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Review Article

Development of Microencapsulation: A Review of Literature

Mohd Gayoor Khan[1], Vinod Gauttam[2], H S Chandel[3], Asra Ali[4], Kasma Tariq[5]

[1]Truba Institute of Pharmacy, Bhopal, Madhya Pradesh, India, [2]Principal, IES College of Pharmacy, Madhya Pradesh, India, [3]Principal, Truba Institute of Pharmacy, Bhopal, Madhya Pradesh, India, [4]Research Scientist, Macleods Pharmaceuticals Ltd., Mumbai, India, [5]Director, Business Intelligence Services, Arogya Retail Chains, Madhya Pradesh, India

Abstract

It is a new technology that has been used in the cosmetics industry as well as in the pharmaceutical, agrochemical and food industries, being used in flavors, acids, oils, vitamins, microorganisms, and among others. Microencapsulation is a process in which active substances are coated by extremely small capsules the success of this technology is due to the correct choice of the wall material, the core release form and the encapsulation method some important microencapsulation aspects such as the capsule, wall material, core release forms, and encapsulation methods and their use in food technology. Microencapsulation is receiving considerable attention fundamentally, developmentally, commercially, etc.

Key words: Controlled release, Cosmetics, Microcapsules, Microencapsulation, Microorganism

INTRODUCTION

Microencapsulation is a rapidly expanding technology. As a process, it means applying relatively thin coating to small particles of solid or droplets of liquids and dispersons for the purpose of this chapter; microencapsulation is arbitrarily differentiated for micro coating techniques, in that the former involves the coating of particles ranging dimensionally from several tenths of micron to 5000 microns in size. As the technology has developed, it has become apparent that the concept offers the industrial pharmacists a new working tool. Microencapsulation provides the means converting liquids to solid, of alternative colloidal and surface property of providing environmental protection, and of controlling the release characteristics or availability of coated materials. Several of these properties can be attained by micro packaging technique; however, the uniqueness of microencapsulation is the smallness of the coated particles and their subsequent use and adaptation to a wide variety of dosage form and product applications, which therefore might not have been technically feasible because of the smallness of the particles, drug moieties can be widely distributed through the gastrointestinal tract, thus potentially improving drug absorption. This new technology does not exclude problem areas; for instance, no single microencapsulation process is adaptable to all core materials candidates or product applications. Difficulties, such as incomplete or discontinuous coating, inadequate stability or shelf-life of sensitive pharmaceuticals, nonreproducible and unstable release characteristics of coated products, economic limitations are often encountered in the attempt to apply a particular microencapsulation method to a specific task. Many times, successful adaptation is, in part, a result of the technical ingenuity of the investigators.[1-6]

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Microencapsulation is receiving considerable attention fundamentally, developmentally, and commercially. In view of this interest, it is the purpose of chapter to present a description of the more prominent microencapsulation method to be discussed are air suspension conservation- phase separation, spray drying and congealing, and polymerization techniques. A survey of the ever expanding patent and published literature reveals that not all microencapsulation techniques are included within the methods cited in this chapter however, the methods described represent the currently established,

Corresponding Author: Mohd Gayoor Khan. Truba Institute of Pharmacy, Bhopal, Madhya Pradesh, India.

mostly highly developed and widely used commercial processes, although some may not be applicable to pharmaceuticals at this time.

