Poster

Complex nanoparticle systems in motion: a holistic analytical approach for dynamical studies in biological environments

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In multidisciplinary research, the development of new models for X-ray tools holds potential in application areas such as materials and life sciences. Bridging the different worlds of X-ray diffraction, scattering and imaging overcomes gaps between methods, allowing a holistic approach. The combination of 3D morphological and structural understanding of materials is key to the discovery of mechanisms taking place in complex systems. Functionalized nanomaterials and their interaction with bodily fluids or human tissue triggered our attention to the systematic study of materials-bio interactions.

Today, applications of nanoparticles (NPs) in medicine are increasingly important. However, once NPs are transferred to a biological environment, their interactions become complex and not yet fully understood. Different parameters such as ionic strength, pH conditions and the presence of biomolecules such as proteins initiate alterations in the structural and surface properties of NPs, thus influencing their colloidal stability. In nanomedicine, NP colloidal stability in a biological environment directly influences the product efficacy, cellular response and biocompatibility. Therefore, we are especially interested in detailed investigations of NP interactions and their structural changes in processes such as drug administration, which take place in realistic environments. In our laboratory, we have developed a characterization method based on small-angle X-ray scattering (SAXS) for in-situ, label-free, and dynamic studies on both early events and advanced stages of NP interactions after exposure to a biological environment. A specially designed microfluidic system is combinable with SAXS instruments in the laboratory and at synchrotron facilities, as well as with neutron-based experiments (SANS) (Figure 1).

Dynamical studies will be highlighted for nanoparticle systems alongside their current applications in nano-therapeutics.

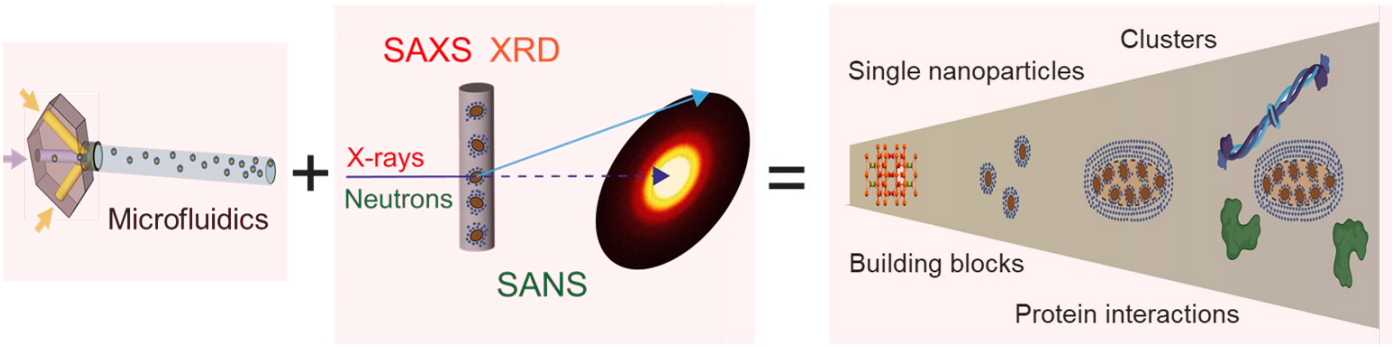

Figure 1. Scheme showing the combination of microfluidics with SAXS / SANS for in-situ investigations of early events in NPs interactions in biological environments.

We present a generic approach to analysing nanoparticle systems and their respective transformations in biological environments like human blood serum. Our studies include silica [1] and gold [2] nanoparticle systems, and extend to iron-carbohydrate complexes [3, 4], which are widely used in intravenous (IV) drug administration to treat iron deficiency anaemia. Studies suggest that early interactions between nanoparticles and blood upon IV injection are key for understanding how differences in physicochemical characteristics lead to variance in clinical outcomes.

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