

ELECTROWINNING OF ZINC — EFFECT OF METALLIC IMPURITIES AND ADDITION AGENTS

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The electrowinning of zinc is sensitive to metallic impurities especially from the points of view of current efficiency and purity of the deposit. Moreover, the effect of impurities in combination is in general detrimental to electrolysis than of single impurity. The organic addition agents are known to influence the nature of deposit and current efficiency. In this context, studies have been made with regard to the influence of addition agents like fish glue, avitone, gelatin and sodium lignin sulphonate. Among the additions studied avitone shows promise from the point of view of current efficiency. The influence of metallic impurities like nickel, cobalt and antimony individually and in combination has also been investigated.

Keywords: Metallic impurities, addition agents, current efficiency and deposit nature.

INTRODUCTION

Addition agents such as glue, sodium lignin sulphonate, gelatin, peptine, avitone, alkaloids, various gums etc., are often used to increase current efficiency as well as the physical character of the deposit. The colloidal particles migrate and deposit at the electrodes. Points of crystal growth or any other projection on the electrode will be the regions of higher current density than the normal surface and colloidal particles deposit in clusters on these points and by insulating action reduce the amount of current to these points. This action tends to smooth out the deposit. The presence of impurities is a major problem for zinc electrowinning industries by decreasing the current efficiency and changing the deposit morphology [1-6]. Antimony which is one of the more harmful impurities was also found to produce an inferior deposit morphology due to poorly defined zinc platelets having a (002) preferred orientation [1,3]. Cobalt and nickel which are difficult to remove from the electrolyte can have disastrous effect on zinc current efficiency due to resolution of zinc deposit resulting from galvanic cell formation. Previous workers [7-9] have shown that an induction period exists before nickel and cobalt have any appreciable effect on current efficiency for zinc deposition after which it decreases rapidly with time. The length of the

induction period decreases with increasing temperature and acid concentration and decreasing current density.

The present study was made to examine the effect of addition agents like glue, gelatin, sodium lignin sulphonate and avitone on the nature of deposit and current efficiency and the effect of cobalt and nickel and their interaction with antimony during the initial stage of zinc deposition.

EXPERIMENTAL

A modified hull-cell and a planar cell were employed to study the effect of addition agents and metallic impurities for zinc deposition on nature of deposit and current efficiency respectively.

The hull-cell (267 ml) having holes (6 mm dia) in the parallel sides of the cell is placed in a trough containing 1400 ml of the electrolyte. This arrangement minimises concentration change in the hull-cell during electrolysis. A lead anode (6.0 x 6.5 cm) and an aluminium cathode (10.0 x 7.5 cm) were employed as electrodes. The electrolyte was zinc sulphate solution of 50 g l⁻¹ zinc and 150 g l⁻¹ sulphuric acid. A d.c. current of 2A was passed to get a current density range of 100-800 Am⁻². The addition agents viz. glue, gelatin, sodium lignin sulphonate and avitone were added to the electrolyte in the concentration range of 5-20 ppm. The zinc deposit on the

cathode is marked with a hull-cell standard scale to identify the various current density regions and the deposit is cut accordingly to compute the current efficiency.

A planar cell of 1 litre capacity having an aluminium cathode and a lead anode of dimension 15.1 x 5.2 cm was employed. Zinc sulphate solution containing 50 gl^{-1} Zn and 150 gl^{-1} H_2SO_4 was used as electrolyte. The electrolysis was carried out at a current density of 400 A.m^{-2} for a period of 4 hours. Nickel and cobalt were added as their sulphates and antimony as potassium antimony tartarate to the desired concentration level in the electrolyte.

RESULTS AND DISCUSSION

Fig. 1 shows the relative performance of the addition agents viz. avitone, sodium lignin sulphonate, gelatin and fish glue on current efficiency for zinc deposition. It can be seen that sodium lignin sulphonate and gelatin has no pronounced effect on current efficiency whereas in the case of fish glue there is a decrease in current efficiency at higher concentration of the addition agent. This lowering of current efficiency may be due to the promotion of hydrogen discharge. In the case of avitone as addition agent higher current efficiency is obtained in the concentration range of 5-20 ppm as compared to other three addition agents.

The effect of antimony on current efficiency for deposit electrowon at 400 A.m^{-2} is shown in Table I. The presence of 0.05 ppm antimony in the electrolyte resulted in a current efficiency of 84.7% which decreased to 15.5% when its concentration increased to 0.3 ppm.

