has been attempted and commercialized using various methods like spray, spray chilling or spray cooling, extrusion, freeze drying, coacervation and molecular inclusion. Flavor and fragrance in special active material are applied widely in lifestyle, which might bring pleasant olfactory and gustatory sensations. In this review, we wish to emphasise on microencapsulation of flavor or fragrances, materials and methods of encapsulation, advantages and applications in cosmetic preparations.**

***Keywords:* Microencapsulation technology, fragrance, core material, coating material, application.**

I. INTRODUCTION

Microencapsulation may be a process by which solids, liquids or maybe gases is also enclosed in microscopic particles by formation of thin coating of wall material round the substance. the method had its origin within the late 1930s as a cleaner substitute for paper and carbon ribbons as sought by the business machines industry. The ultimate development within the 1950s of production of paper and ribbons that contained dyes in tiny gelatin capsules released on impact by typewriter key or the pressure of a pen or pencil was the stimulus for the event of host microencapsulated material[1]. The primary research resulting in the event of microencapsulated procedures for the pharmaceuticals was published by Bungen burg de Jong and Kan in 1931 and prohibited the preparation of gelatin spheres coacervation process[2]. Fragrance play a vital role and are widely employed in many products like perfume, soap, cream, lotion, shampoo, washing up liquid, food, wine, cigarette etc [3]. Fragrance and flavors are complex mixtures of comparatively volatile substance and liable components of which the sensory perception will be changed as a results of heating, oxidation, chemical interaction and volatilization[4]. Microencapsulation technology is an efficient method to reduce the harm of the issues. Encapsulation is that the technique by which one material or mixture is coated with or entrapped within another material or system. The coated material is termed active or core material and also the coating material is named shell, wall material, carrier or encapsultant. A microcapsule could be a small sphere with uniform wall around it. the method for encapsulation of sensitive compounds consists of two steps, the primary is after emulsification of core material, like the 'liquid aroma' system with a dense solution of wall material like polysaccharide or protein [5]. The second is drying or cooling of the emulsion. the most aim of this critique is to summarise the application and also the advantages of the encapsulation technologies, types and application of the encapsulates and to explain the flavor mechanism.

II. RELEASE MECHANISM

After the literature review, the following mechanisms of Drug release from Microspheres are described [6].

1. Degradation controlled monolithic system

The drug is dissolved in matrix and is distributed uniformly throughtout. The drug is strongly attached to the matrix and is released on degradation of the matrix. The diffusion of the drug is slow as compared with degradation of the polymer matrix [7].

2. Diffusion controlled monolithic system

The active is released by diffusion before or concurrent with the degradation of the polymer matrix. Rate of release also depend upon where the polymer degrades by homogeneous or heterogeneous mechanism [8].

3. Diffusion controlled reservoir system

The active is encapsulated by a rate controlling membrance through which the agent diffuses and therefore the membrance erodes only after its delivery is completed. During this case, drug released is unaffected by the degradation of the matrix [9].

4. Erosion

Erosion of the coat thanks to pH and enzymatic hydrolysis causes drug release with certain coat material like monostearate, beeswax, stearly alcohol [10].

III. BASIC CONSIDERATION OF MICROENCAPSULATION TECHNIQUES

Microencapsulation often involves a basic understanding of the final properties of microcapsules, such because the nature of the core and coating materials, the stability and released characteristics of the coated materials and microencapsulation methods.The intended physical characters of the encapsulated product and therefore the intended use of the ultimate product must be also considered[11].

Core material	Coating material	Vehicle
•solid •liquid	•polymers,waxes,resins. •Proteins,polysaccharides.	•Aqueous •No aqueous

A. Core material

The core material, defined as the specific material to be coated, will be liquid or solid in nature. The composition of the core material is varied because the liquid core can include dispersed or dissolved material. The solid core is a mix of active constituents, stabilizers, diluents, excipients and release rate retardants or accelerators [1,2].

B. Coating material

The coating material should be capable of forming a film that is cohesive with the core material, be chemically compatible and non reactive with the core material and supply the required coating properties like strength, flexibility, impermeability, optical properties and stability. The total thickness of the coating achived with microencapsulation technique is microscopic in size[2].

C. Matrix

The wall matrix (film) used for flavor encapsulation must meet several criteria, a number of which are it must form and stabilize an emulsion, retain flavors during encapsulation, protect flavor during storage from evaporation and reaction, and then release flavor to the ultimate product on consumption. Based on these criteria, various edible films employed in the encapsulation of flavorings[2,3].

IV. COATING MATERIAL PROPERTIES

The Material should have the following properties for Microcapsules, these properties affect the microencapsulation process, purpose and it's uses.

