Review Article

Microencapsulation Technology a Holistic Approach in the Field of Pharmaceutical Sciences a Review

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ABSTRACT

Microencapsulation is a technique that uses a coating to encapsulate microscopic particles or droplets in order to generate miniature capsules with therapeutic properties. The substance contained within the microcapsule is referred to as the core, internal phase, or fill, whereas the wall is referred to as a shell, coating, or membrane. A microcapsule is a small object that contains essential items, internal components, or fillers and is encased by a shell, cover, or membrane. Microcapsules range in size from 1 to 1000 micrometres. This approach is frequently used for medication administration, molecular protection, and robustness. The microencapsulation programme has been established as a different delivery mechanism for multiple treatment regimens and offers potential benefits beyond those of normal medication delivery systems. Microencapsulation is a well-established review dedicated to the preparation, properties, and applications of individually encapsulated novel small particles, as well as significant improvements to tried-and-tested techniques relevant to micro and nano particles and their use in a wide range of industrial, engineering, pharmaceutical, biotechnology, and research applications. Its scope extends beyond conventional microcapsules to all other small particulate systems, such as self-assembling structures that involve preparative manipulation.

Keywords: Microencapsulation, Microcapsules, microscopic particles, Engineering, Pharmaceutical.

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INTRODUCTION

In the induction and decrease of bacteria, microencapsulation has been frequently exploited. Bacterial cell encapsulation is a natural phenomenon that happens when bacteria proliferate and create exopolysaccharides, which are high-density polymers with sugar residues. Exopolysaccharide structures can operate as protective capsules, reducing bacteria's exposure to potentially dangerous ambient elements. Microencapsulation of bacterial cell formation has been used in the food and dairy industries in the past, as mentioned in another review. In recent years, microencapsulation implantation of probiotic cells, or "living microbes that, when delivered in appropriate quantities, provide the host with health advantages," has sparked interest in the treatment of a variety of intestinal infections and other diseases. However, in chronic GIT conditions, probiotics cells orally administered should be treated and strive to progress. As a result, microencapsulation can be employed to prevent cell transport. As explained later, probiotic microencapsulation has been demonstrated to be beneficial in situations of kidney failure and cardiovascular disease. As explained later, probiotic microencapsulation has been demonstrated to be beneficial in situations of kidney failure and cardiovascular disease[1-3]. A microcapsule is a small area that contains critical components, internal components, or fillers and is enclosed by a shell, cover, or membrane. Microcapsules range in size from 1 to 1000 micrometres. This approach is frequently used for medication administration, molecular protection, and robustness. The microencapsulation programme has been established as a different delivery mechanism for multiple treatment regimens and offers potential benefits beyond that of normal medication delivery systems. Traditional and current methods for the preparation of microcapsules are covered on this page, along with their copyright. Co-acervation, polymerization, and hot melts are all examples of solvent exchange methods [Figure 1].

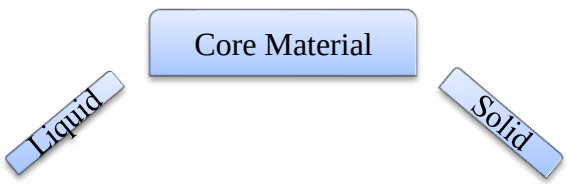

Figure 1: Basics of Microencapsulation

Microcapsules are made using some of the most cutting-edge techniques[4]. The Novel Drug Delivery System (NDDS), for example, is frequently utilised for the delivery of probiotics, medications, pesticides, food, and other items.

Although tremendous progress has been made in the field of microencapsulation, there are still many obstacles in the selection of key components, cover materials, and process techniques that must be solved quickly. [5, 6].

An IUPAC is a hollow micro particle with a solid shell that surrounds a basic processing space that can be found in either permanent or temporary enclosures. [7, 8] [Figure 2].

MICROENCAPSULATION TECHNIQUES:

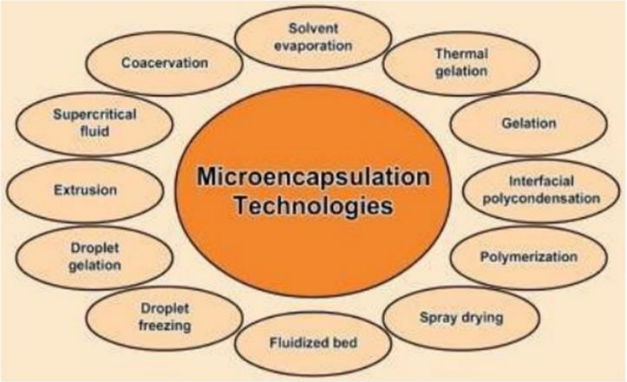

Figure 2: Microencapsulation Methodologies.

