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Study of Corrosion Behaviour Using Tafel Diagrams for a Brass Plate Electroplated with an N-Co Alloy

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Abstract**—*The aim of this research is to improve the corrosion resistance of a brass substrate by using nickel-cobalt composite electroplating in an alkaline bath of ammonium citrate and to study corrosion through potentiodynamic polarization curves. And compare the results with (brass Nickel-plated, brass and nickel-cobalt brass) in a solution of 3.5% sodium chloride, as it was found that the corrosion rate of uncoated brass is about (15.125 mpy) and for nickel-only-plated brass, the corrosion rate was found (4.856 mpy), while the corrosion rate of nickel-cobalt coated samples (0.748 mpy).*

Keywords**—** *Nickel-cobalt composite electroplating, corrosion rate.*

I. INTRODUCTION

The two primary categories of coating for metals are those that are protective and those that are attractive. This is not to suggest that a protective coating cannot be ornamental; rather, the coating's primary purpose is protection, with ornamentation being an optional extra. [1]

The surface of the material in modern industry is of great importance because it affects the behaviour of the material. For example, corrosion response reactivity with the environment (oxidation, sulfidation, dissolution by solvents, etc) and wear characteristics, are critically dependent on surface properties. The coating performance is often a cost–effective alternative to a substitution of superior bulk material).

Coating advantage could be used for corrosion resistance, wear resistance… etc.

Specimen Analysis and Preparation:

Specimen An analysis

The specimens used in the study were Cu Zn alloy sheet metal of dimension (30×30×0.6) mm. Table (1) indicates the quantitative chemical analysis for the specimens (C27200) Yellow Brass. [2]

TABLE 1. Chemical evaluation of the sample (base metal)

Cu	Pb	Fe	Zn
63.5%	0.07%	0.07%	36.36%

Plating Bath Preparation.

Sulphate-citrate plating bath was employed in the investigation. The composition of the plating bath is shown in Table (2). A plating bath with various concentrations was used to make the deposition layer harder.

TABLE 2 Indicate the content of this bath.

Bath Chemical composition	Content
Nickel Sulphate	30g/l
Cobalt Sulphate	4g/l-15g/l
Ammonium Chloride	5g/l
Sodium Citrate	120g/l

Bath Control.

A hot plate of type HS10-2 a was used to keep the temperature of the solution at 55°C plus or minus 1°C at the time of plating. During the plating procedure, a hot plate of type HS10-2 a was employed to maintain the solution's temperature at 55°C plus or minus 1°C.. Ammonium hydroxide (NH4) OH was used to adjust the pH of the bath and maintain pH 8. For the trials, a DC power supply of the SPS-3610 type was used to supply 2–6 Amp to the plating bath.[3]

Cell Construction.

In Fig., a schematic representation of the cell utilized in the plating tests is displayed (1). The cell comprises a 1005010 mm pure nickel anode with an effective area, a brass sample as the cathode, and the bath as the electrolyte. The necessary current is impressed using a DC power supply. A digital multimeter was used to gauge the actual current flowing through the cell.

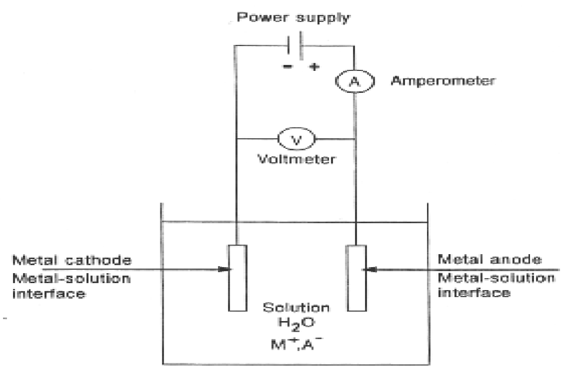

Fig. 1. Schematic diagram indicate the plating cell

II. MATERIALS AND METHODS

Testing Techniques.

To ascertain the chemical makeup of various coated specimens, XRD analysis was employed.. The positioning of the atoms in the lattice has a distinct periodicity for each phase. The measured inter-atomic lengths are specified for each phase as the X-ray radiations are diffracted by the various lattices.

XRD was used to keep track of the surface structure and phase fluctuations of the individual specimens. Using an X-ray

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diffractometer with a copper target and nickel filter, specific samples from each group were measured. XRD data were gathered and analyses using the Braggs equation shown below:

$$\lambda n = 2 d \sin \theta$$

where: n = integral number, λ = wavelength
θ = diffraction angle

Fig. 2. (XRD) Measurement unit utilized.

