Warta IHP/J. of Agro-based Industry
Vol. 8, No.2, pp, 1-6 ,1991

Ulasan/Review

MICRO ENCAPSULATION : APPLICATION AND TECHNIQUES

Mikroenkapsulasi : Penerapan dan Teknik

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Summary - Perkembangan ilmu dan teknologi memungkinkan berkembangnya teknologi proses dan pengawetan di bidang pangan umumnya dan flavor khususnya. Teknik enkapsulasi (encapsulation) adalah suatu cara yang dikembangkan untuk memperpanjang masa simpan dan memperbaiki penampilan (performance) suatu produk antara atau akhir, sehingga memberikan beberapa keuntungan dalam pemakaian selanjutnya. Penerapan dan beberapa teknik enkapsulasi diulas dalam artikel ini.

INTRODUCTION

Micro encapsulation is not a new technology. It was pioneered by National Cash Register Co. (Dayton, Ohio) in 1930s and it was first commercially applied in 1954 to a product that has revolutionized business forms industry-wide : carbonless copy paper (DZIEZAK, 1988).

Micro encapsulation is defined as a technology of packaging solid, liquid, or gaseous materials in miniature, seal capsules that can release their content at controlled rates under specific conditions (TODD, 1970). The miniature packages, called "micro capsule" may range from sub micron to several millimeters in size and are ideally spherical (BAKAN, 1978); however their shape is heavily influenced by the structure of the original unencapsulated material. In the encapsulate, the active portion is termed the core, internal phase, or fill. The encapsulating material is called the shell, coating, or wall material.

Micro encapsulation is a physical process where thin film or polymer coats are applied to small solid particles, droplets of liquid or gases (BAKAN, 1973). Micro capsules on the other hand are defined as particles ranging from several tenth of a micrometer to a few thousands micrometer. In contrast, nanocapsules and capsules produced by macro coating techniques have diameters of less than 2000 Angstrom and greater than 5000 micrometer respectively (BAKAN, 1978; BAKER, 1986).

Coating material should be insoluble in, and non-reactive with the core. Plasticizing, cross-linking, surface treatment and multiple coating are used to alter performance qualities of coating (DEASY, 1984; BAKAN, 1978), and the thickness of coat is manipulated to alter permeability and stability of micro capsules. Some type of coating materials are presented in Table 1.

Table 1. Type of coating materials used to produce micro capsules.

Class of coating material	Specific types of coating
Gums	Gum arabic, agar, sodium alginat, carrageenan
Carbohydrates	Starch, dextran, sucrose, corn-syrup, carboxymethyl cellulose, ethyl cellulose, methyl cellulose, nitro cellulose, acetyl cellulose, cellulose acetate-phthalate, cellulose acetate-butylate-phthalate
Lipids	Wax, paraffine, tristearin, stearic acid, monoglycerides, diglycerides, beeswax, oils, fats, hardened oils
Inorganic materials	Calcium sulfate, silicates, clays
Protein	Gluten, casein, gelatine, albumin

Source : JACKSON and LEE (1991)

APPLICATION

Several classes of materials relating to food products have been encapsulated namely acids, amino

acids, colorants, enzymes, microorganisms, flavour, fats and oils, vitamins and minerals, salts, sweeteners and gasses, and this article will deal with the flavour encapsulation.

Making liquid flavour behave like dry powders is the major use for encapsulation in the food industry. Micro encapsulated flavour provide the convenience of a solid form over a liquid one, with reduce the volatility and less oxidation (REINECCIUS, 1989; HEATH, 1985; MUTKA and NELSON, 1988; and PAGINTON, 1985).

Citrus oils are very susceptible to oxidation due to sites of unsaturation in the mono- and sesqui-terpenoid structure. Oxidative deterioration results in off-flavours described as painty or turpentine-like (JACKSON and LEE, 1991) and stale/musty (NAGY *et al,* 1988). By encapsulating this oil in maltodextrin, the stability can be improved.

