Prilling process: an alternative for atomization and producing solid particles of emulsions

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Abstract

The changes of microstructure in simple and double emulsions during spraying process (without chilling) have been investigated for different air to liquid (A/L) ratio. The experimental results showed that the change of microstructure was influenced by A/L ratio. On the other hand, the atomization of simple and double emulsion through prilling (spray chilling) was carried out for production of solid particles. It showed that the structure of solid particle differed from original emulsion, but it kept same order of core structure (encapsulation); where the microstructure has been investigated by cryo-scanning electron microscopy (cryo-SEM). The encapsulation capacity can be investigated by using fluorescence material..

Introduction

Atomization of emulsion is a growing interest for food, flavor, cosmetics and pharmaceutical industries. In the food industry, inner oil or water phase are used for carrying oil-soluble/water-soluble nutrients or flavors that are coated by the outer shell. Emulsions, which carry both oil and water-soluble additives to the food at the same time, are also commonly sprayed [1]. It is a big challenge for food and flavor industries to encapsulate functional components having controlled release properties [2, 3]. Present work shows that the prilling (spray chilling) process can be an alternative for atomization of simple and multiple emulsions for encapsulation of functional ingredients.

Materials and Methods

Two different model emulsion systems have been investigated for simple emulsion, where continuous phase sunflower oil contains 2% span-20 (Fluka, Switzerland) as emulsifier and 5% PGPR (Polyglycerol Polyricinoleate, DANISCO, Denmark) as stabilizer (as well as emulsifier) for W/O emulsion. On the otherhand, continuous water phase contains 2% tween-20 (Fluka, Switzerland) as emulsifier and 10% PEG (Polyethylene Glycol; Clariant, Switzerland) as stabilizer for O/W emulsion. Similarly, double emulsion were prepared as W/O/W and O/W/O by using same emulsifier and stabilizer.

Simple emulsions were produced using the rotor-stator (Polytron, Kinematica AG.) device. The size of the droplets depends on the power applied on it. After making the emulsion, the size of emulsion droplets were measured by Laser Diffraction Particle Size Analyzer (LDPSA; Backman Coulter) and some pictures were also taken by inverse light microscopy (Nikon). Using these simple emulsions, the double emulsions were produced by rotating membrane (ROME, Kinematica AG.) emulsification. The sizes of the double emulsions mainly depend on the rotational speed of membrane, the flow rate of continuous and disperse phase, viscosity, and surface tension. After making the double emulsions, the outer emulsion droplets were again measured by LDPSA and similarly some pictures are taken by light microscopy as shown in figure-1a. Thus, the initial microstructure of the spraying material was well defined.

Our aim of the present project is to develop an effective spray nozzle for atomization of emulsions (a matrix for encapsulation of functional ingradients) that can be used for gentle spraying of emulsion keeping internal structure unchanged. Therefore, present studies show the chracterization of simple/multiple-emulsions atomization using available commercial nozzles. Simultaniously, a theoritical work is also going on for the modeling and simulation of prilling process (with the collaboration with Michigan Technological University, Houghton, USA) to predict the particle size. Some work done on it for one phase system has already been published in ICLASS 2009 [4].

Results and Discussion

The microstructure changes of simple and multiple emulsions during spraying process (without chilling) were investigated for different air to liquid (A/L) ratio. The experimental results showed (Figure-2a) that the change of microstructure was influenced by A/L ratio. The droplet size decreased with increasing air pressure at constant feed rate. Viscosity of the emulsion increased with decreasing droplet size of emulsion (Figure-2b). An-

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other set of experiment was carried out for atomization of simple and double emulsion through prilling for production of solid particles. The microstructure was investigated by cryo-scanning electron microscopy (cryo-SEM). It showed that the structure was differed from original emulsion, but it kept same order of core structure (encapsulation) as shown in Figure-1b. The encapsulation capacity can be investigated using fluorescence material or adding some nutrient (vitamin/Fe-salt).

