Synchrotron radiation based Soft X-ray electron spectroscopies: from molecules to nano-objects

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Soft X-ray photoelectron spectroscopy (XPS) is a method of choice in a wide variety of research fields, as it is benefitted in research from fundamental quantum mechanics to applied materials science. In this progress report, we give examples of recent applications of synchrotron radiation (SR) excited gas-phase photoelectron spectroscopy of different samples with increasing complexity from a relatively simple molecule to multicomponent nanoparticles. As an outlook, we give an example of imaging of nano-objects in biological matter with soft X-rays.

SR excited photoelectron-photoion coincidence (PEPICO) technique enables to study photoionisation dynamics in a multidimensional way. One can look at fragmentation taking place as a function of photon energy (e.g single out effects of resonant excitations), certain electronic final states or selected fragment ions. Energy-selected PEPICO measurements of dimethyl disulfide molecule performed at PLEIADES beamline at SOLEIL synchrotron allowed to unravel a detailed correlation between the ionic fragmentation and the molecular ionic states, especially revealing a spin-orbit component selective fragmentation. A more complex molecule, avobenzone, was studied at recently opened FinEstBeAMS beamline at MAX IV SR facility. This large organic molecule exhibits a complex fragmentation pattern with little initial state selectivity, highlighting the propensity for effective transfer of charges in the final states.

High brilliance of the state-of-the art SR facilities makes it possible to study very dilute samples, such as gas-phase nanoparticles. Thus, we can benefit from extreme surface sensitivity of XPS when studying very fragile, *in situ* generated nano-objects which would suffer from deposition, or we want otherwise be free from substrate effects. Two examples are given, an XPS investigation of *in situ* generated multicomponent salt particles showing a different surface composition depending on the solvent of the solution from which they are aerosolised, and surface characterisation of *ex situ* generated nanoparticles.