- ❖ Stability of core material.
- ❖ Inert toward active ingredient.
- ❖ Controlled released under specific condition.
- ❖ Film-forming, pliable , tasteless, stable.
- ❖ Non-hygroscopic, no high viscosity, economical.
- ❖ Soluble in an aqueous media or solvent or melting .
- ❖ The coating can be flexible, brittle, hard , thin etc.

Table 1. List of coating material [12].

Water soluble resins	Water insoluble resins	Wax & liquid	Enteric resin	Application and benefits	Limitations
Gelatin,gum arabic,PVP, CMC, methyl cellulose, arbino qalactan, polyvinyl acrylate, polyacrylic acid.	Ethyl cellulose, Polyethylene, polymethyl acrylate, cellulose nitrates, silicone.	Paraffin, carnauba wax, beeswax, stearic acid, stearyl alcohol.	Shellac, zein, cellulose acetate, phthalate	Polymer are the substance of high molecular weight made up of by repeating monomer. Easy use, smooth surface, hot melt extrusion, taste masking, protection from chemical degradation.	Oxidation, Sensitivity, Needs preservation borate hinders swelling, Organic solvent residual.

V. CLASSIFICATION

Microencapsules are classified into three categories

1. Mononuclear/ single core.
2. Poly nuclear /Multiple core .
3. Matrix type.

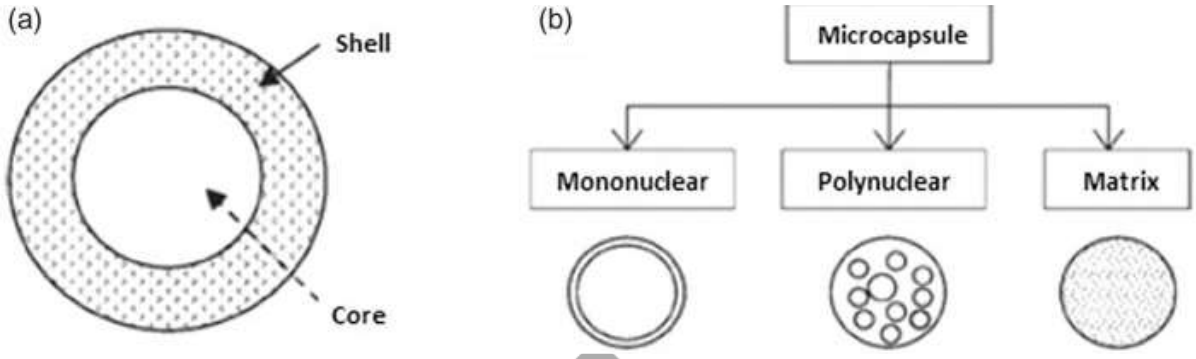

Fig. 1. Showing the details basic of Microencapsulation

Mononuclear type microcapsules contain shell round the core, which poly nuclear having many cores enclosed within the shell. In case of matrix, the core material homogeneously distributed into shell material. Due to the presence of additional external wall aggregated microcapsules vary in size and shape. Microcapsule of the membrances also are detected by SEM [13].

VI. FACTORS INFLUENCING PROPERTIES OF MICROCAPSULES

A. Material properties

The polymer used plays a significant role for drug encapsulation which further depend upon

- Solubility of polymer.
- Concentratation of polymer.
- The organic solvent used.
- Solvent removal rate.
- Dispersed and continues phase ratio.
- Nature of drug hydrophilic /hydrophobic.

B. Dispersed phase

- Viscosity of dispersed phase.
- Volume fraction of both dispersed to continues phase.
- Drug quantity in dispersed phase.
- Surfactant concentration.
- Operating parameters
- Agitation rate/time.
- Temperature
- Geometery of agitator and reactor [14].

VII. MICROENCAPSULATION TECHNIQUES

Various techniques are available for the encapsulation of core material. Broadly the methods are divided into three types. Mainly Chemical methods, Physico-chemical methods, Physcio-mechanical methods[15].The following are the various microencapsulation techniques and therefore the process involved in each technique.

