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Effect of SnO_2/SiO_2 nano particle dispersant on the performance characteristic of complex multi-doped composite coating produced through electrodeposition on oil and gas storage tap

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ABSTRACT

The effect of SnO_2/SiO_2 nano particle dispersant on the performance characteristic of complex zinc multi-doped composite coating produced through electrodeposition is studied. The degradation behaviour in term of wear and chemical corrosion activities were considered as a major factor in service. The wear mass loss was carried out with the help of reciprocating tester. The electrochemical corrosion characteristics were investigated using linear polarization technique in 3.5% simulated sodium chloride media. The outcome of the analysis shows that the developed coating was seen to provide a sound anti wear characteristics in its multidoped state. The corrosion resistance properties were observed to be massive compared to the binary based sample. It is expected that this characteristic will impact on the performance life span of storage tap in oil and gas.

Introduction

Studies in the past decades have shown that the cost of corrosion in industries is worth $170 annually [1,2]. This cost ranges from the production technique demand to the environmental threat imposed from drilling muds left un treated [3]. The muds hamper the drilling equipment, storage tank, well casing and pipelines. In an attempt to remove this corrosive muds, acid used to minimise this existence damage the walls and form attack on the metal resulting in eroded blisters [4,5].

Dealing with these corrosion catastrophes with imposed complications of high temperature to high pressure occurrence and stress initiation in production requires enormous effort [6]. Nanocomposite assisted coatings are seen as the most thrilling and ever growing field of composite alloy development with aim of forming new novel material that can provide multifunctional properties [7]. These high performance properties are applicable to potential area such as oil and gas, electronics, and most locomotive system such as in automotive, aerospace and other energy systems [8–12]. Lately, Zn nanocomposite alloys have grown with substantial interest as anodes for oil and gas applications [13,14]. They were made by integrating of small grain-composite sized oxide particulate inform of ceramics, metals and polymers like ZnO, TiO_2, and Al_2O_3 into the Zn lattices by co-deposition route [14].

So far few works by researcher are in open literatures concerning the role of nano-sized metal oxides containing SnO_2/SiO_2 in a single bath for preventing corrosion damage in oil and gas sector which we are addressing in this work.

Materials and method

Substrate and surface preparation

Electrodeposition of $Zn\text{-}SnO_2\text{-}SiO_2$ nanocomposites was carried out using two electrode single cell systems. Mild steel coupon was used as cathode. The mild steel was sectioned into 45 mm × 40 mm × 20 mm. Zinc sheets of 85 mm × 45 mm × 5 mm were obtained from open market as anodes. The substrate contains 99.2% Fe and other elements. The anode was commercially sourced with (99.99%). Prior to the deposition, the electrolyte was centrifugally stir at 400 rpm under 70 °C heating rate to obtained dissolution of possible agglomeration. Formulated designed compositions of the coating matrix is as follows $ZnSO_4$ is 75g/L, $NaSO_4$ 15g/L, SnO_2nano particles 10g/L, SiO_2 nanoparticles 5–15g/L, Sodium Chloride 0.5g/l, Thiourea 5g/L.

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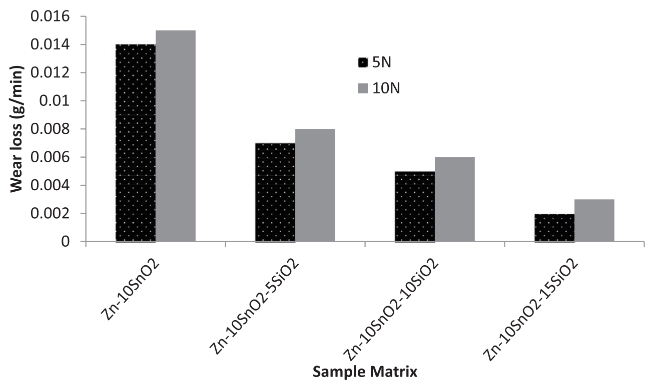

Fig. 1. Variation of wear rate with time.

Table 1
Polarization data extrapolated from Tafel slope for matrix Zn- SnO_2-SiO coating.

Sample	Ecorr Obs. (V)	icorr (A/ cm^2)	Corrosion rate (mm/year)	Polarization resistance (Ω)
Zn-10SnO_2	−1.5200	2.04E-02	1.10000	14.6000
Zn-10SnO_2-5SiO_2	−1.0650	5.20E-04	0.06726	100.738
Zn-10SnO_2-10SiO_2	−1.0512	1.42E-04	0.02831	218.050
Zn-10SnO_2-15SiO_2	−1.0364	5.37E-05	0.01023	225.860

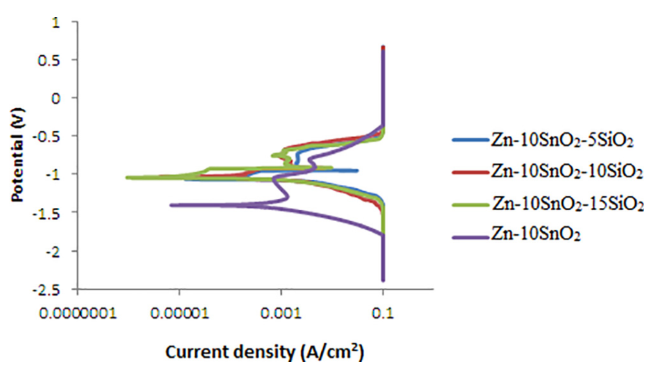

Fig. 2. Potentiodynamic polarization curves of Zn- SnO_2-SiO_2 composite coating.

