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Testing the applicability of the k_0-NAA method at the MINT's TRIGA MARK II reactor

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Abstract

The Analytical Chemistry Laboratory at MINT is using the NAA technique since 1980s and is the only laboratory in Malaysia equipped with a research reactor, namely the TRIGA MARK II. Throughout the years the development of NAA technique has been very encouraging and was made applicable to a wide range of samples. At present, the k_0 method has become the preferred standardization method of NAA (k_0-NAA) due to its multi-elemental analysis capability without using standards. Additionally, the k_0 method describes NAA in physically and mathematically understandable definitions and is very suitable for computer evaluation. Eventually, the k_0-NAA method has been adopted by MINT in 2003, in collaboration with the Nuclear Research Institute (NRI), Vietnam. The reactor neutron parameters (α and f) for the pneumatic transfer system and for the rotary rack at various locations, as well as the detector efficiencies were determined. After calibration of the reactor and the detectors, the implemented k_0 method was validated by analyzing some certified reference materials (including IAEA Soil 7, NIST 1633a, NIST 1632c, NIST 1646a and IAEA 140/TM). The analysis results of the CRMs showed an average u score well below the threshold value of 2 with a precision of better than $\pm 10\%$ for most of the elemental concentrations obtained, validating herewith the introduction of the k_0-NAA method at the MINT.

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Keywords: Neutron activation analysis; k_0 standardization method; Reactor neutron spectrum; γ-ray spectrometer; Certified reference materials

1. Introduction

The application of neutron activation analysis (NAA) requires a neutron source, e.g. from a research reactor or a neutron generator. At MINT, NAA makes use of the only research reactor in the country, the 1 MW TRIGA MARK II reactor that was built in 1980s. It provides facilities for long- and short-time irradiations at rotary rack (RR) and pneumatic transfer system (PTS), respectively. The normal operating power of the reactor is 750 kW with a thermal neutron flux of about $10^{12}\,\mathrm{cm^{-2}\,s^{-1}}$. For activation of elements in various types of sample matrices, use is mainly made of thermal neutrons. Thanks to the high (n, γ) cross-section values for most elements, NAA is a sensitive analytical tool.

Recently, the Analytical Chemistry Laboratory has adopted the k_0 standardization method of NAA (k_0-NAA) to complement comparative or relative method, which is regarded as the preferred method for NAA. The k_0-NAA method has been launched in mid-1970s and a recent review provides more insights into core principles, quality assurance and further results of continuous methodological development [1]. There are many advantages that can be attributed to the k_0-NAA method, especially arising from the concept of the k_0 factors, which are accurately measured compound nuclear constants that are independent of irradiation and measurement conditions [2]. Recently, k_0 factors of most of the analytically relevant

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