

Supplementary Information

The effect of reaction conditions and presence of magnesium on the crystallization of nickel sulfate

*Ina Beate Jenssen*¹, *Oluf Bøckman*², *Jens-Petter Andreassen*,¹ and *Seniz Ucar*^{1,*}

¹*Norwegian University of Science and Technology, Trondheim, Norway*

²*Glencore Nikkelverk AS, Kristiansand, Norway*

* *Correspondence to: seniz.ucar@ntnu.no*

A. XRD spectra of nickel sulfate hydrates

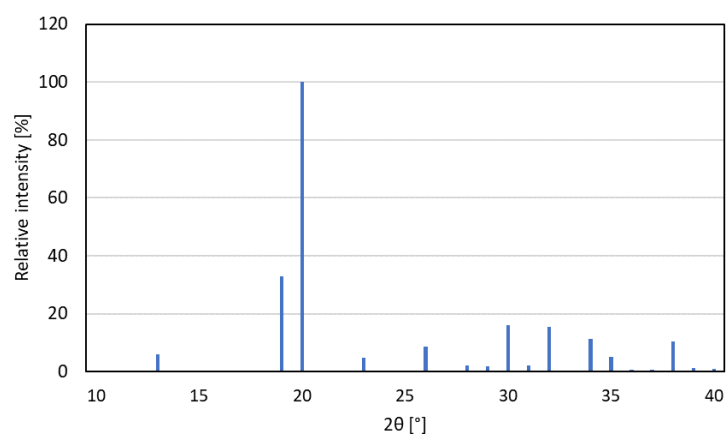


Figure A.1: XRD spectrum of α -NiSO₄·6H₂O, values adapted from the International Centre for Diffraction Data database (ICDD), PDF 04-010-2482; primary, indexed quality, T = 298 K.

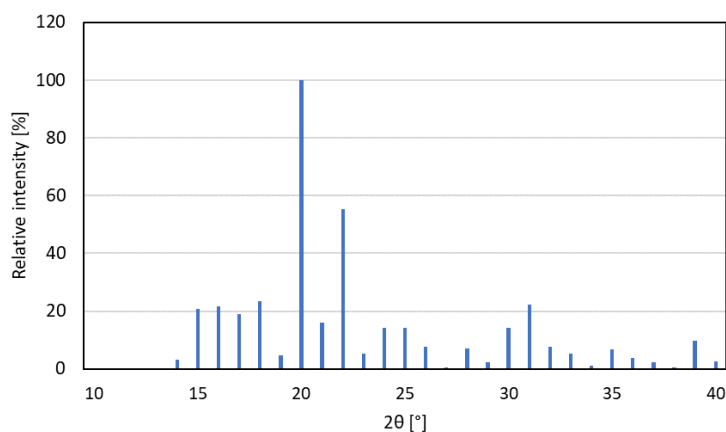


Figure A.2: XRD spectrum of β -NiSO₄·6H₂O, values adapted from the International Centre for Diffraction Data database (ICDD), PDF 04-009-4324; primary star quality, T = 294 K.

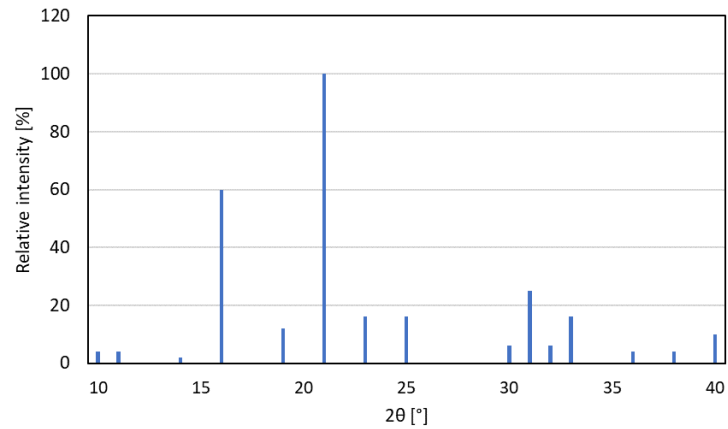


Figure A.3: XRD spectrum of $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$, values adapted from the International Centre for Diffraction Data database (ICDD), PDF 00-001-0403; primary indexed quality, $T = 298 \text{ K}$.

