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Characterization concept for the disposal of radioactively contaminated mercury wastes from the decommissioning of nuclear facilities

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The disposal of mercury from nuclear applications that contains radionuclides due to contamination or neutron activation is very challenging, not only due to its radiotoxicity but also due to its high chemotoxicity and mobility in the environment. Elemental mercury has been used in several nuclear facilities, for example as coolant and shielding material in early fast reactors, as sealant in hot cells, as target material in spallation targets and as catalyst in isotope separation research. In Jülich, about 600 kg of radioactively contaminated mercury originate from the decommissioning of hot cell facilities in which mercury was used as a sealant material. A disposal concept for such radioactive mercury wastes is currently developed in the framework of the German national research project PROMETEUS (PROcess of radioactive MErcury Treatment under EU Safety-standards), funded by the German Federal Ministry of Education and Research under grant numbers 15S9266A–B. This disposal concept includes a (radiological) characterization, decontamination and possibly a clearance of the purified mercury as well as a safe disposal, i.e. conversion and solidification / immobilization of the radioactive residues.

A comprehensive radiological characterization concept for mercury was developed and is the focus of this work. The main challenges of the radiological characterization originate from the inhomogeneity of the waste material as well as the inhomogeneous activity distribution and the high density of mercury which leads to a high intrinsic radiation shielding. The characterization starts with the non-destructive gamma-spectrometric measurement of the samples, for which a special gamma detector arrangement was set up consisting of two semi-planar HPGe detectors facing each other. This setup allows the simultaneous measurement of thin mercury samples from opposite sides, thus increasing the efficiency of the measurements and also allowing the detection of inhomogeneities in the samples. The gamma detector setup is not only interesting for waste characterization, but furthermore it can be used for clearance measurements after a decontamination procedure of mercury wastes. This decontamination procedure including vacuum distillation and washing techniques aims at a separation of (radioactive) residues from mercury to enable a subsequent clearance of the mercury.

Following the non-destructive gamma-spectrometric characterization, aliquots of the material are dissolved to perform further characterization methods, i.e. LSC measurements and alpha spectrometry. A chemical separation of mercury and the different radionuclides is performed to quantify alpha-emitting nuclides. This is achieved by dissolution of the material and a subsequent separation by extraction chromatography. Mercury is thereby separated from the alpha-emitting nuclides as it significantly reduces the efficiency and resolution of alpha-spectrometric measurements and in a subsequent step different alpha-emitters are separated from each other to be measured accurately. This paper presents recent results from the chemical separation and characterization of radioactively contaminated mercury wastes.

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