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Temperature and humidity effects on ferric sulfate stability and phase transformation

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Abstract

Evolution of concentrated $Fe_2(SO_4)_3$ solution, a process including both evaporation of the solution and post-evaporation aging of the precipitates, was studied at 2 and 50 °C under controlled relative humidity (RH). At 50 °C and 42–47% RH, ferricopiapite [$Fe_{4.67}(SO_4)_6(OH)_2 \cdot 20H_2O$] and rhomboclase [$(H_5O_2)Fe(SO_4)_2 \cdot 2H_2O$] first crystallized from the starting solution, and then combined to form kornelite [$Fe_2(SO_4)_3 \cdot 7.5H_2O$] at 42% RH or to paracoquimbite [$Fe_2(SO_4)_3 \cdot 9H_2O$] at 46–47% RH. At 2 °C and 34–43% RH, initially crystallized ferricopiapite and rhomboclase appeared to be stable and did not proceed to form a single ferric sulfate hydrate phase over 385 days. At both 2 and 50 °C and RH ≤ 31%, an amorphous ferric sulfate formed. The amorphous ferric sulfate was preserved longer at low RH conditions, e.g., RH ≤ 11%, than higher RH, at which it slowly transformed to crystalline phases of rhomboclase and ferricopiapite, as observed at 31% RH and 50 °C. Combining the results from this study and those from our previous study at 25 °C, the ferric sulfate phase evolution at 2, 25, and 50 °C were mapped and compared. Temperature shows a strong effect on the evolution kinetics; low *T* may inhibit the evolution from reaching an equilibrium state. Also, an RH and *T*-controlled in situ X-ray diffraction (RH-*T*-XRD) method was used to study phase transitions of ferric sulfate hydrates at temperatures from 25 to 80 °C. A dehydration of paracoquimbite to ferric sulfate pentahydrate [$Fe_2(SO_4)_3 \cdot 5H_2O$] was identified at 80 °C. The results are discussed with a previously constructed ferric sulfate RH–*T* phase diagram by Ackermann et al. (2009).

Keywords: Ferric sulfate, humidity, phase diagram, ferricopiapite, sulfate, paracoquimbite, amorphous sulfate