Chemical state of dissolved aluminum in silicic acid solution and its adsorption behavior to silica

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Introduction

When aluminium (Al) exists in silicic acid (or silicate) (Si) solution, the Al concentration is apparently higher than the solubility of gibbsite and the chemical behaviour of Al is significantly different from that in simple Al salt solution without Si. The difference may be due to an interaction between Al and Si, that is, the formation of complexes composing of Al and Si (HAS_A and HAS_B) [1]. Therefore, it is important to elucidate the chemical state of Al in natural waters containing Si and the adsorption affinity to silica from the viewpoint of geochemical behaviour in hydrosphere and toxicity of Al to living things. In this study, Si/Al atomic ratio of aluminium species and coordination number of the Al were examined for dissolved Al in silicic acid solution (1 ppm Al and 50 ppm Si) in the pH range from 3 to 10 at ordinary temperature. Moreover, adsorption behaviour of the Al species to amorphous silica was also examined.

Results and discussion

Chemical state of ionic Al species in silicic acid

Ionic Al species can be adsorbed to ion exchange resins. The Si/Al atomic ratio of the Al species adsorbed by cation and anion exchange resins and coordination number of the Al were examined by spectrophotometric method and ^{27}Al MAS NMR. At pH 2.8~3.6, Al was present as 6-coordinated Al. At pH 4.8~6.4, Al may be present as both 4- and 6-coordinated Al. On the other hand, above pH 7, Al was present as 4-coordinated Al species with various Si/Al atomic ratios. The Si/Al atomic ratio increased with pH.

Adsorption behavior of the Al species to amorphous silica

At pH 3.0~3.6, almost all Al did not adsorb to silica. However, the adsorption proportion suddenly increased at pH 4.8 and monotonously decreased to pH 9. Above pH 9, the adsorption proportion increased again with pH.

By combining the both results, the chemical state of Al in silicic acid solution and the adsorption behavior will be discussed.

[1] J. Beardmore, X. Lopz, J. I. Mujika, C. Exley, Scientific Reports (2016).