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ScienceDirect

Energy Procedia 119 (2017) 910–915

Energy Procedia

www.elsevier.com/locate/procedia

International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES17, 21-24 April 2017, Beirut Lebanon

# Structural properties and microhardness performance of induced composite coatings filled with Cocos nucifera-tin functionalized oxide

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**Abstract**

The potential of Cocos nucifera (CJ)-tin functionalized oxide prepared in sulphate bath on zinc based electrolyte was examined in an attempt to improve the structural behaviour and examined the microhardness characteristics of the developed coatings. The microstructural evolution was checked using scanning electron microscope attached with energy dispersive spectrometer (SEM-EDS). The microhardness properties of the composites were investigated by means of high impact diamond base microhardness indenter with an average of 5 relative intervals. The results show a film containing Zn-SnO2-CJ deposits on the mild steel resulting into strong crystal structure. The effect of Cocos nucifera-tin functionalized oxide as complex agent was noticed to improve the structural build up, strong compactness and decrease porosity.



*Keywords:* Crystals; Coatings; Microhardness; Coconut juice (CJ)

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10.1016/j.egypro.2017.07.144

# 1 INTRODUCTION

The massive use of low carbon steel in structural and aesthetic applications is due to its availability, low cost and physical properties [1-3]. This property has made mild steel versatile among metallic alloys in service [4]. The major challenge has been severe structural degradation of mild steel as a result of metal interactions between external environments in term of wear plastic deterioration, low hardness characteristics and poor corrosion resistance [5-6].

In other to salvage these menaces, several protective prevention methods have been engaged over decade by researcher to extent the service life of mild steel [7]. Electrodeposition is a traditional method but ever reliable deposition concept with tendency of impacting compactness, evenness and provides thin film on metal [8-9]. Moreso, with deposition technique, composite coatings are produced by dispersing nanosized particles in a coating matrix for better structural and mechanical performance [10]. Composite particle such as ZrO2, MgO, SiO2 and TiO2 have been co-deposited to produce functional properties [11-13]. In coating technology especially, the electrolytic deposition, the incorporation content, particles and process variable are important factor that determine the efficient of electrolyte and the kind of coating produced [14-15].

Study had also showed that extractive juice as additive agent influences structural properties which also impact possible mechanical potential on coatings [16]. In an attempt to better the morphology of the electrodeposited coatings and resist agglomeration a newly developed multifunction particle with eco-friendly fluid instead of adding multiple solid particle distribution is envisage [17, 18]. The technique combines traditional technique of electrodeposition with sol gel method in form of juice to obtain solid uniform metal composite coatings [19].

In this present study, attempts were made to produce Zn-SnO2 composite coatings using Cocos nucifera-tin functionalized oxide enhanced Zn base electrolyte. The microstructure and microhardness properties of the Zn-SnO2-CJ embedded coating were studied and compared with Zn-SnO2 alloy coating.

# 2 EXPERIMENTAL METHOD

## *2.1 Preparation of Substrate*

Mild steel specimens of (40 mm x 20 mm x 1 mm) sheet were used as substrate and zinc sheets (30 mm x 20 mm x 1 mm) were prepared as anodes. The working mild steel specimens have a weight composition as described in Table 1. The cathode was mild steel coupons and anode was pure zinc (99.99%). The mild steel specimens were polished mechanically using different grades of emery paper in the order of 60, 120, 400, 800 and 1,600 µm to erase any existing impurities and marks. The samples are further degreased and immediately water washed.

Table 1: Nominal chemical composition (wt. %) of mild steel substrate

| 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 |

## *2.2 Formation of Deposited Coating*

The mild steel substrate earlier prepared was activated by dipping into 10% HCl solution for 5 seconds followed by rinsing in distilled water. Analytical grade chemicals and distilled water were used to prepare the plating solution at room temperature. Prior to plating, the coconut juice was added to the prepared Zn-SnO2 alloy particles electrolytic solution as indicated in table 2. The formulations were then heated to 40ºC to easy admix and dissolution of any agglomerate in the bath solution. The bath produced is concurrently stirred as heating trend lasted for 3hours before plating.

