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Utilization of accelerator and reactor based nuclear analytical techniques for chemical characterization of automobile windshield glass samples and potential of statistical analyses using trace elements towards glass forensics

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ABSTRACT

Glass forensics is an important area in forensic crime investigations, wherein glass origin or source finding is necessary mainly through chemical composition. In the present work, Nuclear Analytical Techniques namely external (in air) Particle Induced Gamma-ray Emission (PIGE) and Instrumental Neutron Activation Analysis (INAA) were utilized for complete chemical characterization of twenty-five "as received" windshield glass samples of six car manufactures. Concentrations of four major elements (Si, Na, Mg and Al) by PIGE using proton beam and nineteen elements including sixteen trace elements by INAA using research reactor neutrons were determined. Both the methods were validated by analysing matrix matched glass certified (standard) reference materials. Trace elemental concentrations including rare earth elements (REEs) and ternary plot using concentrations of major, transition elements and REEs were utilized to obtain preliminary grouping of the analyzed glass samples. Statistical tools namely K-mean, Cluster Analysis and Principal Component Analysis (PCA) using trace elemental concentrations were utilized for grouping studies, important for forensic applications. Among these statistical analysis techniques, PCA results confirmed that windshield glasses from six manufactures clearly belong to six different groups.

1. Introduction

Chemical characterization of materials is most important step in chemical quality control exercises in various fields including materials sciences and forensic sciences. It involves quantification of composition (major and minor elements) as well as trace elements by suitable analytical techniques, in order to ascertain the quality of materials. If the sample matrices are of glass, ceramics, metals and alloys, then a technique that can analyze sample without destruction or dissolution is preferred. Between glass and ceramics, glass objects are often analyzed in various fields including material sciences and forensic studies [1–3]. It is being used for many applications in day-to-day life including decoration, utensils/container glasses and automobile windshield glasses [4,5]. Due to fragile nature of glasses, automobile windshield glasses or simple door window glasses are often collected as evidentiary material from the crime scenes like hit and run cases, murders and burglary and their chemical analyses by suitable techniques are important for forensic investigation [3].

Elemental concentrations mainly at trace level are source specific to a particular glass type, which is helpful to identify source of glass/windshield glass. Before tracing the source or origin or the authenticity of a sample, the elemental concentration of that sample is being compared with the data bank of similar type of samples. So, it is necessary to have the data bank of elemental concentrations of the possible types of evidences/glasses which are frequently seized from a crime scene. In the case of windshield glasses, elemental concentration data bank should be available for various known models of different manufactures/brands of automobiles (e.g., cars) and their corresponding commercially available models. To create the data bank, it is necessary to analyze various models of car windshield glasses with suitable techniques which can give major, minor and

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