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Immobilization of Cr(VI) by hydrated Portland cement pastes with and without calcium sulfate

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Highlights:

- The impact of calcium sulfate on the immobilization of Cr(VI) was investigated.
- The CrO_4-U phase was formed as a primary retention phase for Cr(VI).
- The leachability of Cr(VI) was pH-dependent.
- The conversion from CrO_4-U phase to CrO_4-ettringite was discussed

ABSTRACT

This work aims to illustrate the impact of high concentrations of Cr(VI) (based on Na_2CrO_4) on the hydration assembly and microstructural development of hydrated Portland cement, and the results also present the role of calcium sulfate on the immobilization of Cr(VI) in Portland cement. The results showed that the immobilization of Cr(VI) in hydrated Portland cement was attributed to the formation of CrO_4-U phase, a analogue of SO_4-U phase ($3CaO{\cdot}Al_2O_3{\cdot}CaSO_4{\cdot}0.5Na_2SO_4{\cdot}15H_2O$). The growth of CrO_4-U phase on the surface of clinker particles formed a diffusion barrier and hence increased the setting time. Increasing the calcium sulfate dosage impaired the Cr(VI) immobilization due to the competition between CrO_4^{2-} and SO_4^{2-} integrated into the U phase. The generalized acid neutralization capacity (GANC) test indicated that the Cr(VI) leaching behavior was a function of the leachate pH value. As the pH decreased to 11.8, the CrO_4-U phase was converted quickly to CrO_4-ettringite, which generated a slight increase in Cr(VI) concentration. The most leaching sector, approximately 89.3% of added Cr (1 wt% of cement), was found in the pH range 11.8–10.5 due to the dissolution of secondary CrO_4-ettringite. It could also be shown that the C–S–H had little chemical binding for Cr(VI).

Keywords: Hexavalent chromium; Portland cement; Immobilization; Calcium sulfate; U phase.

1. Introduction

Chromium is a toxic contaminant commonly generated from industrial activities, such as electroplating, leather tanning, production of pigments, stainless steels and other alloys. In the natural environment, chromium exists in several oxidation states and the most stable forms are trivalent Cr(III) and hexavalent Cr(VI). Cr(III) is low toxic and is considered as an essential trace