- Micro particles are frequently made up of two parts:[9,10.]
- It aids in improving patient compliance.
- Formulation of specific medication components
- Micro particles are usually made up of two parts.

1. Primary material
2. Material for the coat, wall, or shell.

- To increase bioavailability
- A distribution system
- It aids in the reduction of context re-use.
- It aids in the formation of solids.
- Change the way you're removing drugs.
- Patient compliance must be enhanced.
- Benefits: reducing evaporation of the main ingredient by reusing context in connection to the external environment (limited flexibility).
- In order to improve bioavailability.
- To change the drug's release.
- Increasing the patient's compliance.
- To create a targeted medicine delivery system.
- Reduce the core's responsiveness in regard to the external environment.
- To reduce the rate of evaporation of the core material. (Volatility reduction)
- To turn a liquid into a solid and hide the core taste[11,12]

Different aspects:

Different Concepts of Physical Microencapsulation [Figure 03]:

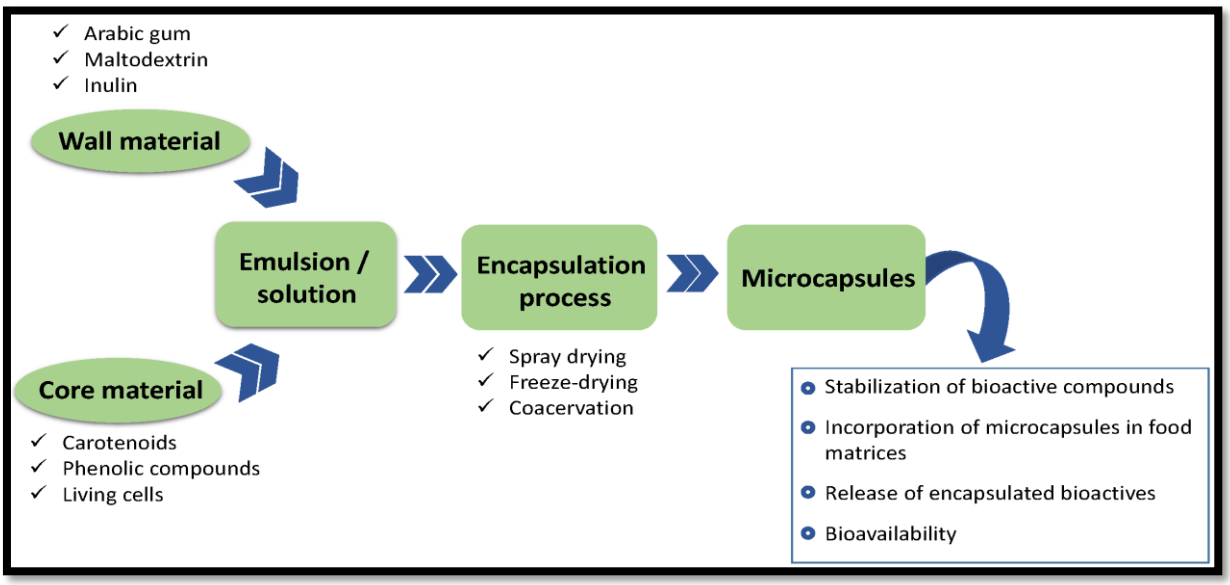

Figure 3: Physical Microencapsulation Different Concepts

Physical methods

1. Grease the pan. The pan coating process is one of the oldest industrial techniques for creating small, coated particles or tablets, and it is widely employed in the pharmaceutical industry. While the coating substance is poured carefully, the granules are crushed in a dish or other device. [13]
2. Air-suspension Coating the coating of particles with solutions or melts in the air provides more control and flexibility. While suspended in an upward-moving air

stream, the particles get covered. A perforated plate with distinct patterns of holes inside and outside, a cylindrical insert supports them. To fluidize the settling particles, only enough air is allowed to rise through the outer annular region. The majority of the rising air (which is frequently hot) passes +through the cylinder, causing the particles to rapidly climb. They settle back onto the outer layer and proceed downward, resuming the cycle when the air stream diverges and slows at the top. In a few minutes, the particles pass through the inner cylinder several times, [14:]

