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Corrosion resistance behavior of PVA/ZrO_2 composite in 3.5% NaCl

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Corrosion occurs on the walls of marine structures and leads to surface damage. The main cause of the corrosiveness are chloride ions. Every product created from metal due to its low cost and easy availability mild steel find its role. The polymer composites are having multiple adsorption sites for bonding with metal surface and provides higher inhibition efficiency than the corresponding monomers. In the present work, the corrosion inhibition of mild steel in 3.5% NaCl by PVA/ ZrO_2 composites were studied. The composite samples were characterized by using XRD, FTIR and SEM. Electrochemical impedance spectroscopic techniques were used to explore the enhanced corrosion resistance of composites. The corrosion inhibition efficiency of PVZr composites were found to increase with increase in concentration of ZrO_2.

Keywords: PVA, ZrO_2, XRD, FTIR, SEM, corrosion inhibition.

Introduction

Corrosion is the deterioration of a metal and its properties due to chemical, electrochemical and other reactions of the exposed metal surface with the surrounding environment[1]. Corrosion of metals takes place due to the gradual environmental interaction on the metal surface. It affects the structure, properties and the physical appearance of the metals. It is most commonly associated with rust, in particular the rusting of metals such as iron. Seawater systems are used by many industries such as shipping, offshore oil and gas production, power plants and coastal industrial plants. Marine corrosion is degradation of metal in marine environment. The corrosion of these structures lead to reduced life and increased maintenance costs. So, it is important to protect the metals from corrosion. The present work describes the preparation of PVAZr composites and its application to corrosion prevention. The formed composite coating acts as a protective layer on the metal surface by the reaction between the solution and the corroded metal surface[2]. PVA is a polymer, due to its exceptional properties such as non-toxicity, non-carcinogenity, water solubility, biodegradability[3–7].

Experimental

Preparation of PVZr composites:

PVZr composites were prepared by sol gel method[8].

Characterization techniques:

The prepared PVZr composites were characterized by XRD, FTIR and SEM and electrochemical studies were performed using 3.5% NaCl.

Results and discussion

The XRD pattern of PVZr composites shows characteristic PVA peaks. With increase in the concentration of ZrO_2 peaks intensities with respect to the polymer decreases. Peaks also become broad in nature. This clearly indicates crystallinity of PVA gets influenced by the presence of ZrO_2 (Fig. 1). The average crystallite size is found to be 0.1456 μm.

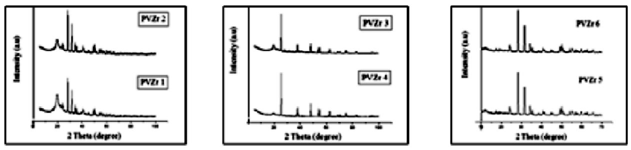

Fig. 1. XRD spectra of PVZr composites.

The changes in the vibrational frequencies of the above mentioned peaks in the FTIR spectrum of PVA, ZrO_2 and PVA/ZrO_2 confirms the formation of the composite. This may be attributed to the interactions between the O-H groups of PVA and the oxygen atoms of ZrO_2 (FTIR spectra not shown here). The I_{corr} of bare mild steel is 35.1 μA/cm^2. The incorporation of ZrO_2 into the PVA matrix (Fig. 2) reduced the corrosion currents of PVZr 6 to 0.8 μA/cm^2 respectively. This indicates that the addition of ceramic oxide in PVA matrix has improved the corrosion resistance (Table 1).

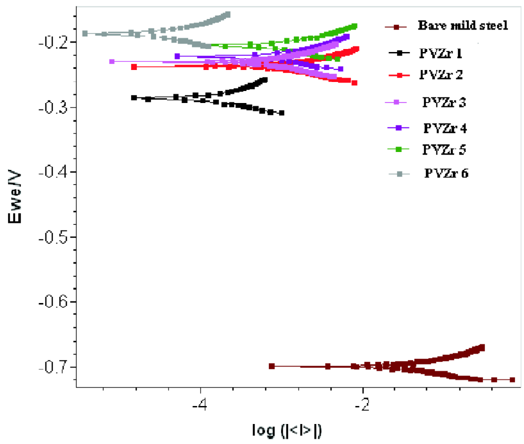

Fig. 2. Tafel plots for bare mild steel and PVZr composites.

Table 1. Corrosion parameters obtained from polarization studies for bare mild steel and coated PVZr composites

System studied	E_{corr} (mV)	I_{corr} (μA/cm^2)	Corrosion rate (mpy)
Bare mild steel	–706	35.1	10.72
PVZr 1	–291	9.3	2.83
PVZr 2	–241	8.2	2.50
PVZr 3	–233	6.4	1.95
PVZr 4	–229	4.8	1.48
PVZr 5	–211	2.5	0.76
PVZr 6	–192	0.8	0.25

The R_{ct} (Table 2) values increased as the concentration of ceramic oxide is increased, whereas C_{dl} values decreased. This is because the water molecules in the electrical double layer (Fig. 3) are replaced to a very large extent by the composites having a very low dielectric constant[9]. This suggests that the polymer composites function by adsorption at the metal solution interface[10].

Table 2. Electrochemical parameters obtained from impedance studies for bare mild steel and coated PVZr composites

System studied	R_{ct} (Ω cm^2)	C_{dl} (μF)
Bare mild steel	23.4	2.583×10^{-2}
PVZr 1	1911	4.660×10^{-3}
PVZr 2	2332	3.189×10^{-3}
PVZr 3	5616	2.224×10^{-3}
PVZr 4	6206	1.982×10^{-3}
PVZr 5	7708	0.986×10^{-3}
PVZr 6	18375	0.614×10^{-3}

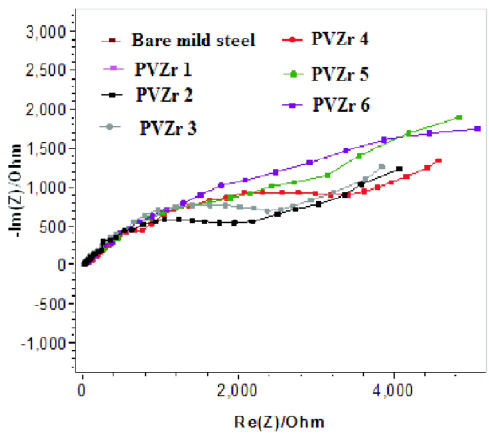

Fig. 3. Nyquist plots for bare mild steel and PVZr composites.

Conclusion

The corrosion inhibition of mild steel in 3.5% NaCl by PVA/ZrO_2 composites were studied. Electrochemical impedance spectroscopic techniques were used to explore the enhanced corrosion resistance of composites. The corrosion inhibition efficiency of PVZr composites were found to increase with increase in concentration of ZrO_2.

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