Synthesis of functional food powder of simple and multiple emulsions through prilling process

Bipro N. Dubey, Manuela R. Duxenneuner, and Erich J. Windhab

Lab. of Food Process Engineering, Institute of Food, Nutrition and Health,
ETH Zurich, Switzerland (bdubey@ilw.agrl.ethz.ch)

INTRODUCTION

Our aim is to produce microstructured food powder from simple and multiple emulsions employing prilling process [1-3]. The solid powder of emulsion will have better stability than its pre-emulsion. Therefore, emulsion powder will have longer shelf life that is desirable for economical reason. Present challenges are the understanding of the physical transformations of the internal emulsion structure during spraying and the investigation of the efficiency of spray process in terms of maintaining the microstructure. Spraying and prilling processes are independently well known for several industrial applications. Due to complex characterization of the process, spraying of multiphase complex micro-structural fluid system (such as multiple emulsions, or micronutrient encapsulated double or multiple emulsions) in food process engineers is rather little investigated. Micro-structural change of emulsions (unlikely Newtonian fluid) during air-assisted spraying is not only depending on shear viscosity and surface tension, but also on elastic properties of emulsions and interfacial tension between two phases. Double (DE) or multiple emulsions are mostly unstable during shelf life [4]. In this work, the influence of process parameters on the microstructure of the emulsions during spraying (without chilling) is investigated. Prilling experiments are then carried out to produce solid particles of emulsions and their microstructures are investigated by cryo-SEM to compare with the pre-emulsion.

MATERIALS & METHODS

For the continuous phase of W/O- emulsion, we used sunflower oil or fat (palm stearin; Florin AG.) containing 2-5 %wt Span 20 (Fluka, Switzerland) as emulsifier and 2-5 %wt PGPR (Polyglycerol polyricinoleate, DANISCO, Denmark) as stabilizer as well as emulsifier. On the other hand, the continuous phase (in O/W-emulsion), water, contains 2 %wt Tween 20 (Fluka, Switzerland) as emulsifier and 10 %wt of PEG (Polyethylene Glycol; Clariant, Switzerland) as stabilizer. A rotor-stator device (Polytron PT6000, Kinematica AG.) was employed to produce the simple emulsions. Double emulsions (O/W/O and W/O/W) are prepared by a two-steps method (Rotational membrane) using the same emulsifier and stabilizer as before with concentrations that satisfies the weighted HLB (hydrophilic-lipophilic balance) value of higher than 10 for W/O/W and lower than 8 for O/W/O [5]. Spraying and prilling experiments were carried out using an external mixing nozzle (1/4J-SS+SU2-SS-2850, Spraying System AG.) with an inner diameter of 0.5 mm. The microstructures of solid particles were finally investigated by cryo-scanning electron microscopy (cryo-SEM, SEM Gemini 1530, Electron Microscopy ETH Zurich).
RESULTS & DISCUSSION

Different types of emulsions (such as O/W, W/O, W/O/W) were sprayed without chilling to investigate the influence of process parameters on the microstructure of the emulsions in terms of emulsion droplet size and size distribution. The result shows that the emulsion droplet size decreases with increasing air pressure, or air to liquid mass ratio (ALR). Experiencing the above elucidation, we carried out several prilling experiments with different emulsion systems to observe the parameter impact in produced solid powder particle. We observed that the better results (in terms of maintaining internal structure) were found for water-in-fat emulsions (in Figure 1a) compared to O/W or W/O. Therefore, the second prilling experiments were done with DE (such as water-in-fat-in-water), and it showed that their internal structure was differed from the pre-emulsion. However, some order of internal droplets was still maintained as shown in Figure 1b. Additionally, we observed that a higher ALR is required to produce finer particles. The higher ALR eventually leads to the destruction of internal structure of DE. In our experiment, the mean size of the produced powder particles (40 % water-in-fat emulsion) was about 450 μm (sieving technique) through prilling process applying 3 bar air pressure.

![Figure 1. Cryo-SEM picture of solid particle produced by prilling process from (a) 80 % water-in-fat and (b) 30 % (60 % water-in-fat)-in-water emulsion.](image)

CONCLUSION

Amongst others, prilling process is employed to make microstructured solid particles from emulsions. The microstructure is highly influenced by process parameters such as air pressure, ALR and total mass flow rate. To maintain the microstructure unchanged and to produce rather fine particle by prilling process, an optimization of process parameters is required.

REFERENCES