3. Extrusion centrifugal: a spinning extrusion head with concentric nozzles is used to encapsulate liquids. A jet of core liquid is enveloped by a layer of wall liquid, or meltdown, in this process. Due to Rayleigh instability, the jet wants to break up into core droplets, each coated with the wall solution, as it passes through the air. A molten wall may be rigid while the droplets are in flight. The wall solution can be toughened or a solvent can be evaporated. Because the majority of the droplets are within 10% of the mean diameter, they form a tight ring around the spray nozzle. As a result, following formation, the capsules can be hardened by capturing them in a ring-shaped hardening bath. This method is ideal for producing particles with a diameter of 400–2000 m. The procedure is only suitable for liquid or slurry since the droplets are created by the breakdown of a liquid jet. It is possible to reach a high production rate, with up to 22.5 kg of microcapsules produced per nozzle per hour per head. There are 16 different nozzle heads to choose from: [16, 17, 18, 19].

4. **Vibrational** Nozzle Core-Shell Encapsulation or Microgranulation (matrix-encapsulation) can be achieved by combining a laminar flow through a nozzle with an extra nozzle or liquid vibration. The vibration must occur in the Rayleigh instability's resonance, resulting in relatively uniform droplets. Any low viscosity liquid (0–10,000 mPas has been shown to work), such as solutions, emulsions, suspensions, melts, and so on, can be used.Soldification can be done using an internal gelation (e.g., sol-gel processing, melt) or an exterior gelation depending on the gelation technology utilised (additional binder system, e.g., in a slurry). The technique produces droplets with diameters ranging from 100 to 5000 micrometres and has applications for different sized droplets. The units are generally used in enterprises and research, with capacities ranging from 1 to 10,000 kg/h and working temperatures ranging from 20 to 1500 °C (room temperature up to molten silicon). Nozzle heads are offered in quantities ranging from one to many hundred thousand [18, 19]

5. **Spray–drying** When an active ingredient is dissolved or suspended in a melt or polymer solution and becomes trapped in the dried particle, spray drying is used as a microencapsulation process. The capacity to handle labile materials due to the brief contact time in the dryer is one of the key benefits, and the operation is also cost-effective. The thickness of the fluids to be blown in recent spray dryers can be as high as 300 mPa.s [20.]

Chemical procedures

Interfacial polymerization is a type of polymerization that occurs between two surfaces. The two reactants in a polycondensation meet at an interface and react quickly in interfacial polymerization. The classical Schotten-Baumann reaction between an acid chloride and a substance containing an active hydrogen atom, such as an amine or alcohol, polyesters, polyurea, and polyurethane, is the foundation of this approach. Thin flexible walls form quickly at the interface under the correct conditions. An aqueous solution containing an amine and a polyfunctional isocyanate is added to a pesticide and diacid chloride solution that has been emulsified in water. The presence of a base is required to neutralise the acid produced during the reaction. At the emulsion droplet contact, condensed polymer walls develop instantly, [21.]Polymerization in situ The direct polymerization of a single monomer on the particle surface is used in a few microencapsulation procedures. Cellulose fibres, for example, are encased in polyethylene and immersed in dry toluene in one procedure. Deposition rates are typically around 0.5 m/min. Coating thicknesses range from 0.2 to 75 metres. Even across sharp projections, the coating remains consistent.

Matrix polymerization (C.Matrix) During the creation of nanoparticles, a composite is embedded in a polymer matrix throughout a number of procedures. Spray-drying, in which the particle is created by evaporation of the solvent from the matrix material, is a basic process of this type. A chemical alteration, on the other hand, can cause the matrix to solidify.

Microencapsulation Methods Selection A single microencapsulation process cannot be used to encapsulate a wide range of medications. Understanding the physicochemical features of a medicine and finding an encapsulating process and polymeric materials that best match those properties is critical when building a new microparticle system for that drug. Because water is the most extensively used solvent system, a drug's solubility in water is often a useful starting point for a survey. The drug's physical state can also limit your options.

Recent Developments:

1. Bhathena et al. examined the use of APA microencapsulated bacteria, specifically feruloyl esterase (FAE) active L. fermentum, to reduce triglyceride and cholesterol levels, which are key risk factors for coronary artery disease. The viability and enzymatic activity of microencapsulated FAE-active L. fermentum in simulated gastrointestinal conditions were investigated. During GI exposure, it was discovered that the lifespan of free and microencapsulated L. fermentum cells differed by 2.5 logs. In diet-induced hypercholesterolemic rodents, greater probiotic durability and FAE activity resulted in huge decreases in serum total cholesterol, LDL cholesterol, and serum

triglyceride levels. Microencapsulated L. fermentum was used in similar research for the treatment and prevention of metabolic syndrome. [25].

