Hydrothermal Synthesis of GTS-type Sodium Titanosilicate and its Sm3+ Ion Exchange

Keiko Fujiwara*[1], Tetsuo Hasegawa[1], and Akihiko Nakatsuka[1]

[1]Graduate School of Sciences and Technology for Innovation, Yamaguchi University (GSSTI, Yamaguchi Univ.) – Ube 755-8611, Japan

Abstract

Grace titanosilicates (GTS), represented by pharmacosiderite, have three dimensional tunnel-type structures. Na-GTS (Na4Ti4Si3O16·6H2O) crystallizes as a rhombohedral phase (space group ; a = 7.812 Å, α = 88.79∘) close to cubic system. In this structure, four TiO6 octahedra linked by edge-sharing form a Ti4O16 cubic cluster; the clusters are linked through SiO4 tetrahedra to form a three-dimensional framework with an interconnected pore system of 8-ring channels, occupied by the alkali-metal ions and adsorbed water molecules. The radioactive waste water continues to accumulate at the crippled Fukushima Daiichi Nuclear Power Plant. It is important to investigate the Sm3+ ion exchange properties of Na-GTS for the application of GTS to the removal of Sm radioisotopes from the radioactive waste water. In the present study, Sm3+-exchanged form [Na4(1-x)Sm4x/3(Ti4Si3O16) · nH2O] of Na-GTS prepared hydrothermally are investigated by powder XRD to examine the occupied positions of Sm3+.
The starting materials for the hydrothermal synthesis were NaOH, amorphous SiO2 fine powder and TiCl4 aqueous solutions. For the synthesis of Na-GTS, the starting mixtures with the molar ratios of TiO2/SiO2 = 0.32 and Na2O/TiO2 = 5.62 were hydrothermally treated at 100 ∘C (0.23 MPa) according to the reported procedure. The Sm3+-exchanged forms were obtained by shaking of the synthesized Na-GTS (0.5 g) in the aqueous solution of SmCl3 (25 mL) at 25 ∘C for 6 hours. The concentration of Sm3+ in the aqueous solution was varied in the range from 0.01 to 0.5 M. The obtained samples were filtrated, washed and dried at 80 ∘C, after which they were examined by powder XRD. The Sm concentrations in the supernatant solutions were analyzed with atomic absorption spectrometry to evaluate the ion-exchange amounts.

The sample with the composition x = 0.95 was obtained after the treatments of Na-GTS in 0.5 M SmCl3 aqueous solutions. The increase in concentration of the SmCl3 aqueous solution increases the exchange amount. The comparison of the observed and simulated XRD patterns suggests that Sm3+ ions are almost equally distributed on both 4e and 6g sites in the cavities of GTS framework.

*Speaker