Effect of solution constituents on electroless deposition of Ni-based alloys

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Binary and ternary Ni-based alloys (Ni-P, Ni-W-P, and Ni-Mo-P) are attractive materials as electrocatalysts for hydrogen oxidation reaction in polymer electrolyte fuel cells (PEMFC) [1]. In this study, effect of solution constituents on the electroless deposition of these alloys is systematically investigated.

The constituents of the electroless solution are given in table 1. The deposition rate was determined by weighing the samples before and after deposition. The composition and microstructure of the film were examined by EDX and XRD analysis respectively.

XRD patterns show increasing amorphization of film structure with increasing P content.

Figure 1 shows the functional dependence of deposition rate on solution constituents for Ni-P. Similar experiments for Ni-W-P and Ni-Mo-P were also conducted. Electroless deposition rates of Ni-based alloys increase with increasing concentration of $NiSO_4$ or NaH_2PO_2 or Na_2WO_4 (Ni-W-P) but decrease with increasing concentration of Na_3Citrate or Na_2MoO_4 (Ni-Mo-P).

Functional dependence of deposit composition on solution formulation for Ni-P is shown in figure 2. Similar experiments for Ni-W-P and Ni-Mo-P were also conducted. The content of P in the film increases with increasing concentration of Na_3Citrate or NaH_2PO_2 but decreases when increasing the concentration of $NiSO_4$, Na_2WO_4 or Na_2MoO_4. The content of W or Mo increases with increasing concentration of Na_2WO_4 or Na_2MoO_4 respectively.

The effect of sodium gluconate (SG) addition on the deposition rate of Ni-Mo-P is shown in table 2. Adding SG to the solution as a complexing agent for MoO_4^{2-} can significantly improve the deposition rate as shown in the table and also increase the contents of Mo and P.

Corrosion resistance and catalytic properties are strongly dependent on alloy composition and on the electrolyte used for their growth, and determine the conditions for the potential application of these alloys as electrode materials in PEMFC.

Reference

1. Guojin Lu, G. Zangari, The 199th Electrochemical Society Meeting. Meeting Abstracts, Washington DC, 2001, Abstract 31.

Table 1 Electroless solution formulations

$NiSO_4 \bullet 6H_2O$	15-40 g/L
$NaH_2PO_2 \bullet H_2O$	15-40 g/L
$Na_3Citrate \bullet 2H_2O$	20-60 g/L
$Na_2WO_4 \bullet 2H_2O$	10-30 g/L
$Na_2MoO_4 \bullet 2H_2O$	1-25 g/L
pH	9-11
Temperature	90 °C
Time	1 hour

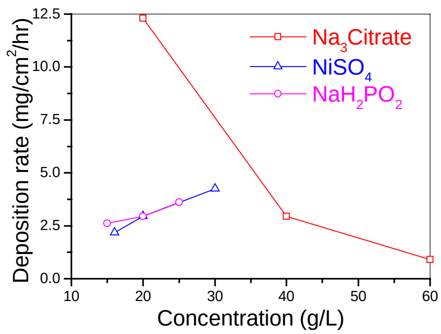

Fig. 1 Effect of concentration of constituents on the deposition rate of Ni-P

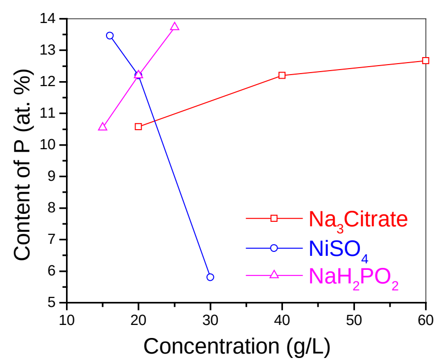

Fig. 2 Effect of concentration of constuituents on the composition of Ni-P

Table 2 Effect of adding SG on the deposition rate and deposit composition for Ni-Mo-P

	W/ gluconate	W/O gluconate
2.5g/L	34 mg/hr	17.7 mg/hr
Na_2MoO_4	$Ni_{84.5}Mo_{13.5}P_{2.0}$	$Ni_{90.7}Mo_{7.5}P_{1.8}$
10g/L	9.6 mg/hr	3 mg/hr
Na_2MoO_4	$Ni_{79.3}Mo_{14.0}P_{6.7}$	——