ROBL-CRG	**Experiment title:** **EXAFS investigation on uranium uptake by plants**	**Experiment number**: 20_01_030
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Report:

Experimental: To obtain first results on the change of uranium speciation during the soil-to-plant transfer, we have investigated the uranium uptake by lupins. The uranium speciation were investigated in dependence on the growth-conditions and the pieces of the plants. The three different growth-conditions were a) soil culture without uranium (injection of $2.5 \cdot 10^{-2}$ M $UO_2(NO_3)_2$ in roots or shoot axis), b) soil culture (1 g U(VI) in 1 kg soil) and c) hydroponics ($2.5 \cdot 10^{-2}$ M $UO_2(NO_3)_2$). After harvesting for case a, b and c, the lupins were washed, separated into roots, shoot axis and leafs, and cut in small pieces. The U L_{III}-edge EXAFS spectra of the dried samples were recorded in fluorescent mode using a 4-pixel germanium detector.

Results and discussion: The raw L_{III}-edge k^3-weighted EXAFS spectra of the samples 1-8 and their corresponding Fourier transforms are shown in Fig. 1 and the fit results with the experimental conditions in Tab. 1. According the results in Tab. 1 the average radial U-$O_{ax.}$ distance between U(VI) and the axial oxygen atoms is 1.79 Å. The data are mainly influenced from the changes in the radial U-$O_{eq.}$ distances between U(VI) and the equatorial oxygen atoms and the coordination number of the equatorial oxygen atoms (Tab. 1).
If one consider that two different U-$O_{eq.}$ distances determine the data then a simple cluster analysis can show the dependencies between the uranium speciation in different pieces of plants and the growth-conditions. If the U-$O_{eq.}$ distances of 2.29 ± 0.02 Å and U-$O_{eq.}$ distances equal or greeter than 2.36 ± 0.02 Å are characteristic for bonding type A and B then the experimental conditions can arranged like Tab. 2.

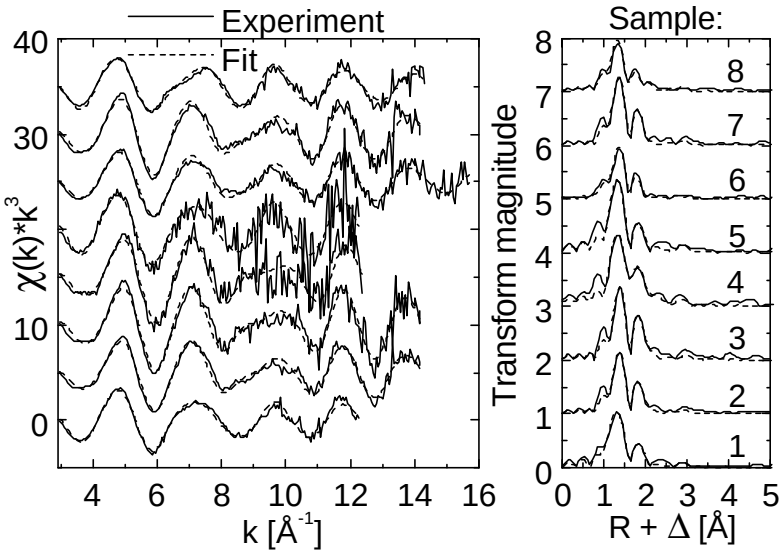

Fig.1: Raw L_{III}-edge k^3-weighted EXAFS spectra of the plant samples (left) and their corresponding Fourier transforms (right)

Tab. 1: EXAFS structural parameters of the plant samples with different preparation conditions.

Sample	preparation	$U\text{-}O_{axial}$		$U\text{-}O_{equatorial}$		
		R	$\sigma^2 \cdot 10^{-3}$	N	R	$\sigma^2 \cdot 10^{-3}$
1	i, root	1.783(2)	2.7(1)	4.4(5)	2.359(7)	12(1)
2	i, shoot axis	1.793(2)	1.6(1)	2.8(2)	2.295(4)	4.5(5)
3	s, root	1.794(2)	0.8(2)	3.5(3)	2.289(4)	3.5(6)
4	s, shoot axis	1.783(5)	1.2(3)	4.0(6)	2.268(8)	4(1)
5	h, root	1.786(7)	0.8(4)	6(2)	2.36(2)	15(5)
6	h, shoot axis	1.787(2)	1.9(1)	2.8(4)	2.310(7)	7(1)
7	h, leaf	1.788(2)	1.2(1)	3.9(4)	2.297(6)	6.1(8)
8	h, i, root	1.779(2)	2.4(1)	3.6(5)	2.412(8)	11(2)

i – injection, s – soil culture, h – hydroponics, N - coordination number, R - radial distance in Å with an uncertainly of ± 0.02 Å, σ^2 - Debye-Waller factor in $Å^2$, the standard deviations are given in parenthesis.

Tab. 2: The bonding types A ($R_{U\text{-}Oeq.}$ = 2.29 ± 0.02 Å) and B ($R_{U\text{-}Oeq.}$ ≥ 2.36 ± 0.02 Å) in dependence from the experimental conditions for the samples 1-7.

growth-conditions	root	shoot axis	leaf
hydroponics ($2.5 \cdot 10^{-2}$ M $UO_2(NO_3)_2$)	B	A	A
soil culture (1 g U(VI) in 1 kg soil)	A	A	-
injection ($2.5 \cdot 10^{-2}$ M $UO_2(NO_3)_2$)	B	A	-

From Tab. 2 one can obtain that the bonding type A is characteristic for the shoot axis and is independent from the growth-conditions. The root and the shoot axis show bonding type A if the plants were grown as soil culture. For the root the bonding type change dependent on the growth-conditions. Bonding type B is also characteristic for sample 8 (hydroponics and additional injection of U(VI)). In case of the bonding type A the average coordination number of 3-4 equatorial oxygen atoms and the short average bond distance of 2.29 Å corresponds to the expected structural parameters observed for uranyl phosphates /1/.

References

/1/ Hennig, C., et al., Radiochimica acta, accepted (2000)