Zinc-Nickel Alloy Electroplating in Alkaline Electrolyte for Corrosion Resistance Improvement

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OBJECTIVES

This research was to improve corrosion resistance of low carbon steel through Zinc-Nickel alloy electroplating in alkaline electrolytes, and to investigate structure-corrosion resistance relationships.

EXPERIMENTAL PROCEDURES

Zn-Ni alloy was electrodeposited on 10x15 cm^2 low-carbon steel sheets in alkaline electrolytes. The bath electrolyte was composed of NaOH 130 g/l, ZnO 15 g/l, $NiSO_4 \cdot 6H_20$ 7-40 g/l, and Triethanolamine (TEA, Ni-complexing agent) 55-128 g/l. Plating conditions were current density of 4 -10 A/dm^2, room temperature (28°C), and pH of 3.5 with air bubble agitation. Coating surfaces were controlled to obtain thicknesses of 8 and 16 μm.

Specimens were tested and characterized using Suga ISO-3-CY salt spray unit, Autolab Eco Chemie potentiodynamic unit, and JEOL JSM-5800 scanning electron microscope equipped with energy dispersive spectroscope.

RESULTS AND DISCUSSION

Zn-Ni alloy coated surfaces yielded about 3 – 10 wt.% Ni with morphologies that could be grouped: whisker, nodular, pyramid and dendritic growth. The period of showing 5% red rust was after 240 - 384 hours. The optimum bath conditions were NaOH 130 g/l, ZnO 15 g/l, $NiSO_4 \cdot 6H_20$ 5.39 g/l, TEA 80 ml/l, current density of 4 A/dm^2, and 16 μm thick. The conditions provided Zn-Ni alloy coated surface with the greatest corrosion resistance of 384 hours (5% red rust) and corrosion rate of 15.89 mpy. with dense whisker morphology.

Despite coating thickness, corrosion resistance of Zn-Ni alloy coated on the low-carbon steel surface increased with the increasing of Ni contents in the coatings (Figure 1). Ni content in coatings increased proportionally to Ni content in electrolyte. It was found that corrosion resistance was descended in relation with coating morphologies: whisker > nodular > pyramid > dendritic growth as shown in Figure 2.

CONCLUSION

Increasing Ni contents causes an increasing in corrosion resistance. The morphology of the Zn-Ni alloy coated surfaces may be used to indicate and determine the corrosion resistance.

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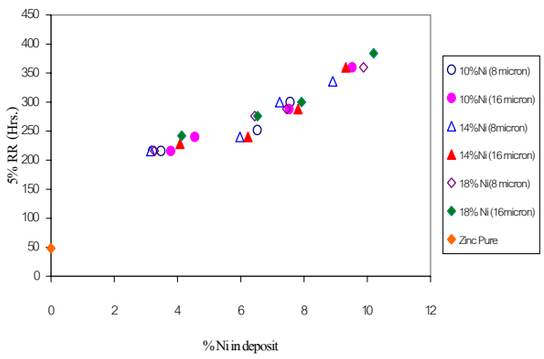

Figure1: Relationships between nickel content in coatings (wt%) and corrosion resistance (hours of 5% Red Rust)

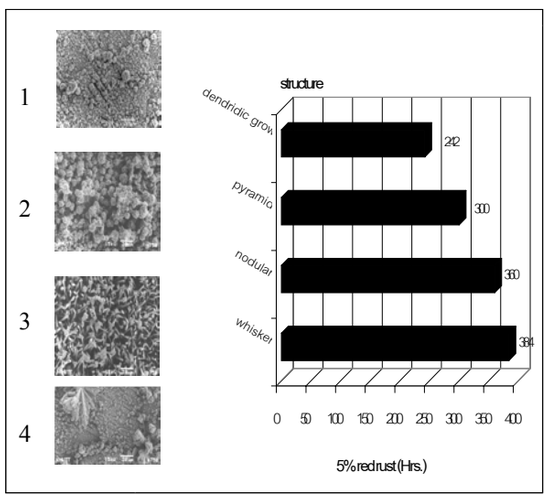

Figure2: Relationships between morphologies of coating (wt%) and corrosion resistance (hours of 5% red rust).
1: dendritic growth structure, 242 hrs
2: pyramid structure, 300 hrs
3: nodular structure, 360 hrs
4: whisker structure, 384 hrs