IMMOBILIZATION OF SPENT NUCLEAR GRADE RESINS IN LOW CARBON CEMENT: STUDY OF THE REACTION KINETICS.

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Abstract

Ion exchange resins are widely used to purify liquid effluents from nuclear power plants, representing the largest contribution in volume and activity to the inventory of intermediate- and low-level radioactive waste in Spain. Once saturated, the spent resins are managed by their immobilization in Ordinary Portland cement (OPC) matrixes. However, OPC production entails significant energy costs and a carbon footprint, as well as an environmental impact due to the mines necessary to extract its raw materials (limestone and clay). For this reason, this work studies a more sustainable immobilization solution by replacing 100% of the Portland clinker with other sources of aluminosilicates that are by-products of other industries (blast furnace slag from steel production and fly ash from coal combustion). In absence of the Portland clinker, it is necessary the use of an alkaline activator to obtain a material with good binding properties, in this work powder sodium silicate (7% by weight). These greener and alternative formulations are called Alkali-Activated cement. Ion exchange resins can be incorporated into the main reaction product (gel) structure or locked in the lattice of zeolites or secondary reaction products. To assess the behaviour of these new formulations in the presence of spent resin, the kinetics of the reaction is analysed by isothermal calorimetry. Three different slag/fly ash blend proportions have been evaluated (100% slag, 85% slag-15% fly ash, 70% slag-30% fly ash). The percentages of spent resin incorporated are set with the logistics requirement of setting must initiate in the first 24h, so setting time of the different formulations has also been evaluated through Vicat needle test. The maximum amount of spent resin with viable setting is 12.5% resin/binder for 100% slag formulation, 10% for 85% slag-15% fly ash, and 5% for 70% slag-30% fly ash. The heat release curves show that the acceleration/deceleration peak corresponding to gel formation shifts to longer times with lower intensities and broader peak shapes as fly ash and resin content increase. The location and the intensity of the acceleration peak have been modelled using lineal regression, in order to enable the simulation of the reaction with other requirements.

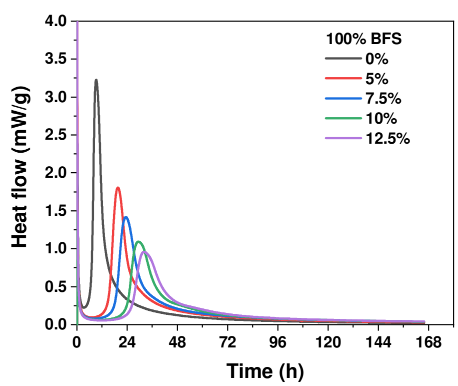

Figure 1 – Heat flow of the alkali-activated 100% slag paste with an incorporation of 5, 7.5, 10 and 12.5% of spent ion-exchange nuclear grade resin.