Table 2. Various Microencapsulation Techniques and their advantage and disadvantage

Sr.No.	Techniques	Advantages	Disadvantages
1.	**Pan coating**	Applicable to wide range of coat and coat material and process flexibility.	Not applicable to very fine particles (less than 500um), needs great amount of coating material. High material loss and time consuming.
2.	**Air suspension coating**	Applicable to solid cores irrespective of size, shape and wide range of coating material. It requires to skilled labour or expertise.	Not suitable for thermosensitive cores.
3.	**Coacervation phase separation**	Protect active principles from being altered by exposure to heat or from their partitioning out into dispersing phase.	Difficulties in scaling up and use of large amount of organic solvent. Complex coacervates are highly unstable.
4.	**Solvent Evaporation**	Prevent eventually hydrolysis of the drug or polymer	Low yield
5.	**Emulsification polymerization**	High strength and flexible capsule shell wall. Not easy to break and large scale synthesis.	Difficult to encapsulate aqueous cores.
6.	**Spray drying and spray congealing**	Can be use without organic solvents. High yield. Ability to handle labile material.	Core loading is 20-30%, low boiling point compound volatilize from microcapsule.
7.	**Multiorifice centrifugal**	Slower release properties of the microcapsule and high through put rate.	Drops are from by the breakup of a liquid jet, the process is only suitable for liquid or slurries.
8.	**Fluidized bed coating**	Total control over temperature and obtain desirable thickness of coating.	Lower duration, too high inlet air temperature lead to inhomogeneous looking films.
9.	**Lyophilization**	Minimizes the changes associated with high temperature	High cost and long process time
10.	**Liposomes entrapment**	Either aqueous or liquid soluble material can be encapsulated	Mainly used on a laboratory scale.
11.	**Sol gel Encapsulation**	Low temperature processing, ease of fabrication and precise microstructural and chemical control	High cost of precursor.

The selection of microencapsulation method and coating materials are interdependent. Based on the coating material or method applied, the suitable method or coating material is chose selected from a good style of natural or synthetic polymers, reckoning on the material to be coated and characteristics desired within the final microcapsules[16].

VIII. IDEAL COATING MATERIALS AND CHARACTERISTICS [17].

The coating material are considered suitable for microencapsulation on the basis of following characteristics.

1. Good rheological properties at high concentration and simple work ability during encapsulation.
2. The flexibility to disperse or emulsify the active material and stabilize the emulsion produced.
3. Non-reactivity with the fabric to be encapsulated both during processing and on prolonged storage.
4. The flexibility to seal and hold the active material within its structure during processing or storage.
5. The power to completely release the solvent or other materials used during the method of encapsulation under drying or other desolventization conditions.
6. The flexibility to produce maximum protection to the active material against environmental conditions (e.g., oxygen, heat, light, humidity).
7. Solubility in solvents acceptable within the food industry (e.g., water, ethanol).
8. Chemical non-reactivity with the active core materials.
9. Inexpensive.

Because no single coating material can meet all the standard listed above, in practice either coating materials are employed in combinations or modifiers like oxygen scavengers, antioxidants, chelating agents and surfactants are added. Some commonly used biocompatible and food-grade coating materials are listed in Table 3. However, chemical modifications of the present coating

materials to control their properties are also being considered. Those modified coating materials exhibit better physical and mechanical properties when put next to individual coating materials [18].

Table 3. Commonly Used Biocompatible and Coating Materials

Sr. No.	Category	Coating Materials	Widely Used Methods
1.	Carbohydrate	Starch, maltodextrins, chitosan, corn syrup solids, dextrin, modified starch, cyclodextrins	Spray- and freeze-drying, extrusion, coacervation, inclusion complexation
2.	Cellulose	Carboxymethyl cellulose, methyl cellulose, ethyl cellulose, cellulose acetate phthalate, cellulose acetate butylate-phthalate	Coacervation, spray drying, and edible films
3.	Gum	Gum acacia, agar, sodium alginate, carrageenan	Spray-drying syringe method (gel beads)
4.	Lipids	Wax, paraffin, beeswax, diacylglycerols, oils, fats	Emulsion, liposomes, film formation
5.	Protein	Gluten, casein, gelatin, albumin, peptides	spray drying [19,20,21,22,23,24].

The various material use for microencapsulation exhibit variety of shape such as sperical, ablong or irregular and can be aggreates.

IX. COMMON MATRIX MATERIAL

The following are most commonly used material as matrix.

1. Lipids (waxes, paraffin, oils, fats, etc.)
2. Inorganics (silicates, clays, calcium sulfate, etc.)
3. Polysaccharides and sugars (gums, starches, celluloses, cyclodextrin, dextrose, etc.)
4. Proteins (gelatin, casein, soy protein, etc.)
5. Synthetics [acrylic polymers, poly (vinylpyrrolidone), etc.]

The differences between matrix encapsulation and true encapsulation of a substance. In matrix encapsulation the resulting particles are found as aggregates of actives (molecule) during a matrix material, having their significant Slice on the surface of the particles. True encapsulation is employed for processes resulting in core-shell-type products, where actives/particles are enclosed in a shell. Environmentally friendly biodegradable polymers have gained more attention as carriers matrix thanks to their biocompatibility and biodegradability. They will be synthetic origin like polyesters, poly(*ortho*-esters), polyanhydrides, and polyphosphazenes, or natural like polysaccharides like chitosan, mucopolysaccharide, and alginate [24].