Fat encapsulated cinnamon allows bread and sweet dough to be stored with minimal loss of flavour (ANDRES, 1976). However, cinnamon is micro encapsulated for the reason more than just protection against loss. The spice contains cinnamic aldehyde that can kill yeast or decrease yeast activity (DZIEZAK, 1988), so encapsulation allows the cinnamon to be added to the dough before fermentation.

The encapsulated whole spice in sausage making have been discussed by FLINT and SEAL (1985). Encapsulated oleoresin in water soluble coating, not only penetrates the fatty part of the sausage but surrounds muscle fibre as well. This assures an even dispersion of spice throughout the product, which is described for natural antioxidant properties of some spices.

The performance of several oligosaccharides as a coating material in encapsulated orange oil was studied by INGLET et al (1987). The High Dextrose Equivalent (DE) maltodextrins and syrup solids permit the formation of encapsulated products with excellent stability to oxidation. Different enzyme-hydrolyzed starches yielded encapsulated orange oils varied in stability.

Using orange oils as a core and gum arabic as a coating material, RISCH and REINECCIUS (1987) studied the effect of emulsion size on flavour retention and shelf stability. They concluded that smaller emulsion size will give abetter retention and shelf stability of flavour. This tend to a less orange oils is lost during drying process and less powder, therefore, is needed in the finished product to achieve the same flavour level.

MICROENCAPSULATION TECHNIQUES

There are many techniques can be employed for microencapsulation of food ingredients, and the selection of them depends on economics, sensitivity of cores, size of microcapsules desired, physical/chemical properties of both core and coating, application for the food ingredients and the release mechanism (JACKSON and LEE, 1991).

The methods available are spray drying, co-crystallization, spray chilling and spray cooling (DZIEZAK, 1988; TAYLOR, 1983; LAMB, 1987), extrusion (REINECCIUS, 1989), air suspension coating (KONDO, 1989; DZIEZAK, 1988; BLENFORD, 1986), multi-orifice centrifugal extrusion (DZIEZAK, 1988; BAKAN, 1978), coacervation/phase separation (DZIEZAK, 1988; BAKAN, 1978; TODD, 1970; BLENFORD, 1986; MCKERNAN, 1973), liposome (FENDLER and ROMERO, 1977; KAREL, 1990; LAW and KIRBY, 1987, MASSON, 1989), inclusion complexation (PAGINTON, 1985; SAENGER, 1980), and interfacial polymerization (TODD, 1970). Only the first two methods will be discussed since the first one is the most widely used in the food industry and the latter provide the relative simple procedure and requires an inexpensive encapsulation medium.

Spray drying

Spray drying is a well-established unit operation which has been used industrially in many ways for over half a century. The principle of spray drying comprises several stages such as the preparation of the solution slurry or emulsion to be dried, the atomization of this liquid feed material in the drier chamber, the regulation of temperature and velocity of the drying gases, and the removal and recovery of the dried product (HEATH, 1981); and in addition have been explained the type of the dryers which depends on the direction of flow of the hot drying gases namely cocurrent, countercurrent and mixed flow dryer respectively. In cocurrent dryer (figure 1) the feed liquor is atomized into a stream of hot gases at its inlet whereas in countercurrent (figure 2) the hot air enters at the bottom of the drying chamber and the atomized spray at the top; and in mixed flow dryer (figure 3) the hot air enters from two opposite side of the drying chamber just above the atomizer to provide a better turbulence.

For the flavour encapsulation, the coating materials mostly carbohydrate such as dextrins, sugars, starches and gums or protein such as gelatin and soy

protein. The flavour encapsulation process involve the formation of an emulsion or suspension of coating of coating amd core material, nebulization of an emulsion into a drying chamber containing circulating hot dry air (BALASSA and FANGER, 1971).