Wear and corrosion test

Wear deformation properties were examined using sliding wear tester with model CERT UMT-2 at room temperature. The counter body was set at a varying load of 5 N and 10 N, with displacement–time ratio of 5 mm/s, displacement amplitude of 2 mm in 20 min. A Si_3N ball with HV 50 g-1600 was selected as abrasive slider body. Sample work piece were sectioned to contain 2 cm by 1.5 cm of the holder. The corrosion behaviour mechanism study was examined with autolab PGSTAT 101 Metrohm Potentiostat with the help of three – electrode cell assembly in a 3.5% NaCl static ambient temperature as described by [5].

Results and discussion

Tribological mitigation studies

Analyses of the comparative tribological resistance of all deposited coating with their matrixes were presented in Fig. 1. The wear deformation was examined with 5 and 10 N load. A careful observation shows that all fabricated composite coating show resilient to wear deformation due to SiO_2 ceramics metal composite on Zn/SnO_2 lattice. No doubt a progressive decrease in the wear rate was obtained with concentration of SiO_2. In general, the coating properties of all the ternary alloys were excellent owing to the physical attestation of the uniform distribution of particles with unique crystal orientation. It is of necessity to mention that the characteristic of coating is a reflection of individual composite thrust and composite functional affinity to resist massive dislocation against the counter body. Even do there were plastic deformation as the wear load increases, the geometric of wear loss are minimal compare to that of non-silica induced coating with about 0.015 g/min which is in line with study by [5].

Polarization measurements

Table 1 shows the values of E_{Corr}, I_{Corr}, corrosion rate (CR) and polarization resistance (R_P) for all deposited matrix. Fig. 2 shows the extrapolated Tafel slope of electrodeposited alloys. Comparing the composite deposited coatings, it can be seen that the higher the concentration of SiO_2 particulate the better the electrochemical resistance properties. From the polarization curves of Zn-10SnO_2-15SiO_2 composite coating in Fig. 2, there was a massive shift and alteration toward a more positive region for all ternary alloys. Nevertheless, the best among all coating which is Zn-10SnO_2-15SiO_2 alloy was found to have provided an improved polarization potential of −1.0364 V with high polarization resistance of 225.860 Ω and low corrosion rate of 0.01023 mm/yr. The binary control sample Zn-10SnO_2 composite alloy possess polarization potential of -1.5200 V, lower polarization resistance of 14.6000 Ω and high corrosion rate of 2.04E-02 mm/yr. In all the performance characteristics can be traced to the solid solute solution and perfect activities of SiO_2 participation in the developed alloy series as reported by [3].

Conclusion

Nano structured SiO_2 particulates were used to produce Zn-10SnO_2-SiO_2 composite coating from chloride-sulphate bath. The incorporation of SiO_2 into the zinc rich coating was seen to improve both the corrosion resistance and impact positively on reduction in wear plastic deformation characteristics.

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References

[1] Anawe PAL, Raji O, Fayomi OSI. Proc Manufact 2017;7:562–6.
[2] Anawe PAL, Fayomi OSI, Popoola API. Der Pharma Chem 2017;9(9):36–42.
[3] Ayoola AA, Efeovbokhan VC, Bafuwa OT, David OT. Int J Sci Techol 2014;4(4):66.
[4] Fustes J, Gomes ADA, Silva MI. Pereira. J Solid State Electrochem 2008;121:1435.
[5] Fayomi OSI, Popoola API, Loto CA. Int J Electrochem Sci 2014;9:3885.
[6] Shivakumara S, Manohar U, Naik YA, Venkatesha TU. Bull Mater Sci 2007;30:455.
[7] Fayomi OSI, Popoola API, Aigbodion VS. Alloy Comp 2014;617:45.
[8] Kwok CT, Cheng FT, Man HC. Surf Coat Technol 2006;200:3544.
[9] Popoola API, Pityana SL, Popoola OM. South Afr Inst Min Met 2011;111:345.
[10] Noor EA, Al-Moubaraki AH. Int J Electrochem Sci 2008;3:806.
[11] Popoola API, Fayomi OSI. Int J Phys Sci 2011;6:2447.
[12] Anawe PAL, Fayomi OSI. Res Phys 2017;7:777–88.
[13] Anawe PAL, Fayomi Port OSI. Electrochim Acta 2017;35(5):297–303.
[14] Anawe PAL, Raji O, Fayomi OSI, Efeovobohkan V. Proc Manufact 2017;7:556–61.