Controlled Particle Synthesis in a Hot-Wall Reactor and Controlled Electrostatic Manipulation of the Aggregation Process

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Particle synthesis in a hot-wall reactor is a reliable process for the production of nanoparticles due to the fact that all relevant process conditions – e.g. temperature distribution, pressure, flow field, residence time distribution – can be controlled in a wide range of values. A set-up which provides the required specifications to produce spherical particles with a relevant mass production rate (i.e. g/h), has been installed recently. Adjustable air and precursor flow into the reactor allow for a wide range of possible synthesis parameters, particularly the concentration of precursor at the reactor entrance. Due to the adjustable parameters it is possible to gain a well-defined aerosol. At the end of the heated zone this well-defined aerosol mostly consists of spherical particles which is quenched rapidly with cold air, using a water cooled probe.

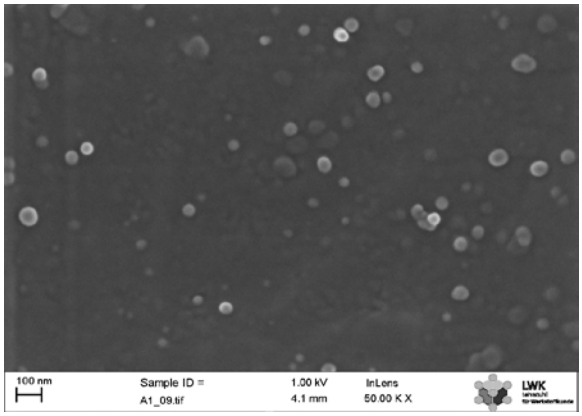

Figure 1. Exemplary SEM image of synthesized TiO_2 nanoparticles

For different applications it is desired to have only single particles or at least only small soft aggregates. To drastically reduce aggregation there is the possibility to ionize the quench air within the probe. The effect of ionized quench air on the stabilization of the aerosol at the end of the reactor will be demonstrated. A heat exchanger further downstream was designed to reach a constant temperature around 200 °C offering the possibility to further modify the particles in this section. For example the manipulation of the aggregate structure downstream of the sintering zone by charging particles with opposite polarities will be addressed in the near future. Therefore two parallel coaxial corona chargers being able to handle high flow rates and concentrations have been designed. As corona emitting source a 0.05 mm wolfram wire is used. The length of the two active corona zones is adjustable independent from each other by shielding the corona wires with a movable glass / steel pipe.

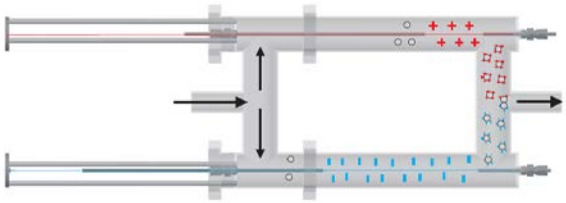

Figure 2. Designed parallel coaxial corona chargers.

The chargers are implemented downstream of the heat exchanger with opposite polarities. This offers the possibility to manipulate the aggregation process hence the final aggregate shape. Experiments showed that the charger is able to reach a sufficiently high electrical charge on the particles while the particle losses are acceptable. Using a different charger setup could further reduce losses.

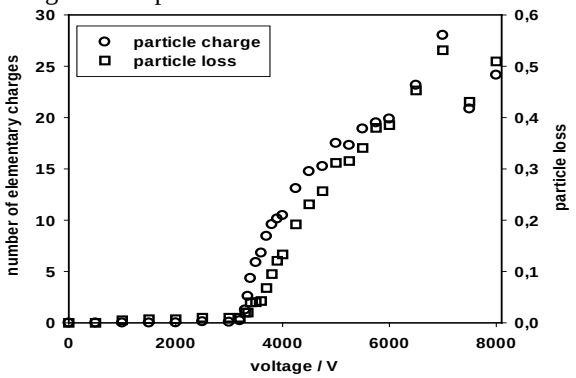

Figure 3. Number of charges per particle and particle loss for NaCl particles (100 nm mean diameter)

In the focus of interest are particularly chain-like aggregates with an alternating sequence of different materials. To realize the chain shape, the coagulation process needs to be faster than the neutralization by recombination in the contact point, cf. Fig. 4.

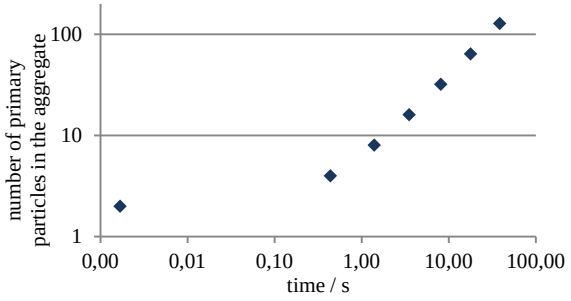

Figure 4. Coagulation time of charged 100 nm particles with $c_{inital} = 10^{14}/m^3$.