

ELECTROWINNING OF COBALT FROM A SULFATE-CHLORIDE SOLUTION AS AN OPTION FOR TREATMENT OF INDUSTRIAL EFFLUENTS

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In recent years, cobalt has found new applications in electronic and catalytic industries with an increase in industrial activities. Nanocrystalline alloys, such as Co-Mo, Co-P, Ni-P and Co-W alloys, are being developed in attempt to replace hexavalent chromium to improve corrosion, wear and erosion resistance to electrolytic components (Erb, 1995). However, the recovery of cobalt from the waste solutions generated from the above processes is a challenging problem. The effluents might contain a number of chemical components. Some of these components may be valuable for recycling or have a detrimental impact on the environment when being discharged without treatment. One of optional treatments is to recover directly cobalt from the specific and complex sulfate-chloride system using electrowinning method. In this paper, the effect of various operational factors, such as cobalt concentration, bath pH, current density, bath temperature, chloride concentration, electrode distance and plating duration on cobalt electrowinning from a complex sulfate-chloride system were studied.

Experimental results showed that cobalt concentration had a significant influence on cobalt deposition from the specific system. Current efficiency decreased markedly when cobalt concentration was reduced to less than 10g/L. The experimental results indicated that desirable cobalt concentration should be higher than 40 – 50g/L. It was revealed that current efficiency decreased with an increase in current density from 100 to 800A/m² while a sharp increase was noted when applied current density was raised from 50 to 100 A/m². The current efficiency decreased from 96.7% at 100A/m² to 92.8% at 800A/m². This reduction might be attributed to high rate of hydrogen evolution and rapid depletion in cobalt ions or complexes on the surface of cathode because of enhanced cobalt deposition rate when the current density was increased. The effect of current density on the surface morphology of deposits which was studied using SEM examination indicated clearly that the deposits developed at low current densities were more uniform and cobalt crystals were smaller than those produced at high current densities. These results support the findings which was observed by Das and Subbaiah (1984).

The investigation showed that current efficiency increased significantly with an increase in electrolyte pH at a pH range of 1-5. After pH was increased to more than 3, the improvement on the current efficiency was not obvious. The study of deposit morphology, which is shown in Fig. 1, pointed out that the characteristics of deposits varied substantially with the electrolyte pH. The electrowon cobalt produced at higher pHs appeared to be rougher, duller and richer in porosity in comparison with the deposits with brighter, more compact and uniform structures at low pHs. Considering a detrimental influence on deposit quality which could be caused by the inclusion of cobalt hydroxide complexes, such as CoOH⁺, Co(OH)₂, in the deposit (Jeffrey et al, 2000; Nakahara and Mahajan,

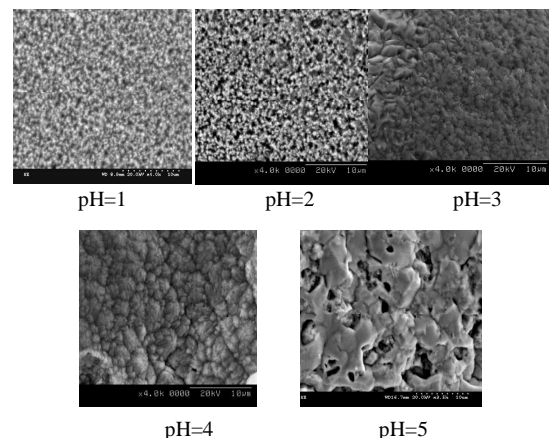
1980) and the deposit generated at a high pH was dull and brittle, it was suggested that the electrowinning should be operated at electrolyte pH 3.

In the concentration range studied, chloride ions had little effect on the current efficiency. However, it was observed that the energy consumption slightly decreases with increasing chloride concentration. SEM examination revealed that the surface morphology of the deposits was quite strongly affected with the addition of chloride ions. The deposits formed from the pure sulfate solution appeared to be uniform and compact fibrous crystallites. With an increase in chloride ions, larger size crystallites with central-faced polyhedral structures were developed. XRD determination suggested that preferred crystal orientation of the electrowon cobalt was affected with a change in chloride concentration.

The study also indicated that current efficiency was improved with both enhancing temperature and reducing electrode distance. The processing temperature had a substantial impact on current efficiency and deposit morphology.

References:

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Cobalt Concentration: 50g/L, Cobalt Sulfate/Cobalt Chloride: 4:1,
Electrowinning Time: 2 hours, Bath Temperature: 60°C,
Current Density: 200A/m², Electrode Distance: 10mm

Fig. 1 SEM images of cobalt deposits from various pH solutions