Chemical methods capsules for carbonless paper and for many other applications are produced by a chemical technique called complex concertation. This method of encapsulation takes advantage of the reaction of aqueous solutions of cationic and anionic polymers such as gelatin and gum Arabic. The polymers form a concentrated phase called the complex coacervate. The coacervate exists in equilibrium with a dilute supernatant phase. As water-immiscible core material is introduced into the system, thin films of the polymer coacervate coat the dispersed droplets of core material. The thin films are then solidified to make the capsules harvestable. Interfacial polymerization (IFP) is another chemical method of microencapsulation. This technique is characterized by wall formation via the rapid polymerization of monomers at the surface of the droplets or particles of dispersed core material. A multifunctional monomer is dissolved in the core material, and this solution is dispersed in an aqueous phase. A reactant to the monomer is added to the aqueous phase, and polymerization quickly ensues at the surfaces of the core droplets, forming the capsule walls. IFP can be used to prepare bigger microcapsules, but most commercial IFP processes produce smaller capsules in the 20-30 micron diameter range for herbicides and pesticide uses, or even smaller 3-6 micron diameter range for carbonless paper ink. Polymer-polymer incompatibility, also called phase separation, is generally grouped with other chemical encapsulation techniques, despite the fact that usually no actual chemical reaction is involved in the process. This method utilizes two polymers that are soluble in a common solvent; yet do not mix with one another in the solution. The polymers form two separate phases, one rich in the polymer intended to form the capsule walls, the other rich in the incompatible polymer meant to induce the separation of the two phases. The second polymer is not intended to be part of the finished microcapsule wall, although some may be caught inside the capsule shell and remain as an impurity. *In situ* polymerization is a chemical encapsulation technique very similar to IFP. The distinguishing characteristic of *in situ* polymerization is that no reactants are included in the core material. All polymerization occurs in the continuous phase, rather than on both sides of the interface between the continuous phase and the core material, as in IFP. Examples of this method include urea-formaldehyde (UF) and melamine formaldehyde (MF) encapsulation systems. Centrifugal force processes were developed in the 1940s to encapsulate fish oils and vitamins, protecting them from oxidation. In this method an oil and water emulsion is extruded through small holes in a cup rotating within an oil bath. The aqueous portion of the emulsion is rich in a water-soluble polymer, such as gelatin, that gels when cooled. The resulting droplets are cooled to form gelled polymer-matrix beads containing dispersed droplets of oil that are dried to isolate. Similar in concept to centrifugal force processes, submerged nozzle processes produce microcapsules when the oil core material is extruded with gelatin through a two-fluid nozzle. The oil droplets are enveloped in gelatin as they are extruded through the nozzle. Then, the capsules are cooled to gel the walls, before being collected and dried.[7-10]

TECHNIQUES TO MANUFACTURE

Microcapsules Physical Methods

The pan coating process, widely used in the pharmaceutical industry, is among the oldest industrial procedures for forming small, coated particles or tablets. The particles are tumbled in a pan or other device while the coating material is applied slowly. Air suspension coating gives improved control and flexibility compared to pan coating. In this process the particulate core material, which is solid, is dispersed into the supporting air stream and these suspended particles are coated with polymers in a volatile solvent leaving a very thin layer of polymer on them. This process is repeated several hundred times until the required parameters such as coating thickness are achieved. The air stream which supports the particles also helps to dry them, and the rate of drying is directly proportional to the temperature of the air stream which can be modified to further affect the properties of the coating. The recirculation of the particles in the coating zone portion is effected by the design of the chamber and its operating parameters. The coating chamber is arranged such that the particles pass upward through the coating zone, then disperse into slower moving air and sink back to the base of the coating chamber, making repeated passes through the coating zone until the desired thickness of coating is achieved. Centrifugal extrusion liquids are encapsulated using a rotating extrusion head containing concentric nozzles. In this process, a jet of core liquid is surrounded by a sheath of wall solution or melt. As the jet moves through the air it breaks, owing to Rayleigh in stability, into droplets of core, each coated with the wall solution. While the droplets are in flight, the molten wall may be hardened or a solvent may be evaporated from the wall solution. Since most of the droplets are within ± 10% of the mean diameter, they land in a narrow ring around the spray nozzle. Hence, if needed, the capsules can be hardened after formation by catching them in a ring-shaped hardening bath. This process is excellent for forming particles 400-2,000 μm (16-79 millions) in diameter. Since the drops are formed by the breakup of a liquid jet, the process is only suitable for liquid or slurries.

