Data analysis and study of the influence of deposition power on the microstructural evolution and functionality of metallic phase composite coating

T. Monyai, O.S.I. Fayomi, A.P.I. Popoola

Department of Chemical, Metallurgical and Materials Engineering, Tshwane University of Technology, P.M.B. X680 Pretoria, South Africa

Department of Mechanical Engineering, Covenant University, P.M.B. 1023 Ota, Nigeria

Abstract

In anticipation for resolution of deterioration catastrophe on metallic materials, researches in the field of corrosion remains. Zn–Ni–NbO₂ deposits were obtained on mild steel substrate using D.C. power source. The thermal stability properties of the coatings were determined by micro-hardness evaluations before and after heat treatment at 250 and 350 °C. The surface structure analysis was done by Scanning Electron Microscope and X-ray diffraction while the wear evaluations were obtained and compared. The weight gain and coating thickness were obtained and found to be in correlation with the wear results. The coating developed in this study is recommended for metallic surface improvement engineering applications.

© 2018 Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
Subject area: Materials Engineering  
More specific subject area: Surface Science and Engineering  

Type of data: Table, Figures  
How data was acquired: Electrodeposition process from an electrolyte bath containing the NbO2 enhancing particle was done at a temperature of 35 °C. Prior to deposition the samples were mechanically and chemically prepared. The deposition voltage was varied between 0.5 and 10 V. The post plating analysis was done revealing the morphology structures through SEM/EDS and XRD. The effect of high temperature was explored at temperatures between 250 and 350 °C, average microhardness evaluations were utilised as stability indicators.

Data format: Raw, Analyzed  
Experimental factors: Calibrated equipment was used in the process of obtaining the results to ensure precise and correct results data.

Experimental features: The deposited coatings were obtained from an electrolyte connected to DC power at 0.5 and 1.0 V for 20 min at a controlled temperature of 35 °C. The influence of the change in deposition applied voltage was investigated along with the additive composition variation.

Data source location: Department of Chemical, Metallurgical and Materials Engineering, Tshwane University of Technology, Pretoria, South Africa and Mechanical Engineering, Covenant University, Ota Ogun State, Nigeria  
Data accessibility: Data are available within this article

Value of the data

- The resulting data will be useful for materials engineers by guiding them on the reaction of the formulated deposition electrolyte for a specific temperature application.
- The obtained data can be used to report on the relationship between the different variable in the study.
- The data is useful in providing a useful range of additive concentration enough for the improvement of the substrate material

1. Data

The depositions process was performed at 20 min at a voltage power supply variations between 0.5 and 1.0 V with temperature of 35 °C. The distance between the anode and cathode was kept constant while the NbO2 enhancing additive composition was varies between a concentration of 10 and 15 wt%. The data for the formulation of bath framework is presented in Table 1. The coating thickness, weight gained, coating per unit area data were obtained after weighing the final mass and

| Composition       | Mass concentration (g/l) |
|-------------------|--------------------------|
| ZnSO4             | 150                      |
| Na2SO4            | 10                       |
| H3BO3             | 20                       |
| (NH4)2SO4         | 20                       |
| Glycine           | 10                       |
| Nickel powder     | 60                       |
| NbO2              | 10–15                    |

**Constant parameters**

| Parameter       | Value          |
|-----------------|----------------|
| pH              | 5              |
| Voltage         | 0.5 V and 1.0 V|
| Time            | 20 min         |
| Temperature     | 35 °C          |

Table 1

Summarized bath formulation (Zn–Ni–NbO2 deposition).
gauging the coating thickness. A set of data were obtained from XRD analysis and the plotted into a graph while the microstructures results were generated directly from the PC connected to the SEM-EDS machine. The average microhardness data were obtained from five points for 15 s dwell with 100 g of load. Results show a good progression of coating strengthening effect of particulate with response to its process parameter.

2. Experimental design, materials and methods

Locally sourced mild steel sheet was sectioned to dimensions of 40 mm × 30 cm × 2 mm while the Zinc sheets of 85 mm × 45 mm × 5 mm with 99.99% were prepared as anodes. The sectioned mild steel specimens were prepared by polishing and grinding using successive grades of silicon carbide paper grit. The chemical composition of the mild steel substrate obtained from spectrometer analyzer as shown in Table 2. Analytical grade chemicals and distilled water were used to prepare the plating solutions with compositions and parameters shown in Table 1. The formulated solutions were then heated to 35 °C for easy admix and dissolution of any agglomerates in the bath solution as described by [1–3]. The electrolytic deposition of Zn–Ni–NbO$_2$ deposition fabricated alloy coatings was performed in a single cell containing two zinc anodes and a single cathode at a time [4,5]. The set up was done such that the distance between the anode and the cathode was kept at 10 mm (see Table 3). The prepared cathode and anodes were connected to the D.C. power supply through conducting wires. Applied voltage between 0.5 and 1.0 V was set to run for 20 min in order to successfully produce desired deposited specimens [6]. The results of the variation were seen in Table 4. Morphological, phase orientation, wear and micro-hardness characterizations were done to further investigate the produced deposits and the outcome presented in Figs. 1–5.
Fig. 1. Solid x-ray diffraction profile for Zn–Ni–10NbO$_2$–1.0V alloy.

Fig. 2. SEM/EDS spectra showing the surface morphology of Zn–Ni–10NbO$_2$–1.0V deposition at mag ×1000.

Fig. 3. SEM/EDS spectra showing the surface morphology of Zn–Ni–15NbO$_2$–1.0V deposition at mag ×1000.
Acknowledgement

The authors acknowledge Tshwane University of Technology Surface Engineering Research Centre (SERC), Technology Innovation Agency (TIA-TSC) Pretoria, South Africa; the Research Facilities Provider, and National Research Foundation for financial support is appreciated. Dr. Fayomi appreciates Covenant University for open access funding.

Transparency document. Supplementary material

Transparency document associated with this article can be found in the online version at doi:10.1016/j.dib.2018.02.007.
References

[1] O.S.I. Fayomi, A.P.I. Popoola, T. Monyai, Improving the properties of mild steel by ternary multilayer composite coatings via electrodeposition route, Bull. Chem. Soc. Ethiop. 30 (3) (2016) 449–456.

[2] R.Q. Fratari, A. Robin, Production and characterization of electrolytic nickel–niobium composite coatings, Surf. Coat. Technol. 200 (2006) 4082–4090.

[3] D. Blejan, L.M. Muresan, Corrosion behaviour of Zn–Ni–Al₂O₃NXSA nanocomposite coatings obtained by electrodeposition from alkaline electrolytes, Mater. Corros. 63 (2012) 1–6.

[4] A. Conde, M.A. Arenas, J.J. Damborenea, Electrodeposition of Zn-Ni coatings as Cd replacement for corrosion protection of high strength steel, Corros. Sci. 53 (2011) 1489–1497.

[5] A.E. Elsherief, M.A. Shoeb, Characterization of electrodeposited Zn–Ni alloy from an all-chloride solution, Corros. Prev. Control 50 (2003) 25–30.

[6] T. Monyai, O.S.I. Fayomi, A.P.I. Popoola, Influence of transitional rare earth metals composite on the ternary based sulphate rich coatings, Procedia Manuf. 7 (2017) 537–542.