SYNCHROTRON RADIATION AS A TOOL OF BIOCHEMICAL ANALYSIS IN BRAIN CANCERS

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The recent development of synchrotron radiation based microprobe beamlines has enabled spatially resolved XRF (X-ray fluorescence), XANES (X-ray absorption near edge structure spectroscopy) and FTIRM (Fourier transform infrared microspectroscopy) at cellular and subcellular level. Synchrotron radiation XRF (SR-XRF) microprobe analysis as a multielemental analytical method was applied to simultaneous imaging of chemical elements in human brain tumors. Micro-XANES technique which gives information primarily about geometry and oxidation state was used to determine the chemical state of Fe and S in brain gliomas. FTIRM that provides direct information on the molecular composition of the tissue was applied to determine organic composition of brain cancers. The SR-XRF and Fe XANES measurements were performed at the bending magnet beamline L at HASYLAB. Micro-imaging of sulfur oxidation states using XANES measurements was carried out on beamline ID21 at ESRF. FTIRM measurements were performed on SMIS beamline at the synchrotron SOLEIL.

The SR-XRF research allowed detection of P, S, Cl, K, Ca, Fe, Cu, Zn, Br and Rb in human brain tumors. The topographic analysis enabled to determine two-dimensional distribution of elements in characteristic tissue structures in case of cancerous tissues. The Fe XANES analysis in selected points of the tissue showed that all the XANES spectra obtained for the brain glioma samples are situated between the spectra measured for reference materials containing Fe in the second and third oxidation state (Fig. 1). However, taking into account inhomogeneity of the tissue structure the knowledge based on the results from random points seems to be insufficient. Therefore, the micro-imaging of iron oxidation states were performed. The mapping of different chemical form of iron allowed finding areas were bivalent or trivalent iron compounds were dominant.

The results of S XANES analysis showed that cancer cells accumulate sulfur mainly as sulfide (S2-) form. The preliminary results indicated also higher accumulation of this form of sulfur in glioma of IV grade of malignancy in comparison with the samples of II grade neoplasms. The presence of sulfate (S+6) species was revealed in histological structures outside the cancer cells. The sulfite (S+4) form of sulfur was not detected in the scanned areas of tissue.

In the FTIRM the tissue areas were mapped to generate two-dimensional images of the main biological molecules of interest. Integrated intensities of selected bands were extracted after raster scanning of the sample. The obtained IR maps were compared with the microscopic view of the slices prepared previously for histopathological examination. It allowed determining biochemical composition of the structures of different types of cancerous tissue. The preliminary studies showed differences in biomolecular composition between the studied cases of brain tumors. It will be used in the future (when statistically reliable number of samples will be investigated) to identify biological molecules typical for various types of brain cancers.

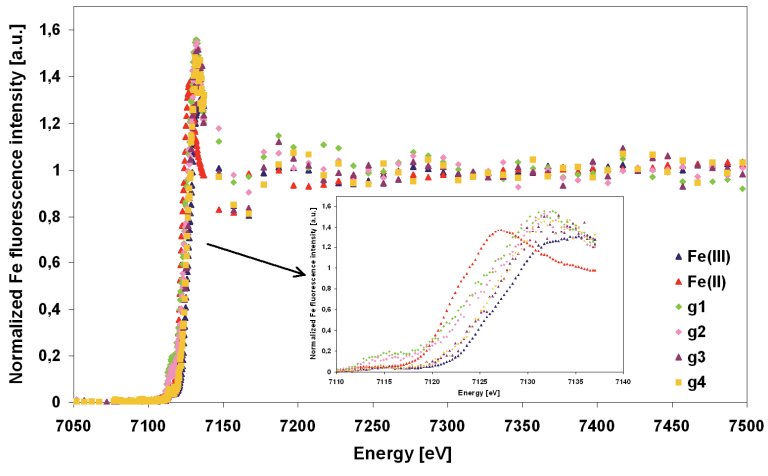

Figure 1. The Fe XANES spectra different cases of glioma tissues (g1-g4) and reference materials.

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