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Chromatographic separation of calcium isotopes by using crown ether resin and acidic solutions

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Natural calcium consists of six isotopes. The heaviest isotope ^{48}Ca is a double-beta-decay nuclide and important for the study of neutrinoless double-beta decay. Since the natural abundance of ^{48}Ca is very low (0.187%), the enrichment of ^{48}Ca on a large scale is anticipated. However, the enrichment is very difficult, since calcium has no appropriate gaseous compounds which are usable as mediums for isotope separation processes such as gaseous diffusion, centrifugation, etc. Therefore, we have studied the chemical isotope separation based on the isotopic fractionation between chemical compounds in solution phase and in adsorption phase. The enrichment of calcium isotopes was observed at the adsorption band boundary of chromatography using benzo-18-crown-6 ether resin. For this purpose, the crown ether resin was synthesized by condensation polymerization of crown ether monomer and organic materials in porous silica beads. In our previous work calcium isotope separation by crown ether resin has been studied by using concentrated HCl solutions, mixed medium of alcohol and acid and organic solvents, etc. In the present work, attention was placed on the engineering aspects of the chromatographic separation system. Prior to the chromatographic isotope separation experiments, adsorption experiments were conducted in batch wise to obtain information on the adsorption of calcium in benzo-18-crown-6-ether resin (B18C6) at different conditions of HBr concentration. Then calcium isotope enrichment experiments were conducted by breakthrough-mode column chromatography using aqueous HBr feed solutions and B18C6 resin. Observed separation coefficients were 3.9x10-3 ~ 4.3x10-3. Determined engineering parameter HETP (Height Equivalent to a Theoretical Plate) were 2.6 ~ 6.7 mm; the HETP clearly showed the dependence on the concentration of calcium in feed solution. Discussion was extended to the analysis on the productivity of the separation system using the concept of separative power. Results indicate that the separative power is approximately proportional to the stage velocity. This fact suggests that the increase in the band speed is an effective measure to increase the capability of the separation system. A conceptual design of ^{48}Ca enrichment plant is presented as a summary of the basic research work on the chromatographic calcium isotope separation.

Biography

Academic Degrees received from Tokyo Institute of Technology; Master of Engineering in 1969 and Doctor of Engineering in 1973. Occupational Career: Chemical Engineer for Asahi Chem. Co. (1972 - 1974), Research Staff of Tokyo Institute of Technology (Research Associate, Associate Professor and Professor) (1974 - 2009), Professor Emeritus in2009. Published papers are 185. Award of Atomic Energy Society of Japan in 2003, Award of Japan Association of Ion Exchange in 2004 and Fellow of American Association for the Advancement of Science in 2006.

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