Corrosion Rate

The corrosion behaviour of the samples was examined using potentiodynamic polarization curves at 25 ºC, room temperature. A 0.5 mV/sec scan rate was used to modify the voltage, which changed in relation to the current. The saturated silver/silver chloride electrode (SCE) shown in Fig served as the reference point for measuring the electrode potentials (3). The working electrode was the sample, and the counter electrode was a platinum wire.[4] The experiments were done in a fresh, 3.5 per cent NaCl solution that wasn't expired. Only a 1 cm2 region could be exposed because epoxy glue was used to preserve the specimen before each test. Following two minutes in the solution, the potentiodynamic tests were initiated. Fig depicts the potentiostat (3)

Testing Equipment

Auto lab computerized potentiostat was used for testing The current work aims to investigate the parameters that affect the Ni-Co alloy deposition from a mixture of citric acid and sodium citrate.(impact of pH, the effect of time, the influence of temperature, the effect of temperature on the percentage of cobalt in the deposit, the effect of current density, the effect of time, the effect of temperature). Give a list of the qualities of the coating layer (Surface morphology, Composition of the coated film, hardness measurements and corrosion behaviour).

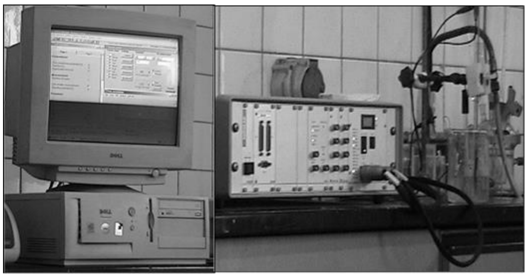

Fig. 3. Potentiostat

Composition of the Coated Film

The coating film's composition was ascertained using X-ray diffraction analysis (XRD), as illustrated in Figure (4). XRD signals reveal the presence of Co particles in the nickel matrix.

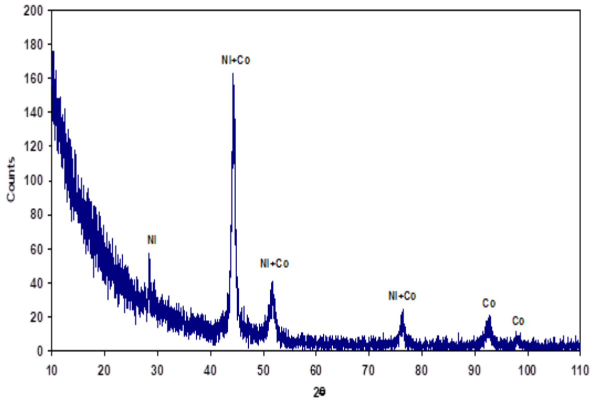

Fig. 4 Patterns of the Ni/Co gradient in XRD

III. Results and Discussions

Corrosion Behavior

Brass is one of the materials which are frequently used in marine environments, for example in cooling systems that utilize seawater, condensers and pipelines in some technological applications. In this environment there is a high degree of salinity and the contents of chloride ions are sufficient to cause pitting for brass and other materials. The corrosion of our coated samples in 3.5% NaCl solution was tested using the potentiodynamic polarization technique.

Inspection of the figure reveals that the corrosion rate obtained by the Tafel extrapolation method is lower in the case of Ni-Co than the brass.

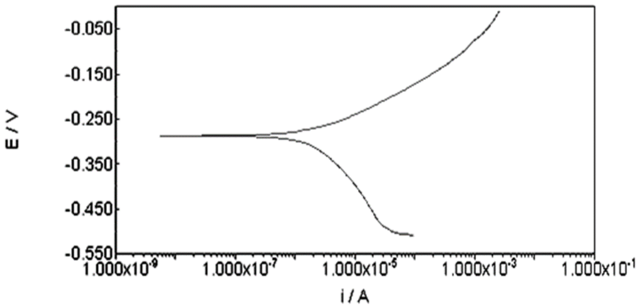

Fig. 5a. Tafel plot for Cu- substrate in 3.5% NaCl.

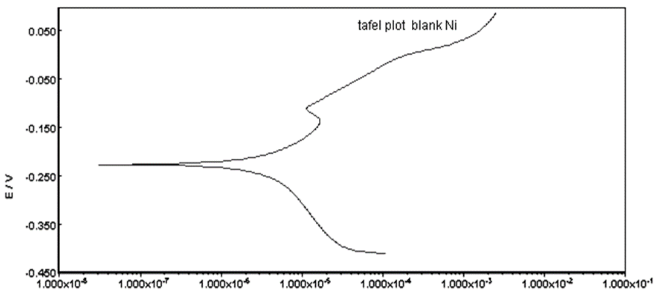

Fig. 5b.Tafel plot for Ni plating in 3.5% NaCl.

