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Random-Summing Correction of the Doppler-broadened Boron Peak

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1. Introduction

Prompt gamma activation analysis by using a neutron capture is based on the measurement of the prompt gamma-rays during the irradiation of a target. Boron is a representative element, for which this method shows good applications. Elemental analysis is carried out after a calibration between reference sample masses and their count rate, i.e. analytical sensitivity. Analytical sensitivity is maintained as nearly constant for low elemental masses but deviates from a constant value due to various reasons, which are the neutron self-shielding, gamma-ray self-absorption and neutron scattering in the samples, and the pile-up effect or random summing during the transmission of the pulses through the electronics such as a preamplifier, amplifier and ADC etc. In this study, the pile-up effect is corrected by using a simple method to extend the analytical mass region.

2. Experimental

Measurements were carried out at the PGAA facility of HANARO [1,2]. Samples were prepared by dissolving a high-grade boric acid (H_3BO_3) powder in 0.2 cc of purified water. The liquid samples were then heat-sealed in FEP(fluorinated ethylene propylene resin) tubings with an inner diameter of 4 mm and a 0.5 mm thickness. The count rates of the prompt gamma-rays from the B(n,αγ)Li reaction were measured for the boron elemental mass up to 18.4 mg.

3. Conclusion

As shown in Figure 1, boron peak is subject to the Doppler-broadening effect and decomposed by using a different method from that for a sharp gamma-ray peak. Figure 2 shows a random-summed continuum and peak on a high count rate spectrum. The combination of the Compton events (CC) and boron full energy absorption events (B) produces a continuous random summed continuum below the boron-boron random summing peak. Loss counts rates were determined by using a resolving time of the electronics for the RS_{B+CC} and R_{B+B} regions. Count rates of the small peaks measured in the RS_{B+CC} region at a bare target condition are left out from the determined count rate of RS_{B+CC}. Corrected boron peak count rate is:

$$n_{B}^{corr} = n_B + n_{B+CS} + 2n_{B+B} \quad (1)$$

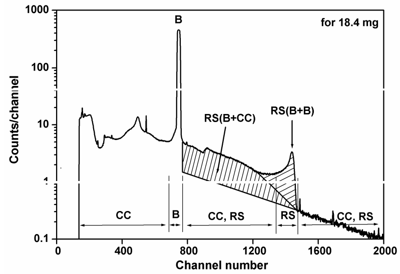

Figure 2. Random-summed continuum and peak on high count rate spectrum.

Figure 3 shows a calibration plot of the count rates vs. boron mass. Its slope is a analytical sensitivity, which clearly deviates from a linearity at 6.8 mg with about 23% dead time. As a result of a random-summing correction, the linearity is extended to 6.8 mg and the deviation at 10.2 mg is diminished to 5%. But only a random summing correction is not sufficient to explain the non-linearity. Remaining non-linearity will be gamma-ray self-absorption, neutron self-shielding and neutron scattering in the samples, for which a further study will be carried out by using various samples with various matrices.

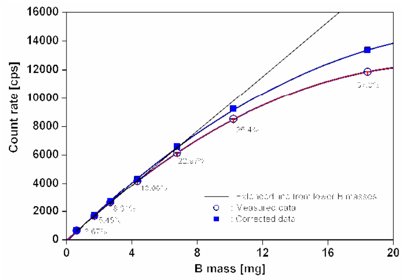

Figure 3. Calibration plot with random summing correction.

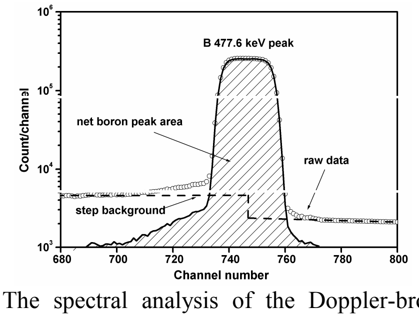

Figure 1. The spectral analysis of the Doppler-broadened boron peak.

REFERENCES

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[2] C.S. Park, G.M. Sun, S. H. Byun, H. D. Choi, Journal of Radiological and Nuclear Chemistry, 265 (2005) 283.