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Chemical Characterization of Nuclear Materials: Development a New Combined X-ray Fluorescence and Raman Spectrometer

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New mobile analytical device based on combination of X-ray fluorescence and Raman spectrometer has been developed for prompt and quantitative characterization of chemical component from Al to U in nuclear waste or undeclared materials. The excitation source of the X-ray fluorescence spectrometer is an air-cooled X-ray tube with Ag transmission anode. For collection of secondary X-ray photons and data processing compact Amptek X-ray detector system is applied with silicon drift X-ray detector. The XRF system operates in confocal mode with focal volume around 1-4 mm3. Varying the geometrical position and orientation of the sample optional part of its surface can be analysed. The Raman unit includes thermoelectrically cooled laser source having 500 mW power at wavelength 785 nm. In order to obtain spectral information from sample surface a reflection-type probe is connected by optical fibers to the Raman spectrometer. A mini focusing optics is set up to the sensor-fiber that provides the system to operate as confocal optical device in reflection mode. The XRF spectrometer with X-ray detector, Raman probe and X-ray tube are mechanically fixed and hermetically connected to an aluminium chamber, which can be optionally filled with helium. The chamber is mounted on a vertical stage that provides moving it to the sample surface. A new model and computer code have been developed for XRF quantitative analysis which describes the mathematical relationship between the concentration of sample elements and their characteristic X-ray intensities. For verification of the calculations standard reference alloy samples were measured. The results was in good agreement with certified concentrations in range of 0.001 100 w%. According to these numerical results this new method is successfully applicable for quick and non-destructive quantitative analysis of waste materials without using standard samples.

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