Two-dimensional μXAFS for uranium in kidney of rats exposed to uranyl acetate

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Introduction

The uses of uranium in the nuclear industry and military applications have led to growing public concern over its health effects. Renal toxicity is a hallmark of uranium exposure. The site-specific accumulation of uranium in the S3 segments of the renal proximal tubules has been demonstrated to be characteristic during uranium renal toxicity[1, 2]. But the details of cellular localization of uranium and its chemical condition in kidney have not been well understood. In the present study, SR-μXRF and two-dimentional μXAFS were applied for renal section specimens to investigate intracellular behavior and chemical form of uranium in the proximal tubules in kidney.

Experimental

Uranium acetate was dissolved in saline and administered to Wistar male rats (10 weeks old) by subcutaneous injection of 0.5 mg kg^{-1} body weight. The animals were sacrificed at 1 day after administration and the kidneys were removed. Frozen kidney sections (in 10 μm thickness) placed on polypropylene film were used for the measurements. SR-μXRF and μXAFS measurements were performed at BL37XU, SPring-8, Japan, using an energy dispersive SR-XRF system[3]. Quantitative analysis of uranium in micro-regions was performed using thin section standards of uranium for microbeam analysis (10 μm; 0-500 μg/g) [4]. Uranium maps in kidney were obtained by SR-μXRF and then the uranium accumulated areas (3×9 μm^2) in the epithelium of the proximal tubules were further analyzed by two-dimensional μXAFS with 1×1 μm^2 resolution.

Results and Discussion

Uranium was distributed in the proximal tubules in the inner cortex and the outer stripe of the outer medulla with highly concentrated uranium in micro-regions near the nuclei (50-fold above mean uranium concentration). U L_{III}-edge XAFS spectra of each measurement point in the uranium accumulated areas indicated the alternation of oxidation state and chemical condition of uranium in the micro regions after uranium exposure.

Two-dimensional μXAFS for tissue specimens would be powerful technique for toxicological studies of uranium and the chemical information with high resolution would provide new insights for reducing renal uranium toxicity and effective decorporation of accumulated uranium from the kidneys.

References

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