SPRAY DRYING: APPLICATION IN MICROENCAPSULATION OF FOOD INGREDIENTS

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Spray drying is one of the most commonly used microencapsulation and drying technologies in food and pharmaceutical industries. It produces the microcapsules in the micrometer to millimeter range. Microencapsulated food ingredients are used for developing healthy and novel functional foods.

MICROENCAPSULATION

Microencapsulation[1] is a process of coating of small particles of solid or liquid material (core) with protective coating material (matrix) to produce microcapsules in the micrometer to millimeter range. The active agent that is encapsulated is called as core material, the active agent, internal phase, or payload phase. The material that is encapsulating is called as coating, membrane, shell, carrier material, wall material, external phase or matrix. There are two forms of encapsulates they are i) reservoir type; and ii) matrix type (Figure 1). In reservoir type, the active agent is surrounded by an inert diffusion barrier. It is also called single-core or mono-core or core-shell type. In matrix type, the active agent is dispersed or dissolved in an inert polymer.

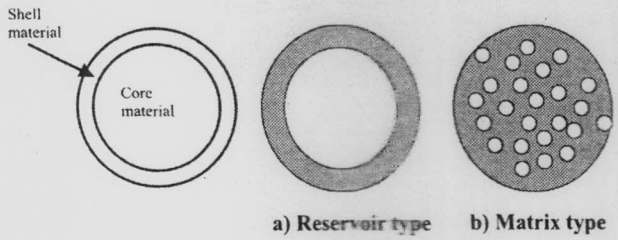

Fig. 1. Morphology of microcapsule

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PURPOSE OF MICROENCAPSULATION

In the food industry, the microencapsulation process is applied for following purposes[2];

- To protect the core material from degradation and to reduce the evaporation rate of the core material to the surrounding environment.
- To modify the nature of the original material for easier handling.
- To release the core material slowly over time at the constant rate.
- To mask unwanted flavor or taste of the core material.
- To reduce each nutrient interaction with other ingredients

SPRAY DRYING

Spray drying[3] is one of the most commonly used microencapsulation and drying technologies in food and pharmaceutical industries because the process is flexible, economical, efficient, easy to scale-up, easily available equipment and produces good quality powder. It has been extensively used in the encapsulation of bioactive food ingredients such as proteins, fats, vitamins, enzyme and flavours. Microencapsulation of food ingredients by spray drying involves three major steps;

1) Preparation of Emulsion: For encapsulation of any bioactive compounds, preparation of stable emulsion is a primary step[3]. Emulsion is a

mixture of two or more liquids that are normally immiscible. To aid the process, the addition of emulsifiers is required. Emulsifier is a substance that stabilizes the emulsion by reducing the interfacial tension between the two phases by forming a rigid interfacial film which serve as mechanical barrier to coalescence. Once the wall or coating material is selected for encapsulation of active ingredient, it must be hydrated. After solubilization of wall material, the active ingredient to be encapsulated (ex. flavors, vitamins, minerals, oil etc.) can be added to wall material solution. Then, the mixture to be homogenized to create small droplets of active ingredient within the wall material or encapsulating solution. A typical ratio of encapsulating agent to core material is 4:1. Emulsion can be prepared either two layers or multilayer system (Figure 2) for improved stability[4].

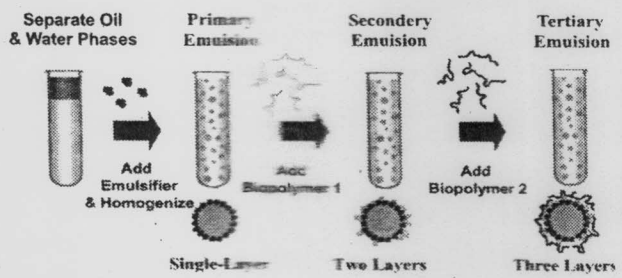

Fig. 2. Preparation of Multilayer emulsion

2) Atomization of the In feed Emulsion: The core-wall material mixture or emulsion is fed into a spray dryer where it is atomized through a nozzle or spinning wheel. The major components of a standard spray dryer include an air heater, atomizer, main spray chamber, blower or fan, cyclone and product collector (Figure 3).

