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X-ray fluorescence imaging in toxicology

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Atomic transitions in elements, including Mn, Fe, Cu, Zn, Pb relevant in toxicology can be excited upon interaction with X-rays in 10-13 keV energy range. Recording resulting X-ray fluorescence (XRF) with high spatial resolution results in quantitative images of metal ion distributions in tissue sections. Different X-ray focusing optics allows for tissue level imaging (5-20 micron) resolution or subcellular level imaging (30-200 nm) of distributions of biologically relevant (Fe, Cu, Zn) and toxic (Mn, Pb). Development of beamlines with high X-ray photon flux at 3rd generation synchrotron sources allows to obtain high resolution XRF maps of ppm amounts of elements in thin tissue sections. Using XRF, we studied Mn distribution in rat model of occupational Mn exposure. We found that globus pallidus and substantia nigra compacta are areas in the brain that accumulate most Mn. Imaging the Mn distribution in dopaminergic neurons, we determined that intracellular Mn range between 40–200 micromolar; concentrations as low as 100 micromolar have been observed to cause cell death in cell cultures. This is a first direct link between Mn exposure and Parkinson's disease. We have previously reported localized Cu-rich aggregates in astrocytes of the subventricular zone in rodent brains with Cu concentrations in the hundreds of millimolar. Based on a [S]/[Cu] ratio and X-ray absorption spectroscopy, metallothionein is proposed as a binding protein. An analysis of metallothionein (1,2) knockout mice by XRF will be presented.

Biography

Yulia Pushkar has completed her PhD in Biophysics at Freie Universität Berlin, Germany and Post-doctoral studies at University of California, Berkeley & Lawrence Berkeley National Lab. She is an Associate Professor of Physics and has published over 60 research articles including these in Science, Nature, Journal of American Chemical Society and PNAS.

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