The moisture of the emulsion droplets evaporates on contact with the hot air and the remain solids of the coating material entrap the core. Spray drying is useful for heat sensitive food ingredient especially flavour compounds, since drying is very rapid and the core is heated to temperature much lower than 100°C (KONDO, 1989). However, loss of low boiling point compounds as a core material may occure (TAYLOR, 1983). Physical properties of microcapsules depend on the temperature of nebulization, solid content of the emulsion (30 to 70%), and temperature of the emulsion (BALASSA and FANGER, 1971; REINECCIUS, 1987).

Some disadvantages of spray drying are loss of boiling point core compounds, but it also provides advantages such as diversity and availability of machinery, good keeping qualities of microcapsules, variety of particle sizes that can be produced and excellent dispersibility of particles in aqueous media (TAYLOR, 1983).

Co-crystallization

Co-crystallization is one of the more exciting areas of encapsulation research since the procedure is relatively simple. Co-crystallization involves the inclusion of compounds between the sucrose crystals (JACKSON and LEE, 1991). The usefulness of sucrose as the carrier (coating) material for flavour in this method because of its following properties : inexpensive nature, quick dissolution and producing a clear or turbidity-free solution, heat stability and non-hygroscopicity, and indefinite shelf life under ambient conditions (CHEN *et al,* 1988).

Granulated sucrose which is composed of solid, dense, monoclinic spherical crystal with limited surface is not suitable as a carrier for flavour encapsulation. The sucrose structure has to be modified to a microsized, irregular, agglomerated form in order to increase void space and surface area for flavour incorporation (CHEN *et al,* 1988). The encapsulation process can be achieved because of the spontaneous crystallization of sucrose which produce aggregates of micro- or fondant-sized crystal ranging from 3 to 30 micrometer while causing the inclusion or entrapment of all non-sucrose material within or between sucrose crystal (MULLIN, 1972).

The co-crystallization concept and essential steps for the preparation of a co-crystallized flavour are shown in figure 4 and 5. The supersaturated sucrose syrup which is obtained by concentrating, maintained at a temperature high enough to prevent crystallization. The flavour material is then added to the concentrated syrup with vigorous mechanical agitation, providing nucleation for the sucrose/ingredient mixture to crystallize. As the syrup reach the temperature at which the crystallization begin, a substantial amount of heat is emited; and agitation is continued to promote and extend crystallization until eventually the agglomerates are discharged from the vessel (CHEN *et al,* 1988). The process is then accomplished by drying and screen the products to a uniform size (CHEN *et al,* 1982a, 1982b).

Co-crystallized flavour offer direct tableting characteristics which provide significant advantages in candy and pharmaceutical industries (RIZUTTO *et al,* 1984). In addition, co-crystallized product is granular, free flowing and non-caking.

The basic concept of co-crystallization can be broaden actually to include a virtually unlimited number of flavour used in food industry (CHEN *et al,* 1982a, 1982b, 1983) so it can serve the present and future needs of the food industry.

Conclusion

Although microencapsulation has found applications in the food industry the technology remains far from fully exploited. More research is needed to find out the best quality product obtained by the cheap and simple method. For Indonesia in particular where the advanced facilities are limited, the co-crystallization is the best choice method to be studied, understood and implemented.

