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PIXE Determination of Element Distribution in *Fomes fomentarius*

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ABSTRACT

Samples of the *Fomes fomentarius* have been collected in nature, together with bark and a piece of substrate wood. For PIXE analysis, slices have been cut from the fruit body. The slices have been analyzed by a proton beam at many points from the fruit body surface to the core, or across the fruit-substrate interface. The analysis has been performed by external proton beam in low pressure nitrogen atmosphere. Nine to twelve elements heavier than silicon have been found above the limit of quantitation. Chlorine and manganese have shown an interesting behavior.

Keywords: wood-rotting fungi, *Fomes fomentarius,* element distribution, external PIXE.

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1. INTRODUCTION

Accumulation of heavy metals in fungi is well known phenomenon. It was observed also in wood-rotting fungi [1 - 3]. Although uptake, transport and accumulation of heavy metals are interesting both from the point of view of wood-rotting fungi physiology and for wood preservation based on metal salts wood-protective fungicides, only little is known on elements distribution in fruit body and its interface with the fungus inhabited wood. To obtain information on many heavy elements present, PIXE analysis is quite effective way, collecting information of broad spectrum of elements simultaneously with rather high sensitivity. In such a way, using external microPIXE, profiles of several elements were obtained studying interaction between living xylem of sycamore and wood inhabiting fungi [4]. Because of fungus outgassing, it is not possible to use vacuum PIXE. We have used external PIXE arrangement [5] together with proton beam collimated to 1 mm diameter with target in low pressure nitrogen. We have studied well-known species of wood rotting fungus – *Fomes fomentarius.*

2. EXPERIMENTAL

Samples were prepared from fruit bodies taken together with bark from birches in Krc forest. The body was cut approximately across its central part by a rough saw at first and then a fine slices were cut across all the body, from hymenium or cortex through its core and tree surface layer by a fine machine scroll saw to obtain section as smooth as possible. A horsehair brush was used then to clean the cut carefully. Held by a flexible claws on a movable sample holder, the sample could be placed in front of the proton beam at points 1.7 mm distant along a line. Up to 20 points along the line could be analyzed by protons with energy 2.1 MeV at the target surface.
To avoid charging of the sample and the huge enhancement of continuous non-characteristic background of spectrum, the sample irradiation in a gassy environment of suitable density can be done. In Fig.1, spectra from the same sample of a fungus in low-pressure nitrogen are shown. In pressure of 2 Pa, charging is not yet compensated, however pressure 15 Pa is high enough to compensate the charging effect. To find a critical pressure for charging compensation, full spectrum area was

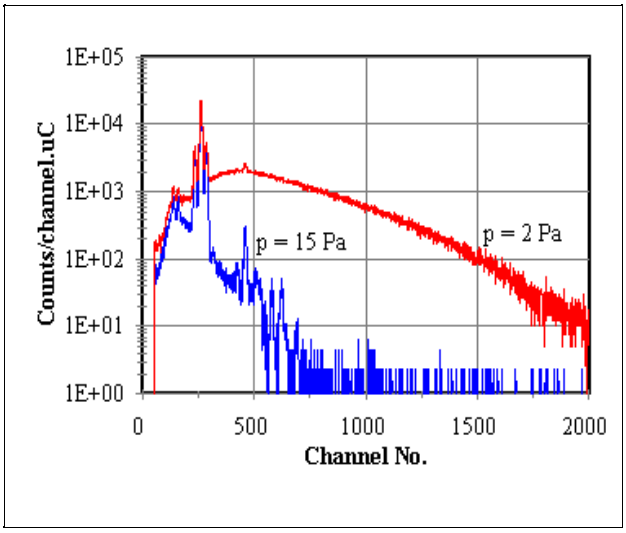

FIGURE 1. Spectra from the same sample, taken in N_2 atmosphere of 2 Pa or 15 Pa at the target.

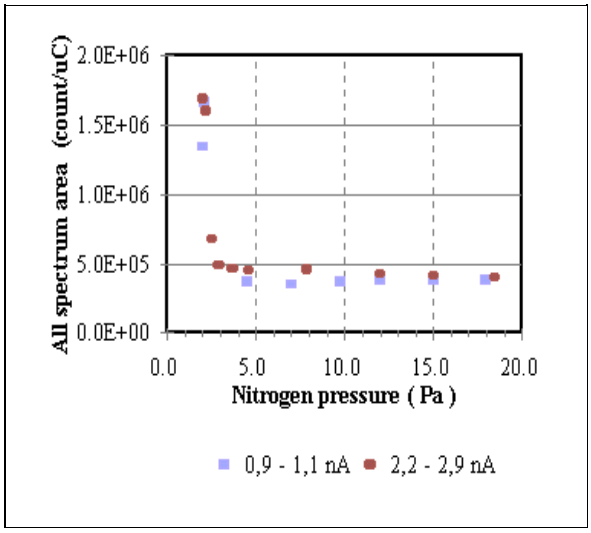

FIGURE 2. Full spectrum area as a function of N_2 pressure at the target.

measured depending on pressure of nitrogen at the sample. Fig. 2 shows, that between 2 and 4 Pa there was the critical pressure. During our measurements, the samples of fungi were analyzed with external proton beam in nitrogen atmosphere of pressure about 10 Pa. The charge of protons bombarding the sample was measured with the use of detection of the protons backscattered from the exit window foil [5]. The extraction of proton beam through the exit window foil results in its broadening due to straggling. However, we used only 1.5 μm thick Mylar foil, which does not scatter the beam too much. The ion beam current distribution at the target had an FWHM smaller than 1 mm when in vacuum beam had a diameter 1 mm. The ion beam current ranged from about 1 to several nA. No damage in the irradiated spots was observed; only sometimes the spot became slightly lighter.

