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Evaluation of Responses from Electrolytic Multilayer Hybrid Coating for Extended Application

P.A.L Anawe[a] O. Raji[a,*], O.S.I Fayomi[a, b]

aDepartment of Petroleum Engineering, Covenant University, P.M.B. 1023, Canaan land, Ota, Nigeria
bDepartment of Chemical, Metallurgical & Materials Engineering, Tshwane University of Technology, P.M.B X680, Pretoria, South Africa

Abstract

This paper examines the electro-mechanical responses of electrodeposited Zn-ZnO-MgO composite coating from sulphates bath with emphasis on its hardness and wear characteristics. The ZnO/MgO modified Zn series co-deposition was obtained from ordinary sulphate-based bath consisting of 16g/l MgO and 30g/l ZnO particulate. The particles were dispersed by mechanical agitation at 200 rpm. The presence of the MgO and ZnO were confirmed by high magnification optical microscope (OPM). The hardness and wear propagation were examined by diamond based microhardness tester and MTR 300 Abrasive wear tester. The results indicate that the inclusion of the nano-sized particulate leads to excellent tribological behavior and increase hardness behavior. The thermal stability characteristic was also sustained over time.

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1. Introduction

Environment that actually affects a metal are often characterized by micro environmental conditions and macro-mechanical properties [1-3]. It is indeed the reactivity of this local environment that determines the real hardness and tribological damage [4] while the basic mechanical challenge, the structural and protective coating, influences the nature of prevention [5]. Protective coatings are perhaps the most extensively used system mechanical damage control. They are used to provide long-term protection under a broad range of hardness and anti-wear environments,

* Corresponding author. Tel.: +234-80-3545-2869; +27-83-582-8119.
E-mail address: rajiobafemi@yahoo.com

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ranging from atmospheric contact to the most demanding counter body [6-7]. Simple oxides such as Al_2O_3, TiO_2, ZrO_2, CeO_2 and SiO_2 are commonly used due to their ease of availability. These oxides can be incorporated into plain Zn matrix or Zn alloy [8]. ZnO nanoparticles were found to improve abrasive nature of Zn-Al when they were incorporated within the optimal concentrations. It was established that these particles have significant effect on the surface morphology of the coatings [9]. MgO was found to aid improved hardness when incorporated at reasonable conditions. Research has shown that incorporation of ZnO into a metal matrix often guarantee positive results on the mechanical behavior [10-11]. There is no sufficient fact in the available literature that provides insight about incorporation of ZnO and MgO nanoparticles into Zn matrix and their special properties. Therefore, this research aims to fabricate Zn-ZnO-MgO nanocomposite coatings for industrial application.

2. Experimental Procedure

Carbon steel samples of 40 mm x 40 mm x 2 mm dimension with the chemical composition presented in Table 1 were used as substrate and 99.99 % zinc sheets were used as anodes. Analar grade chemicals were used all through this experiments. The surface preparation of the mild steel sample was prepared with different grades of emery paper in the order of 60 µm, 120 µm, 400 µm, 800 µm and 1,600 µm to render free of defects. Samples were activated by dipping in 1M HCl solution at room temperature for 5 seconds followed by rinsing in distilled water. The prepared sample was dipped in a solution containing dissolved bath constituents which was heated for 1hour and simultaneously stirred at 200 rpm to obtain homogenous solution. Cathode and anodes were connected to the D.C. power supply through a rectifier. Electrodeposition was carried out with applied voltage of 3 volts for 20 minutes, while the depth of dipping and the distance of the cathode from the anode were kept constant. Immediately after the plating, rinsing was done in distilled water and samples were air-dried. The bath composition and process parameters are shown in Table 2 while the summarized data of Zn-ZnO-MgO plated samples for constant plating time at various current is shown in Table 3. The surface morphology of the electrodeposits was observed using optical microscope (OPM) at 100µm. Micro-hardness studies were carried out using a Diamond pyramid indenter EMCO Test at a load of 200 g for a period of 5s.

Table 1: Chemical composition of the low carbon steel

Element	C	Mn	Si	P	S	Al	Ni	Fe
Composition	0.15	0.45	0.18	0.01	0.031	0.005	0.008	Balance

Table 2: Bath Composition of Zn-ZnO-MgO coating

Composition	**Mass Concentration (g/L)**
$ZnSO_4$	75
ZnO	30
K_2SO_4	50
Boric Acid	10
MgO	8 -16
$NaSO_4$	75
Glycine	10
Thiourea	10
pH	4.8
Voltage	I Volt
Time	20 min.
Temp.	40^{o}C

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