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Production of sub-micron emulsions by ultrasound and microfluidization techniques

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Abstract

The purpose of this study was to produce an oil-in-water nano-emulsion by microfluidization and ultrasonication for spray drying encapsulation. Maltodextrin combined with a surface-active biopolymer (Hi-Cap) at a ratio of 3:1 were used as the continuous phase, while dispersed phase consisted of D-limonene. Results showed that microfluidization was an efficient emulsification technique producing small emulsion droplets with narrow distributions compared with conventional emulsifying devices. The main problem was that increasing the microfluidization energy input beyond moderate pressures (40–60 MPa) and cycles (1–2) lead to "over-processing" of emulsion droplets due to re-coalescence. In general, it was not possible to decrease emulsion droplet size below 0.5 μm by microfluidizer. For ultrasound emulsification, increasing the energy input through improving sonication time helped to reduce emulsion size with minimum re-coalescence of new droplets, but the results were depending on the coarse emulsion preparation method.

Keywords: Re-coalescence; D-Limonene; Emulsification; Encapsulation; Droplet size distribution; Biopolymer

1. Introduction

It has been well documented that emulsion droplet size[1] (EDS) plays an important role in the retention of volatiles and surface oil content of encapsulated powders during spray drying (Liu, Furuta, Yoshii, & Linko, 2000, 2001; Risch & Reineccius, 1988; Soottitantawat et al., 2005, Soottitantawat, Yoshii, Furuta, Ohkawara, & Linko, 2003). It has been proved that the lower the emulsion size, the higher is the encapsulation efficiency. Accordingly, many emulsion properties such as stability, rheology, and colour, depend on the EDS and size distributions (Becher, 2001; McClements, 2005). Based on EDS, emulsions can be divided into micro- (10–100 nm), mini (nano)- (100–1000 nm) and macro-emulsions (0.5–100 μm) (Windhab, Dressler, Feigl, Fischer, & Megias-Alguacil, 2005). Nano-(submicron) emulsions are kinetically stable systems that can be transparent (EDS < 200 nm) or "milky" (EDS ≈ 500 nm) (Izquierdo et al., 2002; Tadros, Izquierdo, Esquena, & Solans, 2004), and because of their very small EDS and high kinetic stability, they have been applied in various industrial fields, for example, personal care and cosmetics, health care, pharmaceuticals, and agrochemicals (Schulz & Daniels, 2000; Sonneville-Aubrun, Simonnet, & L'Alloret, 2004).

Production of nano-emulsions by "low-energy emulsification" methods like PIT (phase inversion temperature) technique involves transitional inversion induced by changing factors that affect the HLB of the system, such as temperature, electrolyte concentration, etc., or catastrophic inversion induced by increasing the dispersed phase volume

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[1] In rest of the discussion, instead of using different terms such as droplet diameter, droplet size, emulsion size, etc. which may become confusing, emulsion droplet size or simply EDS will be used.

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