

Mineralogical Analysis of Phosphate-Based Recycled Ceramics and its Applications for Immobilization of Co(II) from Aqueous Systems

CHANBI LEE¹, SEON-YONG LEE², CHULMIN CHON²,
CHANGWOO KIM¹ AND HUIJEONG HWANG¹

¹Gwangju Institute of Science and Technology

²Korea Institute of Geoscience and Mineral Resources

In present days, with increasing consumption and landfill capacity of waste ceramics, it is essential to evaluate their environmental effect for particularly reducing the risk of soil and groundwater contamination. Notably, some ceramics contain 30-50 % bone ash during the manufacturing process, necessitating a careful examination of phosphate-based ceramics.

In this study, we investigated the mineralogical characterization and cobalt (Co) removal behavior on of phosphate-based recycled ceramics (Bone china porcelain, BC) in aqueous systems through batch experiment coupled with X-ray diffraction (XRD), X-ray fluorescence (XRF), Raman spectroscopy, and extended X-ray absorption fine structure (EXAFS) analysis. The mineral phases of BC were quartz (SiO₂), plagioclase feldspar (NaAlSi₃O₉-CaAl₂Si₂O₈), and Ca-phosphate mineral (Merrillite, Ca₉NaMg(PO₄)₇). Removal efficiency of Co²⁺ ions, as radioactive and hazardous cations in natural aqueous systems, by BC was evaluated with batch experiments varying contact time, pH, and Co²⁺ concentration (isotherm). Equilibrium time for cobalt removal was determined to be 48 hours, with cobalt removal capacity of ~ 0.30 mmol/g. At an initial cobalt concentration below 50 ppm and optimized initial pH of 4, (Ca-Co) ion-exchange was identified as the dominant removal mechanism of cobalt in aqueous solutions. The removal efficiency was 80.36 % at initial cobalt concentration with 10 ppm, decreasing with increasing concentration of cobalt. At concentration above 50 ppm, XRD analysis of the recovered sample revealed new Bragg reflections identifying the cobalt phosphate octahydrate (Co₃(PO₄)₂·8H₂O). This result indicated that the main removal mechanism of cobalt at high concentration was precipitation, rather than ion-exchange. The maximum cobalt removal capacity of BC was 0.4 mmol/g (23.57 mg/g), with equilibrium data fitted to the Langmuir isotherm model. Findings of this research, therefore, has important applications of recycled phosphate-based ceramics for cobalt removal and immobilization, with broader implications for removal and recovery of hazardous and radioactive metals from aqueous solutions.