Influence of polymer content on droplet size distributions in atomized spraying liquids

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INTRODUCTION

To obtain a reproducible and specification conforming product quality it is mandatory to control the process parameters for granulation and layering or coating. One important parameter for the development of coating and granulation processes in high shear and fluid bed processes is the spraying system [1] e. g. the application of a feasible droplet size coming out of the respective spraying nozzle. Too large droplets could result in oversized granules or in pellets´ agglomeration, whereas too small droplets could lead to spray drying, dust, reduced yields or assay values or deviating dissolution results.

In contrast to other process parameters like inlet air volume or spray rate the droplet size cannot be directly controlled but is mainly resulting from the applied atomization air pressure [2] as well as from spray rate, nozzle [2, 3] and formulation of the spraying liquid.

In the present study the influence of the polymer content i. e. the viscosity of the spraying liquid on the droplet size distributions for atomized spraying liquids was statistically evaluated at different atomization air pressures and spray rates.

MATERIAL AND METHODS

Materials

Polyvinylpyrrolidon (Kollidon^{R} 30, PVP) was used as binder in aqueous solutions of 5 – 20 % (w/w).

Methods

Viscosity measurement

The viscosity of the spraying liquids was determined using a falling sphere viscosimeter (Höppler), with a sphere of 0,78 cm and a density of 2,41 g/cm³.

Laser diffraction

Droplet sizes (Sauter diameters, d10, d50, d90) of spraying liquids atomized with an HS04 nozzle (1,5 mm, Schlick) were measured with Malvern Spraytec STP 5321 laser diffraction, 2mW He-Ne Laser (632.8 nm), lens 300 mm to detect droplet sizes 0,1 – 900 µm, distance nozzle laser beam 100 mm in a right angle, determination time 10 s, determination frequency 10 Hz at 1,0 bar, 2,0 bar, 3,0 bar, 4,0 bar spray pressure applying spray rates of 50 g/min until 200 g min.

Statistical evaluation

Data were statistically evaluated applying Stavex 5.2 from AICOS Technologies AG.

RESULTS AND DISCUSSION

Increasing droplet sizes were measured with increasing solid concentration (polymer contents), increasing spray rates and decreasing atomization air pressures [fig. 1].

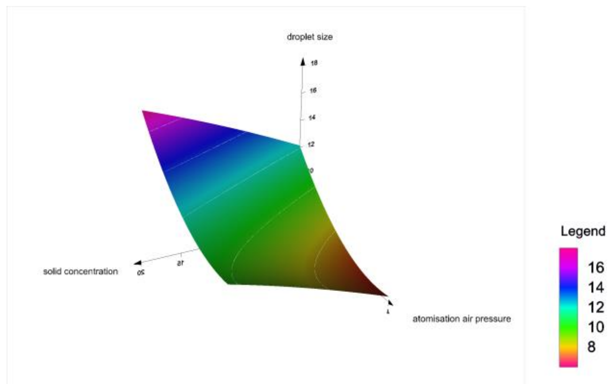

Figure 1. Droplet size distribution (Sauter diameter); spray rate: 150 g/min

Keeping the polymer content constant (e.g. at 20 %) as well as the atomization air pressure (e. g. 2 bar, fig. 2) results with increasing spray rates in larger droplets (d50:14 µm => 30 µm) and slightly broader droplet size distributions (80 % between 27 µm resp. 63 µm) shown as d10, d50 and d90).

Increasing atomization air pressure (constant spray rate (e. g. 150 g/min) and polymer content (e. g. 20 %), fig. 3) reduced the droplets sizes (d50: 31 µm => 16 µm) while simultaneously more narrow droplet size distributions were measured (80 % between 61 µm resp. 31 µm).

With increasing polymer contents but constant spray rate (e. g. 150 g/min) and atomization air pressure (e. g. 2 bar, fig. 4) larger droplets (d50: 22 µm => 11 µm (water) or 12 µm for 5 % PVP) and broader distributions (80 % between 42 µm resp. 13 µm (water) or 18 µm (5 % PVP solution) were detected.