B. Temperature profiles

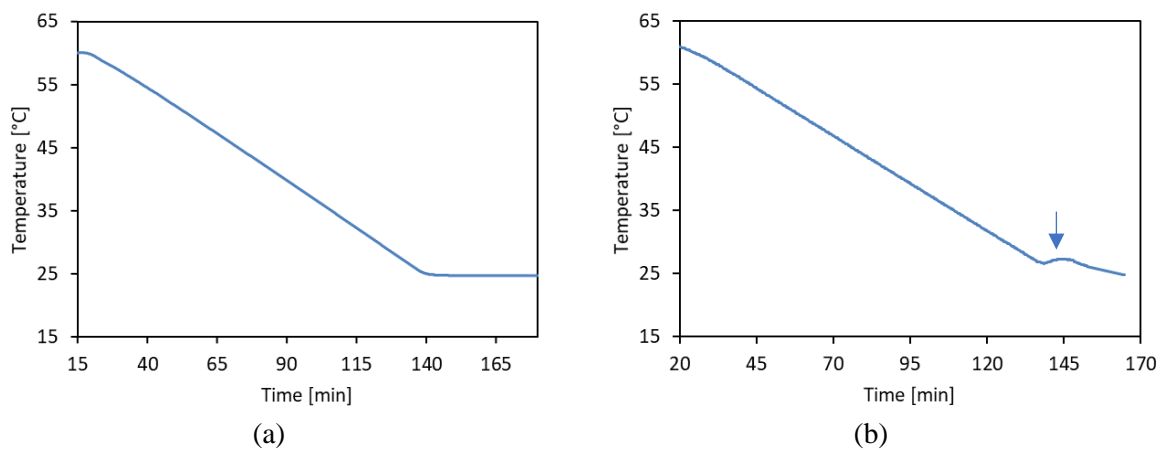


Figure B.1: Temperature evolution as function of time during crystallization of nickel sulfate for temperatures unseeded experiment with (a) no magnesium and (b) $18 \text{ mg g}^{-1} \text{ Mg}$. Note the temperature increase in (b), representing crystal formation, whereas no temperature increase is seen, hence no crystal formation, in (a). The cooling rate in both cases is 0.29 °C min^{-1} .

C. Light microscopy images

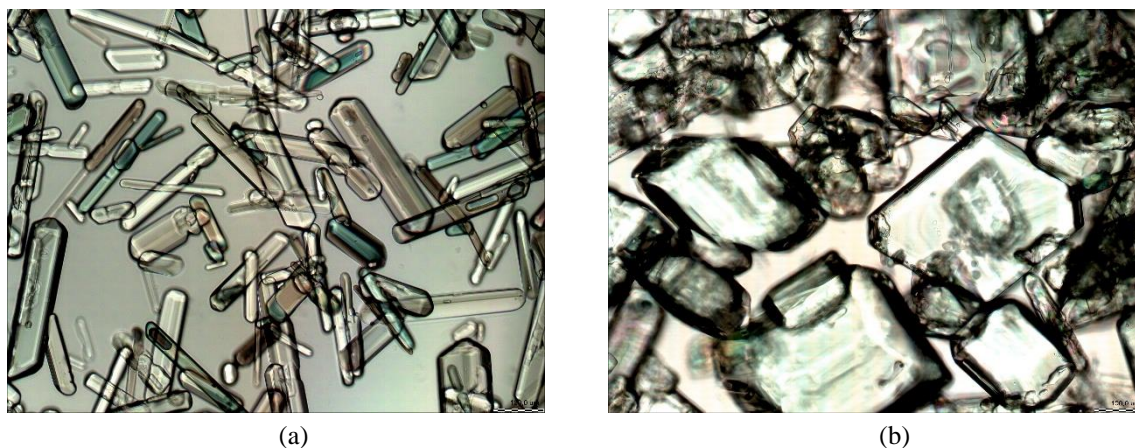


Figure C.1: Light microscopy images of nickel sulfate precipitated with 0.2 g α -NiSO₄·6H₂O seeds and no magnesium present. (a) Product consisting of α -NiSO₄·6H₂O, β -NiSO₄·6H₂O and NiSO₄·7H₂O, formed at 25 °C and (b) β -NiSO₄·6H₂O precipitated at 70 °C. Corresponding micrographs obtained from SEM in Figure 6 in the article.

