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A Review

Microencapsulation in food processing - A review study

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Abstract : Microencapsulation is one of the efficient, advanced and promising technologies in the field of food processing. The technology involves the protection of different valuable food constituents present in a food product by the use of a suitable covering material on it. Besides, protecting the covering material allows the release of the core material in a controlled way increases shelf life and enhances the sensory qualities. The process of microencapsulation can be done by various methods such as coacervation, polymer-polymer incompatability, solvent evaporation, spray drying, fluidized bed technology, pan coating, spinning disc, extrusion, interfacial polymerization etc. This technology is being used in various fields including pharmaceutical, vectorisation, artificial organs, single dose treatment, agriculture (fungicide, herbicide, insect repellent, artificial insemination), food, printing, cosmetic, textile and defense. No single microencapsulation process is adaptable to all core materials. It is a complicated process and requires skilled person to handle the whole process. As worldwide demands for functional coatings continue to increase, new, cost effective microencapsulation technologies will be developed and the technology will remain at the forefront of future.

Key Words : Microencapsulation, Covering materials, Value addition

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Introduction

Microencapsulation is an advanced emerging technology that leads to the protection of different food components or functional constituents against various processing conditions by covering them inside a polymeric or nonpolymeric material and allowing their controlled release under particular conditions. Besides, it also enhances the sensory quality by masking the unpleasant taste, aroma, and flavors. As mentioned by Gudas *et al*. (2000), in chewing gums, the encapsulated flavors escape only on chewing. It increases food safety by inhibiting the growth of the microbes (Hasanvand *et al.,* 2015; Sengupta *et al*., 2001). Different bioactive compounds, such as omega-3 and omega-6 fatty acids, vitamins, phenolic compounds, and carotenoids are now widely used to develop products with numerous functional properties to meet up the rising consumer demands. Several food constituents which are widely encapsulated include different flavoring agents, lipids, antioxidants, essential oils, pigments, probiotic bacteria, and vitamins

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(Azeredo, 2005). Different coating materials are used depending on their rheological properties, their ability to disperse the active compound and stabilize it, inertness towards the active compound and their ability to properly hold the active compound. Some of the widely used coating materials include polysaccharides, lipids, gums and proteins. In the recent past, complex food formulations have been demonstrated in the food industries like the use of certain volatile flavors in instant mixes, fatty acids in the dairy products, which are highly prone to auto-oxidation.

Microencapsulation process :

Microencapsulation is the technology of packaging of specific (core) substances (solids, liquids or gases) in miniature, sealed capsules with a matrix (carrier) in order to protect their special properties during storage, distribution or multiple use. In a microsphere, the active substance is dispersed in the structure of the matrix substance (Jansuz and Ewelina, 2004). The process can be carried out by various ways termed as coacervation, polymer-polymer incompatability, solvent evaporation, spray drying, fluidized bed technology, pan coating, spinning disc, extrusion, interfacial polymerization etc.

Microencapsulation technologies :

Coacervation :

It involves the separation of a liquid phase of coating material from a polymeric solution followed by the coating of that phase as a uniform layer around suspended core particles. In general, the batch type coacervation process consists of three steps *i.e.* formation, deposition and solidification under continuous agitation (Jyothi *et al.,* 2009). Sweet orange oil was encapsulated by (Jun-xia *et al.* 2011) coacervation using soybean protein isolate (SPI) as the wall material.

Polymer encapsulation by rapid expansion of supercritical fluids :

In this process, supercritical fluid containing the active ingredient and the shell material are maintained at high temperature and then released at atmospheric pressure through a small nozzle. The sudden drop in pressure causes desolvation of the shell material, which is then deposited around the active ingredient (core) and forms a coating layer.

Hydro gel microsphere :

The microspheres made of gel-type polymers, such as alginate, are produced by dissolving the polymer in an aqueous solution. Then, the active ingredient is suspended in the mixture and extruded through a precise device, producing micro droplets. Then, it falls into a hardening bath that is slowly stirred. Usually a solution of $CaCl_2$ is used for hardening bath. The size of microspheres can be controlled by using various extruders or by varying the polymer solution flow rates (Desai and Park, 2005).

