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Nanoparticle technology: scalable processes for functional particles

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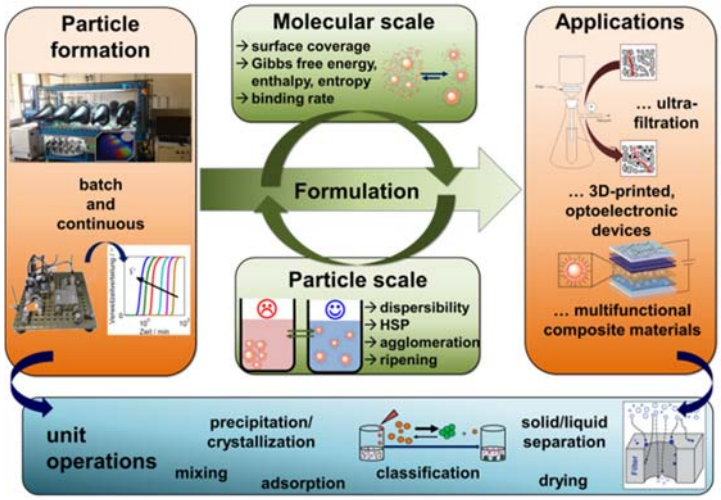

High-quality, multifunctional nanoparticles (NPs) with defined surface properties that are tailored to a specific application are a still unsolved issue, both at the lab as well as at larger scale. To date, no scalable process engineering for colloidal nanoparticles does exist.

Small NPs clearly below 100 nm bring both, opportunities and hurdles. On the one hand outstanding properties are obtained; on the other hand NPs are demanding i) due to reproducibility requirements, i.e. particle size distributions (PSDs) that have to be controlled with Å-accuracy, ii) due to the dominating role of the interface where molecular properties need to be quantified in terms of thermodynamics but also in terms of kinetics, iii) due to unknown process-structure-property relationships between molecular quantities and particle properties as well as iv) due to unknown process-structure-property relationships between particle properties and macroscopic application performance.

To develop scalable processes for colloids that take all these aspects into account, we start with NPs of outstanding reproducibility derived by an automated synthesis robot. After in-depth characterization, NPs are controlled in terms of their interface by ligand exchange reaction. For the latter, a toolbox is developed to characterize thermodynamics and kinetics on a molecular level.[1,2] To subsequently relate those findings with the particle scale, we use Hansen solubility parameters (HSP) determined by analytical centrifugation (AC). Throughout all these investigations, our objective is to use high throughput experimentation (HTE) to glean in-depth physico-chemical and engineering understanding.

Finally, we make use of customized NPs in various fields, e.g. ultrafiltration,[3] or new processes like classification by size selective precipitation (SSP).[4] We believe that our methodological concept paves the way to various new applications of NPs with substantial outreach stretching from optoelectronic devices to life sciences and medicine.

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