Determination of Uranium in Groundwater Samples by Photon Electron Rejecting Alpha Liquid Scintillation Spectrometry

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Abstract

The activity determination of uranium in groundwater samples have been performed by photon electron rejecting alpha liquid scintillation spectrometry(PERALS). It has advantage of fast sample preparation and good sensitivity. For the analysis of uranium, extractive scintillation cocktail solution URAEX^{TM} was used. The extraction efficiency was evaluated under different chemical conditions including pH and sulfate concentration. The activity ratio of ^{234}U to ^{238}U was investigated some groundwaters in granite region and the results show ratio variance from 0.87 to 1.40.

Introduction

Uranium concentration and ^{234}U to ^{238}U activity ratios in environmental water samples are important in constructing the geochemical balance of these radionuclides and understanding their behavior in the environment, and also concerned with radiation safety and monitoring.

In a closed system, most uranium daughters grow into secular equilibrium with parent, so the daughter-parent activity ratio becomes unity. However, groundwater and geothermal waters are not closed systems and interact with the solid phases with which they come into contact. Different geochemical behaviors of the radionuclides lead to significant radioactive disequilibria in these waters and sometimes in the associated solids. In ground waters, the $^{234}U/^{238}U$ activity ratio is generally greater than unity. Such disequilibrium is a consequence of phenomena induced by alpha recoil, involving preferential oxidation or solution of ^{234}U relative to ^{238}U. Both thermodynamic and kinetic factors play a role in creating and maintaining the disequilibria.

For the determination of uranium, several techniques are usually used. These techniques include radiochemical method, fluorometry, mass spectrometry etc. Among those techniques, radiochemical method and mass spectrometry could determine radionuclides. The mass spectrometry could provide high sensitivity, but its

high cost and complex sample treatment made difficult to use the equipment to the environmental samples. And also, alpha spectrometry using semiconductor detector is another sensitive technique, but it has complicated sample preparation procedures. Recently, alpha liquid scintillation by PERALS® spectrometry provides an attractive method for measuring alpha emitting nuclides.

In the present work, uranium in granite groundwater samples was extracted using URAEX™ extracting cocktail solution and determined by PERALS® spectrometry and also ICP-MS was used. The extraction efficiency was investigated some different chemical conditions. And $^{234}U/^{238}U$ ratio in granite region grounwater was examined..

Experimental

The photon electron rejecting alpha liquid scintillation spectrometer(model 8100) is a apparatus produced by Ordela Inc.(Oak Ridge, TN). It is based on the use of liquid-liquid extraction by extractive scintillation cocktail. And the extractive scintillator URAEX are supplied by ETRAC(Oak Ridge, TN). It contains tertiary amine as extractant, naphthalene and 2-(4-biphenylyl)-6-phenyl-benzoxazole(PBBO) as scintillator in tolune solvent. Uranium was selectively extracted in 100 ml pyrex bottle according to the fig. 1. procedure. And the extraction efficiency was investigated about pH 0.1 to 7 and 0.01 to 1 M sulfate concentration.

Results and Discussion

For uranium analysis in groundwater samples, the samples were acidified about pH 1 with 1N HNO_3 solution. And the samples were analyzed with ICP-MS and alpha liquid scintillation spectrometer. The analytical results were shown in Table 1. The analytical results of $^{234}U/^{238}U$ activity ratios in granite groundwater samples were different with the sampling site. It reflects different geological environment and water rock interaction.

Reference

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Sample Water (100*ml*)

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Add H_2SO_4, adjust pH 1

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Add 0.1M Na_2SO_4

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Add URAEX scintillator(1.5 *ml*)

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Agitate 5 *min* with magnetic stirrer

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Transfer 1 *ml* organic phase to counting cell

↓

Ar purging for 2 *min*

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Counting with PERALS

Fig. 1. The diagram of uranium analysis procedure.

Table 1. Analytical results of uranium in groundwater samples.

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Sample	U content(ppb)	U activity(*pCi/L*)	$^{234}U/^{238}U$ activity ratios
1	43.4	22.1	1.12
2	23.8	15.8	1.40
3	215	138.2	1.02
4	23.9	13.7	1.23
5	35.8	30.8	0.87
6	77.3	47.3	1.08
7	33.8	21.2	1.29
8	18.8	11.6	1.07