A high production can be achieved, up to 22.5 kg (50 lb) of microcapsules can be produced per nozzle per hour. Vibrational nozzle core-shell encapsulation or micro granulation (matrix-encapsulation) can be done using a laminar flow through a nozzle and an additional vibration of the nozzle or the liquid. The vibration has to be done in resonance with the Rayleigh in stability and leads to very uniform droplets. The liquid can consist of any liquids with limited viscosities (0-10,000 mPa·s have been shown to work), e.g., solutions, emulsions, suspensions, and melts. The solidification can be done according to the used gelation system with an internal gelation (e.g., sol-gel processing, melt) or an external (additional binder system, e.g., in a slurry). The process works very well for generating droplets between 20 and 10,000 μm (0.79-393.70 millions), applications for smaller and larger droplets are known. The units are deployed in industries and research mostly with capacities of 1-20,000 kg per hour (2-44,000 lb/h) at working temperatures of 20-1500°C (68-2732°F) (room temperature up to molten silicon). Heads are available with from one up to several hundred thousand nozzles. Spray–drying Spray drying serves as a microencapsulation technique when an active material is dissolved or suspended in a melt or polymer solution and becomes trapped in the dried particle. The main advantages are the ability to handle labile materials because of the short contact time in the dryer and the operation is economical. In modern spray dryers the viscosity of the solutions to be sprayed can be as high as 300 mPa·s. Applying this technique, along with the use of supercritical carbon dioxide, sensitive materials like proteins can be encapsulated.

Chemical Methods

Capsules for carbonless paper and for many other applications are produced by a chemical technique called complex concertation. This method of encapsulation takes advantage of the reaction of aqueous solutions of cationic and anionic polymers such as gelatinoids gum Arabic the polymers form a concentrated phase called the complex cooperate. The coacervate exists in equilibrium with a dilute supernatant phase. As water-immiscible core material is introduced into the system, thin films of the polymer coacervate coat the dispersed droplets of core material. The thin films are then solidified to make the capsules harvestable. IFP is another chemical method of microencapsulation. This technique is characterized by wall formation via the rapid polymerization of monomers at the surface of the droplets or particles of dispersed core material. A multifunctional monomer is dissolved in the core material, and this solution is dispersed in an aqueous phase. A reactant to the monomer is added to the aqueous phase, and polymerization quickly ensues at the surfaces of the core droplets, forming the capsule walls. IFP can be used to prepare bigger microcapsules, but most commercial IFP processes produce smaller capsules in the 20-30 micron diameter range for herbicides and pesticide uses, or even smaller 3-6 micron diameter range for carbonless paper ink. Polymer-polymer incompatibility, also called phase separation, is generally grouped with other chemical encapsulation techniques, despite the fact that usually no actual chemical reaction is involved in the process. This method utilizes two polymers that are soluble in a common solvent; yet do not mix with one another in the solution. The polymers form two separate phases, one rich in the polymer intended to form the capsule walls, the other rich in the incompatible polymer meant to induce the separation of the two phases. The second polymer is not intended to be part of the finished microcapsule wall, although some may be caught inside the capsule shell and remain as an impurity. *In situ* polymerization is a chemical encapsulation technique very similar to IFP. The distinguishing characteristic of *in situ* polymerization is that no reactants are included in the core material. All polymerization occurs in the continuous phase, rather than on both sides of the interface between the continuous phase and the core material, as in IFP. Examples of this method include UF and MF encapsulation systems. Centrifugal force processes were developed in the 1940s to encapsulate fish oils and vitamins, protecting them from oxidation. In this method an oil and water emulsion is extruded through small holes in a cup rotating within an oil bath. The aqueous portion of the emulsion is rich in a water-soluble polymer, such as gelatin, that gels when cooled. The resulting droplets are cooled to form gelled polymer-matrix beads containing dispersed droplets of oil that are dried to isolate. Similar in concept to centrifugal force processes, submerged nozzle processes produce microcapsules when the oil core material is extruded with gelatin through a two-fluid nozzle. The oil droplets are enveloped in gelatin as they are extruded through the nozzle. Then, the capsules are cooled to gel the walls, before being collected and dried.

The applications of microencapsulation might well include sustained-release or prolonged-action medications, taste-masked chewable tablets, powders and suspensions, single layer tablets containing chemically incompatible ingredients, and new formulation concepts for creams, ointments, aerosols, dressings, plasters suppositories, and injectable. Pharmaceutically related areas, such as hygiene, diagnostic aids, and medical equipment design, also are amenable to microencapsulation applications. Three important areas of microencapsulation applications are the stabilization of core materials, the control of the release or availability of core materials, and separation chemically reactive ingredients within a tablet or powder mixture.

