ON THE UTILIZATION OF DINONYL NAPHTHALENE SULFONIC ACID FOR THE DETERMINATION OF ENVIRONMENTAL URANIUM CONCENTRATION IN AIR, SEA WATER, AND SOIL

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I INTRODUCTION

The dinonylnaphthalene sulfonic acid (HD) forms micelles in non-polar organic solvents, and can be used as an analogues of cross-linked resinous strong acid cation-exchangers. Since HD shows strong extraction of metals from the aqueous phase to the organic phase, it has been used by the authors in bio-assay studies for the determination of gross alpha activity in urine.¹⁾ Based on this experience the HD has again been studied for the determination of uranium concentration in environmental samples which will be described below.

II EXPERIMENTAL

Air sampling was performed on the rooftop of a two-storey building which houses the offices and laboratories of Tsing Hua Open-pool Reactor (THOR) at Hsinchu (120°58' E, 24°48' N) by means of a low volume air sampler. The filter was changed once in a week. Soil samples were taken from the surface

and from a depth of 30—50 cm below the surface at the location of interest around THOR. Rocks and foreign material such as leaves were excluded. Sea water samples were taken from the surface along the sea shore of the power reactor site which is under construction in North Taiwan.

The dusty filter paper and the dry powdery soil were dissolved in and the sea water was diluted with 10 cm³ of 9.4 N perchloric acid, respectively. A few milligrams of soil, a few milliliters of sea water, and one dusty filter paper were needed for analysis. The extraction yield of uranium can reach 90%, and was determined through various concentrations of perchloric acid versus extraction yield with known quantity of uranium as tracer.¹⁾ Then the 8×10⁻³ F solution of HD in *n*-hexane was added to extract back the uranium to the perchloric acid with an extraction yield of about 85%.

The extraction yield is a function of perchloric acid. An extraction yield of 90% can be reached at either high (>2 N) or low (<2 N) acidity. However, in practice low acidity (<2 N) is preferred. The extraction yield is also a function of HD concentration in *n*-hexane. Therefore, the HD solution was limited to 8×10⁻³ F.

Little shaking time will extract 80% of the uranium, and so is the settling time. In practice a few minutes are enough.

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Table 1 Uranium concentration in air.

Sample No.	Sampling time	Concentration (g/liter)	S.D. (%)
F-1	73.7.3—73.7.7	4.43×10^{-14}	9.1
F-2	73.7.7—73.7.13	3.37×10^{-14}	4.4
F-3	73.7.13—73.7.18	4.36×10^{-14}	4.8
F-4	73.7.18—73.7.25	3.42×10^{-14}	7.2
F-5	73.7.25—73.7.26	3.92×10^{-14}	3.8
F-6	73.7.26—73.7.27	4.42×10^{-14}	7.5

S.D.=standard deviation.

Table 2 Uranium concentration in sea water.

Sample No.	Location	Concentration (g/liter)	S.D. (%)
S-1	23°22' N 120°08' E	1.17×10^{-5}	8.2
S-2	23°08' N 120°10' E	1.27×10^{-5}	1.9
S-3	24°30' N 120°40' E	5.18×10^{-6}	2.5
S-4	24°07' N 120°25' E	1.06×10^{-5}	8.9
S-5	24°50' N 120°53' E	5.32×10^{-6}	5.0
S-6	25°15' N 121°45' E	1.25×10^{-5}	9.4

Table 3 Uranium concentration in surface soil.

Sample No.	Concentration (g/g soil)	S.D. (%)
S-2A	1.262×10^{-6}	2.4
S-3A	1.618×10^{-6}	7.4
S-4A	6.007×10^{-7}	6.5
S-5A	1.131×10^{-6}	5.3
S-7A	7.950×10^{-7}	5.8
S-8A	5.300×10^{-7}	5.8

Table 4 Uranium concentration in soil of 30 cm depth.

Sample No.	Concentration (g/g soil)	S.D. (%)
S-4B	4.417×10^{-7}	6.7
S-5B	5.194×10^{-7}	3.4
S-7B	1.413×10^{-7}	8.0
S-8B	3.109×10^{-7}	9.4
S-21B	2.297×10^{-7}	7.5
S-23B	3.251×10^{-7}	2.2

A fluorometer of reflection type by Jarrell Ash Co. was used to detect the fluorescence from the trace amount of uranium in the environmental samples. Little amount (0.1 cm^3) of organic phase was pipetted into a platinum dish, and 0.4 g fusing agent containing sodium fluoride (98%) and lithium fluoride (2%) was added. The fusing time was 2.5 min at $850^\circ\text{--}900^\circ\text{C}$, and the cooling time was 25 min after fusion.

Calibration curves for three different types of environmental samples were obtained by adding the known concentrations of U_3O_8 to the filter paper, deionized water, and soil, respectively. The determination range was from 3.37×10^{-4} to 4.43×10^{-14} g/liter for air sample.

III RESULTS AND DISCUSSION

The experimental results with a sample size of six along with 1 S.D. in percentages for different environmental samples were listed in **Table 1, 2, 3** and **4**.

Similar determinations by different methods have also been carried out in this laboratory, *e.g.*, the application of fission track etching process for the determination of low level uranium concentration in

liquids and aerosols,²⁾ and the application of gamma-ray spectrometry method for the determination of uranium in soil.³⁾ All these methods show consistent results *e.g.*, sample S-2A of **Table 3** was $1.262 \times 10^{-6} \pm 2.4\%$ g/g soil by HD extraction, and was $1.360 \times 10^{-6} \pm 2.5\%$ g/g soil by gamma-ray spectrometry method. However, the fluorometric method with HD as the extractant proves to be the simplest yet most efficient one which can be employed in daily routine survey of uranium concentration in environmental samples, since little shaking time and settling time of about 4 min each will extract 80% of the alpha-emitters such as uranium, thorium, and plutonium as described in the authors' previous report.¹⁾

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