

Removal of several types of sodium and potassium salts from aqueous solutions based on their natural fixation

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ABSTRACT

Inspired by the mechanism of plant roots for the fixation of inorganic salts, we developed a novel method for the removal of sodium and potassium salts including chloride, nitrate, and sulfate under pseudo-natural conditions. In this method, a plant was first cultured in NaCl, NaNO₃, or Na₂SO₄-containing aqueous solution. Subsequently, simulated adsorptions or precipitations under pseudo-physiological conditions were conducted based on the elemental composition of the plant's root after cultivation. The key species likely involved in the fixation of these inorganic salts were studied by using additional simulated adsorptions or precipitations. The results showed that oxalic acid and tartaric acid were effective for the fixation of Na⁺ and K⁺ ions, respectively. In addition, calcium phosphates were demonstrated to be effective for the fixation of NaCl, KCl, NaNO₃, and KNO₃ at a pH range of 7–7.5. The removal percentage increased with increasing initial concentrations of these salts and decreasing temperatures. The mechanism for the removal of NaCl, KCl, NaNO₃, and KNO₃ is through their adsorption on formed calcium phosphate floccules that have a large surface area. With the aid of Coulombic interaction, the adsorption and growth of a tested salt on the formed calcium phosphate floccules continues until it reaches an equilibrium with solvation interaction. Meanwhile, Ca²⁺ was an effective salt-fixing species for potassium sulfate, and the removal percentage increased with increasing concentration of SO₄²⁻ ions. The removal mechanism is attributed to the formation and precipitation of insoluble potassium–calcium sulfate. In addition, a high removal efficiency could be achieved by removing the formed precipitate promptly from the treated aqueous solution.

Keywords: Bio-inspired technology; Biomimetic separation; Desalination; Sodium salt; Potassium salt

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