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Radiochemical analysis for the determination of radionuclides difficult to measure for characteristics and decommissioning of nuclear facilities

With increasing numbers of nuclear facilities, especially nuclear power reactors, being closed in recent years and from now on, a considerable work is going to be carried out all over the world for decommissioning these nuclear facilities. For this purpose, characterization of various wastes from decommissioning is required for evaluation of the radioactivity inventory in various materials and decision making for management of the produced waste. This is carried out by quantitative determination of various radionuclides present in the materials.

The neutron activation products of components and impurity in the materials used in the nuclear facilities, such as ³H, ¹⁴C, ³⁶Cl, ⁴¹Ca, ⁶⁰Co, ⁵⁵Fe, ⁶³Ni, ¹³³Ba, ¹⁵²Eu, ¹⁵⁴Eu, and some transuranics, are the main contributors to the total radioactivity, especially in the construction materials. But some long-lived fission products, such as ⁹⁰Sr, ⁹⁹Tc, ¹²⁹I, and ¹³⁷Cs, are the major concern for materials contaminated by spent nuclear fuel. Of these radionuclides, the gamma emitting radionuclides, such as ⁶⁰Co, ¹³³Ba, ¹⁵²Eu, ¹⁵⁴Eu, or ¹³⁷Cs, are easily measured by gamma spectrometry. However, the determination of pure β and α emitters including ³H, ¹⁴C, ³⁶Cl, ⁴¹Ca, ⁵⁵Fe, ⁶³Ni, ⁹⁰Sr, ⁹⁹Tc, ¹²⁹I and some transuranics is the major challenges, because they could not be measured without separation from the matrix of the samples and from all other radionuclides, this entitles them as the radionuclides difficult to measure.

Radiochemical analysis is the only way to complete the determination of the radionuclides difficult to measure by including a complete separation of individual radionuclides from the matrix and other radionuclides before measurement by β counting, α spectrometry, or mass spectrometry. Although plenty of analytical methods have been reported for the determination of these radionuclides since the discovery of radioactivity, the suitable methods are not always available for the purpose of decommissioning. This is because a large number of samples are required to be analyzed during the decommissioning, which needs simple and rapid methods to provide a good analytical capacity. In addition, the sample matrix varies very much from concrete, graphite, exchange resin, to various metals, which requires different radiochemical methods for different sample matrix and target radionuclides.

In the past few years, our laboratory developed various radiochemical analytical methods aiming at characterization of various decommissioning waste by determination of various radionculides difficult to measure. This presentation gives an overview of these analytical methods with some examples including (1) rapid determination of tritium and ¹⁴C in solid materials, such as graphite, concrete, steel, aluminium, paint, silica gel, soil, and dust; (2) determination of ¹⁴C in high tritium samples, such as heavy water, waste water, and oil; (3) determination of ³⁶Cl and ¹²⁹I in graphite, steel, concrete, waste water, and dust; (4) determination of ⁴¹Ca and ⁹⁰Sr in concrete; (5) determination of ⁵⁵Fe and ⁶³Ni in graphite, concrete, steel, aluminium, sediment, sand, waste water, seawater, and lichens.

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