Fig. (5). demonstrates a polarization curve comparison for the brass substrate [5], alloy coatings and 3.5 weight per cent NaCl solution. According to these investigations, plain nickel and brass substrates, as well as other Ni-50% Co alloys, did not display the same level of corrosion resistance as the Ni-37.5% Co alloy.

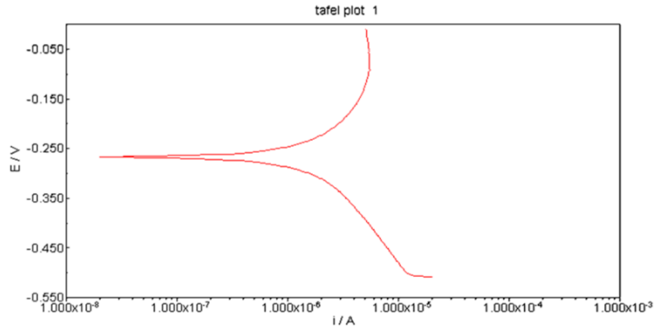

Fig. 5c. Tafel plot for Ni-Co alloy at 37.5% Co on deposit

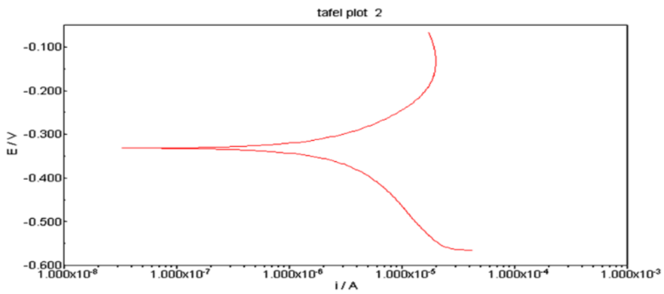

Fig. 5d. Tafel plot for Ni-Co alloy at 50% Co on deposit.

TABLE 3. Corrosion resistance data.[6]

Sample NO	Ba (V/dec)	Bc (V/dec)	Rp (Ω)	Corrosion rate (mpy)
Brass	0.214	o.127	1.355x103	15.125
Ni plated Brass	0.208	0.128	6.166x103	4.856
A	0.193	0.195	2.014x104	0.748

A: Ni-Co alloy coated Brass (37.5% Co in deposit, 2A/dm^2, time 1 hr, pH 8 and temp. 55°C).
Where: βa: Beta anode, βc: Beta cathode and Rp: Polarization resistance

Efficiency In Corrosion Resistance

The efficiency of coat (E) is calculated by the equations below:

[1] Efficiency of (Ni plated brass)

$$= \frac{Brass - \ Ni\ plated\ Brass}{Brass} \times 100$$

$$= \frac{15.125 - 4.856}{15.125} \times 100 \equiv 67.9\%$$

[2] Efficiency of (A) $= \frac{Brass - \ A}{Brass} \times 100$

$$= \frac{15.125 - 0.748}{15.125} \times 100 \equiv 95\%$$

A: Ni-Co alloy coated Brass (37.5% Co in deposit, 2A/dm^2, time 1 hr, pH 8 and temp. 55°C).

IV. Conclusion

(1) This study describes a special alloy Yellow Brass coating method that makes use of an alkaline citrate bath.
(2) Alkaline citrate bath has an environmentally friendly effect and low cost compared with commercial watt's bath.
(3) Ni-Co alloy coating has higher corrosion resistance than Ni coating. The corrosion rate in the nickel-plated brass sample was only 4.856 mpy and in the sample coated with the Ni-Co composite alloy 0.748 mpy This shows a clear improvement in corrosion resistance by using electroplating of a nickel-cobalt composite alloy
(4) Using the dynamic polarization technique, the corrosion of specimens coated in 3.5 per cent NaCl solution was examined. It has been demonstrated that the Tafel extrapolation approach results in a lower corrosion rate for Ni-Co than for copper.
(5) Plain nickel and copper surfaces, as well as other Ni-50 Co alloys, did not exhibit the same level of corrosion resistance when polarization curves for the copper substrate, alloy coatings, and 3.5% sodium chloride solution were shown.

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