Plotting the droplet sizes versus the viscosities of the spraying liquids results in acceptable correlations both for increasing atomization air pressures (at constant spray rates,

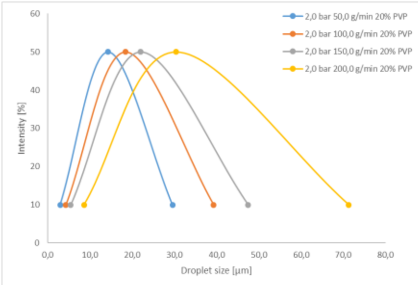

Figure 2. Droplet size distribution (d10, d50, d90); atomization air pressure 2,0 bar, 20 % PVP, increasing spray rates

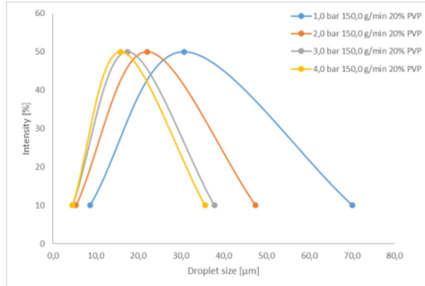

Figure 3. Droplet size distribution (d10, d50, d90); spray rate 150 g/min, 20 % PVP, increasing atomization air pressures

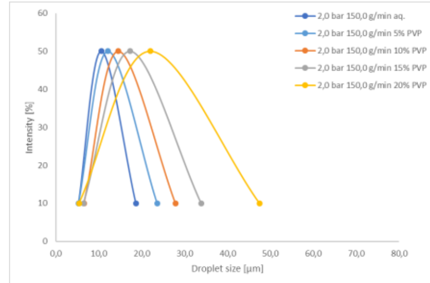

Figure 4. Droplet size distribution (d10, d50, d90); atomization air pressure 2,0 bar, spray rate 150 g/min, increasing PVP content

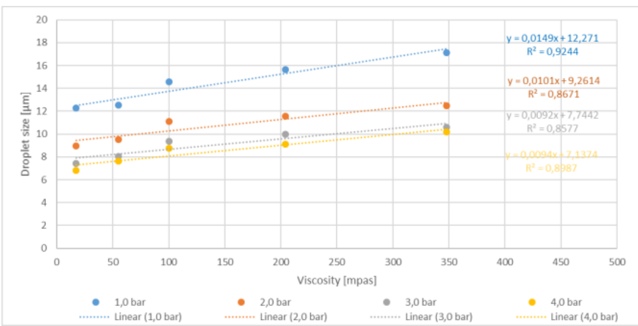

Figure 5. Droplet size distribution (Sauter diameter); correlation to spraying liquid viscosity (spray rate 150 g/min)

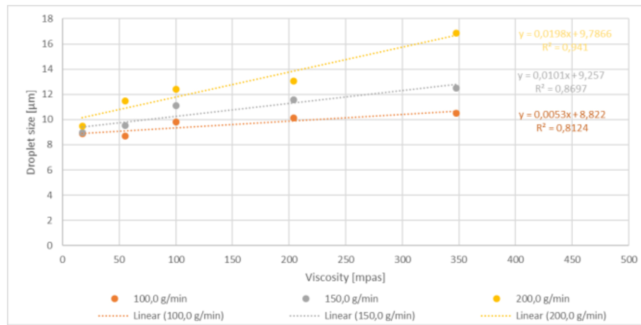

Figure 6. Droplet size distribution (Sauter diameter); correlation to spraying liquid viscosity (atomization air pressure 2,0 bar)

here 150 g/min, fig 5) as well as for increasing spray rates (at constant atomization air pressures, here 2,0 bar, fig 6), of 100, 150 and 200 g/min allowing an estimation of the droplet sizes via equations displayed in the diagrams. An increase of the viscosity of the spraying liquid, e. g. by increasing the polymer content will result in larger droplets. By reducing the spray rate or increasing the atomization air pressure the droplet size can be re-adjusted.

CONCLUSION

Droplet size distributions of aqueous PVP solutions were measured applying the laser diffraction technology. Droplet sizes increase with higher spray rates and lower atomization air pressures, in the same time broader droplet size distributions were measured.

With increasing polymer content (higher viscosity) in the spraying liquid, larger droplets are obtained. To receive the same droplet size while increasing the polymer content would result in lowering the spray rate or increasing the atomization air pressure.

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