

1-4 How to Effectively Remove Iodate from Solutions?

— Coprecipitation of Iodate with Barite (BaSO_4) Was Evaluated at a Molecular Level —

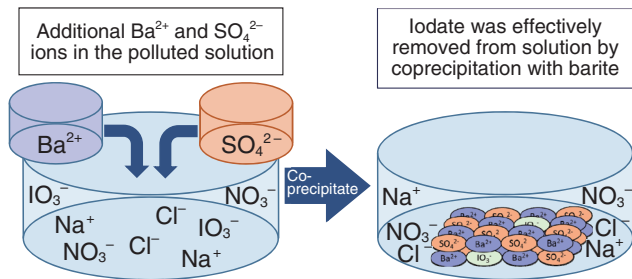


Fig.1-7 Design of IO_3^- coprecipitation with barite

We add BaCl_2 and Na_2SO_4 into a solution containing iodate by adjusting the $[\text{Ba}^{2+}]/[\text{SO}_4^{2-}]$ molar ratio. Barite is rapidly precipitated, and iodate is effectively removed from solution even in the presence of competitive anions in solution.

Radioactive iodine (^{129}I) is of great concern owing to its high environmental mobility and long-term radiotoxicity (^{129}I : half-life = 1.6×10^7 years). In the environment, iodine exists in two oxidation states (-1, +5), and it is mostly dissolved in natural water and radioactive liquid wastes as iodide (I^-) and iodate (IO_3^-). To date, the formation of AgI is the only method available for I^- removal, and there is no effective method for removing IO_3^- from contaminated natural water and waste liquid. In the present study, we developed a new technique for removing radioactive IO_3^- from aqueous solutions by using barite (BaSO_4). Although a variety of toxic and/or radioactive elements in the cationic form and selenium (Se) oxyanions can be removed from aqueous solutions by coprecipitation with barite, the removal of IO_3^- had not been investigated yet.

Barite is rapidly precipitated by mixing BaCl_2 aqueous solution in Na_2SO_4 aqueous solution (= coprecipitation). A diagram of IO_3^- coprecipitation with barite is shown in Fig.1-7. This study investigated the coprecipitation of IO_3^- with barite and found that IO_3^- can be effectively removed by this method. The main parameter affecting iodate removal is the $[\text{Ba}^{2+}]/[\text{SO}_4^{2-}]$ molar ratio in the initial aqueous solution. Results showed that iodate was effectively removed from the aqueous solution by coprecipitation when the $[\text{Ba}^{2+}]/[\text{SO}_4^{2-}]$ ratio was high. Extended X-ray absorption fine structure analysis also indicated that the incorporated IO_3^- was strongly bound to the crystal lattice of barite by the substitution of the SO_4^{2-} site in the structure when the IO_3^- concentration was low. It is believed that the charge compensation problem due to the substitution of IO_3^- for SO_4^{2-} was achieved by the substitution of Na^+ for the nearest Ba^{2+}

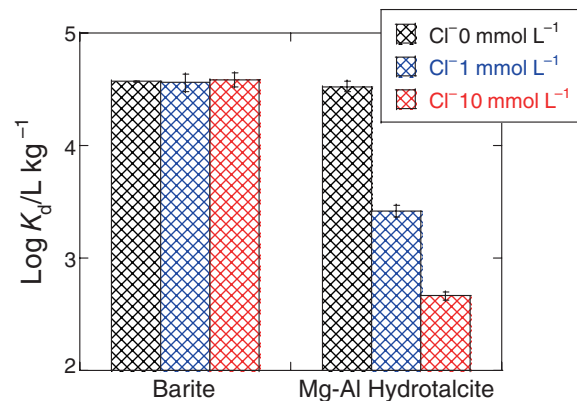


Fig.1-8 Comparison of iodate removal between barite and Mg-Al layered double hydroxide (LDH)

The K_d values of iodate for barite and Mg-Al LDH in the presence of Cl^- ions are estimated. The K_d of Mg-Al LDH decreased with increasing competitive Cl^- concentration, while that of barite was nearly independent of the Cl^- concentrations.

because Na^+ , which was not detected in the barite prepared without IO_3^- , was detected in the IO_3^- -bearing barite ($2\text{IO}_3^- + 2\text{Na}^+ \leftrightarrow \text{Ba}^{2+} + \text{SO}_4^{2-}$).

Subsequently, we investigated the influence of competitive anions on IO_3^- removal efficiencies by comparing with adsorption on hydrotalcite-like Mg-Al layered double hydroxide (LDH). Mg-Al LDH is a well-known inorganic layered mineral with a high anion exchange capacity, and the anion is intercalated into interlayer spaces. Many papers have reported on the removal of anionic contaminants by LDH. Fig.1-8 shows the distribution coefficient (K_d) of IO_3^- for barite prepared under the optimum condition and that for the Mg-Al LDH with and without the addition of NaCl in the initial aqueous solution. K_d is the ratio of concentrations of a solute (in this case, IO_3^-) between a liquid phase and a solid phase (barite or Mg-Al LDH). The higher the K_d , the higher is the selectivity of the solute to the solid phase. The K_d of Mg-Al LDH decreased with increasing competitive Cl^- concentration, while that of for barite was nearly independent of the Cl^- concentrations. At an initial Cl^- concentration of 10 mmol L^{-1} , the K_d of barite was two orders of magnitude greater than that of Mg-Al LDH. Hence, the coprecipitation method using barite performs better than the conventional adsorption method using LDH for IO_3^- removal when competitive anions are present. IO_3^- was also effectively removed from aqueous solutions in the presence of NO_3^- and SO_4^{2-} , which are also environmentally common anions. Coprecipitation with barite will be a promising tool for removing radioactive IO_3^- from various aqueous solutions contaminated with IO_3^- .

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Reference

Tokunaga, K. et al., Effective Removal of Iodate by Coprecipitation with Barite: Behavior and Mechanism, Chemosphere, vol.266, 2021, 129104, 10p.