X. METHODS OF MICROENCAPSULATION

1. Spray Drying

Spray drying is the most common microencapsulation technique utilized in food industry. Spray drying technique for producing encapsulated flavouring was discovered by A Boake Roberts in 1937, when acetone was accidently added to tomato puree which helped him to keep up color and flavor of tomato powder during spray drying. Subsequently, spray drying has become the foremost important commercial process for creating dry flavorings. Vitamins, minerals, colorants, fat and oil flavour, aroma compounds, oleoresins and enzymes are encapsulated using this system. It is an economical, as well as an effective. Method for safeguarding materials and is most generally employed, particularly for flavors that specialized equipment is not required. For encapsulation purposes, modified starch, maltodextrin, gum or others are hydrated to be used because the carrier or wall material. The material for encapsulation is homogenized with the carrier material usually at a ratio of 1: 4. The mixture is then fed into a spray dryer and atomized with a nozzle or spinning machine. Water is evaporated by the new air contacting the atomized material. The capsules are then collected after they fall to the under side of the drier. Microencapsulation by spray drying offers advantages over conventional microencapsulation techniques by producing microcapsules via a comparatively simple, continuous process[16].

2. Spray Chilling

In spray chilling, the material to be encapsulated is mixed with the carrier and atomized by cooled or chilled air as critical heated air utilize in spray drying. The outer material is typically vegetable oil within the case of spray cooling (45 to 122°C) or a hydrogenated or fractionated edible fat with in the case of spray chilling (32 to 42°C). Froze liquids heat-sensitive materials and those not soluble within the usual solvents will be encapsulated by spray chilling / spray cooling. It is the smallest amount, expensive encapsulation technology and is routinely used for the encapsulation of a variety of organic and inorganic salts like ferrous sulfate, vitamin, mineral or acidulents moreover as textural ingredients, enzymes, flavors and other functional ingredients to boost heat stability, delay release in wet environments, and/or convert liquid hydrophilic ingredient into free flowing powders[25].

3. Spray Cooling

Spray cooling is called as ‘matrix’ encapsulation because the particles are more adequately described as aggregates of active ingredient particles buried within the fat matrix, while ‘true’ encapsulation is typically reserved for processes resulting in a core/shell

form of microencapsules. A matrix encapsulation process leaves a major proportion of the active ingredient lying on the surface of the microcapsules or protruding of the fat matrix, thus having direct access to the environment. Particles produced by a matrix encapsulation process generally release their entire content within a some minutes after being incorporated within the food. A non negligible proportion of active ingredients also can be found on the surface of core/shell sort of microcapsule, but the majority of the ingredient is encapsulated and far slower release kinetics are typically obtained. Although the method does not cause and ideal encapsulated, the properties obtained by spray cooling/ chilling are sufficient to realize the required delayed release of the ingredient within the actual application. However, a powerful binding of the ingredient to the fat matrix can prevent the discharge of the ingredient whether or not matrix is melted and/or damaged during processing[26].

4. Extrusion and Centrifugal extrusion

Extrusion microencapsulation has been used almost exclusively for the encapsulation of volatile and unstable flavors in glassy carbohydrate matrices. The most advantage of this process is that the very long time period imparted to normally oxidation-prone flavor compounds, like citrus oils, because atmospheric gases diffuse very slowly through the hydrophilic glassy matrix, thus providing an almost impermeable barrier against oxygen. Shelf lives of up to 5 years are reported for extruded flavor oils, compared to typically 1 year for spray dried flavors and a some months for encapsulated citrus oils. Carbohydrate matrices within the glassy states have excellent barrier properties and extrusion may be a convenient process enabling the encapsulation of flavors in such matrices.This process can be used for encapsulating nutraceuticals. These processes will be, theoretically use glassy carbohydrates as shell material, like fluidize bed coating, but extrusion remains the foremost suitable process for such shell materials. The premise of the method was developed by Schultz et al,and later improved by Swisher. A lower temperature process is developed, within which a mass of potato starch, glycerol and water is processed and gelatinized during a twin screw extruder at about 100°C. The mass is then cooled down and therefore the bioactive formulation is injected within the last barrel, where the temperature should approximately be 50°C. The extruded ropes are turn over pieces and dried[26,27].

