

## The mechanism and kinetics of $\alpha$ -NiS oxidation in the temperature range 670–700 °C

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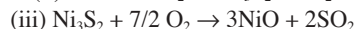
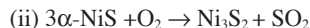
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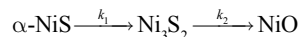
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### ABSTRACT

The oxidation behavior of synthetic  $\alpha$ -NiS in air has been investigated over the temperature range 670–700 °C. The  $\alpha$ -NiS was ground and sieved to give a particle size ranging from 53 to 90  $\mu\text{m}$ . Three oxidation paths were observed:



No  $\text{Ni}_3\text{S}_2$  (heazlewoodite) was observed over the course of  $\alpha$ -NiS oxidation at 670 and 680 °C. The dominant oxidation path at this temperature is path i. At 700 °C, however, all three oxidation paths were observed. As an intermediate oxidation product,  $\text{Ni}_3\text{S}_2$  steadily exsolved from  $\alpha$ -NiS, reaching a maximum quantity after about 80 min of oxidation, declining afterward, and approaching annihilation at 160 min of oxidation. Experimental results show that the exsolution of  $\text{Ni}_3\text{S}_2$  is likely triggered by the loss of one third of S in the  $\alpha$ -NiS structure with the release of  $\text{SO}_2$  rather than by an intrinsic thermal decomposition of  $\alpha$ -NiS to  $\alpha\text{-Ni}_{1-x}\text{S} + \text{Ni}_3\text{S}_2$ . The eventual annihilation of  $\text{Ni}_3\text{S}_2$  was caused by a further oxidation of  $\text{Ni}_3\text{S}_2$  to NiO. Oxidation paths 2 and 3 form a typical single chain reaction:



The approximate values of  $k_1$  are  $k_2$  are  $3 \times 10^{-4}\text{s}^{-1}$  and  $5 \times 10^{-4}\text{s}^{-1}$  respectively.

Oxidation temperature was found to play important roles both in the oxidation kinetics and the oxidation mechanism. By decreasing 10 °C from 680 to 670 °C, the average reaction rate ( $dy/dt$ , where  $y$  is the reaction extent) over the experiment time scale almost decreased to one third of its original rate (from  $3.3 \times 10^{-5}\text{s}^{-1}$  to  $1.2 \times 10^{-5}\text{s}^{-1}$ ). The reaction mechanism in the temperature range 670 to 680 °C is constant with  $E_a = 868.2 \text{ kJ/mol}$ .

**Keywords:** NiS, oxidation, chain reaction, kinetics