Polymerization in sprays – one step from a monomer to a powder polymer

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Abstract

Spray drying of powder polymers is a common technique to generate well defined polymer particles in shape and size. To have a good solid handling spherical particles in a size range of 10 to 1000 µm are usually desired. The whole process seems to be standard processing but even the first step, the atomization, could be a bottle neck as we found out in our research. In particular the handling of the atomization is mostly dependent on the molecular structure of the polymer and length of polymer chain. The molecular weight of the polymer has a big influence on the rheological behavior of the solution, if it appears as non-Newtonian fluid with passing a critical concentration. Consequently the rheology of the fluid to be atomized has a big impact on the atomization behavior. Results on spray drying polyvinylpyrrolidone (PVP) solved in water show a change of morphology from particles to filaments with increasing molecular weight and concentrations of the polymer. This relation between molecular weight and atomizing behavior is also important for the current research where a polymerization will take place in sprays.

The spray drying of a reactive system is focus of this research. Here the former described spray drying process is expanded with an additional step, the polymerization or reactive step. Thus, a reactive monomer or partial linked monomer solution is atomized in a modified spray dryer. By decomposing a thermal starter in the fluid the monomer forms chains and consequently polymers. This starter is decomposed under certain kinetics by the drying gas or by the thermal input of a special 3-fluid nozzle (see following passage). The use of this nozzle is necessary because of the aim for optimal utilization of the small retention time within a spray dryer.

The coupling of starter, polymerization and drying kinetics is of special interest within our research. The model substances are water soluble monomers, salts of acrylic acid, and a radical thermal starter, an azo compound. The special tool for controlling starter and polymerization kinetics is the 3-fluid nozzle. This nozzle has three different feeds for the starter solution, monomer solution and the atomization gas, e.g. nitrogen. All feeds are mixed in- or outside the nozzle. In addition the nozzle has a double jacket for keeping a constant temperature inside the nozzle. The presented results show the influence of retention time of the fluids within the nozzle on the degree of polymerization at the nozzle tip. The optimal parameters for setting the start of the polymerization around the nozzle tip are presented. At this optimum a successful droplet formation is guaranteed, non-Newtonian effects are prevented and simultaneously completely polymerized particles with a certain molecular weight are generated in the process' downstream.

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