

Phase transformations accompanying sorption of nickel(II) ions by struvite

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Abstract

The conditions for the formation of struvite, $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$, in a metastable state, and its subsequent recrystallization with crystal morphology change were studied. An important role in this process has supersaturation of the solution by the ions, which are parts of struvite. Introduction of Ni^{2+} ions to the solution during struvite recrystallization results in transition of these ions to struvite phase. The corresponding supersaturation of the solution promotes sorption of Ni^{2+} ions by struvite. Mechanism of sorption corresponds to isovalent and isomorphic exchange of ions $\text{Mg}^{2+} \leftrightarrow \text{Ni}^{2+}$ on the basis of struvite structure.

It was theoretically and experimentally shown that during sorption of Ni^{2+} ions by struvite the formation of solid solution and phase transformation of struvite enriched by Ni^{2+} ions to vivianite (one of two known polymorphic structures of octahydrate of nickel-magnesium orthophosphate) were possible. Increase of temperature promotes a phase transformation of struvite to vivianite. At the boiling point of an aqueous suspension consisting of Ni^{2+} ions and $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$ only vivianite is solid phase product of interaction. The same result is obtained by boiling of the Ni-struvite in water. The results of X-ray diffraction and FTIR-spectroscopy shown the formation of solid solutions of substitution of ions $\text{Mg}^{2+} \leftrightarrow \text{Ni}^{2+}$ on the basis of vivianite structure containing a mixture of magnesium and nickel ions in its composition.

Based on experimental results on the sorption of ions Ni^{2+} by struvite the possibility of phase transformation of struvite to vivianite at 45 ± 0.5 °C was confirmed. Simultaneously it was found that Cl^- and NO_3^- anions in the aqueous phase promote phase transformation of struvite, but this effect was less pronounced for SO_4^{2-} anions. Cations NH_4^+ in the aqueous phase on the contrary contribute to stabilization of struvite. The phase transformation of struvite to vivianite leads to an increase of the molar ratio of $(\text{Ni} + \text{Mg}) : \text{P}$ in the solid phase and under certain conditions causing enrichment of vivianite by nickel.

Formation of vivianite as more stable phase and the possibility of additional sorption of Ni^{2+} ions during the phase transformation can favorably affect the efficiency of struvite using as a meliorant stabilizer for remediation of soil contaminated with heavy metals.

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