Table 2: Bath composition of Zn-SnO2 alloy co-deposition in the presence of potato and coconut juice

| **Composition** | **Mass concentration (g/L)** |
|---|---|
| ZnSO4 | 100g |
| $SnO_2$ | 15g |
| NaSO4 | 35g |
| CJ | 5g-15g |
| Boric acid | 10g |
| Glycine | 10g |
| **Parameters** | |
| pH | 4.6 |
| Time | 10min |
| Current Density | 1.0A |

### *2.3 Structural Characterization*

The structural studies and elemental analysis of the plated samples were verified using a TESCAN scanning electron microscope coupled with energy dispersive X-ray analyser (SEM/EDS). EDX analysis was used to observe the elemental composition.

### *2.4 Micro-Hardness Studies*

The Emco Test is a hardness machine used to determine the hardness of samples. Electrodeposited samples and as-received specimens were determined by the use of Emco micro-hardness tester with a dura scan diamond indenter. Indentations were made across the deposited layer at three locations using a load of 10g for 10sec and the average hardness was used as a final micro-hardness of the materials.

## 3 Results and discussion

Table 3: Summarized data of Zn-SnO2 /Coconut juice (CJ) of electroplated samples.

| **Sample order** | **Time of deposition (min)** | **Current density ($A/cm^2$)** |
|---|---|---|
| Control | - | - |
| $Zn\text{-}SnO_2$ | 10 | 1.0 |
| $Zn\text{-}SnO_2$- 5CJ | 10 | 1.0 |
| $Zn\text{-}SnO_2$-15CJ | 10 | 1.0 |

### *3.1 Structural Characterization*

Fig 1a and b show scanning electron micrographs (SEM) with attached EDS of the deposited samples. From deposition appearance of all fabricated samples, a solid morphology and good adhesion was noticed. The nature of the surface morphology and orientation in Fig 1a unveiled the homogeneous appearance with good dispatches as expected. One significant reason for this behaviour might be as results of the deposition parameter and functional characteristics of the reinforced composite in the zinc metal matrices. Fayomi et al. [6] confirmed that the deposition behaviour and the adhesion strength of any particular electrodeposition often based on the potential, current density and the most especially the time of deposition. From Fig 1b, the addition of **Cocos nucifera** natural additive resulted into more grain crystal with relative dispatches hexagonal noodle like phase. The presence of this sol gel fluid within the zinc lattice contributed to the surface brightness and solid compactness of the developed coating as against the Zn-SnO2 influence.

In all, the fabricated appearance of the coatings shows preferred adhesion and stable deposit. The energy dispersion spectrum (EDS) engaged shows a reasonable elemental composition indicating the presence of Sn, O Zn, SiP, Cl, structural products of Cocos nucifera interference.

The microhardness results of Zn-SnO2 and Zn-SnO2-CJ composite coatings at constant time and current density are presented in Fig. 2. The result showed that Zn-SnO2-CJ had a higher microhardness compared to Zn-SnO2 alloy coatings. Among all deposited coatings CJ admixed had the highest microhardness of 113 HVN for Zn-SnO2-15CJ and Zn-SnO2 possessed 78.8HVN. The as-received sample had 57HVN, an average of 70% increase for the deposited alloy. This change in hardness characteristics is due to the incorporation of Cocos nucifera (CJ)-tin functionalized oxide and microstructural change as a result of the matrix grain refinement forming a dispersion strengthening effect. This is in par with study by [3] that increase in microhardness is a function of the nucleation of grain impedes from the composite matrix creating a dislocation and surface hardening properties.

