Scanning X-ray Microscopy at the Hard X-ray Micro/Nano-Probe Beamline P06 (DESY) for Bio and Bio-Medical Applications

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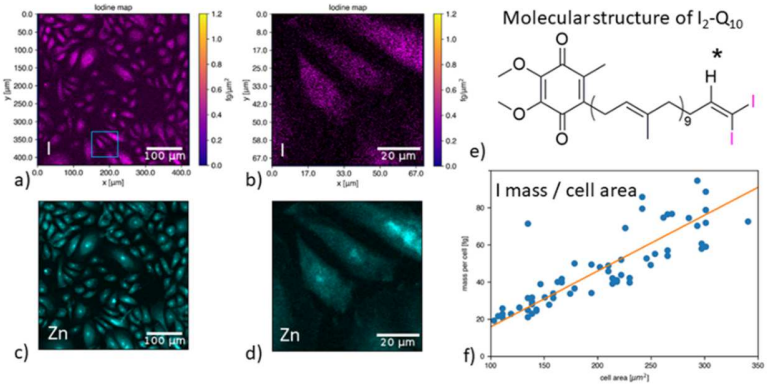
The Microprobe experiment at the PETRA III beamline P06 is a versatile setup for scanning X-ray microscopy with X-ray fluorescence, X-ray absorption spectroscopy and X-ray diffraction / coherent scattering contrasts. It is used for studies in materials sciences, catalysis, cultural heritage, (asteroid-) mineralogy, etc., but the largest share of beamtime is given biological and bio-medical applications. The ability to collect megapixel images in less than an hour facilitates series of 2D images for full 3D fluo-tomography and spectro-microscopy. Samples can be chemically fixed, freeze dried or even fresh (unfixed). The golden standard, however, is shock-freezing and measurement in the frozen-hydrated state in order to avoid beam damage and artefacts of element re-distribution. A cryogenic sample transfer protocol is available both for measurements under a nitrogen cryo-stream or in a cryogenically cooled UHV chamber. Examples are presented for various sample types (tissues, bone, teeth, cells), scanning modes (fast 2D, tomographic 3D), and sample preparation techniques (frozen-hydrated, unfixed, chemically fixed).



The figure summarizes results of a study assessing cellular uptake of exogeneous coenzyme Q10 into human skin [1]. Zinc (cyan) and iodine (magenta) elemental maps for the full scan collected in high flux mode (a,b) and the fine scan of 3 selected cells (c,d), indicated by the blue rectangle in a), collected in high resolution mode. The direct comparison of iodine and zinc emphasizes the homogeneous distribution of iodine among the cytoplasm and agrees with the expected Q10 localization. The large number of individually resolved cells allowed to deduce the correlation between iodine mass per cell and projected cell area. A mean value of 46.5 fg iodine/cell was found with a cell-to-cell uptake variation of 10.7 fg/cell.

[1] T. Staufer, G. Falkenberg, D. Brueckner, et al., *Antioxidants*, **2022**, 11, 1532.