# Mapping of Arsenic in Fern Leaves

R. Underhill,[1] J. Culp,[1] R. Duran,[1] M. Davidson,[2] A. Michailova,[2] Y. Guyoda[3]

[1] *Department of Chemistry, University of Florida, Gainesville, FL, U.S.A.*

[2] *Department of Materials Science, University of Florida, Gainesville, FL, U.S.A.*

[3] *Department of Geology, University of Florida, Gainesville, FL, U.S.A.*

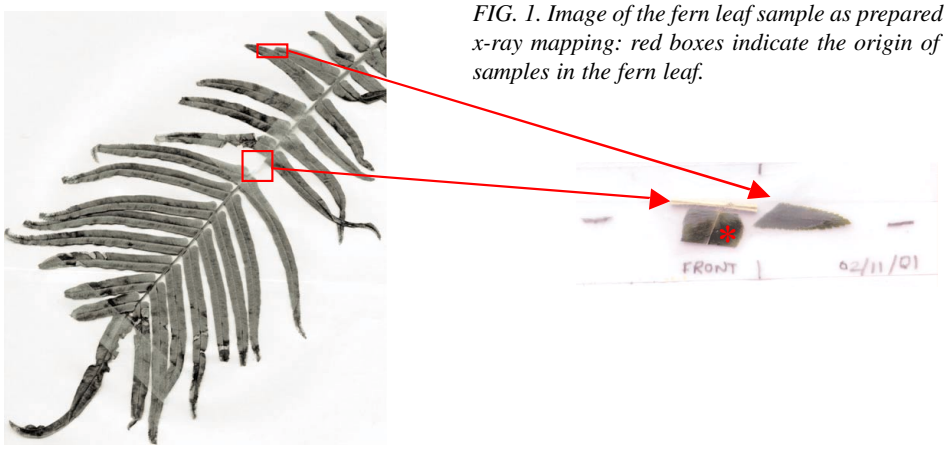


*FIG. 1. Image of the fern leaf sample as prepared for x-ray mapping: red boxes indicate the origin of the samples in the fern leaf.*

We investigated the spatial distribution of arsenic in fern leaves by mapping the As K-edge fluorescence signal with a 200 µm (vertical) x 200 µm (horizontal) x-ray beam. Once the distribution of As in fern leaves is known and different samples from different sites can be compared, one should be able to draw conclusions on As intake and storage and the possible application of fern leaves in phytoremediation of As-contaminated sites.

The fern leaves investigated were cut such that a 1.5-cm portion of the stalk and the leaf, as well as a 1.5-cm portion of the tip of the leaf, could be examined.

The sample was sandwiched between two pieces of Scotch tape and mounted in a sample holder at a 45º angle relative to the incident beam. The fluorescence was measured at a right angle to the incident beam. Measuring the extended x-ray absorption fine structure spectrum averaged over a large sample area showed a significant overall signal from arsenic in the sample. The experiment was then set up to scan the sample using a beam size of 200 x 200 µm, thus mapping the As content with sufficient resolution to follow the As distribution within separate biological units of the leaf (Fig. 1). The sample was scanned below the arsenic fluorescence edge (11,850 eV) and above the edge (11,950 eV). The difference in intensity of emitted fluorescence at a given area of the sample provides information as to where arsenic is present.

Maps of the distribution of arsenic within the selected parts of the fern leaf are shown in Fig. 2. The upper panel shows the raw As fluorescence with increasing degree of red color representing increasing As content. From the raw data, it appears as if the As were concentrated in the stem and veins of the leaf. However, stem and veins are much thicker than the flesh of the leaf and this must be taken into account by normalizing the measured As fluorescence to the local thickness. As a first estimate for this local thickness/density, we have measured the transmittance of x-rays with the same slit settings (see middle panel in Fig. 2: increasing degree of yellow color represents increasing transmittance).

Finally, the lower panel of Fig. 2 shows the fluorescence from As distributed in the selected parts of the fern leaf normalized to the local thickness/density. It can be seen that the arsenic (represented by the lighter areas) is concentrated in the flesh of the leaf near the stalk. Near the tip of the leaf, the arsenic also appears to be concentrated in the veins. We have shown the principal feasibility and benefit of As imaging of fern leaves and plan to further our studies by employing micro-focusing and by comparing ferns of different origin.

## Acknowledgment

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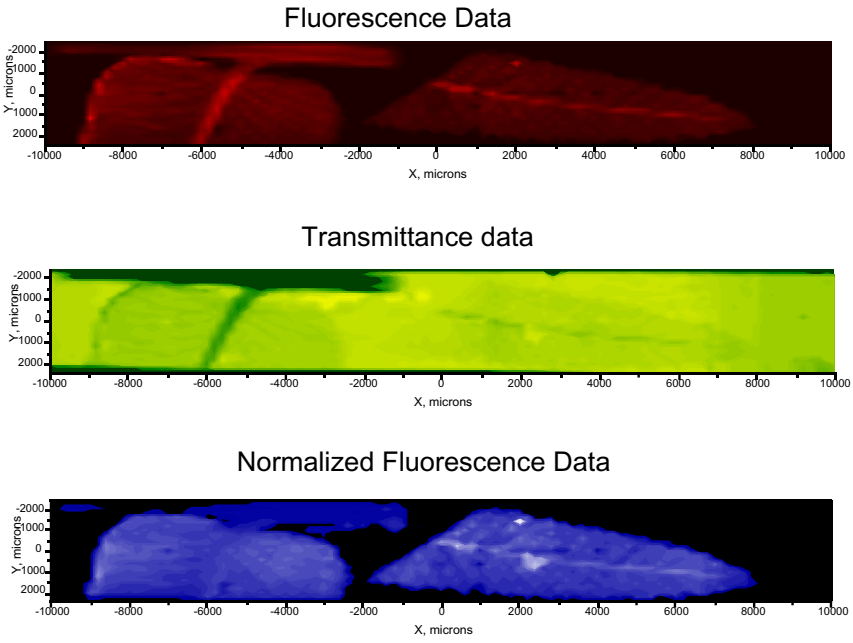


*FIG. 2. Upper panel: raw As K-edge fluorescence from selected parts of a fern leaf (a higher degree of red indicates higher As content). Center panel: thickness of the selected parts of the fern leaf as determined by measuring the transmittance of x-rays (a higher degree of yellow indicates higher transmittance). Lower panel: As fluorescence normalized to the local thickness, representing the relative distribution of As within different parts of the leaf (a higher degree of white indicates a higher As content).*