2. Microencapsulated Lactobacilli in Colon Diseases: Microencapsulated microbes have attracted attention for their potential to modulate colonic inflammation, particularly in the context of colon cancer, but also in the context of other colonic inflammatory disorders like inflammatory bowel syndrome (IBS) and inflammatory bowel disease (IBD) (IBD). Urbanska et al. evaluated the antitumorigenic activities of APA microencapsulated Lactobacillus acidophilus in Min (multiple intestinal neoplasia) mice that have a germline Apc mutation and develop several pretumoric intestinal lesions spontaneously. [26].

3. Microencapsulated Mammalian Cells Regenerative medicine is a branch of medicine that focuses on replacing organs and tissues that have been lost. It's been suggested that delivering mammalian cells to organs like the liver, pancreas, heart, and kidney could help them regenerate. Unfortunately, mammalian cell delivery in vivo poses a number of difficulties. Immune rejection by the host, cell aggregation and poor nutrition, impaired cellular function due to insufficient gene expression, a need for a large number of readily available cells, and a scarcity of human cell donors are just a few of the issues. Due to a scarcity of human donors, researchers have moved to nonhuman mammalian cells, yet the same challenges of immune rejection, decreased cellular function, and readily available cells still exist. Microencapsulated cells may be a viable alternative for overcoming the aforementioned challenges. Bisceglie demonstrated the use of a polymer membrane to encapsulate mouse tumour cells in the 1930s, which was one of the first efforts in this field. These were injected into the abdominal cavity of a pig and were demonstrated to withstand immune system attacks. Since then, a great deal of study has been done in this area. The microencapsulated bacteria may play a role in the creation of a successful colon cancer treatment, as the number of adenomas and gastrointestinal neoplasias in the treated animals was significantly reduced after administration of the probiotic [27].

4. The restoration of liver function is required in hepatic disorders such as acute liver failure, chronic liver disease, and congenital metabolic liver disease. The only effective treatment for end-stage liver disease is orthotropic liver transplantation. The overall success of liver transplantation is limited by the scarcity of organs, the need for immunosuppressive medicine, and the numerous problems involved with the procedure. Recent research has looked into liver cell transplantation (LCT) as a viable therapy, but immunosuppression is still required for successful LCT transplantation. With some essential studies given here, microencapsulation has been recommended as a means to address these problems. Sun et al. conducted the first investigation to assess the therapeutic potential of microencapsulated hepatocytes. In vitro, rat hepatocytes encapsulated in APA microcapsules released urea and albumin, two chemicals produced by a healthy liver. After 35 days, the encapsulated hepatocytes were transplanted into normal Wistar rats and rats with galactosamine-induced fulminant hepatic failure.

5. Other Applications of Microencapsulated Mammalian Cells Microencapsulation of mammalian cells has also been used to treat a variety of disorders. Zhang et al. conducted a significant investigation into the usage of microencapsulated substances. In Sprague-Dawley rats, Chinese hamster ovarian (CHO) cells release vascular endothelial growth factor (VEGF) as a treatment for ischemic heart disease [36]. Anti-CHO levels were much lower in those rats given encapsulated cells than in those given unencapsulated cells, indicating that the encapsulated cells were protected from immunological rejection. The encapsulated CHO cells were shown to be functionally active and secreting VEGF three weeks after transplantation. The cardiac function of the rats treated with encapsulated CHO cells also improved significantly, as evidenced by a decrease in fractional shortening and left ventricular hypertrophy. This study shows that xenotransplantation has a lot of promise in the treatment of ischemic heart disease. [29, 30].

6. Microencapsulation has been shown to be effective in the treatment of other illnesses such as severe anaemia and neurological disease, as well as in parathyroid replacement therapy. Rinsch et al. used encapsulated myoblasts to demonstrate a rise in haemoglobin value after 8 weeks of immunosuppression. Régulier et al. have established that encapsulated myoblasts can secrete erythropoietin, which increased the haematocrit value in anaemic mice by over 85 percent for 80 days. Régulier et al. have established that encapsulated myoblasts can secrete erythropoietin, which increased the haematocrit value in anaemic mice by over 85 percent for 80 days. Wikström et al. observed viable human retinal pigment epithelial cells in microcapsules for almost 3 months, demonstrating the ability of encapsulation to keep encased cells alive and functional. Hasse et al. found that giving encapsulated parathyroid tissue particles to hypocalcaemia patients reduced daily calcium and vitamin D intake by half.Microencapsulated retinal pigment epithelial cells have also been shown to be effective in the treatment of neurodegenerative illnesses such as Parkinson's disease. Genetically modified cells have shown considerable promise in the development of cancer therapies, with microencapsulation enabling immunological rejection to be avoided. It contains a full list of research that has employed microencapsulated mammalian cells for medicinal purposes ([31]).

