# Radiochemical analysis for decommissioning of nuclear facilities

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**Radiochemical analysis for decommissioning of nuclear facilities**

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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 types of materials from the nuclear facilities is required for evaluation of the radioactivity inventory and distribution in various materials and decision making for management of the produced waste. This is implemented by quantitative determination of various radionuclides presenting in these materials.

The neutron activation products of components and impurity in the materials used in the nuclear facilities, such as $^{3}$H, $^{14}$C, $^{36}$Cl, $^{41}$Ca, $^{60}$Co, $^{55}$Fe, $^{63}$Ni, $^{79}$Se, $^{93}$Mo, $^{93}$Zr, $^{94}$Nb, $^{126}$Sn, $^{133}$Ba, $^{152}$Eu, $^{154}$Eu and some transuranics (isotopes of Pu, Np, Am and Cm) are the main contributors to the total radioactivity, especially in the construction materials. While the long-lived fission products, such as $^{90}$Sr, $^{99}$Tc, $^{129}$I, $^{135}$Cs and $^{137}$Cs, are the major concern for materials contaminated by leaked spent nuclear fuel. Of these radionuclides, the gamma emitting radionuclides, such as $^{60}$Co, $^{133}$Ba, $^{152}$Eu, $^{154}$Eu and $^{137}$Cs, are easily measured by gamma spectrometry. While the determination of pure beta and alpha emitters including $^{3}$H, $^{14}$C, $^{36}$Cl, $^{41}$Ca, $^{55}$Fe, $^{63}$Ni, $^{90}$Sr, $^{99}$Tc, $^{129}$I 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 of hard to measure.

Radiochemical analysis is the only way to implement determination of these hard to measure radionuclides by including a separation of individual radionuclides from matrix and other radionuclides before measurement. 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 characterization of various materials from decommissioning. This is attributed to a few reasons including complicate and various components of the sample matrix, some orders of magnitude lower concentration of some target radionuclides comparing to the major radionuclides which needs a high decontamination factors, complicated and active chemical properties of some important target radionuclides, and a large number of samples required to be analyzed during the decommissioning, which needs simple and rapid methods to provide a good analytical capacity. In particular, 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.

Besides the conventional radiometric methods for the measurement of radionuclides, such as liquid scintillation counting, low level beta counting, and alpha spectrometry for these hard to measure radionuclides, some new methods have been proposed and applied. Among them, mass spectrometry especially ICP-MS and accelerator mass spectrometry (AMS) has been widely used for the measurement of long-lived radionuclides, such as $^{41}$Ca, $^{36}$Cl, $^{99}$Tc, $^{129}$I, $^{135}$Cs and transuranics. With these techniques, the measurement time can be significantly reduced from few days to some minutes, enabling to rapid measurement of large number of samples.

In the past few years, a large numbers of radiochemical analytical methods aiming to characterize various decommissioning waste by determination of various radionuclides of hard to measure have been developed in many laboratories. This work aims to present the state of the art analytical methods for characterization of nuclear waste from the decommissioning of nuclear facilities, not only the updated chemical separation

procedure, but also advanced measurement techniques. Meanwhile, some examples of analytical methods will be also presented, including (1) rapid determination of $^{3}H$ and $^{14}C$ in solid materials; (2) determination of $^{36}Cl$ and $^{129}I$ in graphite, concrete and metals (3) Simultaneously determination of multi-nuclides such as $^{41}Ca$, $^{55}Fe$, $^{63}Ni$, $^{90}Sr$ and transuranics; (4) Challenge on the determination of low level $^{93}Mo$, $^{93}Zr$, $^{135}Cs$, $^{79}Se$ and $^{126}Sn$ in decommissioning waste.

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