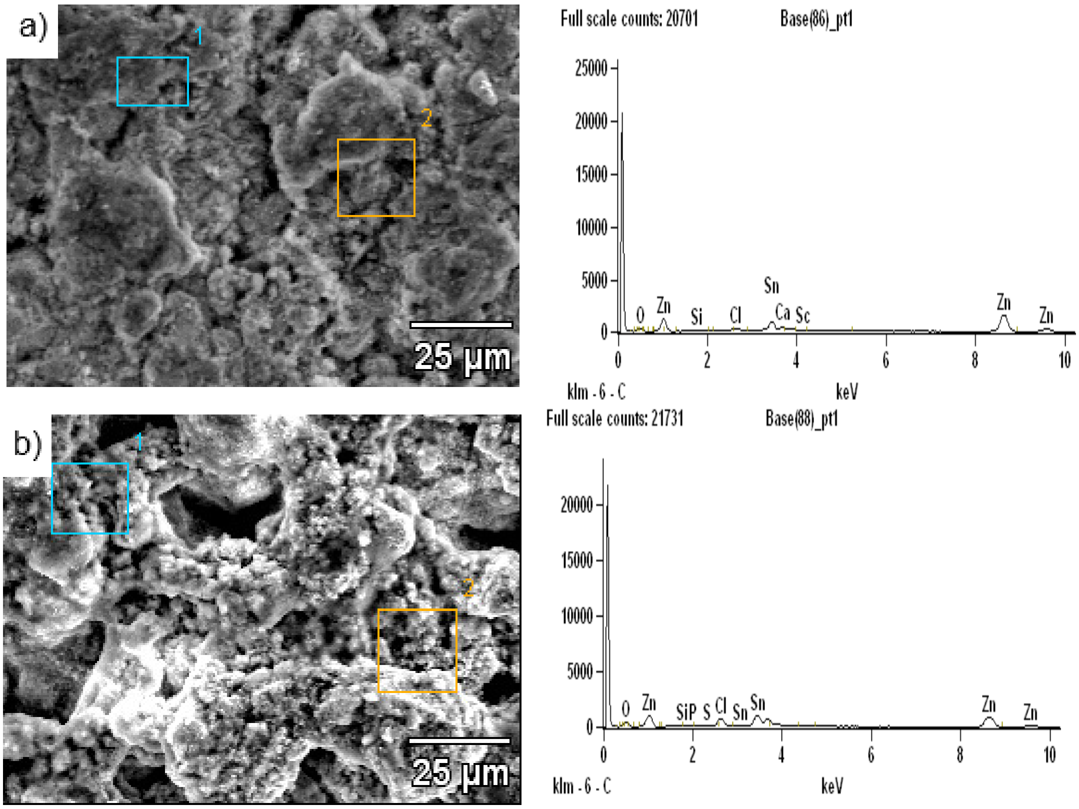


Figure 1: Display SEM/EDS of [a] Zn-SnO2 [b] Zn –SnO2-15CJ 10min at 1.0A.

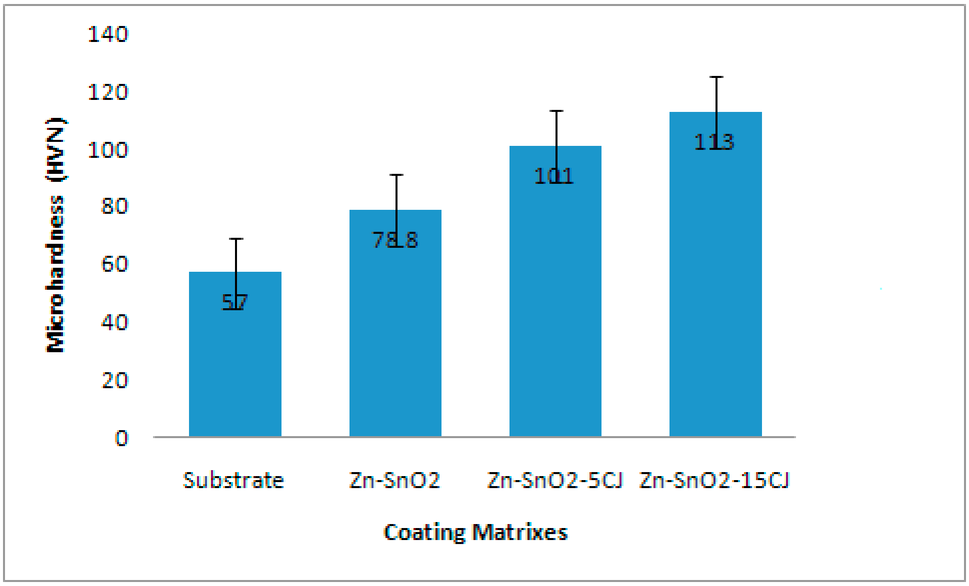


Figure 2: Variation of micro-hardness Zn-SnO2-/CJ

## Conclusion

A successful binary deposition with the presence of **cocos nucifera** juice was attained. SEM/EDS study revealed the presence of the Zn-SnO2 embedded particles with modifies crystal orientation of zinc reinforced coatings. Zn-15SnO2-15 **Cocos nucifera** showed better hardness properties as compared to the rest of the matrixes this is as a result of the embedded grain crystals. The electrodeposition of Zn-SnO2- /CJ samples was observed to impact greatly on the structural behaviour and improved mechanical performance.

## Acknowledgement

The authors would like to acknowledge the National Research Foundation, Pretoria, South Africa for the funding of this study. Covenant University is appreciated for providing the funds for open access publication.

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