

The k_0 -based Internal Monostandard NAA (IM-NAA) Using Reactor Neutrons for Analysis of Large and Non-Standard Geometry Samples: Method Development and Societal Applications

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Instrumental Neutron Activation Analysis (INAA) is one of the most important Nuclear Analytical Techniques (NATs) for non-destructive chemical characterization of materials at major to trace concentration levels with negligible matrix effect due to high penetration powers neutron and gamma rays. The development of k_0 -based NAA using ^{197}Au single comparator enhanced the applicability of analysis of small and standard geometry samples without a priori knowledge of elements present. While dealing with large size and non-standard geometry samples, both relative and k_0 -NAA methods fail to address neutron self-shielding and gamma-ray self attenuation in the samples. In this respect, the Internal Monostandard NAA (IM-NAA) in conjunction with *in situ* detection efficiency is capable of analysing samples of any size and shape, where in internal monostandard takes care of neutron self-shielding and *in situ* relative detection efficiency using gamma-rays of activation products takes care of geometrical and self attenuation effects. The developments in IM-NAA include characterization of irradiation sites of research reactors for sub-cadmium to epithermal neutron flux ratio (f), epithermal neutron flux shape factor (α) using dual/multi monitors by cadmium ratio method and *in situ* relative detection efficiency calibration of HPGe-detector. IM-NAA method was validated using synthetic samples and certified reference materials. As a part of societal applications, IM-NAA method was applied for compositional and/or trace element determination in large and non-standard geometry samples of reactor materials like zircalloys, stainless steels, Ni-based alloys, uranium ores and 1S-grade aluminum clad samples, coal, food and archeological clay ceramics (for provenance study). Large samples were irradiated using low flux thermal column/graphite reflected position of research reactor. IM-NAA method was successfully demonstrated for standard-less compositional characterization of zircalloys, stainless steels and Ni and Ni-Cr based alloys, as all the major and minor elements were amenable to NAA. For forensic applications, IM-NAA keeps promise as a standard-less approach for provenance study of automobile (sodalime) glass samples by utilizing elemental concentration ratios. The method was extended to IM-PGNAA for standard-less compositional analysis of zircalloys and stainless steels.

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