Batch and flow-through continuous stirred reactor experiments of Sr2+-adsorption onto smectite: Influence of pH, concentration and ionic strength

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Strontium-90 ($t_{1/2}$ = 29.1 years) resulting from the nuclear fission process is one of the main constituents connected with nuclear waste fuel. Concerning the physical properties and sorption behaviour one of the suitable buffer materials used as a backfill in the geological disposal systems for high-level radioactive wastes is smectite. The 2 μm clay fractions of di-octahedral smectite were used for adsorption experiments in batch and flow-through experiments that were carried out at different pH (4 and 8) and concentrations ($1.0x10^{-4}$ M $Sr(NO_3)_2$, $2.0x10^{-4}$ M $Sr(NO_3)_2$, $3.0x10^{-4}$ M $Sr(NO_3)_2$ and $4.0x10^{-4}$ M $Sr(NO_3)_2$). Batch experiments were carried out at different ionic strength ($[KNO_3]=10^{-2}$ M and $[KNO_3]=10^{-3}$ M), pH (4 and 8), whereas the concentration ranged between 50 mg $Sr(NO_3)_2$/L and 2.0 g $Sr(NO_3)_2$/L.

There is a significant difference of adsorption rates at pH 4 and pH 8 in flow-through experiments at the $1.0x10^{-4}$ M $Sr(NO_3)_2$ concentration. The Sr^{2+} ions face stiff competition with H_3O^+ ions at pH 4 for the adsorption sites and consequently Sr^{2+} adsorption is lower. The active sites are gradually deprotonated at comparatively higher pH resulting in larger uptake of metal ions. The adsorption rates difference is lower as Sr^{2+} concentration increases because more Sr2+ ions intensify the competition with H_3O^+ for active sites of sorption.

There is an increase on desorption rate in flow-through desorption processes at pH 4, compared with the pH 8, as a result of instability caused by Sr^{2+} ions competition with H_3O^+ ions that reveals the weakly interaction on metal-surface interface.

Batch experiments were performed with a wide range of Sr^{2+} ions concentration at different pH, which allow the understanding of the effect of metal concentration and the effect of extreme conditions of pH and ionic strength on adsorption process. These experiments allow us to conclude that at lower concentrations inside the chosen range, between 50mg $Sr(NO_3)_2$/L and 100 mg $Sr(NO_3)_2$/L, there is a higher amount of Sr^{2+} ions adsorbed on smectite at pH 8 in both ionic strengths. However, when Sr^{2+} concentration increases there are two different situations: at higher ionic strength ($[KNO_3]=10^{-2}$ M) and different pH (4 and 8) significant differences in the amount of Sr^{2+} adsorbed on surface clay are not achieved; on the other hand, at lower ionic strength ($[KNO_3]=10^{-3}$ M), there is a decrease in the amount of metal adsorbed at pH 8 (from 32 mg Sr/g –pH ~ 8 to 37 mg Sr/g – pH ~4).

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