

Synthesis of tailored organic-inorganic nanostructures by charge controlled coagulation

S. Sigmund¹, E. Akgün², J. Meyer¹, M. Wörner² and G. Kasper¹

¹Institute of Mechanical Process Engineering and Mechanics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

²Institute of Process Engineering in Life Science, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany

Keywords: Composite nanoparticles, electrostatic particle coating

Presenting author email: stephanie.sigmund@kit.edu

Based on charge controlled coagulation between monomer droplets and core particles, precisely tailored nano-composites, consisting of polymer coated core particles are synthesised.

Continuous polymer coatings do mainly have protective properties. Depending on the shell morphology, a highly sensitive or reactive core particle can be protected from uncontrolled reactions or can be completely encapsulated from ambience. At the same time a tailored polymer shell can be employed to realize a controlled core particle reaction. By influencing the shell thickness, it is possible to directly modify release kinetics of an active core substance. Therefore, a simple method to control the shell thickness of the generated particle systems is strongly desired.

We will present such a method of controlled coating with enclosed polymer layers. Usually hybrid nanostructures are generated in liquid phase processes (Nabhi et al.). However, aerosol processes offer certain advantages, such as high product purity etc. In our case, by means of attractive interactions between gasborne, electrically charged core particles and inversely charged monomer droplets, selective agglomeration is enforced. At the same time repulsive forces interact between charges of the same polarity. Hence agglomeration among core particles or droplets respectively, is kinetically inhibited. The principle of selective agglomeration between inversely charged droplets or particles is not new (Borra et al., Maisels et al.), but processes taking advantage of selective agglomeration to generate coating structures are rare. Once particles collide with droplets, these will wet the particle surface completely to form an enclosed shell. This shell is polymerized afterwards. Thereby, assuming that one droplet wets one core particle, the droplet size determines the shell thickness. Hence a polymeric shell onto a core particle of the desired thickness can be generated by producing monomer droplets of a definite size.

To do experimental studies on the generation of tailored hybrid nanoparticles, monodisperse silica particles with 150 nm in diameter were chosen as model core particles. Silica particles are brought into gas phase by spraying an aqueous particle suspension and subsequent drying. The charging step takes place in a corona charger. By applying positive high voltage potential, core particles gain multiple

positive charges during this charging step. Monomer droplets are generated by atomizing a solution, consisting of butyl acrylate and photo initiator. Subsequently monomer droplets of the desired droplet size are classified in a DMA at constant voltage. These monodisperse droplets were charged in a second corona charger but with inverse, thus negative polarity. Core and coating material aerosols were mixed in number ratio of 1:1 to achieve coagulation of one droplet with one core particle and therefore to minimize the occurrence of multiple or uncoated core particles. The mixed aerosol is passed through a residence time volume to ensure coagulation and core particle wetting. The homogeneous monomer coating is then directly photo polymerized by irradiation with UV light to form a solid, polymeric shell. To provide coating evidence, the size increase of the core particle size due to the polymer shell is measured in a conventional tandem DMA setup. Supplementary the hybrid particles are analysed visually via transmission electron micrographs.

Shell thickness measurements for several droplet sizes, by tandem DMA and visual analysis will be presented. Those measurements were compared with theoretical calculated shell thickness, from droplet size. The experimentally determined shell thicknesses agreed well with theoretically expected values.

This project is part of the JointLab IP3, a joint initiative of KIT and BASF. Financial support by the ministry of science, research and the arts of Baden-Württemberg (Az. 33-729.61-3) is gratefully acknowledged.

- Borra, J.P., Camelot D., Chou K.L., Kooyman P.J., Marijnissen J.C.M., Scarlett B. (1999). *Bipolar coagulation for powder production: Micro-mixing inside droplets*. *Journal of Aerosol Science*, 30, 945.
- Nabhi, N., Landfester, K., Taden, A., (2011). *Water-Based Inorganic/Polymer Hybrid Particles Prepared Via a Multiple Miniemulsion Process*. *Journal of Polymer Science Part A, Polymer Chemistry*, 49, 5019.
- Maisels, A., Kruis, F.E., Fissan, H., Rellinghaus, B., Záhres, H. (2000) *Synthesis of Tailored Composite Nanoparticles in the Gas Phase*. *Applied Physics Letters*, 77, 4431