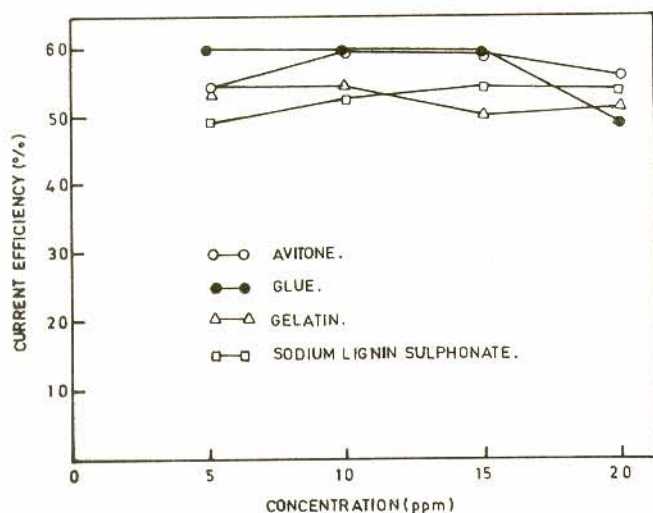


Fig. 1: Effect of various additional agents on the current efficiency for zinc deposition at 400 to 600 A.m^{-2} in hull cell

TABLE I: Effect of antimony on current efficiency for zinc deposition in planar-cell

Concn. of zinc = 50 g/l; Concn. of H_2SO_4 = 150 g/l

Duration = 4 Hours; Temperature = 303 K

Current density = 400 A.m^{-2} ; Current passed = 1.8 A

Concn of antimony (ppm)	Current efficiency (%)
0.00	85.2
0.05	84.7
0.15	72.5
0.30	15.5

The effect of increasing concentration of nickel on current efficiency for electrodeposition of zinc is shown in Fig. 2. The presence of nickel in the electrolyte had a more detrimental effect than cobalt [10]. There is no change in the current efficiency up to a nickel concentration of 5 ppm. However the current efficiency decreases rapidly to 22% and 2.9% when the nickel concentration is 10 and 20 ppm respectively. It has been observed that zinc deposition is associated with vigorous hydrogen evolution indicating that some of the deposited zinc dissolves out resulting in lowering of current efficiency. This behaviour suggests that a local cell (Zn-Ni galvanic cell) formation occurs due to interaction of

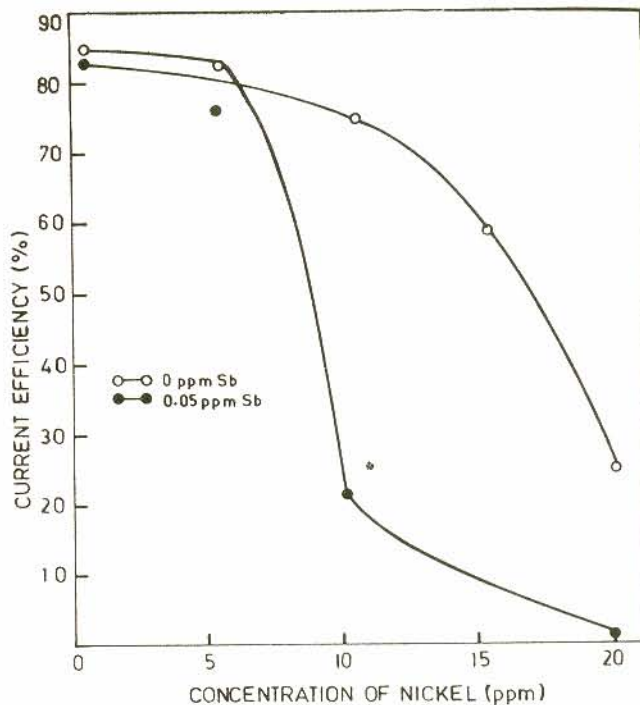


Fig. 2: Effect of nickel in the presence and absence of antimony on current efficiency for zinc deposition at 400 A.m^{-2} in planar cell

