DNAA Application for the Collected Environmental Samples

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1. Introduction

Due to its simple, fast and accurate analytical features, delayed neutron activation analysis (DNAA) has been applied to assay total U mass fraction as well as screen fissile nuclides such as ^{235}U and ^{239}Pu in a variety of samples [1-4]. Uranium can be present in water, air, food, and feed in varying concentrations through leaching from natural deposits such as soil or rocks, emission from the nuclear industry and the combustion of coal and other fuels. In this study, DNAA was applied for the determination of U mass fraction in environmental samples such as soil, sediment, sewage sludge and ashes from an incinerator and a coal power plant.

2. Experiments

2.1 DNAA System

PTS #2 to irradiate a sample rabbit for both INAA and DNAA consists of an automatic irradiation and counter system, which is operated by a programmable logic controller (PLC) and a personal computer connected with electronic signal processing equipment coupled to eighteen He-3 proportional counters for the measurement of delayed neutrons. The eighteen detectors are placed in one concentric ring around the flight tube and encompassed by the polyethylene moderator. The +1350V of bias is applied, and the detectors were divided into three groups with six detectors. Total counts from each detector group are acquired from a 3-channel scalar.

2.2 Delayed Neutron Counting with U Mass

NIST SRMs which have the certified value of U were irradiated with PTS #2 for 60s, decayed for 20s, and counted for 60s. This analytical condition has been known as the most effective one in order to minimize interferences from undesired nuclear reactions. The NIST SRMs used were 1632C-Bituminous Coal (U certified value: 0.513±0.012 mg/kg), 1633a-Coal Fly Ash (U certified value: 10.2±0.1 mg/kg), and 2704-Buffalo River Sediment (U certified value: 3.13±0.13 mg/kg). More than 30 blank rabbits were tested for the identification of background counts under the same condition. The range of background counts was from 323 to 397, and their average was 364±28 counts.

2.3 Environmental Samples

Environmental samples like river sediment and bottom ash from a municipal incinerator were collected and the history for these two samples was explained in published papers [5, 6]. Meanwhile, ash samples from a coal power plant located on the west coast of South Korea and a soil sample from a site (Boryeong city) in the vicinity of the plant were collected and prepared in 2007. Finally, a sewage sludge sample was collected from a sewage disposal plant located in Nonsan city in 2008. The collected samples were dried in an oven for one to three days at 60~100 ^{o}C and prepared by pulverization with an agate mortar (12-950C, Fisher). The amount of the samples used for DNAA was about 200 mg, and the analytical condition was the same as that of the NIST SRMs.

3. Results and Discussion

3.1 Correlation between Counts and Uranium Mass

The results of the delayed neutron counts with the uranium mass of NIST SRMs are shown in Table 1. The range of the U mass was 51.5 ng ~ 740 ng, and the corresponding net counts were 280 ~ 3685. The correlation between counts and U mass is plotted in Figure 1. It turned out that 5.06 delayed neutrons per ng of U were detected and a correlation coefficient is satisfactory as a result of the linearity test.

Table 1: Delayed neutron counts with U mass of NIST SRMs

NIST SRMs	Sample wt. [mg]	U mass [ng]	Net counts
SRM1632C	100.36	51.5	280
	200.15	102.7	556
	300.02	153.9	850
SRM2704	50.20	157.1	824
	100.29	313.9	1620
	200.15	626.5	3213
SRM 1633a	72.94	744.0	3685

3.2 Analytical Results of U in Environmental Samples

The analytical results of U mass fraction in the environmental samples are summarized in Figure 2. Among the six kinds of environmental samples, the bottom ash from a municipal incinerator has the lowest U mass fraction, 1.41±0.11 mg/kg, and fly ash from a coal power plant and sewage sludge have a high U mass fraction of around 8 mg/kg. As it is well-known, the U

concentration of surface soil varies with geological characteristics and industrial activities. From this viewpoint, this study has demonstrated that DNAA can be effectively applied to monitor or to survey the U concentration in various environmental samples as a very fast and reliable analytical technique.

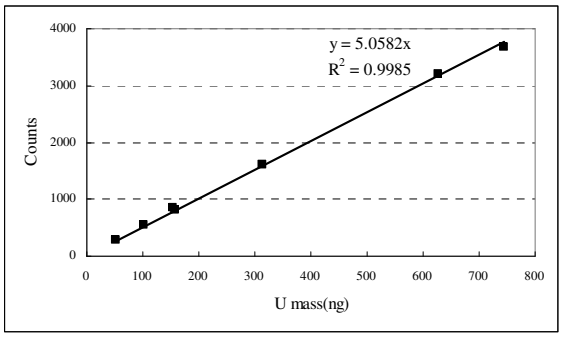

Fig. 1. Correlation between delayed neutron counts and U mass.

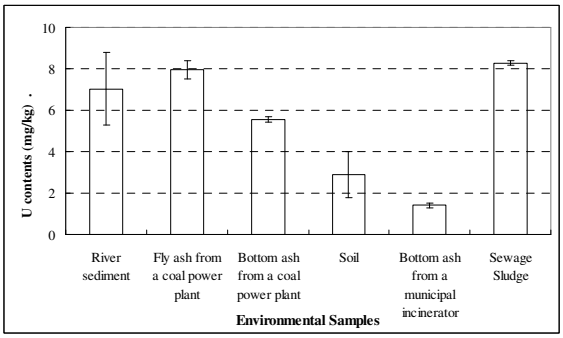

Fig. 2. Delayed neutron counts with U mass of NIST SRMs

4. Conclusion

A DNAA system has been implemented at the HANARO research reactor of KAERI in 2007. Three kinds of NIST SRMs were used to determine the counts of delayed neutrons corresponding to U mass under fixed analytical conditions such as irradiation for 60s, decay for 20s and counting for 60s. On the basis of the results, in terms of a correlation between the counts and U mass, six kinds of environmental samples were analyzed by DNAA. Sewage sludge have the highest U mass fraction. Due to its lower detection limit, DNAA will be applied for the analysis of U in biological samples as well as environmental samples.

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