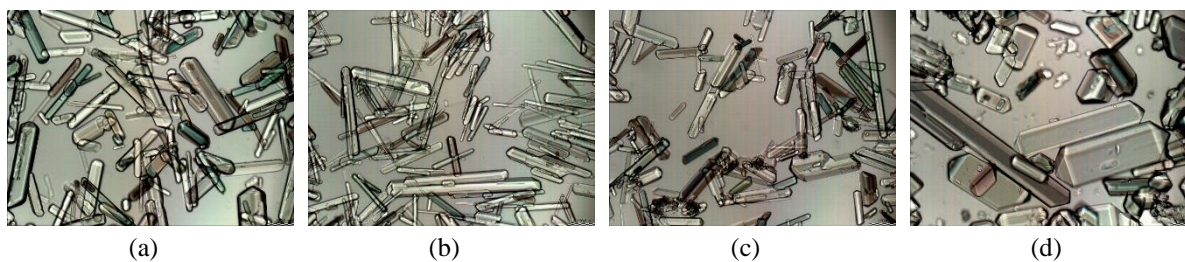
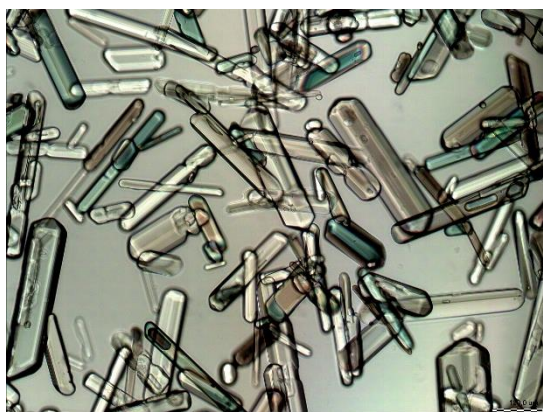
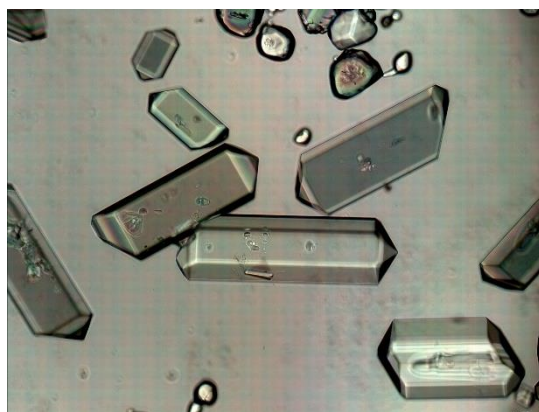


Figure C.2: Light microscopy images of nickel sulfate produced from seeded experiments with 0.2 g α -NiSO₄·6H₂O seeds at 25 °C with (a) 0 mg g⁻¹ Mg, (b) 5 mg g⁻¹ Mg, (c) 9 mg g⁻¹ Mg, and (d) 18 mg g⁻¹ Mg. Corresponding micrographs obtained from SEM in Figure 10 in the article.



(a)



(b)

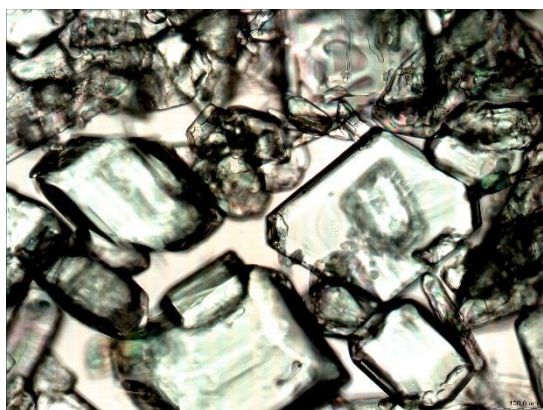


(c)

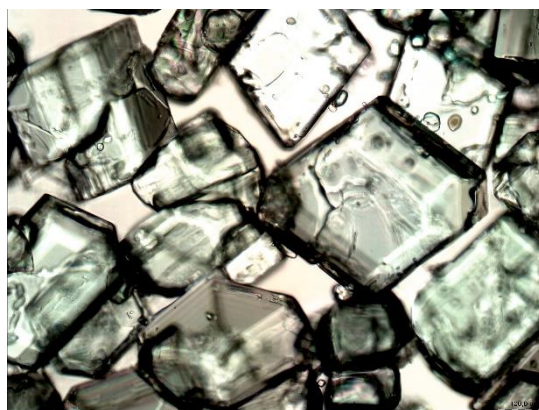


(d)

Figure C.3: Light microscopy images of nickel sulfate produced at 25 °C with different seed amounts: (a) 0.2 g seeds without Mg, (b) 2.0 g seeds without Mg, (c) 0.2 g seeds with 5 mg g⁻¹ Mg, (d) 2.0 g seeds with 5 mg g⁻¹ Mg.



(a)



(b)

Figure C.4: Light microscopy images of nickel sulfate produced at 70 °C with different seed amounts: (a) 0.2 g seeds without Mg, (b) 2.0 g seeds without Mg.