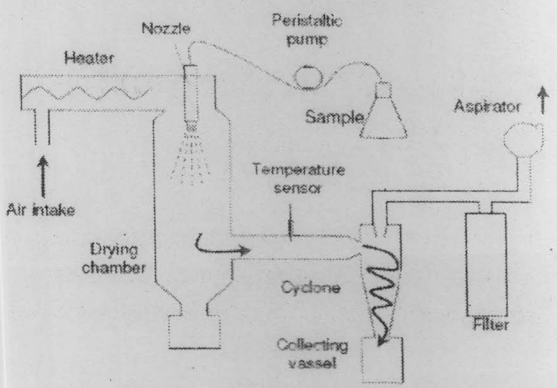

Fig. 3: Schematic diagram of Spray drying

3) Dehydration of the Atomized particle: When the atomized particle contacts hot air flowing in either a concurrent or countercurrent direction, water is evaporated and a dried encapsulated product will be produced. Morphology of microencapsulated product obtained by spray drying will be matrix type with the particle size of 10-400μm.

Coating/wall materials used for micro - encapsulation of food ingredients by spray drying[3]

The choice of a wall material for microencapsulation of food ingredients by spray-drying is very important to achieve better encapsulation efficiency and microcapsule stability. The wall material plays a major role in protection of core or active ingredient from factors that may cause its deterioration and also limit the volatile losses. The criteria for selecting a wall material are mainly based on the physico- chemical properties such as solubility, viscosity, molecular weight, glass/melting transition, film forming, and emulsifying properties etc. Hence, the selection of wall material or encapsulating material according to the desired application is an important task. Wall materials used for microencapsulation of various food ingredients by spray drying are given in Table 1.

Table 1: Wall materials used for microencapsulation of food ingredients by Spray drying[2,8]

Food ingredients	Coating material used
Fish oil	Gelatin, maltodextrin, casein, lactose, sodium caseinate, dextrose equivalence, highly branched cyclic dextrin, methylcellulose, hydroxypropyl methylcellulose, n-octenylsuccinate, derivatized starch/glucose syrup or trehalose, sugar beet pectin, gum arabic, corn syrup solids, egg white powder
Poly phenols: Black carrot extracts (anthocyanins), procyanidins, olive leaf extract, *Hibiscus sabdariffa* L. extract (anthocyanins), soybean extract, grape seed extract, apple polyphenol extract, olive leaf extract, oregano essential oil, mint oil, cardamom oleoresin, black pepper oleoresin , cumin oleoresin, turmeric oleoresin	Maltodextrin, gum arabic, chitosan, citrus fruit fiber, colloidal silicon dioxide, maltodextrin and starch, sodium caseinate, soy lecithin, skimmed milk powder, whey protein concentrate, gelatin
Vitamin C, vitamin A	Tripolyphosphate, cross-linked chitosan, starch, β-cyclodextrin, maltodextrin, gum arabic,
β-Galactosidase, lipase from *Y. lipolytica*	Chitosan, modified chitosan (water soluble), alginate, calcium alginate and arabic gum, α-amalase, gum, α- amalase,
Hydrolysate and peptide	Soy protein isolate, gelatin, whey protein concentrate, alginate, maltodextrin, gum Arabic, carboxymethylated gum

ADVANTAGES AND DISADVANTAGES OF SPRAY DRYING PROCESS[2]

Advantages

- Relatively simple, fast and easy to scale-up, equipment is readily available
- The cost of spray-dring method is 30–40 times cheaper than other encapsulation method
- Both hydrophilic and hydrophobic polymer can be used
- Ideal for production of sterile materials
- Rapid solubility of the capsules
- It increases stability and shelf-life of food product
- It improves handling of the viscous and sticky food materials.

Disadvantages

- Considerable amounts of the material can be lost during the process due to sticking of the microparticles to the wall of the drying chamber.
- Process variables that should be optimied for encapsulation
- Non uniformity of microcapsule size
- Limitation in the choice of coating material
- Produce very fine powder which needs further processing
- Not good for heat sensitive material

CHALLENGES

Microencapsulation by spray drying offers numerous benefits to the materials being

encapsulated. It provides an effective protection for active agent against oxidation, evaporation or migration in food and to convert liquids to powders. In spite of recent developments of spray drying technique, the process remains far from completely being controlled for microencapsulation of active food ingredients. Spray drying technology is yet to become a conventional tool for food industry to produce encapsulated ingredients. To produce effective encapsulated products, the appropriate selection of coating material is great challenge which can be achieved by multidisciplinary based research approach and consideration of industrial requirements and constraints.

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