1.2 APPLICATIONS OF NUCLEAR CHEMISTRY

- **Non-destructive Assay of Nuclear Fuel Materials**

Non-destructive assay systems based on both gamma and neutron counting have been developed for the assay of Pu at various stages of nuclear fuel cycle. Important developments are the setting up of a Hull waste monitor at KARP, development of a 200 L waste drum scanner and development of a Neutron Well coincidence counter. A rapid method for the nondestructive assay of Fast Breeder Test Reactor (FBTR) fuel pins has been demonstrated using two-step process of high resolution gamma-ray spectrometry for isotopic composition measurement.

- **Development of a Segmented Gamma Scanner**

Solid alpha waste, with alpha activity <4000 Bq/g is recommended for shallow land burial. To screen the 200 L waste drum containing solid alpha waste, a facility based on segmented gamma scanning has been set up at Radiochemistry Division. The gamma rays from Pu and Am (hence total alpha activity) are measured using a collimated HPGe detector. Rotation of the drum is done to get the flat response. The drum is scanned in segments by moving the drum vertically across the collimated detector. Standard Pu samples were randomly distributed inside a drum containing cellulosic waste and the gamma response measured for different sample distributions inside the drum. It is seen that 100 mg of Pu can be assayed with an accuracy of ± 30-40% for a counting time of three hours per drum containing cellulosic waste. This facility is proposed to be employed for estimating the total alpha activity in the drum before storage in the interim storage facility.

Followed by neutron well coincidence counting for the total plutonium content.

During the dissolution of spent fuel by chop-leach process in reprocessing plants, small but significant amount of fuel remains as residue because of the incomplete leaching of the crimped hulls. Hence, it is necessary to estimate this material with a reasonable degree of accuracy for proper accounting of nuclear materials. A hull monitor was set up at Fuel Reprocessing Plant (KARP) in Kalpakkam. In this method the activity of $^{144}\text{Ce} - ^{144}\text{Pr}$ (285 days) in the hull is measured using a suitable collimator detector arrangement in the dissolver cell area. Ratio of the activity of $^{144}\text{Ce}$ to U and Pu in the dissolver solution is determined in the chemical laboratory. Assuming that the ratios of $^{146}\text{Ce}$ to U and that of $^{144}\text{Ce}$ to Pu in the hull is the same as those in the dissolver solution, the amount of U and Pu in the hull is computed.
Development of Neutron Counting Systems for Non Destructive Assay of Plutonium

A neutron well coincidence counter based on $^3$He counters in High Density PolyEthylene (HDPE) moderator assembly has been designed and fabricated for the non destructive assay of plutonium in FBTR fuel pins and sub assemblies. The counter has a flat radial and axial response over the active region of the fuel sub assembly. The sample is surrounded by 1.2 mm thick cadmium sleeve to prevent the entry of thermal neutrons in the sample for suppressing the multiplication of neutrons. The reflector geometry ensures that the detection efficiency for (α, n) neutrons is reduced relative to fission neutrons to enhance the accuracy of coincidence counting. A portable neutron slab coincidence counter based on six $^3$He counters in HDPE moderator assembly has been designed and fabricated for in-situ assay of plutonium in sealed containers. The system has been installed at the Radio-Metallurgy Division.


Development of an Ultra Sensitive Method for the Assay of Plutonium by Fission Track Technique

Occupational radiation workers can get exposed to various radionuclides during the course of their work. Proper evaluation of the internal contamination is necessary for the assessment of internal dose to workers, following the intake of radionuclides. The new Derived Investigation Limit (DIL) for Pu compounds of Type S is 0.038 mBq and for Type M is 0.34 mBq, whereas the lowest detection limit of widely used alpha spectrometry is about 0.5 mBq. An indigenous and ultra sensitive method employing Fission Track Analysis (FTA) has been developed which is more sensitive than the existing alpha spectrometric method. The results of the preliminary experiments carried out on actual bioassay samples show that a Pu concentration of 0.1 mBq can be easily measured using the FTA technique. Efforts are underway to further lower the minimum detection limit for Pu using ultra pure reagents.

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