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k_0-Instrumental Neutron Activation Analysis Method Validation for Trace Element Determination using Environmental Reference Materials

BOON SIONG WEE*[1], SHAMSIAH ABDUL RAHMAN[2], MD SUHAIMI ELIAS[2], NAZARATUL ASHIFA ABDULLAH SALIM[2]

[1]Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia; [2]Malaysian Nuclear Agency, Bangi, 43000 Kajang, Selangor, Malaysia.
*Corresponding author: swboon@unimas.my
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ABSTRACT

Presently, the k_0-standardization method of instrumental neutron activation analysis (k_0-INAA) technique has become the preferred method for multi-elemental analysis due to its high metrological value. The reactor neutron parameters (α and f) for rotary rack as well as the detector efficiency were determined and used for k_o-INAA. The information is then used to compute the elemental concentration of certified reference materials (CRMs) using k_0-INAA software developed in Vietnam. This results of the CRMs analysis showed the average z-score were below the threshold value of 2 with precision of about 10% for most of the element concentrations analyzed. The result has been very promising and at present stage, the laboratory is focusing on testing this method and capacity building for our staff. In future, the k_0-INAA technique will be used to analyze air particulate, marine environmental samples, geological samples and archeological artifacts as well as to provide analytical services to clients from industries in particular.

Keywords: Certified reference material, gamma-ray spectrometer, instrumental neutron activation analysis, k_0-standardization method, reactor neutron spectrum

INTRODUCTION

Instrumental neutron activation analysis (INAA) technique has been used commonly in Europe. The Malaysian Nuclear Agency (MNA) has adopted this technique as a routine analytical method for determination of trace elements in various samples. The operation of INAA at MNA is by utilising the 1MW TRIGA MK II reactor built in the 1980s, which produces neutron spectrum consists of thermal, epithermal and fast neutrons. The normal operating power for the reactor is 750 MW with thermal neutron flux in the order of 10^{12} n $cm^{-2}s^{-1}$. Thermal neutrons produced by this reactor are mainly used in the activation of interested elements in various types of sample matrices (Wee *et al.*, 2006; Alnour *et al.*, 2015; Wee & Ebihara, 2017; Chai *et al.*, 2018). This is due to the fact that thermal neutron flux is high and the cross sections for (n,γ) reactions are large therefore they offer a good analytical sensitivity available for INAA.

In recent years, many laboratories around the world have implemented the k_o-standardization method of INAA (k_o-INAA) to complement the comparative method, which is regarded as the preferred method for INAA. The k_o-INAA is a new and improved method of INAA which was developed in 1975 and found to be suitable for multi-elemental analysis of various samples matrices without the use of standards (De Corte, 2018). This method requires simultaneous irradiation of a neutron flux monitor and a sample along with the use of k_o-factors in order to compute the element concentrations in the sample. Eventually, this method has been evaluated and well accepted by many laboratories around the world for multielemental analysis of various samples. A recent review providing more insights into the core principles, quality assurance and achievements in the continuous development of this method have been published (Greenberg *et al.*, 2011).

The advantage of this technique is attributed to the k_o-factors, which are accurately measured compound nuclear constants and they are independent of irradiation and measurement