STUDY OF THE PARTICLE FORMATION AND MORPHOLOGY OF SINGLE MANNITOL-WATER DROPLETS DEPENDING ON THE DRYING CONDITIONS

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Key Words: acoustic levitation, bi-component droplet drying, particle morphology, drying kinetic, numerical simulation

In chemical, pharmaceutical and food processing industry, spray processes have a wide range of applications, especially in the production of tailor-made powder products of defined characteristics from solutions or suspensions. The effects of process parameters (e.g. temperature and relative humidity) on the drying kinetic of a droplet and the properties of the resulting particles are largely based on experience. Still there is a lack of information on the fundamentals of particle formation. To close this gap numerical simulations as well as single droplet experiments were carried out under various conditions. This study concerns the influences of relative humidity, drying temperature and mass fraction on the solid layer formation and on the particles of single droplets consisting of mannitol-water solutions. An acoustic levitator (Fig 1 a)) was used to carry out the single droplet experiments. By means of a camera and a light source shadowgraphy was used to analyze the droplet drying kinetic and the development of the droplet respectively. Raman spectroscopy was used to analyze the polymorphism[1] of oversaturated mannitol-water droplets (relative humidity above 10 %). Using a thin thermocouple (150 µm) the particle temperature was recorded. Typical drying curves showed a continuous decrease of the droplet surface area until the solid layer was formed. The progress of the droplet temperature during the evaporation depends on the increase of the mannitol concentration at the droplet surface and start crystallization. Numerically, the unsteady, one-dimensional mass and energy diffusion equations for spherically symmetric droplets were solved accounting for the occurrence of the solid layer formation. Moreover, the influence of the air humidity on the solid layer formation and the droplet temperature evolution was investigated experimentally and validated by simulations. It was shown that an increase in the humidity of the drying air leads to a delayed solid layer formation[2] and a decrease of the final particle porosity whereas a higher mannitol concentration and a higher temperature have a contrary effect. The validity of the numerical model concerning the time instance of the solid layer formation and the progress of the droplet temperature was confirmed. Using the numerical model the drying of a single droplet was successfully simulated. Additionally a morphology map for the obtained particles from the single droplet experiments was developed.

Figure 1 – a) Process chamber of the acoustic levitator with the Raman probe in the background outside the chamber, b) levitated mannitol-water droplets.