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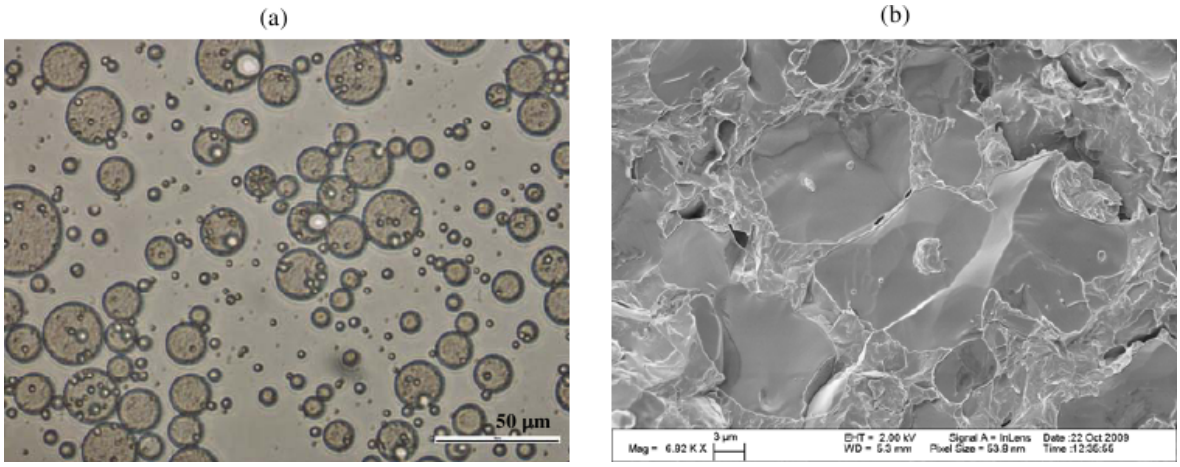

Figure 1. The pictures are; (a) Inverse light microscopic picture of a double emulsion (W/O/W) prepared by ROME, (b) Cryo-SEM picture of the product after prilling

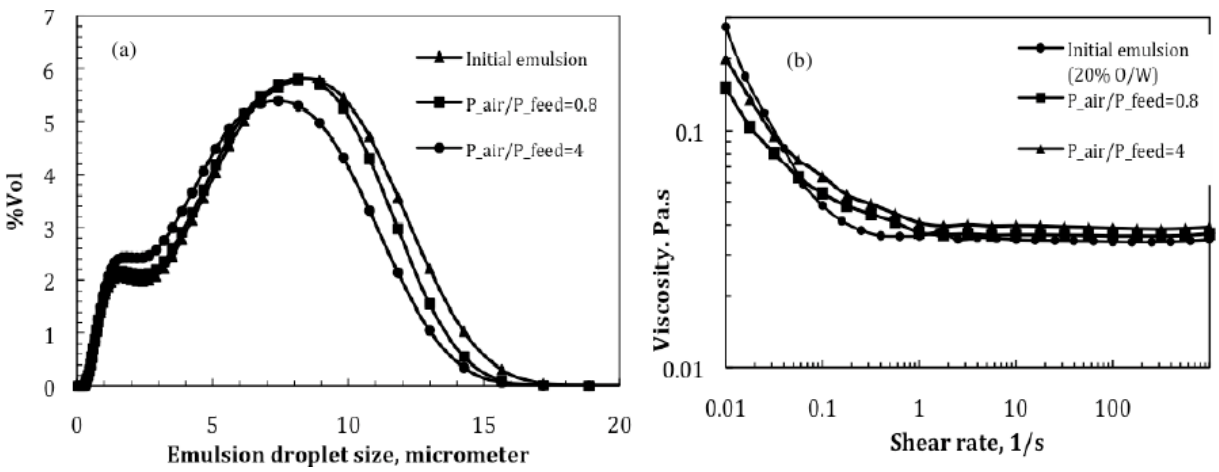

Figure 2. Effect of pressure ratio on size of simple emulsion (O/W); (a) higher the pressure ratio causes for lower the droplet size, (b) lower the droplet of emulsion indicates higher the viscosity