Micro-XANES analysis of metal accumulation in plants on sub-cellular level

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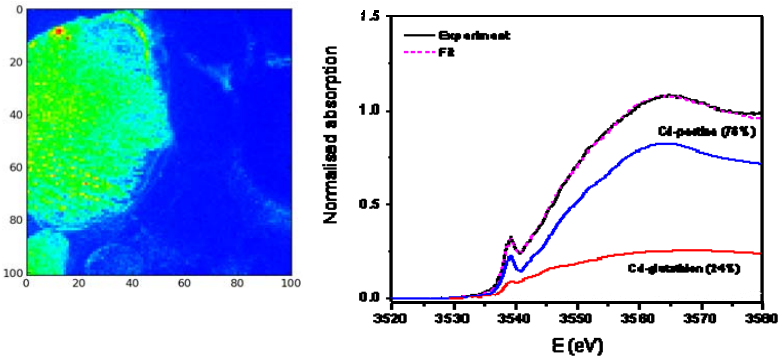
There is a growing need to develop powerful analytical tools for monitoring concentrations and chemical state of trace element in the biosphere and its abiotic environment, due to pollution and degradation of ecosystems worldwide. Increased metal concentrations present in the environment pose a threat to all living organisms from microorganisms and plants to animals and humans, because they interfere with vital biological processes. The goal is to efficiently assess metal bioavailability and toxicity, and gain more knowledge on the mechanisms of metal uptake, accumulation and detoxification in living organisms [1].

In this work we demonstrate that a combination of micro-XRF imaging and micro-XANES and EXAFS analysis represents a powerful and indispensable tool for characterization of metal pollutants on subcellular level. The methodological approaches for efficient micro-XAS experiments are presented, the limitations and sources of potential systematic errors in XANES and EXAFS analysis (especially at low energies) due to self-absorption effects and strong energy dependent penetration depth of X-ray beam in the sample are discussed. Some typical examples of such combined micro-spectroscopy analysis are selected from the following research fields: Cd/Zn hyper-accumulating plants, that can be used for phytoremediation of Cd/Zn polluted and degraded ecosystems, including investigation of the role of externally supplied sulphur compounds in the nutrient solution of the Cd/Zn hyperaccumulator *Thlaspi praecox*, that may alter leaf Cd distribution and Cd ligand environment [2]; biofortification, which aims to increase essential elements (Fe) concentrations in the edible plant parts [3]; microbial regulation of metal (Fe, Pd) uptake and formation of Fe-oxide and Pd nanoparticles, encapsulated in exopolysaccharide to avoid iron toxicity under anaerobic conditions, discovered on a strain of Klebsiella oxytoca, isolated from acid pyrite-mine drainage[4].



Micro-XRF imaging and micro-XANES measurements were performed at ID21 beamline of ESRF Grenoble (project EC-719). The results were complemented by EXAFS analysis on the level of plant organs at XAFS beamline of ELETTRA, (p. 20110086), and at A1 and C beamline of HASYLAB, (p. I-20110511 EC), supported by DESY and the EU FP7/2007–2013, CALIPSO grant agreement, no. 312284.

Figure 1: **Left:** Cd distribution in epidermal cells in leaves of hydroponically grown Cd hyperaccumulator *T. praecox* plants obtained by micro-XRF with lateral resolution of 0.7 μm on ID21 of ESRF. **Right:** Linear combination fit of Cd L_3-edge micro-XANES, measured on a selected spot in the cell, providing information on Cd complexation [2].

References

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