D. Phase transformation in dry state

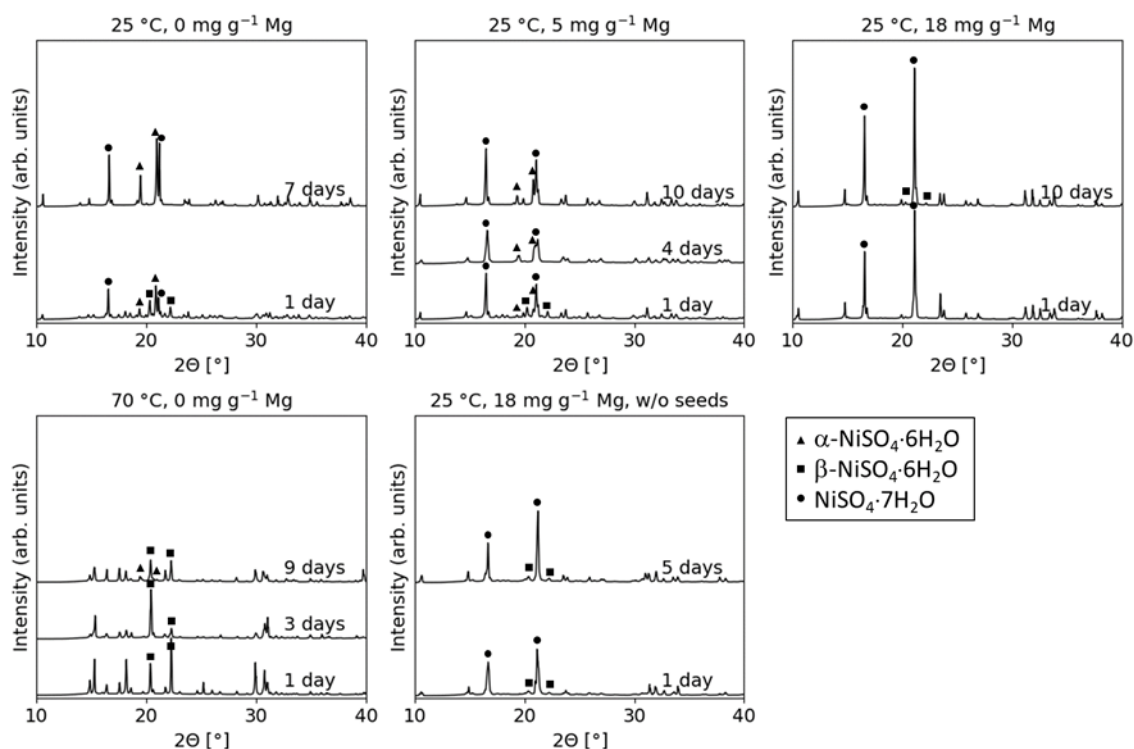


Figure D1. Transformation of nickel sulfate samples in dry state followed by XRD at indicated time points. Nickel sulfate crystallized at the following conditions; with 0.2 g seeds at 25 °C with (a) 0 mg g⁻¹ Mg, (b) 5 mg g⁻¹ Mg, and (c) 18 mg g⁻¹ Mg; (d) with 0.2 g seeds at 70 °C, without Mg, and (e) unseeded at 25 °C, with 18 mg g⁻¹ Mg.

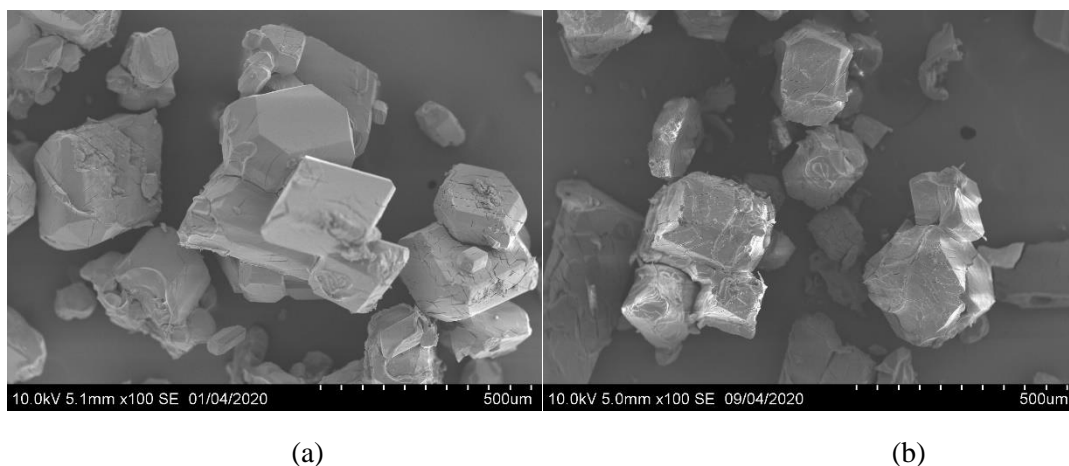


Figure D.2: SEM images of nickel sulfate precipitated at 70 °C with 0.2 g α -NiSO₄·6H₂O seeds and no magnesium present. The images show particles at (a) 1 day and (b) 9 days after the experiment.