

# Recovery of Copper Ions and Reuse of Nitric Acid from Waste Copper Nitrate Solutions

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## Abstract

In the PCB manufacturing or stripping process, waste copper nitrate solution (WCNS) containing at least 40% nitric acid and 80-120 g/L copper ions is discharged, posing environmental and health hazards. Therefore, the reuse of copper ions and nitric acid is necessary. To support a circular economy and sustainable materials management, a mixed suspension mixed product removal (MSMPR) crystallization process was employed to treat WCNS, which produced copper oxalate in the first stage and recycled nitric acid in the second stage. The investigated variables included temperature (25-40 °C), stirring speed (600-900rpm), liquid-flow rate (30-60mL/min), copper ion concentration (1.08-1.27M), and concentration of oxalic acid (0.8-2.0M). A total of 16 experimental runs were conducted. The influence of these variables on the precipitation rate of copper oxalate, particle size, nucleation rate, growth rate, and agglomeration kernel were examined. Additionally, nitric acid was recycled using a vacuum evaporation process to restore its concentration to that of the original source. The results showed that the precipitation rate, particle size, nucleation rate, growth rate, and agglomeration kernel ranged from 4.89 to 11.66g/min; 1 to 5.4 $\mu$ m;  $8.49 \times 10^{12}$  to  $3.00 \times 10^{13}$  no/m<sup>3</sup> s;  $1.9 \times 10^{-10}$  to  $3.69 \times 10^{-9}$  m/s; and  $9.44 \times 10^{-20}$  to  $5.80 \times 10^{-18}$  m<sup>6</sup>/no s, respectively. The composition of solids was analyzed using XRD and SEM. The primary particle size was found to be 32.84-46.99 nm, with SEM images indicating crystal agglomeration. The nitric acid recovery efficiency exceeded 90% in most cases. Finally, correlation equations were expressed in this study.

## Keywords

Copper Nitrate Solution, Crystallization, Mixed Suspension Mixed Product Removal, Vacuum Evaporation