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Validation of the k_0-NAA System at HANARO by Using Synthetic Multi-Element Standards (SMELS)

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1. Introduction

Since the k_0-NAA method was launched by Simonits and De Corte[1], many laboratories have implemented this experimental technique. Synthetic multi-element standards (SMELS) have been prepared by the Institute for Reference Materials and Measurements (IRMM) and Institute of Nuclear Science INW) in Belgium for testing the performance of the k_0-NAA method to be implemented in a laboratory. SMELS consists of three types of spiked polymer matrixes which can be used for short-, medium- and long-lived radionuclides. In previous studies, the homogeneity, the stability and the characterization of the SMELS have been tested and identified by collaboration work between laboratories[2,3]. Now, the SMELS has become available for the validation of new users of k_0-NAA or for a validation of new software packages. This work is intended to validate the k_0-NAA system at HANARO through an analysis of SMELS by employing the k_0-IAEA software which was developed and disseminated by the IAEA in 2005.

2. Experimental

The samples were prepared by weighing three amounts(about 50~100 mg) of the SMELS in polyethylene vials. For the removal of a blank effect, the irradiated samples were transferred to new vials after an irradiation. Samples were irradiated with thermal neutrons by using the Pneumatic Transfer System (PTS) that is connected to the NAA#3 irradiation hole(Φ_{th} = 1.25 x 10^{14} n/cm^2·s, $R_{Cd,Au}$ ≒ 10) at the HANARO research reactor[4]. Gamma-ray measurement was carried out by using a high purity Ge detector of a 25% relative efficiency and 1.85keV resolution (FWHM) at 1332 keV of ^{60}Co and the peak to Compton ratio was 45:1, coupled to a personal computer and 16k-multichannel analyzer. GammaVision software (EG&G ORTEC) was used for the peak analysis and acquisition of the gamma-ray spectra. Analytical conditions are shown in Table 1. Elemental concentrations were determined by the k_0-IAEA software. The implementation of the k_0-IAEA software, from an experimental viewpoint, can be divided into four steps : (i) the first step is to edit the permanent database, input the names of the detectors, the descriptions of the irradiation facilities and sample capsules, material compositions; (ii) the second step is to calibrate the detectors; (iii) the third step is to characterize the irradiation facilities; and (iv) the fourth step is to analyze the samples and to report on them[4].

Table 1. Analytical conditions of SMELS samples

Irradiation time (sample weight)	Decay time	Counting time	Measured radionuclides
1s for Type I (50 ~ 100mg)	~ 15min	300s	^{52}V, ^{66}Cu, ^{128}I
	~ 1h	1800s	^{38}Cl, ^{56}Mn, ^{134m}Cs,
1min for Type I, II, III (100 ~ 200mg)	~ 2d	6,000s	^{69m}Zn, ^{76}As, ^{82}Br, ^{9m}Tc, ^{122}Sb, ^{140}La, ^{142}Pr, ^{143}Ce, ^{175}Yb, ^{198}Au
	~ 5d	40,000s	^{46}Sc, ^{47}Sc, ^{51}Cr, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{75}Se, ^{85}Sr, ^{86}Rb, ^{95}Zr, ^{114m}In, ^{124}Sb, ^{131}Ba, ^{134}Cs, ^{141}Ce, ^{52}Eu, ^{160}Tb, ^{169}Yb, ^{170}Tm, ^{198}Au, ^{233}Pa

3. Results and Discussion

The analytical results were evaluated by creating a ratio of the experimental to assigned values with the mean values obtained from three independent measurements. Figures 1 to 3 show the comparisons of the experimental results with the certified values expressed in the vertical axis.

The u-score is a quantity to assess an agreement between the experimental and the certified value by taking into account the uncertainties of both values. It is defined as:

$$u-score = \frac{|c_e - c_c|}{\sqrt{\sigma_e^2 + \sigma_c^2}}$$

Where c_e and c_c are the experimental and certified values of the elemental concentration, respectively; and σ_e and σ_c are the uncertainties for the corresponding experimental and certified values, respectively. Hence, an experimental result is regarded as good or acceptable when the u-score is lower than 2.

In Figures 1 to 3, most of the elements had a good agreement between the experimentally determined values and the certified values. For two of the elements, Cs and Cu, the following observations can be made; a) Cs at a concentration level of 897 mg/kg was accurately determined via the ^{134m}Cs nuclide (half-life of 2.9h) by using the gamma-ray line of 127.4keV instead of an

ordinary via the ^{134}Cs nuclide with a long half-life of 2.06y, b) Cu at a concentration level of 3,930 mg/kg was also determined accurately via both the ^{64}Cu (1345.7keV) and ^{66}Cu (1039.2keV) radionuclides.

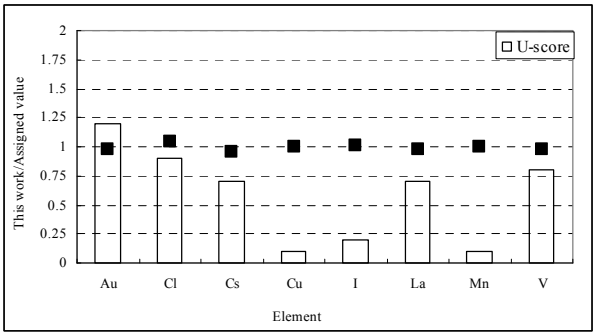

Figure 1. Analytical results of SMELS type-I sample

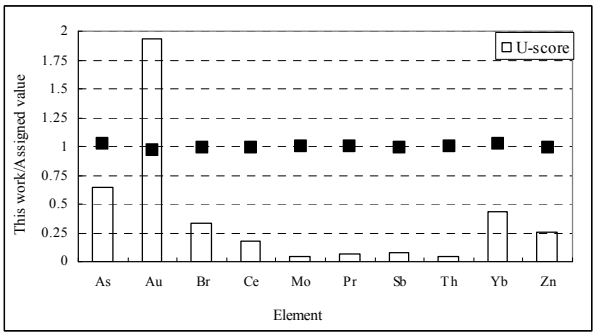

Figure 2. Analytical results of SMELS type-II sample

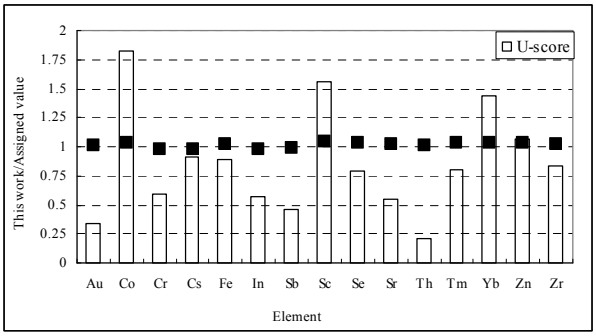

Figure 3. Analytical results of SMELS type-III sample

4. Conclusion

The analysis of SMELS samples was executed by using the k_0-IAEA software and the NAA#3 irradiation hole of the HANARO research reactor. The analytical results agreed well with the certified values and the u-scores for most elements were lower than 2. It can be concluded that the k_0-NAA system at HANARO has been implemented successfully.

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