Uncovering structure, formation and transition of nanoparticles and nano-pharmaceuticals by X-ray scattering

Martin A. Schroer

Nanoparticle Process Technology (NPPT), Faculty of Engineering and CENIDE, University Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany

Contact: martin.schroer@uni-due.de

The properties of nanoparticles strongly depent on their characteristics, such as size, dispersity and shape, which can controlled by the synthesis and modified by processing, *e.g.,* in the form of colloidal suspensions or as nanoscaled powders. In order to obtain a full understanding of these structural properties and their evolution during processing, it is essential to determine it at all relevant length scales – ideally following formation and transition processes under *in situ* and *in operando* conditions.

These requirements are fulfiled by X-ray scattering techniques, that do not only yield access into lengths scales from several Ångstrom up to hundreds of nanometers, but also allow probing the formation and evolution of nanoparticles by time-resolved studies under realistic formation conditions.

In my presentation, I will demonstrate how X-ray scattering, in particular small angle X-ray scattering (SAXS), can be used to explore the structure and structural evolution of various types of nanoparticle systems. I will give examples how to probe structure, formation and transitions in hard, soft and biological matter for different aggregation states, highlighting the broad versatility of SAXS.

In particular, I will show how to follow nanoparticle formation within chemical vapor synthesis reactions **[1]**, utilizing the unique potential of modern synchrotron radiation facilities. I will discuss how X-ray scattering can be used to determine the structure of biological macromolecules in solution **[2]** and help in the development of new nanoscaled pharmaceuticals, such as artificial oxygen carriers or mRNA-based vaccines, as well as how to determine the structure on nanoparticle-bio-composites **[3]**.

[1] M.A. Schroer, A. Levish, Y. Yildizlar, M. Stepponat, M. Winterer, “A versatile chemical vapor synthesis reactor for in situ x-ray scattering and spectroscopy”, *Rev. Sci. Instrum*. **93** (2022), 113706.

[2] M.A. Schroer, D.I. Svergun, “Recent developments in small-angle X-ray scattering and hybrid method approaches for bio-macromolecular solutions”, *Emerg. Top. Life Sci.* **2** (2018), 69.

[3] M.A. Schroer, P.S. Hu, N. Tomasovicova, M. Batkova, K. Zakutanska, P.Y. Wu, P. Kopcansky, „Dependence of the Nanoscale Composite Morphology of Fe_3O_4 Nanoparticle-Infused Lysozyme Amyloid Fibrils on Timing of Infusion: A Combined SAXS and AFM Study“, *Molecules* **26** (2021), 4864.