DIRECT IMMOBILIZATION OF REAL RADIOACTIVE LIQUID ORGANIC WASTE IN NOVEL GEOPOLYMERS: OUTCOMES FROM THE PREDIS PROJECT

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The safe and effective management of radioactive liquid organic waste (RLOW) streams is a challenging task due to their physico-chemical characteristics. This is especially true for low density and strongly nonpolar solvents, e.g. those originating from spent nuclear fuel reprocessing. Such properties hinder their conditioning with conventional cement-based solidification matrices, and severely restrict achievable waste loadings. A safe, sustainable, and cost-effective pre-disposal route for RLOWs is therefore undefined. Within Work Package 5 of the H2020-PREDIS project, a straightforward conditioning strategy based on the direct immobilisation of RLOW in a novel geopolymer was developed as a more effective waste management solution. The conditioning matrix formulation was designed with the goal of achieving optimal physical and mechanical properties whilst maximising waste loading. The developed formulation consists of an alkali-activated metakaolin based geopolymer, prepared through a highshear mixing protocol. Molar ratios of the main constituents (SiO2, Al2O3, K2O, H2O) were optimised to achieve excellent workability, low viscosity and reaction heat comparable to that of ordinary Portland cement, to support the scalability of the process. With the addition of 1-2 wt% non-ionic surfactant, a waste loading of 30 vol% could be achieved with only minimal bleeding, and without significantly altering the properties of the paste. A compressive strength compliant with waste acceptance criteria was achieved within the conventional 28-day curing period. The immobilisation effectiveness of the matrix with respect to radionuclide leaching, and the preservation of mechanical performance following accelerated ageing conditions (28 days water immersion and gamma irradiation at 200 kGy) were also studied. An inactive mixture of tributyl phosphate and dodecane (30/70 vol%), the typical PUREX solvent, was considered as surrogate waste. Additionally, a contaminated solvent deriving from R&D activities on minor actinides partitioning was employed for a case-study of real RLOW. Tests conducted after accelerated ageing confirmed a good resilience of the waste forms, which exhibited only a marginal decrease in compressive strength. A weakness of the matrix was however noted, with samples exposed to a dry atmosphere becoming prone to cracking after water immersion. Leaching of radionuclides from waste forms spiked with tracers was assessed through mass spectrometry measurements, confirming good retention. Equivalent results were obtained for the real RLOW, thus supporting the robustness of the conditioning strategy. Having proven effective, this encapsulation approach could be further developed to increase its durability and provide a safe pre-disposal route for challenging RLOW.

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