The spectra obtained were evaluated as thick target with the use of GUPIX [6], with an assumption that matrix consisted of cellulose and chitin in relation 1 : 1. However, the results can be taken only as semiquantitative, because the analyzed area is smooth only from macroscopic point of view while microscopically is spongy and porous. Concentrations of elements heavier then silicon have been evaluated. In the following only elements with concentrations higher than limit of quantitation (LOQ) will be considered.

3. RESULTS AND DISCUSSION

Ten samples, taken from eight different fruit bodies of *Fomes fomentarius*, have been analyzed in many points on lines going through the fruit body and in several cases also through the interface of fruit body, tree bark and wood. Up to 24 elements heavier then silicon had been searched in the measured spectra and nine to twelve of them were found in concentrations higher than LOQ. Phosphorus, sulphur, potassium, calcium, manganese, iron, copper and zinc were present in all samples, in most of samples was chlorine and, in some samples, also titanium, nickel, barium and strontium were detected above LOQ.

Generally, the most abundant elements were potassium and calcium, in concentrations from some tenths to unit percent, with no strong variation. Phosphorus and sulphur were the second most abundant elements with concentrations typically on the level of hundreds to thousand ppm, not too variable. The other elements are present mostly in concentrations of about ten to hundreds ppm.

A remarkable behavior should be mentioned in the case of chlorine and manganese. In several samples, chlorine concentration was enhanced by an order of magnitude at the region of tree bark, between the mass of fruit body and the wood (Fig. 3). Manganese displayed in all samples the same behavior on the position in the fruit body: lower concentration in peripheral parts and maximum concentration in the region of core or at the interface fruit body – tree bark – swelled wood. In two samples, the manganese concentration maximum was even higher than the concentration of each of the other elements followed, and reached about half percent (see Fig. 3). On the other hand, iron concentration, typically of the order of

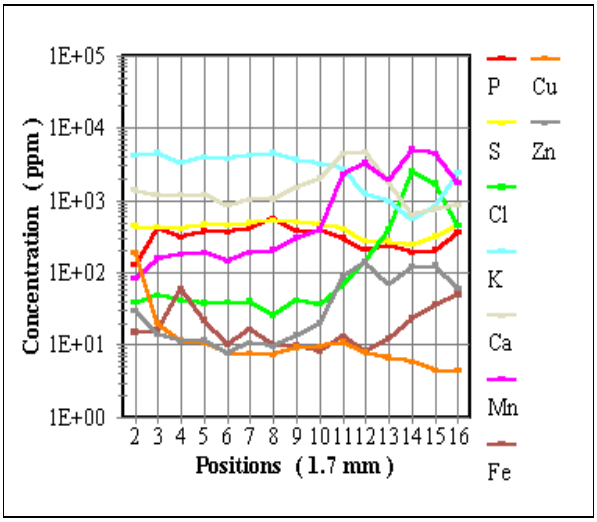

FIGURE 3. Composition along vertical line from cortex (left) through tree bark to wood.

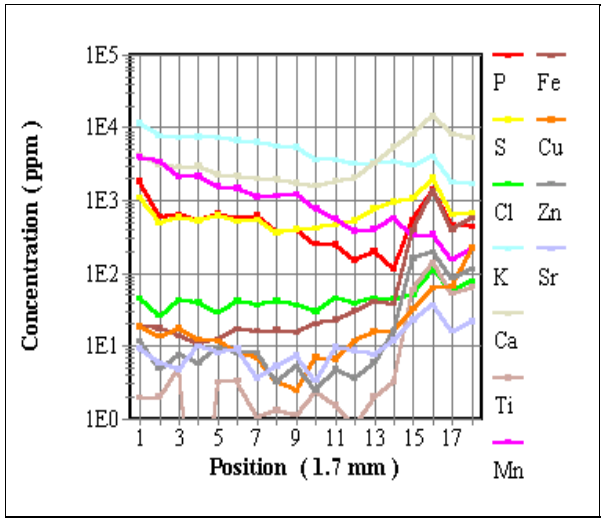

FIGURE 4. Composition along horizontal line from wood (left) to cortex (oblique to the line)

tens ppm, was not too variable through all the fruit body. Also other elements, titanium, copper, zinc, strontium and barium, did not displayed any remarkable systematic tendency in their concentrations behavior. In the case of a sample cut under small angle through cortex, possibility is indicated of an abnormal enhancement of trace elements in a thin surface layer, as can be seen in Fig. 4.

In our previous works, the content of heavy metals in fruit bodies of wood-rotting fungi was examined and significant differences between metal content (Cd, Cu, Al, Be, Pb, Zn) in fungi collected in clean and polluted industrial areas were found [2, 3]. In general, samples from polluted areas contained higher amounts of Pb, Cd, Cu, Al and Be, while zinc content was higher in fungi collected in clean sites.

In this work, the distribution of metals within fungal fruit body was studied with emphasis on Mn distribution. This element plays important role in wood decay by ligninolytic enzymes of white-rot fungi [7]. As it was found, concentration of Mn is highest in the core, the area that contains both hyphae and pieces of decayed wood. On the other hand, low concentrations of Fe, Cu and Zn were found in the core. The metals were expected to play a role in degradation of wood by non-enzymatic radical reactions (Fenton and Fenton-like). However, there is only limited information on the chemical form of the all metals mentioned (complexes with low-molecular compounds vs. proteins or peptides).

The distribution of elements in especially small fruit-bodies cannot be easy studied with either AAS or ICP-MS due to necessary amount of fungal biomass. The study has shown suitability and usefulness of PIXE analysis for studying element distribution of heavy elements in wood rotting fungi fruit bodies. This can help to understand transport and accumulation of inorganic elements in a living organism of such a kind.

ACKNOWLEDGEMENTS

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