Scratch-n-sniff

Scratch and sniff technology generally refers to stickers or cardboard items that have been treated with a fragrant

coating. When scratched, the coating releases an odor that is normally related to the image displayed under the coating. The technology has been used on a variety of surfaces from stickers to compact discs. Minvented the technology in 1965, using a process originally developed for carbonless copy paper called microencapsulation.

Uses of Scratch

Scratch and sniff stickers became popular in the late 1970s, and remained so through to the mid-1980s. In 1977, creative teaching press produced some of the earliest scratch and sniff stickers. These stickers were mainly marketed to teachers as rewards for their students. For a time, scratch and sniff stickers were used to diagnose anosmia, although this practice later declined. Utility companies have enclosed scratch and sniff cards in their bills to educate the public in recognizing the smell of a methane gas leak. In 1987, cards distributed by the Baltimore Gas and Electric Company led to a rash of false alarms when the scents of cards in unopened envelopes were mistaken for real gas leaks.

1. Prolonged release dosage forms. The microencapsulated drug can be administered, as microencapsulation is perhaps most useful for the preparation of tablets, capsules or parenteral dosage forms.
2. Microencapsulation can be used to prepare enteric-coated dosage forms so that the medicament will be selectively absorbed in the intestine rather than the stomach.
3. It can be used to mask the taste of bitter drug.
4. It has been used to protect drugs from environmental hazards such as humidity, light, oxygen, or heat. Microencapsulation does not yet provide a perfect barrier for materials, Which degrade in the presence of oxygen, moisture or heat, however, a great degree of protection against these elements can be provided.
5. From the mechanical point of view, microencapsulation has been used to aid in the addition of oily medicines to tableted dosage forms. This has been used to overcome problems inherent in producing tablets from otherwise tacky granulations and in direct compression to tablets.
6. Microencapsulation can be used to decrease the volatility. An encapsulated volatile substance can be stored for longer times without substantial evaporation.
7. The separations of incompatible substances, for example, pharmaceutical eutectics have been achieved by encapsulation. This is a case where direct contact of materials brings about liquid formation. The stability enhancement of incompatible aspirin-chlorpheniramine maleate mixture was accomplished by microencapsulating both of them before mixing.
8. Many drugs have been microencapsulated to reduce gastric irritation.
9. Microencapsulation method has also been proposed to prepare intrauterine contraceptive device.
10. In the fabrication of multilayered tablet formulations for controlled release of medicament contained in medial layers of tableted particles.

Recent advances in microencapsulation:

Several methods and techniques are potentially useful for the preparation of polymeric microparticles in the broad field of microencapsulation. The preparation method determines the type and the size of microparticle and influences the ability of the interaction among the components used in microparticle formulations. The term microparticle designates systems larger than one micrometer in diameter and is used usually to describe both microcapsules and microspheres.[11-15]

Microparticles-containing drugs are employed for various purposes including - but not restricted to - controlled drug delivery, masking the taste and odor of drugs, protection of the drugs from degradation, and protection of the body from the toxic effects of the drugs. Polymeric carriers being essentially multidisciplinary are commonly utilized in microparticle fabrication, and they can be of an erodible or a nonerodible type. The method is comprised administering an effective amount of an ester prodrug of the active drug such as tazarotene (prodrug of tazarotenic acid) subconjunctivally orperiocularly since a systemic administration requires high systemic concentration of the prodrug. The ester prodrug is contained in biodegradable polymeric microparticle system prepared using the o/w emulsion solvent evaporation methods. Prepared a composition in the form of thin film or strip composed of microspheres containing antibiotic such as minocycline HCl. It was made using a biodegradable polymer, prepared by a modified o/w emulsification technique followed by solvent evaporation. Water-soluble polysaccharide polymers such as pectin were used for making thin film or strip containing microspheres intended for local sustained release administration into the periodontal pocket. The thin film or strip is coated by spray coating with cation salt aqueous solution of calcium or barium chlorides. In one embodiment, Tray nor *et al.* used the o/w emulsion to produce sol-gel microcapsules (containing sunscreens) that are highly positively charged using non-ionizing cationic additives which can include cationic polymers.

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