Centrifugal extrusion is another encapsulation technique that has been investigated and employed by some manufacturers. Variety of food-approved coating systems are formulated to encapsulate products like flavorings, seasonings, and vitamins. These wall materials include gelatin, sodium alginate, carrageenan, starches, cellulose derivatives, gum acacia, fats, fatty acids, waxes, and polyethylene glycol. Centrifugal extrusion could be a liquid extrusion process utilizing nozzles consisting of a concentric orifice located on the outer circumference of a rotating cylinder i.e., the head. The encapsulating cylinder or head consists of a concentric feed tube through which coating and core materials are pumped separately to the numerous nozzles mounted on the outer surface of the device. While the core material passes through the middle tube, coating material flows through the outer tube. The whole device is attached to a shaft such that the top rotates around its vertical axis. Because the head rotates, the core and coating materials are co-extruded through the concentric orifices of the nozzles as a fluid rod of the core sheathed in coating material. Centrifugal force impels the rod outward, causing it to interrupt into tiny particles. By the action of physical phenomenon, the coating material envelops the core material, thus accomplishing encapsulation. The microcapsules are collected on a moving bed of fine-grained starch, which cushions their impact and absorbs unwanted coating moisture. Particles produced by this method have a diameter starting from 150 to 2000 mm [28].

5. Fluidized Bed Coating

Fluidized bed technology could be a very efficient thanks to apply an identical layer of shell material onto solid particles. Interestingly, fluidized bed technology is one in all the few advanced technologies capable of coating particles with any quite shell material like polysaccharides, proteins, emulsifiers, fats, complex formulations, enteric coating, powder coatings, yeast cell extract, etc. Therefore, the controlled release possibilities are considerably more versatile with the fluidized bed technology than with other technologies. Aqueous solutions of hydrocolloids such as gums and proteins, ethanolic solutions of synthetic polymers and melted fats/waxes have all been used as coating formulations in fluidized bed microencapsulation processes. Spray dried microcapsules can even be further coated by fluidized bed, with a fat layer so as to impart better protection and time period. The ultilization of, waxes or emulsifiers as shell materials may be a relatively new but very promising and interesting concept. During this technique solid particles are suspended during a temperature and humidity controlled chamber of high velocity air where the coating material is atomized. Optimal results are obtained with particle sizes between 50 and 500 microns. Particle size distribution should even be narrow. The number of fabric that coats the particles is relies on the length of your time that the particles are within the chamber. This method is applicable for hot-melt coatings like hydrogenated edible fat, stearines, fatty acids, emulsifiers and waxes or solvent-based coatings like starches, gums, maltodextrin[29].

6. Liposomal Entrapment

A liposome or lipid vesicle is defined as a structure composed of lipid bilayers that enclose a variety aqueous or liquid compartments. They have been used for delivery of vaccines, hormones, enzymes and vitamins into the body. They incorporates of one or more layers of lipids and are nontoxic and acceptable for foods. Permeability, stability, surface activity and affinity is varied through size and lipid composition variations. They will have range from 25 nm to many microns in diameter, are easy to create, and might stored by freeze-drying. Phospholipids conjure the outer layer or layers of liposomes. The hydrophilic portion of the lipids is oriented towards the aqueous phase and therefore the hydrophobic groups go along with the hydrophobic ones of other lipid molecules. Folding of the lipid sheet into a spherical shape forms a really stable capsule because of there being no interaction of the lipids with wate. Aqueous or lipid-soluble materials, but not both, are entrapped in these membranes. Liposomes can range from a some nanometers to microns. Food applications of liposomes in cheese making is well known. The foremost common phospholipid in lectin, namely phosphatidyl choline, is insoluble in water and is isolated from soya or fixings. The composition of the phospholipids and also the process used determine if a single or multiple layers are formed. Fatty acids also structure liposomes

and their degree of saturation relies on the source. Animal sources provide more saturated fatty acids. They influence the transition temperature which is that the conversion from a gel to the more leaky liquid form. Although sugars and huge polar molecules cannot permeate through a liposome bilayer, small lipophilic molecules [30].

7. Lyophilization

Lyophilization or freeze-drying, may be a process used for the dehydration of virtually all heat sensitive materials and aromas. It has been accustomed encapsulate water-soluble essences and natural aromas still as drugs. Apart from the long dehydration period required (commonly 20 h), freeze-drying could be a simple technique, which is especially suitable for the encapsulation of aromatic materials. The retention of volatile compounds during the lyophilization depends upon the chemical nature of the system[31].

