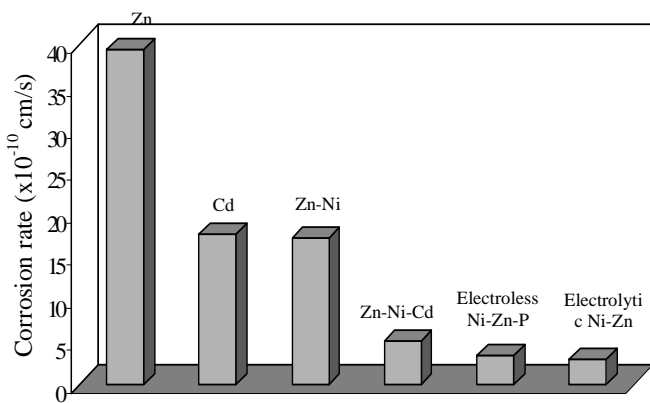


Corrosion and Hydrogen Permeation Properties of Zn-Ni-X (X= P,Cd) Ternary Alloys

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Cadmium electroplate on steel has many advantages such as good lubricity, solderability, low galvanic corrosion with aluminum. Cadmium plating offers an effective barrier protection to the substrate especially in the marine environment. Apart from this, cadmium also offers sacrificial protection¹ to the steel components under corroding conditions. However, cadmium deposition from cyanide baths give rise to unacceptably high hydrogen intake² by plated components of high strength leading to hydrogen embrittlement. According to this analysis, the difference in electronegativity of the coating and the substrate serves as the driving force for the corrosion of the sacrificial



coating under corroding conditions. Owing to the large

Fig 1. Nyquist responses for Zn, Zn-Ni, Cd and Zn-Ni-X alloys.

difference in electronegativity of Zn and Fe, rapid dissolution of Zn occurs under corroding conditions. To increase the barrier properties of zinc coating, research has been aimed in developing effective zinc based coating by alloying zinc with a more noble metal such as nickel. The co-deposition of Zn-Ni is anomalous and a higher percent of Zn is present in the final deposit. Typical nickel composition in the alloy is approximately 20% and any further increase in nickel composition is based on using a higher-than-predicted Ni/Zn ratio in the bath. An enhancement in the nickel composition would lead to more anodic open circuit potential, which in turn will reduce the driving force for the galvanic corrosion. Also the barrier properties associated with nickel rich deposits are superior compared to other coatings.

The approach taken in our work was to develop electroless and electrodeposition process for plating Zn-Ni-X (X=P, Cd) alloys, which will induce barrier properties to the sacrificial Zn-Ni alloy. By introducing a new element in the Zn-Ni alloy one can expect to decrease the Zn-Ni ratio in the alloy and consequently to decrease the Zn-Ni alloy corrosion potential from -1.14 V vs. SCE to even lower values than the corrosion potential of Cd (-0.79 V). Also by introducing a third element in

the alloy the goal was to modify the rate of hydrogen evolution reaction, the hydrogen proton recombination and adsorption kinetics at the surface in order to inhibit corrosion and impede complete the hydrogen penetration in the alloy thus eliminating the hydrogen embitterment.

The deposited Zn-Ni-X alloy has an increased content of nickel as compared to the conventional Zn-Ni alloy. The nickel content in the alloy is as high as 70%. The increase in the nickel content accounts for the decreased corrosion potential of the Zn-Ni-X coatings. The corrosion potential of the Zn-Ni-X alloy is -0.72 V (vs. SCE), which is still electronegative when compared to steel and offers sacrificial protection to steel. The coatings have superior corrosion resistance and barrier properties when compared to conventional Zn-Ni and cadmium coatings. Polarization studies and electrochemical impedance analysis (Fig.1) on Zn-Ni-X coatings show barrier resistance that is higher than the conventional Zn-Ni coatings by an order of magnitude (Fig.2). The compositions of the coatings were analyzed by EDX. The surface morphology of the coatings was studied using SEM (Scanning Electron Microscope). The decrease in the hydrogen embrittlement is characterized as per the ASTM F 519 standards. Corrosion data as per the ASTM B117 standards will also be reported.

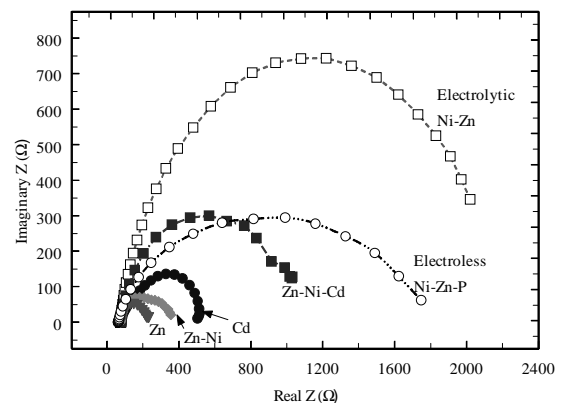


Fig. 2. Comparison Chart of Corrosion rates for different coatings.

References:

1. R. Walker, *Metal Finishing*, 72, 59 (Jan 1974).
2. A. Ashur, J. Sharon, I. E. Klein, *Plat. Surf. Finish.*, 83, 58 (1996).