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Design of a fast neutron activation analysis system with a gamma-ray detector for the detection of explosives

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We designed a fast neutron activation analysis system with a gamma-ray detector for the detection of explosives. By measuring the prompt gamma-rays emitted from the object upon neutron interrogation, the elements of the material can be identified. This is because the gamma-ray energies emitted by inelastic scattering or capture of fast neutrons present a unique signature for each element of interest to detect explosives. To design and optimize a fast neutron activation analysis system for the detection of explosives, we used the Monte Carlo N-Particle code. As a neutron source, a deuteron-tritium pulsed neutron generator emitting 14.1 MeV neutrons was defined for the fast neutron activation analysis. In order to reduce collateral radiation exposed to the gamma-ray detector directly, the neutron collimator and shielding materials with polyethylene, lead, and steel were designed after considering 14 MeV neutrons and the shape of the neutron generator and the gamma-ray detector. TNT, RDX, PETN and Nitroglycerine were simulated as an explosive. Also, in order to optimize the position of the gammaray detector and the detector material, we simulated and measured the flux and the spectrum of gamma-rays by changing the position of the gamma-ray detector surround the object and by changing the gamma-ray detector materials, NaI:Tl, LaBr3:Ce, and Cadmium Zinc Telluride. To compare the detector materials, GEB option in the Monte Carlo N-Particle code was used for Gaussian broadening effect. As a result, pulse height spectrum of gamma-ray acquired and analyzed to identify the pure elements and the explosives. Main peaks at 4.43, 5.11, 6.13, 6.91 and 10.8 MeV for carbon, nitrogen, and oxygen elements were observed. The results of energy spectrum at each position of the detector surround the object for each detector material were acquired. To increase the signal to noise ratio, time selection and background spectrum reduction techniques were applied. The results showed that a detector composed of Cadmium Zinc Telluride located on the same side of the neutron generator has better energy resolution than a detector composed of other materials at different positions, which enables distinguish the peaks emitted from carbon, nitrogen, oxygen elements. To identify the explosives, the major gamma peaks of carbon, nitrogen, and oxygen were labeled and the experimentally calculated O/C and N/C ratios were analyzed. The results matched well with theoretical data.

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