Fluidized bed / Air suspension coating :

In this method, the core material is fluidized by application of air, onto which a coating material is sprayed. This method is common for use in the nutritional supplement market to supply encapsulated versions of vitamin C, vitamin B, ferrus sulphate, sodium ascorbate, potassium chloride and a variety of vitamin or minerals premixes. It has applications in the baked foods, seasonings, fillings, deserts and dry mix puddings (Wilson and Shah, 2007). Coronel-Aguilera and San Martín-González (2015) encapsulated spray dried beta carotene with hydroxypropyl cellulose using fluidized bed coating.

Spray drying :

In this technique, a feed solution, which is a mixture of the core material and the wall material, is atomized and formed into a mist inside a chamber, where hot air is applied to convert the mist into powder. Depending on various factors like the characteristics of the feed solution and operating conditions, powder of varied particle size can be produced. In spray drying, the core material, that is, the material of interest gets trapped in the dried powder. Cardamom Oleoresin was encapsulated within a mixture of maltodextrin, modified starch, and gum Arabic using spray drying and the results showed increased protection of oleoresins (Krishnan *et al.*, 2005). Bayram *et al.* (2005) reported successful encapsulation of sumac flavor in sodium chloride using spray drying. Grenha *et al.* (2023) also reported of the ability of spray-drying to provide the microencapsulation of Se in salt form.

Spray cooling :

In this method, a mixture of core material and wall material is atomized to form a mist inside a chamber, inside which cold air flows. The low temperature within the chamber results in solidification of the micro droplets, leading to the formation of microencapsulated powder. Some successful implementations of this technique in encapsulation includes, microencapsulation of tocopherols within lipid matrix, with encapsulation efficiency as high as 90% (Gamboa *et al*., 2011), encapsulation of iron, iodine, and vitamin A within hydrogenated palm oil to fortify salt, where in the microcapsules formed were highly stable (Wegmüller *et al*., 2006).

Pan coating :

Pan-coating has been recognized as an efficient and promising microencapsulation method in various industries including the pharmaceutical industry essentially for relatively large particles from near a few millimeters to several centimeters in size or diameter. The amount of coating solution applied decides the thickness of the coating (Kumar *et al.,* 2022). Practically, the solid core material placed in a rotating drum is encapsulated by the coating as a solution or suspension in the coating pan. Drying warm air is applied to remove the solvent and finalize the coating deposition on the particles. Two subcategories are considered for pan-coating including conventional pan-coating and vented pan-coating.

Extrusion :

The encapsulates formed using this method are relatively larger in size than formed using any other method and also, this technology is useful with limited wall materials. Besides, it has been used almost exclusively for the encapsulation of volatile and unstable flavours in glassy carbohydrate matrices. It was found that (Favaro-Trindade *et al.,* 2020) by the extrusion processing method, microencapsulation of PRCE (pro anthocyanidin-rich cinnamon extract) by complex coacervation using gelatin and arabic gum is an efficient method to protect bioactive compounds during extrusion process.

Applications of microencapsulation :

This technology has been used in several fields including pharmaceutical (controlled drug release, vectorisation, artificial organs, single dose treatment), agriculture (fungicide, herbicide, insect repellent, artificial insemination), food, printing, cosmetic, textile and defense (Dubey *et al.,* 2009).

Limitations/shortcomings :

Although the technology of microencapsulation has a vast area of applications yet it has some limitations too. No single microencapsulation process is adaptable to all core materials. It is a complicated process and requires skilled person to handle the whole process. In some of the cases, there could also be incomplete or discontinuous coating. This process is non-reproducible and there could also be inadequate stability in shelf-life of the product.

Conclusion :

Microencapsulation technique not only protects the volatile components but also provide flavoring components to the right time. Its release mechanism enhances the acceptability of the product, for example flavoring components of chewing gum, aroma producing substances of spices, etc. It is also an important tool of fortification in food industry. Besides all advantages this technique enhance the cost of product up to certain extent so, it is not very feasible for small scale industry. As worldwide demands for functional coatings continue to increase, new, cost effective microencapsulation technologies will be developed and the technology will remain at the forefront of future.

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