Electrodeposition of Ternary Alloys of Nickel-Cobalt-Zinc from the Pyrophosphate Bath

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ABSTRACT

Studies on the electrodeposition of nickel-cobalt-zinc alloys from the pyrophosphate bath have led to certain peculiar observations, namely, the difficulty in obtaining high nickel deposits, and the decrease in the weight of the deposit with time at certain current densities.

INTRODUCTION

The electrodeposition of alloys of nickel-cobalt[1], cobalt-zinc[2] and nickel-zinc[3] from the pyrophosphate bath has been studied in detail in this laboratory. During the deposition of nickel-zinc alloys from the pyrophosphate as well as chloride[4] baths there were sudden changes in the plate composition and cathode potential for a small change in the current density due to the deposition of alloys of different phases. Similar changes in composition and potential have been observed for cobalt-zinc alloys deposited from the pyrophosphate bath[2]. Glasstone[5] has also noted changes in the potential from that of nickel or cobalt to a potential favouring zinc deposition at higher current densities. In sulphamate solutions for the deposition of nickel-zinc alloys[6], a deposit with high nickel content could be obtained only by electrolysis at controlled cathode potential. Cathode potential-time curves indicated that the potential suddenly drops down to a low value after a certain time and is thereafter practically constant. At this stage it reaches the nickel potential value favouring the deposition of a high nickel alloy. This has been attributed to galvanic corrosion between different phases and also to dezincification. During the deposition of alloys of zinc with nickel or cobalt from pyrophosphate solutions, the cathode efficiency decreased with an increase in the current density and then increased continuously. This appears to be due to the same reason described above.

In view of the peculiar phenomena during the deposition of binary alloys, it was thought that the deposition of the ternary alloy nickel-cobalt-zinc might also be interesting.

EXPERIMENTAL AND RESULTS

The plating solutions contained nickel (as chloride) 0.025M, cobalt (as chloride) 0.05M and zinc (as chloride) 0.3M, ammonium citrate 5 g/l, and potassium pyrophosphate as follows: ratio of pyrophosphate to metal — 3.5 for cobalt and 2.5 for nickel or zinc. The temperature was 60°C and the bath was worked under still conditions. The experimental details have been described in previous papers. The results are presented in Table I and Figure 1. The potential values have a negative sign and refer to the hydrogen scale. The composition of the deposit has been given by weight for a two hour period.

TABLE I

c. d., amp/dm²	*Deposit composition, %*			*Weight, mg.*	
	Ni	*Co*	*Zn*	*1 hr*	*2 hr*
0.5	6	85	9	26	40
1.0	11	72	17	53	118
1.25	11	40	49	56	95
1.5	9	30	61	69	84
2.0	9	26	65	152	125
2.5	8	28	64	176	96

SUMMARY OF RESULTS AND DISCUSSION

At low current densities the cathode potential is practically constant with time, and is favourable for the deposition of a low zinc alloy. At

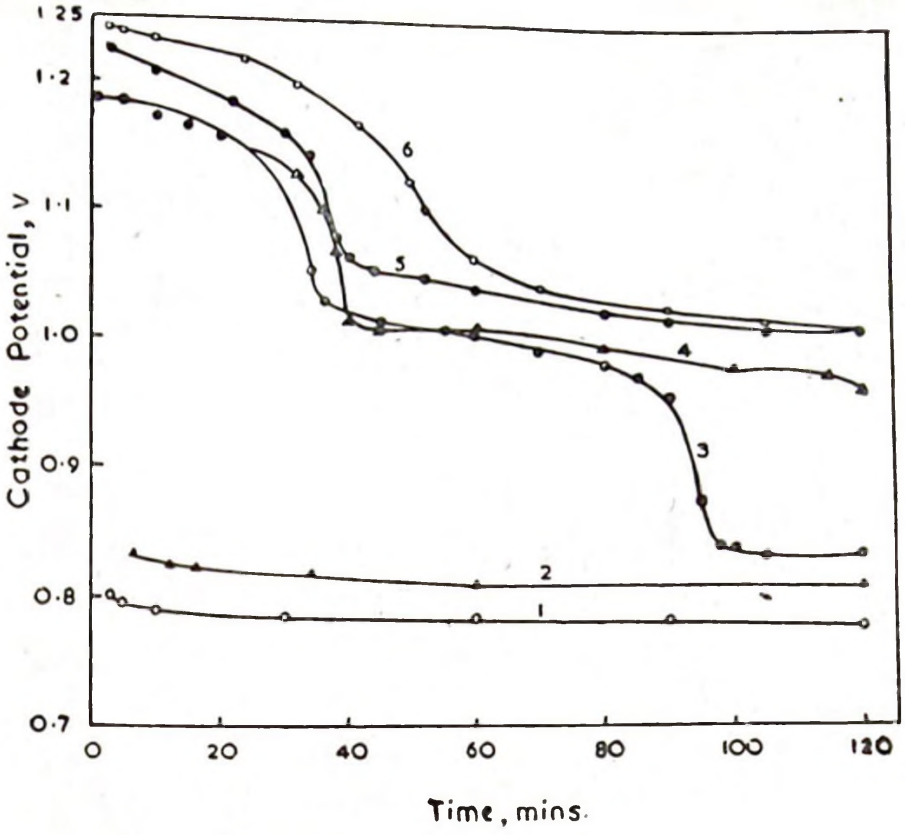


FIG. 1. **Effect of Time on Cathode Potential**

Current density : (1) 0.5, (2) 1.0, (3) 1.25, (4) 1.5, (5) 2.5, (6) 3.0 amp/dm².

1.25 amp/dm², however, the potential suddenly decreases at two places and remains constant after about 100 minutes. At the same time there is an increase in the zinc content of the deposit, but the weight of the deposit for one hour remains the same. The values for 85 and 100 minutes at this current density are 78 and 63 mg respectively. This indicates the loss in the weight of the deposit during electrolysis, possibly due to galvanic corrosion and dezincification. Similar drops in the potential occur at the higher current densities recorded. The zinc content of the deposit increases at a current density of 1.5 amp/dm² and beyond. The increase in the weight of the deposit for the one hour period is also normal The decrease in the weight of the deposit with increase in time at 2.0 and 2.5 amp/dm² can also be explained as due to dissolution of zinc in the system.

Further work is needed in order to provide a satisfactory answer for the peculiar observations made during the deposition of this ternary alloy.

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