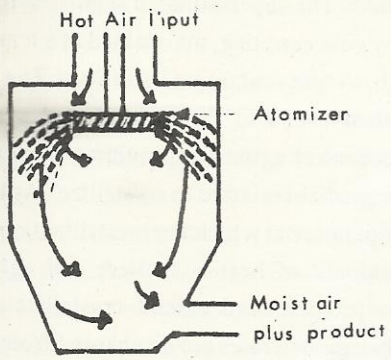

Fig.1. Cocurrent Dryer

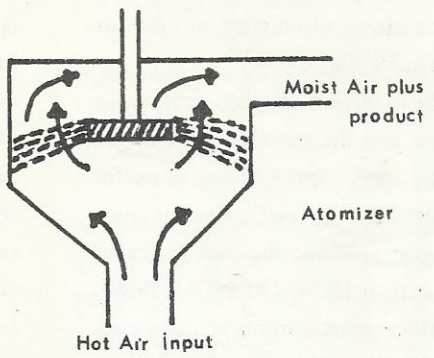

Fig 2 Countercurrent Dryer

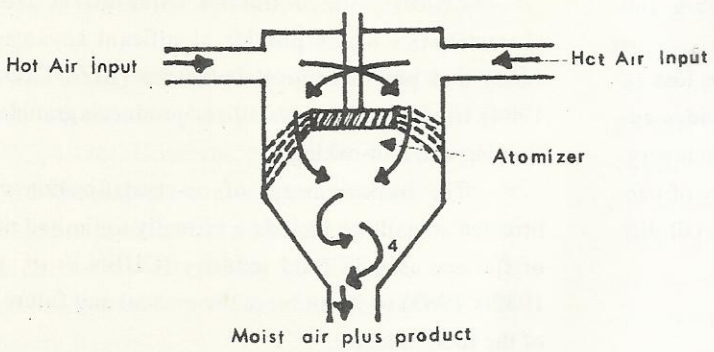

Fig.3. Mixed Flow Dryer

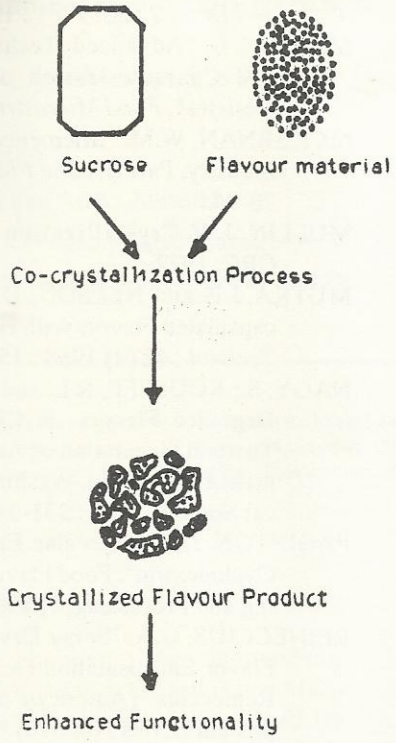

Fig.4 The Co-crystallization Concept.

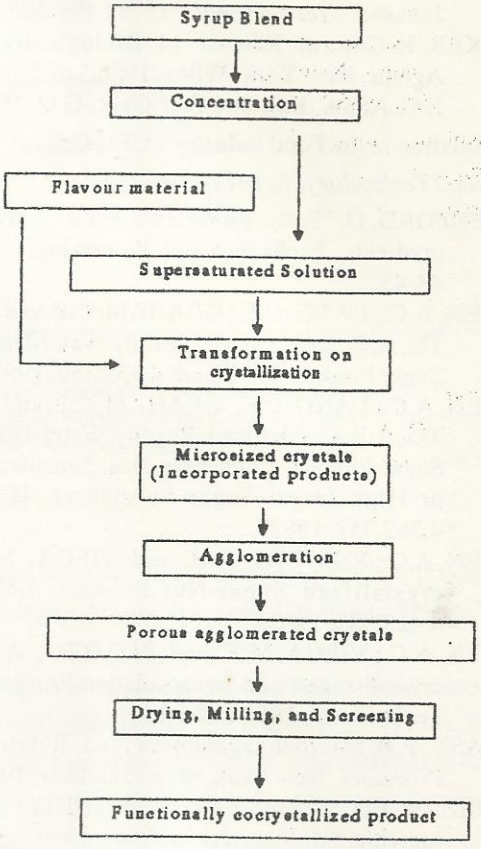

Fig. 5, Essential Steps for the Preparation of a Cocrystallized Flavour

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