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Natural zeolite additives for the optimization of cementitious immobilization of simulated cesium and barium radionuclides in borate liquid waste

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Boric acid liquid waste is used in pressurized water reactor (PWR) systems to help maintain steady state operating temperature control because it is an efficient neutron absorber for activity management. The boric acid liquid waste produced by the system may contain trace concentrations of radioisotopes produced by nuclear fission, such as ^{137}Cs and its metastable decay daughter ^{137m}Ba (also called ^{137m}Cs). It is therefore essential for researchers to store this high-volume liquid waste in suitable repository conditions because, if these radioisotopes are not effectively immobilized, they may become bio-available in earth natural systems. Our research primarily aims to assess the geochemical effects of natural zeolite (i.e., clinoptilolite and mordenite) additives in sulfoaluminate cement (SAC) and Portland cement (OPC) blends to maximize chemical and mechanical stability for immobilizing borate liquid waste and contained fission isotopes, as previously mentioned, in solidified cement paste waste forms.

We added the natural zeolite additions at ratios of 0%, 5%, 10% and 15%, respectively, to a benchmarked OPC to SAC mix (i.e., 80% OPC to 20% SAC) to accomplish our study goal, based on the results of our previous experiment. The cement paste samples were then mixed with liquid waste that contained Cs and Ba isotopes to simulate nuclear reactor boric acid liquid waste, and they were allowed to cure for 28 days. Prior to undergoing standardized compressive strength testing, morphological examination using scanning electron microscopy (SEM), and mineralogy analysis using X-ray diffraction (XRD), the cured solid waste forms underwent an 11-day standardized reference leaching test. The liquid waste solutions (leachate) from the leaching test were analysed using inductively coupled plasma optical emission spectroscopy (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) to assess elemental and isotopic changes. The cement wasteforms with a 5% clinoptilolite addition showed the best stabilizing capacity, both chemically and physically, according to the results.