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Development and optimization of a simple internal beam current monitoring approach using $^{29}Si(p,p'\gamma)^{29}Si$ reaction in particle induced gamma-ray emission for compositional characterization of glass samples and application to automobile windshield glasses

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Abstract
Beam current monitoring or normalization is an important aspect in ion beam analysis utilizing particle accelerator for materials characterization. We present an innovative idea of using ^{29}Si, present in the sample, as an internal beam current normalizer for the quantification of low Z elements by particle induced gamma ray emission (PIGE) method. The current normalized count rate of analytes (Si, Na, Mg, Al and/or B) with respect to prompt gamma-ray at 1273 keV from nuclear reaction $^{29}Si(p,p'\gamma)^{29}Si$ is utilized for the concentration determination. Quality control exercise was carried by analyzing certified/standard reference materials of sodalime and borosilicates glasses. Cross validation of proposed method was carried out by analysing two different glass samples by three different methods namely in situ current normalized PIGE method using fluorine as current normalizer, external PIGE using tantalum as current normalizer and ED-XRF. Analysis of variance and student's t test were performed to examine the reliability of the results. The optimized method was applied for chemical characterization of forensically important automobile windshield glass samples.

Keywords PIGE · ^{29}Si as internal current normalizer · Soadlime and borosilicate glass · Compositional analysis · Low Z elements · Automobile windshield glass

Introduction

Ion beam analysis (IBA) experiments are generally carried out with accelerated proton or deuteron particles as projectiles for chemical characterization of materials [1–3]. IBA techniques namely particle induced gamma-ray emission (PIGE) [2] and particle induced X-ray emission (PIXE) [3], are performed for analysis of materials either in vacuum or in air. Between vacuum chamber and external (in air) IBA, the later one is simpler in experiment, faster and it can analyse "as received" samples with non-standard geometries. In external IBA experiments, the projectile like proton experiences minimum energy loss and minimum straggling when beam passes through suitable exit windows [1], whereas no loss in current occurs as the range of the projectile is higher than the thickness of the exit window. Other techniques like Rutherford back scattering (RBS) and nuclear reaction analysis (NRA) are preferably performed in vacuum chamber. These IBA techniques have been applied to the various fields including the analysis of various type of samples namely archaeological sample, cultural heritages, rubies and coin analysis, glass beads, glass analysis, paintings and forensic samples [2–15]. These types of relative method of analysis require same current for sample and standard and thus measurement of beam current or current normalization is necessary for their quantitative analysis. A brief literature review of beam current measurement or normalization is briefly described below.

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