7. .Biologically active drugs such as risperidone (an antipsychotic) and testosterone have been encapsulated in biodegradable and biocompatible polymers such as PLGA to create microparticles. To create microparticles, testosterone is used. Microencapsulation techniques have also been developed to deliver an adjuvant or antigen encapsulated in PLGA microparticles as vaccine formulations. Similarly, emulsion technology has been used to encapsulate dietary supplements such as vitamins and oil compounds. In a 2007 study, 32, Ratnakar Tandale demonstrated the microencapsulation of vitamin C and gallic acid, as model antioxidants, in whey protein.

8. Anticancer drugs have also been delivered through microencapsulation. In a recent study, Patel et al. proved the benefit of ionotropic gelation in encapsulating verapamil HCl in a combination of sodium alginate, hydroxypropyl methylcellulose, and hydroxymethylcellulose polymers. The loading and release kinetics of the medication were studied in the microspheres. Solvent exchange has also been used to encapsulate other bioactive molecules that are more prone to denaturation, such as proteins and DNA/RNA, [33,34].

9. In the broad subject of microencapsulation, several technologies and procedures for the creation of polymeric microparticles are potentially beneficial. The type and size of microparticles are determined by the preparation procedure, which also influences the capacity of the components employed in microparticle formulations to interact. Microparticles are systems with a diameter greater than one micrometre and are commonly used to describe both microcapsules and microspheres. Pharmaceuticals containing microparticles are used for a variety of objectives, including regulated drug delivery, disguising the taste and odour of drugs, protecting drugs from degradation, and protecting the body from the drugs' hazardous effects. Polymeric carriers are often used in microparticle manufacturing because they are multi-disciplinary and can be erodible or non-erodible [35,36].

10. A large number of publications and patents have recently been released. Hughes devised a method for delivering active medicine to the posterior area of a mammal's eye over time in order to cure or prevent a disease or illness that affects mammals. Because systemic administration requires a high systemic concentration of the prodrug, the method entails providing an effective dose of an ester prodrug of the active drug, such as tazarotene (prodrug of tazarotenic acid), subconjunctivally or periocularly. The ester prodrug is included in a biodegradable polymeric microparticle system made by evaporating the solvent from an o/w emulsion. Lee et al. created a microsphere-based composition in the form of a thin film or strip containing antibiotics such as minocycline HCl. It was manufactured with a biodegradable polymer that was made using a modified o/w emulsification process and solvent evaporation. For creating thin films or strips containing microspheres intended for local sustained release administration into the periodontal pocket, water-soluble polysaccharide polymers such as pectin were employed. Spray-coating with a cation salt aqueous solution of calcium or barium chloride coats the thin film or strip. Traynor et al. employed the o/w emulsion to make highly positively charged sol-gel microcapsules (containing sunscreens) by utilising non-ionizing cationic additions such as cationic polymers in one embodiment.

CONCLUSION

The micro fabricated device has the potential to be more effective than traditional drug delivery systems. Many medications have established microspheres and microcapsules as distinct carrier systems that can be modified to attach to specific tissue systems. As a result, micro-capsules and microspheres can be employed not only for controlled release but also for targeted medication delivery to specific body sites. Although great progress has been made in the field of microencapsulation, the field still faces numerous hurdles. The development of less expensive biopolymers for microencapsulation technology, as well as the creation of universally recognised evaluation methodologies, particularly for bioadhesive microspheres, is both critical. As a result, in order to design safe and efficient specific systems in the future, in-depth examinations of both the biological and technological components of these systems will be required.

Microencapsulated Products: The following is a list of Watson's microencapsulated products; it is not comprehensive. Watson also produces a variety of custom micro-encapsulations and toll-manufactured items.

50% Ascorbic Acid

Ascorbic Acid 70%

Ascorbic Acid (75% Non-GMO)

Ascorbic Acid (85% EC)

Beta Carotene 1%

Beta Carotene 15%

Beta Carotene Dispersion 22%

Beta Carotene Dispersion 30%

Caffeine 50%

List of Abbreviation

LCT-Liver Cell Transplant

LDL -Low density level-

HCl-hydrocloric acid

DNA-Deoxyribonucleic acid

RNA-ribonucleic acid

IBD-Inflammatory bowel disease

IBS (Inflammatory Bowel Syndrome)

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