Imaging of Au nanoparticles within Cypress leaves using absorption edge radiography and micro-CT

[1]B. De Samber, [2]W. Schroeder, [3]C.G. Schroer, [4]G. Wellenreuther, [1]L. Vincze and [4]G. Falkenberg

[1]X-ray Microspectroscopy and Imaging (XMI), Ghent University, Krijgslaan 281 – S12, B-9000 Ghent
[2]Forschungszentrum Juelich, 52425 Juelich
[3]Institute of Structural Physics, TU Dresden, D-01062 Dresden, Germany
[4]HASYLAB at DESY, Notkestrasse 85, D-22607 Hamburg

Cyperus stems, to which 20nm Au nanoparticles were added to the transpiration stream, were analysed at the P06 Hard X-ray Micro/Nanoprobe by means of 1) absorption microtomography and 2) element-specific imaging by means of differential imaging above/below the L_3 absorption edge of Au (11900 eV). In plants, the transpiration stream is the uninterrupted stream of water, which is taken up by the roots and via the xylem vessels transported to the leaves.

Fig. 1 shows radiography images acquired with a PCO4000 high-resolution X-ray camera taken with (upper images) and without (lower images) the sample, above (left) and below (right) the Au-L_3 absorption edge. Field of view of the radiograph is 1.4 mm horizontally by 0.9 mm vertically. From the radiographs, artefacts in the scintillator/window are visible, as well as changes in beam intensity profile when changing the energy above and below the Au-L_3 edge.

Fig. 2 (upper images) shows the flat field corrected images of the *Cyperus* sample above (left) and below (right) the Au-L_3 edge. In both flat field corrected radiographs, the *Cyperus* stem tissue is clearly visible with the Au nanoparticle filled xylem stems having different intensities. Although most of the scintillator/window artefacts are removed from the flat field corrected image, intensity gradients in the beam profile are still present, which are caused by temporal changes in beam profile when acquiring the radiograph with and without the sample. Subtracting or dividing the flat field corrected images taken above and below the Au-L_3 edge clearly removes the *Cyperus* tissue and provides selective Au-imaging of the Au nanoparticle filled xylem stems.

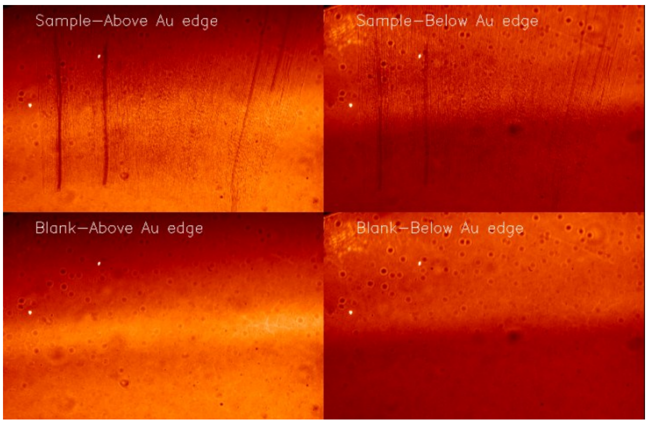

Fig. 1: radiography above/below edge, with/without sample.

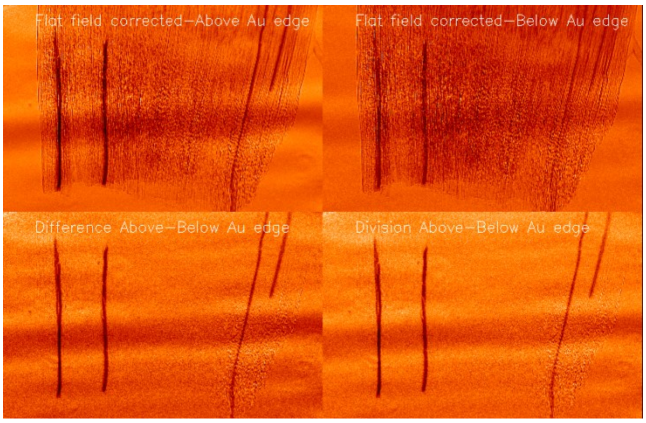

Fig. 2: flat field corrected radiographs above/below edge.

In Fig. 3 cracks in the Au nanoparticle filled xylem vessels can be observed in the subtracted flat-field corrected radiographs above/below the Au-L_3 edge. These could be artefacts of the shock-freezing and subsequent freeze-drying below the vitrification temperature of water. Fig. 4 shows a single cross-section of the *Cyperus* stem by means of absorption microtomography. In the cross-section, the bright areas indicate the xylem vessels filled with Au-nanoparticle solution.

From the results, it can be concluded that absorption microtomography combined with differential imaging above and below absorption edges is a powerful tool for tissue-specific localisation of metals within biological specimens. In principle, both techniques can be combined by performing absorption microtomograms at different energies.

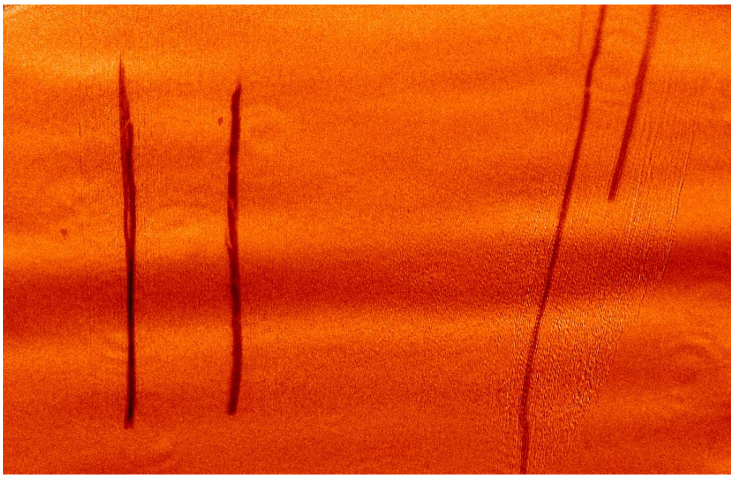

Fig 3: Flat field corrected images above and below Au-L3 edge

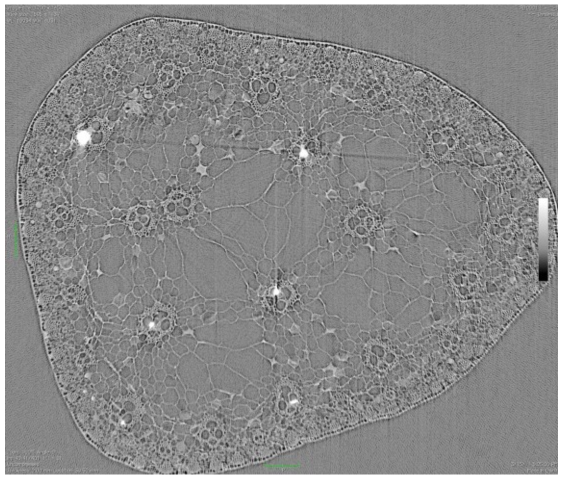

Fig. 4: absorption CT cross-section *Cyperus*