Synchrotron X-ray chemical microscopy for subcellular study

S. Bohic[a,b], P. Cloetens[a], K. Double[c], O. Hignette[b], G. Martinez-Criado[b], P. Bleuet[b], J. Susini[b], S. Labouré[b], R. Tucoulou[b]

[a]INSERM U-836 Grenoble, France

[b]ESRF, Grenoble, France

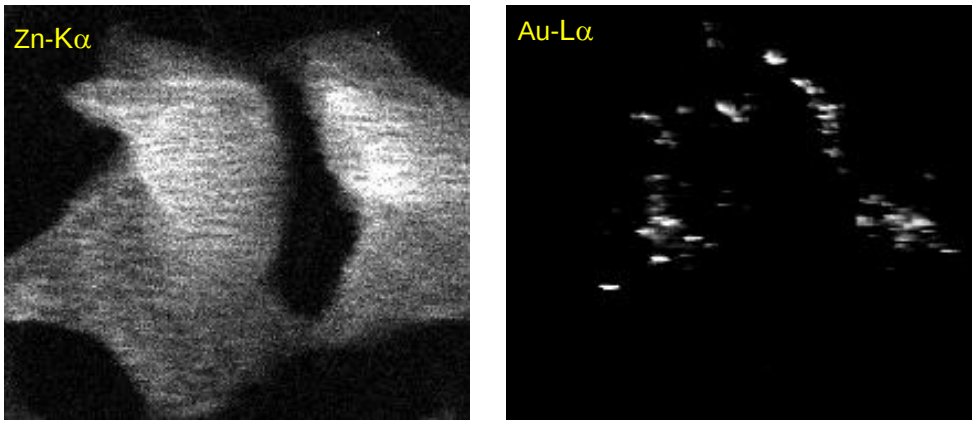
[c]POWMRI, Randwick, Australia

E-mail: bohic@esrf.fr

Very little is known about the sub-cellular distribution of metal ions in cells. However, some metals like zinc, copper and iron are absolutely essential cations fulfilling important biological functions in all living cells. They are for instance involved in the transport of electrons, energy metabolism or DNA synthesis. A wide diversity of enzymes has a metal as a co-factor. This also applies to the brain where these elements control key neural processes. The scientific field investigating the relationships between metals and brain function is named metalloneurochemistry (Burdette, 2003, PNAS).The recent possibilities offered by synchrotron chemical nanoprobe for biological analysis and particularly sub-cellular chemical imaging (cell metallomic), demonstrated the possibility to work at the level of cell organelles, opening new exciting scientific field of investigation on the role of metal in the pathophysiology of the cell.

The ID22 Nano-Imaging beamline is a part of the micro-fluorescence imaging and diffraction beamline. The aim of this facility is to operate a nano-probe in different modes like: Nano-fluorescence-tomography, Phase-contrast imaging, biology sample nano-fluorescence-scanner, and nano-diffraction experiments. It operates the final experiment end-station where the X-ray is reduced at 80 nm spot-size.

An intense research is ongoing for nanotechnologies and particularly in the field of nanomeddicine. The advent of synchrotron nanoprobe as a multimodal nano-imaging tool is expected to play an important role in the nanomedecine field. Understanding the impact of these particles on human cells and tissues will be crucial for environmental safety reasons and for reliable diagnosis and treatment of diseases. Recent progress in contrast agent development has produced a number of new agents that are directly responsive to biological activities. Efforts are made to make new diagnostic imaging agents, but the most challenging part is the delivery of these multifunctional agents. Multielemental X-ray fluorescence nanoscopy combined with fastly frozen cell preparation treated with various nanovehicles will take advantage of metal atoms most often incorporated in these nanostructures (Fe, Ti, Se, Zn, Cd, Gd…) and will yield critical data that can be used to streamline and guide their design.



XRF elemental map using the ID22NI Nanoprobe on 2 human lung fibroblast cells incubated in presence of 13 nm gold nanoparticles. Image size: 210x190 pixel (HxV), pixel size 200 nm. X-ray spot size: 100 nm, dwell time: 100 ms, photon flux ~ 5.10+11 ph/s at 17 keV. *[Coll. Dr Kysela, Genome Stability and DNA Repair Group, The Medical School, University of Birmingham]*