8. Coacervation

Coacervation, often called ‘‘phase separation,’’ is taken into account as a real microencapsulation technique, because the core material is totally entrapped by the matrix. This method involves the precipitation or separation of a colloidal phase from an aqueous phase both, simple and complicated methods of coacervation is used. In simple coacervation, a nonsolvent or a more water-soluble polymer is employed. The polymer competes for the solubility for gelatin protein solution by polymer is employed. The polymer competes for the solubility for gelatin protein solution by hydrophobic interaction. In complex coacervation, the capsule is formed by the ionic interaction of two oppositely charged polymers, commonly the positive charges on protein molecules and anionic macromolecules such as gelatin and gum Arabic. The complex coacervate is produced when the two opposite charges are neutralized with each other coacervation involves the separation of a liquid phase of coating material from a polymeric solution followed by the coating of that phase as a homogeneous layer around suspende core particles. The coating is then solidified. In general, the batch-type coacervation processes consists of three steps and are dispensed out under continuous agitation[32].

1. Formation of a three-immiscible chemical phase
2. Deposition of the coating
3. Solidification of the coating

A large numbers of coating materials are evaluated for coacervation microencapsulation but the foremost studied and well understood coating system is gelatin/gum acacia system. However, other coating systems like gliadin, heparin/gelatin, carrageenan, chitosan, soya protein, polyvinyl alcohol, gelatin/carboxymethyl cellulose, B-lactoglobulin/gum acacia, and guar gum/dextran are also suitable for coacervation microencapsulation. In recent years, modified coacervation processes have also been developed that may overcome a number of the issues encountered during a typical gelatin/gum acacia complex coacervation process, especially when handling encapsulation of heat-sensitive food ingredients such as volatile flavor oils[33].

9. Centrifugal Suspension Separation

Centrifugal suspension could be a newer microencapsulation process. The method in theory involves mixing the core and wall materials so adding them to a rotating disk. The core materials leave the disk with a coating of residual liquid. The microcapsules are then dried or chilled after removal from the disk. The entire process can take between a some seconds to minutes. Solids, liquids, or suspensions of 30 mm to 2mm may be encapsulatedin this way. Coatings is 1–200 mm in thickness and include fats, polyethylene glycol (PEG), diglycerides, and other meltable substances. Since this can be a non-stop, highspeed method which will coat particles, it is highly suitable for foods. One application is protect product that are sensitive to or readily absorb moisture, like aspartame, vitamins, or methionine[34].

10. Cocrystallization

Cocrystallization is a new encapsulation process utilizing sucrose as a matrix for the incorporation of core materials. The sucrose syrup is concentrated to the supersaturated state and maintained at a temperature high enough to prevent crystallization. A predetermined amount of core material is then added to the concentrated syrup with vigorous mechanical agitation, thus providing nucleation for the sucrose/ingredient mixture to crystallize. Because the syrup reaches the temperature at which transformation and crystallization begin, a considerable amount of warmth is emitted. Agitation is sustained so as to push and extend transformation crystallization until the agglomerates are discharged from the vessel. The encapsulated products are then dried to the specified moisture if necessary and screened to an identical size. It is very important to properly control the rates of nucleation and crystallization as well as the thermal balance during the various phases[35].

11. Inclusion Complexation

Molecular inclusion is another means of achieving encapsulation. Unlike other processes discussed, this system takes place at a molecular level; â-cyclodextrin is usually used because the encapsulating medium. â-Cyclodextrin may be a cyclic derivative of starch made from seven glucopyranose units. They are prepared from partially hydrolyzed starch(maltodextrin) by an enzymatic process. The external a part of the cyclodextrin molecule is hydrophilic, whereas the inner part is hydrophobic. The guest molecules, which are a polar, may be entrapped into the a polar internal cavity through a hydrophobic interaction. This internal cavity of about 0.65nm diameter permits the inclusion of essential oil compounds and might take up one or more flavor volatile molecule. During this method, the flavor compounds are entrapped inside the hollow center of a â-cyclodextrin molecule[23,32].

