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>From the Correspondents

News from Lawrence Berkeley National Lab

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Prompt Gamma Activation Analysis: An Old Technique Made New

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It must be made very clear that PGAA is not a radioanalytical process, but instead it is a process for assaying any element (isotope), whether radioactive or nonradioactive, with universal application. To be sure, there are many different analytical techniques that individually may be used to assay specific elements or, in the case of gamma spectroscopy, radionuclides. But, not one of these other analytical techniques may be used to assay virtually all elements and isotopes in one analysis. PGAA, however, by the very nature of the underlying physical process, may potentially be used to assay all elements and isotopes simultaneously. So what is PGAA and what are its possible uses, especially for health physicists, who are concerned with the potential for mitigating radiological concerns and with dose and contamination issues?

In review, an atom of any element or isotope, whether nonradioactive or radioactive, has a certain affinity (cross section) for absorbing (capturing) a thermal or 'cold' neutron. A thermal neutron is one that has an average kinetic energy of about 0.025 eV at an ambient temperature of about 25 degrees C and a 'cold' neutron is one that has been further slowed (i.e., cooled) to energies less than 0.025 eV. When an atom captures a neutron, that neutron transfers its binding and kinetic energies to the new nucleus, which gains one atomic mass unit by the addition of that neutron. In practice, the kinetic energy of a thermal or 'cold' neutron (< 0.025 eV) is negligible in comparison with the contributed binding energy (typically several MeV) and will not be considered further. The binding energy represents the energy above the ground state of the new nucleus, excitation energy which must be dissipated by the emission of one or more prompt gammas in cascade to the ground state.

The prompt gammas that are emitted within picoseconds following capture are the focus of PGAA. Since each new nucleus formed by the capture of a neutron emits its own unique signature of one or more prompt gammas, collection of these prompt gammas by a highly efficient gamma spectrometer/multichannel analyzer system provides a basis for identifying and quantifying all elements and isotopes in a given sample. Furthermore, the energies of many of these prompt gammas range well above the highest natural radioactive line in the environment, namely, thallium-208 (2.6 MeV), thereby avoiding background problems.

PGAA is a nondestructive, in-situ technique that obviates the need for sample handling. Since neutron energies may be selected to penetrate any potential container type and many of the prompt gammas are high in energy, PGAA allows the analyst to 'see' through the container. Furthermore, Lawrence Berkeley National Lab is developing a new miniature neutron generator that outputs high neutron intensities using either a deuterium-deuterium (D+D) or deuterium-tritium (D+T) mode of generation, eliminating concerns about radiation doses from a nuclear reactor. Certainly, the Berkeley Lab neutron generator creates a dose field not only from the neutron-production process but also from activation of the immediate surroundings. However, due to the generator's relative compactness, shielding is not a serious problem and detectable activities produced are short-lived.