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Investigation of anticorrosion properties of nanocomposites of spray coated zinc oxide and titanium dioxide thin films on stainless steel (304L SS) in saline environment

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Abstract

The present study reports the anticorrosive nature of nanocomposite thin films of zinc oxide and titanium dioxide on steel substrate (304L SS) using spray coating method. The morphology and chemical constituents of the nanocomposite thin film were characterized by field effect scanning electron microscopy and energy dispersive analysis of x-ray (EDAX) studies. From the EDAX studies, it was observed that nanocomposite coatings of desired stoichiometry can be synthesized using present coating technique. The cyclic voltametric techniques such as Tafel analysis and electrochemical impedance spectroscopy (EIS) analysis were conducted to study the anticorrosion properties of the coatings. The E_{corr} values obtained from Tafel polarization curves of the sample coated with nanocomposites of ZnO and TiO_2 in different ratios (5:1, 1:1 and 1:5) indicated that the corrosion resistance was improved compared to bare steel. The coating resistance values obtained from the Nyquist plot after fitting with equivalent circuit confirmed the improved anticorrosion performance of the coated samples. The sample coated with ZnO: TiO_2 in the ratio 1:5 showed better corrosion resistance compared to other ratios. The Tafel and EIS studies were repeated after exposure to 5% NaCl for 390 h and the results indicated the anticorrosive nature of the coating in the aggressive environment. The root mean square deviation of surface roughness values calculated from the AFM images before and after salt spray indicated the stability of coating in the saline environment.

1. Introduction

The product manufacturing industry has exploited steel due to its excellent durability and greater recyclability. The strenuous effort had been made in the past few decades to improve better wear and corrosion resistance of steel. Corrosion in steel cannot be completely bunged but can be eradicated up to a limit by adopting various corrosion mitigation technologies such as design improvement, coatings, corrosion resistant alloys or composites, catholic and anodic protection, corrosion inhibitors etc. Various materials such as nitrides, transition metal oxides, polymers, nanoparticles incorporated matrices; organic metals, etc have been used as protective coatings on metal surfaces to prevent corrosion [1–8]. Among these materials, thin films of TiO_2 have been widely used, as they provide improved wear resistance, hardness and high corrosion resistance [9–13]. Nanocomposites of titania such as CeO_2/TiO_2, TiO_2/CuO, TiO_2/SiO_2, titanium incorporated polymers etc have been attempted in the past [14–17]. Nanocomposites of ZnO/TiO_2 find a wide range of applications in the field of photo catalysis, dye-sensitized solar cells, humidity and gas sensors etc [18–21]. However, a detailed survey on literature suggests that anticorrosion study of nanocomposites of TiO_2 and ZnO has been scarcely attempted. Thin films of zinc oxide and titanium dioxide have been deposited by a variety of techniques such as anodic deposition, chemical vapor deposition, RF magnetron sputtering, atomic gel epitaxy, electron beam