Microencapsulation processes

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Microencapsulation involves a large number of processes that entrap an active material in mainly spherical particles in order to immobilise it, protect it, control its release and provide new physical properties or functions. Microencapsulation by **solvent evaporation** is a novel technique to enable the controlled delivery of active materials. There are many encapsulation methods and therefore careful selection is required to meet the objectives.
One of the effective methods is ***to disperse*** the active ingredients (as solute, powder etc.) in a polymeric solution. The mixture is then dispersed into droplets and the solvent is evaporated resulting in solid micro spheres entrapping the active ingredients. This technology is expensive and difficult to scale up; in fact it is a batch process which is used in the pharmaceutical industry for producing microcapsules composed of biodegradable polymers.
The other method, so called ***"Spray drying",*** involves spraying in hot air using water as the solvent. It is a typical method in the food industry. The technique is cheap and even if the efficiency of the encapsulation is not perfect, it is the major method for encapsulating food ingredients such as aromas, probiotics, flavours and vitamins.
These two methods may appear quite different but both of them are dealing with solvent evaporation.

Fundamental Aspects by Solvent Evaporation

1. Evaporation depends on ***atmospheric pressure*** in the reactor. At the Fig. 2a solvent evaporates at the liquid surface when the pressure above the reactor is higher than the saturation pressure of the solvent. At lower pressure (Fig. 2b) the system may enter ebullition; gas bubbles start to form. If the pressure decreases even further (Fig. 2c), the bubble forms on the surface of the pre-microcapsules creating disturbances on the droplet surface. While the pressure is very low, the bubble may form inside the droplet, leading to very porous microcapsules. Generally non-porous microcapsules are needed. On the other side, lower pressure speeds up the process and thereby reduces costs. Thus, there is a compromise to be made between performance and quality.
2. Solvent evaporation process has a ***particular profile.*** As the solvent is a major component of the emulsion (up to 90%), initially the evaporation is going on easily, 90% of the solvent is removed in a few minutes although there is a high risk of bubble formation inside the droplets. But after that the rate of evaporation decreases quickly.
3. During evaporation, the droplet reduces its volume by a factor up to 10. This fact influences the structure of the capsule and the distribution of the active ingredients in it. Additionally, while evaporation takes place on the droplet surface, so called ***interfacial turbulence*** takes place as well as local variations in interfacial tension or polymer concentration may result in ***micro-flows*.** All these factors affect the risk of bubble formation inside the beads and may cause other disturbances.

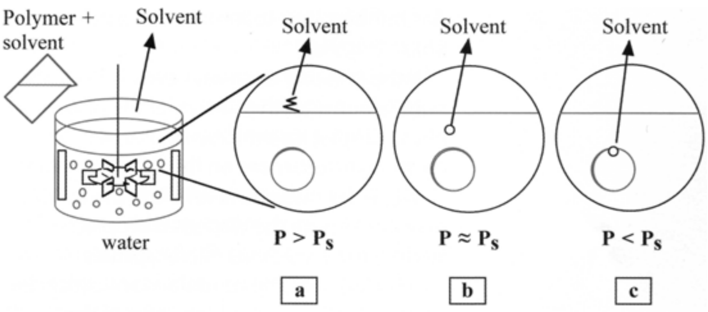

Fig. 2. Evaporation site versus pressure during the microencapsulation process. P: pressure above the reactor; Ps: saturation pressure of the solvent.

4. Rapid evaporation at the droplet surface may provide a quick increase in the polymer concentration that can result in formation of a"skin" around the droplet. This might reduce the process efficiency but it also might have beneficial effects when the "skin" is permeable for the solvent while keeping the active ingredients retained during the formation of microcapsules. Thus, ***the microcapsule structure*** together with the type of ***polymer*** used to form the matrix affect the process. If the "skin" is permeable, the process will be quicker and solvent will pass though the membrane with little effect on the capsules. If the "skin" is impermeable, the process will slow and a "raisin" structure of the droplet will be generated.
5. In some application a so called ***double emulsion*** is used (fine dispersion of minute droplets of one liquid in another in which it is not soluble or miscible), which, if not rapid, may cause losses due to the coalescence cycles.

Studies in Microgravity

On Earth observation and recording of experiments is difficult. In microgravity, on the contrary, it is much easier during the overall process and, besides, normal dynamic coalescence is eliminated.

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