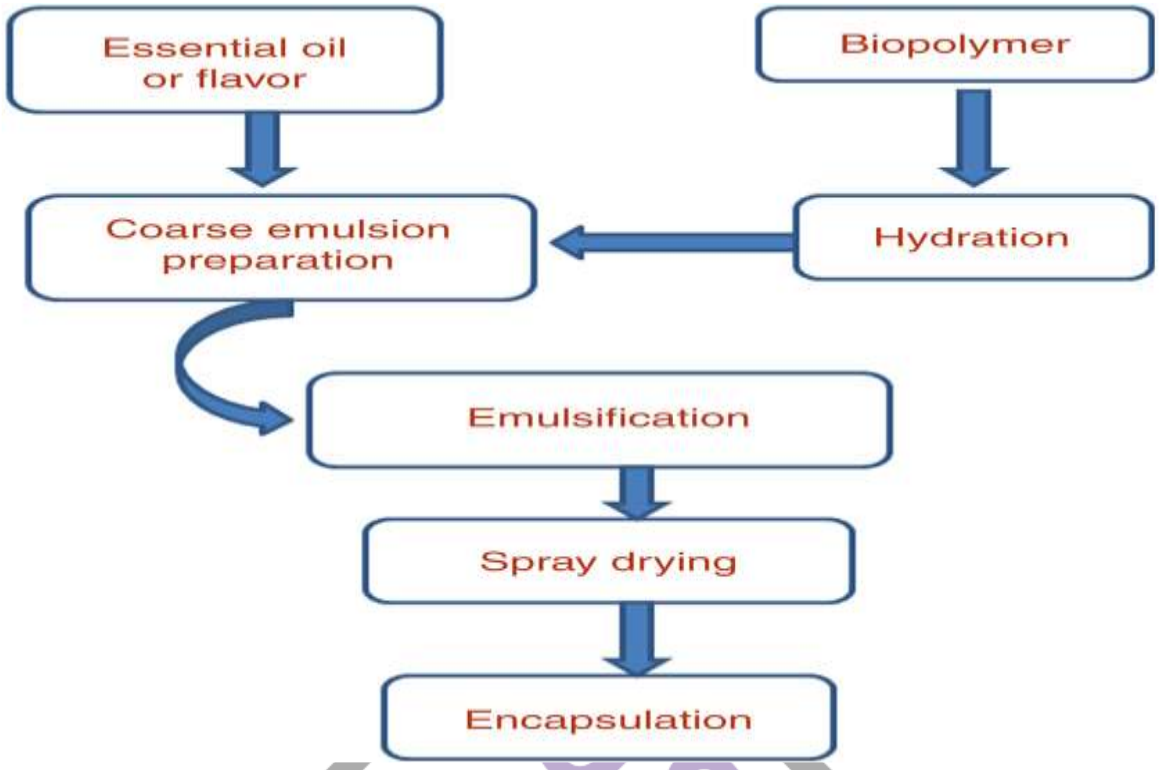

Fig. 2. Showing in latest trend in Flavor and Fragrance Encapsulation industry [36].

The flavor and fragrance industry had a turnover of about USD 38.56 billion in 2020 and increase a CAGR of 4.8% by 2026. The flavor and fragrance market is one among the biggest in production, consumption and import in India. The Indian fragrance market a CAGR of 32.21, expecting a growth of over 10 times that in 2021. This is often attributed to the ascent of the cosmetic industry and about half of this turnover is from flavor industry while about 20–25% of all flavors are estimated to be sold in an encapsulated form. Major part (80–90%) of the encapsulates are prepared using spray-dried method, followed by spray chilling (5–10%), melt extrusion (2–3%), and preparation by melt injection (the remaining 2%).

The physical and chemical properties of the encapsulates rely upon the aroma properties additionally because the carrier material, they form oil droplets. When more hydrophobic carrier material is employed, aroma mixes with the carrier material forming single-matrix morphology, the same as when entrapping water-soluble aroma molecules (like vanillin) in hydrophilic carrier materials. Once encapsulated, the desirable quality is required that the aroma should diffuse oumaterial. As majority of aroma molecules are lipophilic, and because of their inability to combine well with hydrophilic carrier matet within the correct amount at the acceptable time. Research has shown that the molecular size of the carrier material decides the diffusion rate. In general, the diffusion through carrier material decreases with increasing molecular size (stearic hindrance, related to molecular weight), decreasing vapor pressure (volatility), and increasing log P of the aromas. Among the carbohydrate carrier materials the order of retention is alcohols > ketones = esters > acids, with many exceptions. These observations indicate that the presence of chemical groups not only influences the retention, but also other characteristics like polarity, having an inverse relation within which the upper the polarity, the lower the retention[37].

12. Emulsification Process

The importance of imparting emulsifying properties depends upon the sort of flavoring encapsulated, the encapsulation process, and also the final application of the encapsulated flavor. As noted earlier, hydrophilic flavoring do not require emulsions. Though a flavoring labeled as water soluble is mostly a combination of alcohol or humectant at 0.1% or slightly higher usage levels. If flavors, or any part thereof, are insoluble within the system getting used for encapsulation, then an emulsifying matrix is required. Emulsification is required to attenuate flavor losses during the encapsulationprocess (spray drying and extrusion processes). There is ample data within the literature showing that retention of water insoluble flavorings are substantially improved if a good-quality emulsion is ready and used during the encapsulation process.

