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Measurement of Neutron Spectrum Parameters for the NAA#1 and #2 Irradiation Holes at the HANARO Research Reactor

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1. Introduction

Pneumatic Transfer System (PTS) for a neutron activation analysis was newly installed for the safe irradiation of samples at the beginning of 2007. The structural design for PTS #1 was modified and PTS #2 was newly implemented. NAA #1 and NAA #2 irradiation holes for a sample irradiation are interfaced with PTS #1 and PTS #2, respectively. In order to perform a thermal neutron activation analysis with an absolute method, neutron spectrum parameters such as α and *f* for the irradiation holes should be measured for estimating an interfering effect from epithermal neutrons. In this study, the parameters of the NAA #1 and #2 irradiation holes were measured by using Cd-ratio triple monitor methods.

2. Experimental

2.1 Irradiation and Measurement of Monitors

Because the neutrons of the NAA #1 and NAA #2 irradiation holes of the HANARO research reactor are thermalized well, there is only a small fraction of epithermal neutrons when compared to the thermal neutrons ($R_{Cd,Au} > 50$). In this case, the radioactivities induced by the epithermal neutrons in the (n,γ) reactions are very low and then can be overlapped by the statistical fluctuations of the ones induced by thermal neutrons. Therefore, the Cd-ratio method[1,2] should be applied to determine the α and *f* parameters. Four sets of monitors consisting of pieces of Zr sheet (99.7329%, thickness 0.125 mm), Au-Al wire(Au 0.1124%, dia. 0.508 mm), and a pure cadmium cover(thickness 1.0 mm), were used. Each monitor set with and without a cadmium cover was irradiated for 5 minutes. The calibrated gamma-ray spectrometer and GammaVision 5.1 software(EG & G ORTEC) were used for the gamma-ray measurement.

2.2 Calculation of α and f Parameters

The Cd-ratios were determined by the three nuclides of ^{198}Au, ^{97}Zr/^{97m}Nb & ^{95}Zr for three sets of the monitors that are irradiated using NAA#1 and NAA#2. Table 1 shows the relevant nuclear data that were used in this work. Table 2 shows the determined Cd-ratios for three nuclides for NAA#1 and NAA #2 irradiation holes.

Table 1. Nuclear data for Cd-ratio method

Monitor	Effective Resonance Energy, (eV)	Q_0	Gamma Energy (keV)	$k_{0,Au}$
^{197}Au(n,γ)^{198}Au	5.65	15.71	411.8	1 (F_{cd} = 0.991)
^{96}Zr(n,γ)^{97}Zr/ ^{97m}Nb	338	248	743.3	1.30E-05
^{94}Zr(n,γ)^{95}Zr	6260	5	724.2 756.7	9.32E-05 1.15E-04

Table 2. Cd-ratios of three nuclides for NAA #1 and #2

Monitor	^{198}Au	^{97}Zr	^{95}Zr
NAA #1	54	7.65	348
NAA #2	102	14.06	560

The values of the α and *f* parameters were calculated using the following equations

$$\log \frac{(\overline{E}_{r,i})^{-\alpha}}{(F_{Cd,i} \cdot R_{Cd,i} - 1) \cdot Q_{o,i}(\alpha) \cdot G_{e,i} / G_{th,i}}$$

$$\text{versus} \quad \log \overline{E}_{r,i}$$

$f = (F_{Cd} R_{Cd} - 1)\, G_e\, Q_0(\alpha)/G_{th}$

where i denotes isotope 1,2, …. N.

$\overline{E}_r$: effective resonance energy in eV,

G_e : correction factor for epithermal neutron self-shielding,

G_{th} : correction factor for thermal neutron self-shielding,

Q_0 : resonance integral over thermal cross section ratio,

F_{Cd} : cadmium transmission factor for epithermal neutrons, and

R_{Cd} : cadmium ratio.

3. Results and Discussion

The measured α values for NAA #1 and #2 were 0.124 and 0.097, respectively. These results are shown

in Figure 1 and Figure 2. The slope in Figures indicates negative α values.

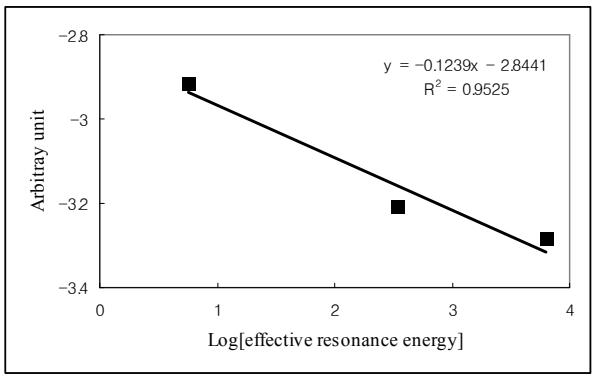

Figure 1. The result of α determination for NAA #1

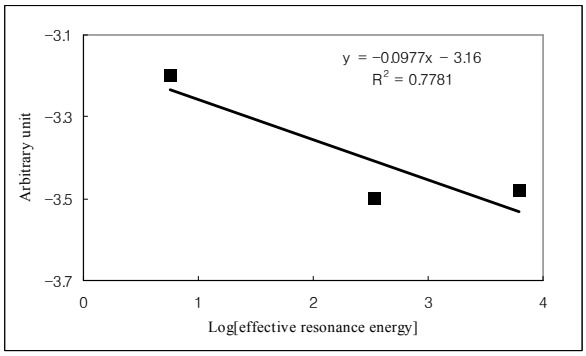

Figure 2. The result of α determination for NAA #2

In addition, *f* values determined by applying the Au-198 nuclide for NAA #1 and NAA #2 were 667 and 1324, respectively. These results imply that a thermal neutron activation analysis can be applied without a high influence due to epithermal neutrons.

3. Conclusions

The Cd-ratio triple monitor method was applied for the determination of the neutron spectrum parameters with the NAA #1 and NAA #2 irradiation holes. It was manifested that the NAA #1 and NAA #2 holes are thermalized well.

REFERENCES

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