Electrodeposition of Cobalt from Chloride Solutions

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Hydrogen evolution takes place simultaneously with cobalt deposition in acid cobalt electrolytes. On a rotating platinum disc electrode the current efficiency was calculated as the charge for anodic dissolution of cobalt at a potential where no other reactions took place divided by total cathodic charge for cobalt deposition. In all the experiments the standard conditions in Table I were kept constant, except for the specific parameter under investigation.

Table I

Standard experimental conditions

Deposition charge	0.6 C
Rotation rate	100 r.p.m
$c_{CoCl_2(aq)}$	0.92 M
$c_{NaCl(aq)}$	0.23 M
pH	1.23 at 60 °C
Temperature	60 °C
All chloride electrolyte	

The solution in Table I is close to the electrolyte used in industrial electrowinning (1,2) The current efficiency for cobalt deposition increased with increasing pH, current density, cobalt concentration and temperature. In comparable cobalt sulphate electrolyte the current efficiency was lower than in chloride electrolytes. This was a result of both higher current density for hydrogen evolution and lower current for cobalt deposition at a given potential.

At pH between 1.08 and 2.08 in chloride electrolytes the Tafel slope for cobalt deposition was -0.066 V/decade at 60 °C, corresponding to a two electron transfer. The reaction order with respect to Co^{2+}(aq) was close to unity, and the reaction order with respect to Cl^{-}(aq) and H^{+}(aq) was close to zero. On this basis the simple reaction mechanism in Eq. 1 was postulated.

$$\mathrm{Co^{2+}(aq) + 2e^{-} \rightarrow Co} \qquad (1)$$

The mechanism in Eq. 1 was also suggested by (3). At pH between 3 and 4.4 the current density for cobalt deposition increased with increasing pH, and the cobalt deposition mechanism in this pH range was dependent on H^{+}(aq) or OH^{-}(aq). The same trends were also observed by (4,5). Increased convection in the electrolyte gave reduction in the current efficiency caused by increased partial current density for hydrogen evolution.

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