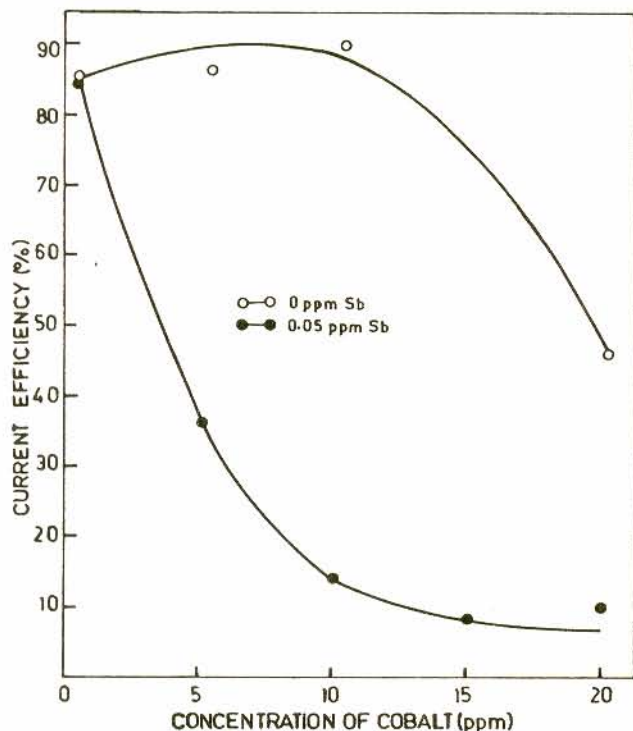


Fig. 3: Effect of cobalt in the presence and absence of antimony on current efficiency for zinc deposition at 400 A.m^{-2} in planar cell

codeposited impurity which acts as cathodic sites promoting the resolution of zinc.

The effect of cobalt on current efficiency for zinc deposition at 400 A.m^{-2} from acid sulphate solution is shown in Fig. 3. The current efficiency remained constant at 85% upto a cobalt concentration of 10 ppm which decreases to 46% at 20 ppm. At higher cobalt concentration vigorous hydrogen evolution was observed and this was accompanied by simultaneous zinc resolution. It has been interpreted in terms of the formation of local Zn-Co galvanic cell.

Interactions among impurities are important particularly because impurities which do not exhibit an effect when present alone can become intolerable when small amounts of another impurity is introduced. The effect of 0.05 ppm antimony in combination with increasing concentration of cobalt on the current efficiency for a 4 hour deposit is also shown in Fig. 3. The presence of 0.05 ppm antimony in the electrolyte without any cobalt or nickel resulted in a current

efficiency of 84.7%. Comparison of current efficiencies show that the electrolytes having antimony and cobalt becomes far worse than the one with cobalt alone. The effect of nickel in the presence of antimony is also shown in Fig. 2. The presence of 0.05 ppm antimony has a beneficial effect on the current efficiency. Thus, for 10 ppm nickel the current efficiency increases from 22% to 79.5% and for 20 ppm nickel it increases from 2.9% to 25%. This indicates that when antimony is present in the electrolyte hydrogen evolution is inhibited and hence zinc deposit re-resolution is lessened.

CONCLUSION

Hull-cell studies indicate that the presence of addition agents like fish glue, gelatin, sodium lignin sulphonate and avitone generally improves the nature of deposit. Higher current efficiency is obtained with the employment of avitone as the addition agent. The effect of metallic impurities like nickel and cobalt and their interaction with antimony on current efficiency is determined. The presence of nickel in the electrolyte has a more detrimental effect than that of cobalt and consequently on deposit resolution. The combined presence of cobalt and antimony in the electrolyte is more deleterious to zinc electrowinning whereas the combined presence of nickel and antimony is found beneficial.

REFERENCES

1. D J Robinson and T J O'Keefe, *J Appl Electrochem*, **6** (1976) 1
2. S A Lumping and T J O'Keefe, *Metal Trans*, **78** (1976) 551
3. D J Mackinnon and J M Brannen, *J Appl Electrochem*, **7** (1977) 451
4. R C Kerby, H E Jackson and T J O'Keefe, *Metal Trans*, **8B** (1977) 661
5. D J Mackinon, J M Brannen and R C Kerby, *J Appl Electrochem*, **9** (1979) 55
6. D J Mackinon, J M Brannen and R C Kerby, *J Appl Electrochem*, **9** (1979) 71
7. M Maja and P Spincil, *J Electrochem Soc*, **118** (1971) 1538
8. I W Wark, *J Appl Electrochem*, **9** (1979) 721
9. M Maja, N Penezzi, R Franesi and G Roventi, *J Electrochem Soc*, **129** (1982) 2695
10. C Bozhkov, M Petrova and St Rasukov, *J Appl Electrochem*, **22** (1992) 73