The foremost common problem encountered during storage of flavors is worsening because oxidation. Flavor encapsulation films diverge greatly in their capacity to safeguard a flavoring from oxygen. For example, dextrose equivalent in maltodextrins coating provides varying protection. The upper the dextrose equivalent, the better the protection against oxidation. However, higher dextrose equivalent materials are poor in drying, yield poor flavor retention, and are very hygroscopic. These observations led to blending of emulsifying wall materials with higher dextrose equivalent maltodextrins, corn syrup solids, or simple sugars. Thus, sufficient emulsifying wall materials are often added to impart necessary emulsifying capacity, and corn syrup solids or simple sugars is also mixed to impart oxidative stability; fortunately, this also lowers product costs. While modified food starches produce an encapsulated flavoring that has excellent flavor retention and emulsion stability, they need traditionally provided very poor protection against oxidation, the starch hydrolysates being inexpensive could also be added for desired quality.

13. Controlled Released Method

Controlled release could also be defined as a way by which one or more active agent or ingredients are made available at a desired site and time and at a selected rate . Many researchers have sought a stronger understanding of the results that governs the fragrance release from complex matrices as this represents an vital target in many cosmetic and personal care product. An summary of chemistry relevant to flavor release has been presented previously. For matrix system encapsulating volatile compound, release depends on several mutually dependent processes like diffusion of the volatile compounds through the matrix ,type and geometry of the particle , transfer from particle, transfer from matrix to the environment , and degradation /dissolution of the matrix material. Not only is flavor retention important, but flavor release from the encapsulated material is additionally essential. Preferably, all encapsulated flavorings should offer controlled release however, sometimes a slow or delayed release is desirable. For example, requirement may well be no release of an encapsulated flavoring during early stages of thermal processing, so a delayed release may lead to less flavor loss, since flavor would be shielded from heat until late in processing. Within the case of an encapsulated flavoring for a dry beverage mix, one desires a rapid release on reconstitution. Thus, the specified flavor release will be dependent upon the appliances. Currently, these controlled release properties may be attained directly through the ultilization of coacervation, extrusion, and inclusion complex formation. Since spray-dried particles are water soluble, controlled release properties is also imparted to them through application of secondary coatings, for example, coating with a fat or shellac. Secondary coatings (eg, fats, oils, and shellacs) are costly and problematic to apply, and therefore it is desirable to accomplish controlled release by choosing the suitable encapsulation technique[38].

14. Flavor Retention Method

For the retention of the flavor, ability of an edible film to trap or hold onto flavor compounds, during the drying process is critical as loss of flavor, strength, and potentially will cause imbalanced in character. During the encapsulation process, lighter and more volatile constituents gets preferentially lost leading to dry flavor, lacking within the very volatile light fresh notes. Another area of concern during encapsulation is lost volatiles upon exit, either in spray-drying process through drier, or into the environment, which must be removed by a costly scrubbing process to safeguard the environment. Therefore, encapsulation materials that provides poor retention result in increased processing costs and decreased product quality. As mentioned earlier, modified food starches are excellent emulsifiers, and emulsion quality encompasses a strong influence on flavor retention during spray drying. Thus, although both gum acacia and modified food starches yield good emulsions[25].

15. Method for Retention Volatile substance

It has been found that in spray-drying encapsulation, loss of some volatiles including flavors is unavoidable. During the processing, many physical parameters including molecular mass, size of the core material and also the force per unit area of vapor pressure of flavor compounds might also affect the retention process. Molecular weight may be correlated to molecular size, which influences the method of diffusion. Large molecular size generally leads to slower diffusion rate, thereby molecules take longer time to achieve the atomized droplet surface during drying, leading to increased retention. Secondly, entrapping of enormous molecule inside makes it impervious, promoting the retention. The same trend was noticed by Voilley in a mixture of 16 aroma compounds encapsulated in glucose, maltose, or corn syrup solids. He found that the retention rate of is amyl butyrate (MW = 158) was higher than that of ethyl butyrate (MW = 116) or ethyl propionate (MW = 102) in all tested wall materials, except in maltose and corn syrup solid with dextrose equivalent[29,40].

RECENT TRENDS

Microencapsulation plays a significant role within the cosmetic industry. These technologies protect active ingredient, mask unpleasant odors and enable controlled release, making them key facilitator of the formulation, storage and application of cosmetic products. Recently, encapsulation of fragrance is principally employed in the textile industry for manufacturing perfumed suits for consumer and cosmetic industry encapsulation of sol gel process are used. Encapsulation of fragrance and flavor industry various essential oils are want to maintain the freshness of cosmetic products. In encapsulation process such a lots of companies use powder material.

CONCLUSION

Microencapsulation of the active may be a process of protection and masking. The active together with facilitation of handling and specific targeting. Encapsulation of fragrance has become very popular, attractive and technologically feasible for value addition. This certainly help in extending the stability and lifetime of the fragrance itself and products also. This review is clearly implicative the actual fact that microencapsulation process is extremely popular and adapted by many researchers and purpolators now a days.

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