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EFFECT OF MoS_2-DOPED CONDUCTING POLYMERS TO THE CORROSION OF MILD STEEL

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Abstract: One of the most common ways of protecting metals from corrosion is to form a film on metal surfaces or to coat them with suitable materials. Thus, metals are protected from corrosive components in their environment. However, in the case of openings at the micro level that may occur in the formation of the coating or in case of scratches and similar openings that may occur after the coating, water and air will reach the metal surface and initiate corrosion. In this study, the effect of polypyrrole (PPy), polyaniline (PANI) and MoS_2-doped PPy and PANI coatings on the corrosion rate of steel were investigated. Corrosion resistances of these coatings were determined by measuring corrosion rates by Tafel Polarization method in 0.1 M NaCl medium. Because of the experiments, it was determined that these homogeneous and adhering coatings were effective against corrosion. The best protection against corrosion was found as 96.7%, 89.0%, 69.5% and 45.2% for PPy + MoS_2, PPy, PANI + MoS_2 and PANI coatings, respectively. MoS_2 additive yielded positive results for both coatings. Better protection of PPy than PANI can be explained by the fact that the oxidation potential of pyrrole (0.6 V) is lower than that of the oxidation potential of aniline.

Keywords: Corrosion, conducting polymers, MoS_2,. Tafel polarization, mild steel.

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INTRODUCTION

Corrosion affects our life in many ways. Everything that is made of metal is affected by corrosion and as a result, corrosion affects our economy directly or indirectly. A large part of the steel produced is lost or becomes unavailable every year due to corrosion (1, 2). Metal lost because of corrosion causes economic losses much higher than its own cost. Because, besides the raw materials, production costs should be considered as losses (3). In addition, depending on the state of the substance released into the environment, it has a negative effect on the life of living things. Various measures are taken to protect metals from corrosion (4).

One of the effective methods to prevent corrosion is to prevent the metal from interacting with the environment (5). The most common way is to create a film on the metal or to coat it. In conductive polymer coatings on the metal surface, generally electrochemical methods are preferred to improve the film thickness by altering the current density, monomer concentration, electrolyte solution quality and pH. Besides the type of metal to be protected, one of the metallic or organic coatings can be made considering the condition of the environment (6, 7).

Organic coatings provide long-term protection from corrosion. However, due to scratches and imperfections in the coating, the metal surface is exposed and the protection deteriorates. For the first time in 1985, De Berry covered steel with PANI and showed corrosion protection in the sulfuric acid medium and accelerated the studies about corrosion protection with conductive polymers (8). With the discovery of the properties of conductive polymers repairing the defects in the coating itself, studies on this subject have intensified (9-11). Due to their redox properties, conductive polymers repair the coating by closing these openings and provide excellent protection (12-16).

The aim of this study was to investigate the effects of MoS_2-doped PPy, PANI coatings in addition to PPy, and PANI coatings on the corrosion protection of mild steel. In this study, protection behavior of conductive polymers, mainly; PPy and PANI on mild steel surface are examined. In addition, the protective effect of the two layer coating system PPy + MoS_2 and PANI + MoS_2 on mild steel is first investigated in NaCl. The Tafel polarization method is used to illustrate the influence of these films on the protection of mild steel in sodium chloride media.

EXPERIMENTAL

In this study, a 3-necked 500 mL reaction flask was used as the corrosion cell. The working electrode was submerged into the middle neck. The reference electrode was placed in one of the neck and the counter electrode was placed in the other. A platinum plate was used as the counter electrode and Saturated Calomel Electrode (SCE) was used as the reference electrode. Prior to each test, the working electrode was sanded with 2000 sandpaper, then cleaned by distilled water, and immersed into ethyl alcohol to accelerate drying. The percentage coating efficiency was calculated according to the following equation. Coatings were obtained on the surface of the mild steel by cyclic voltammetry in 0.1 M $H_2C_2O_4$. CVs and Tafel Polarization curves were obtained at 100 mV / s and at 2 mV / s scan rate respectively (9).

$$Coating\,Efficiency\,\% = \frac{CR(uncoated) - CR(coated)}{CR(uncoated)} \quad \text{(Eq. 1)}$$

RESULTS AND DISCUSSION

PPy and MoS_2-doped PPy coating on the mild steel surface was formed with 10 cycles between 0.0 V and 1.0 V in 0.1 M $H_2C_2O_4$ medium. The resulting voltammograms are given in Figure 1. PPy formation can be understood from the increase in current at 0.6 V.

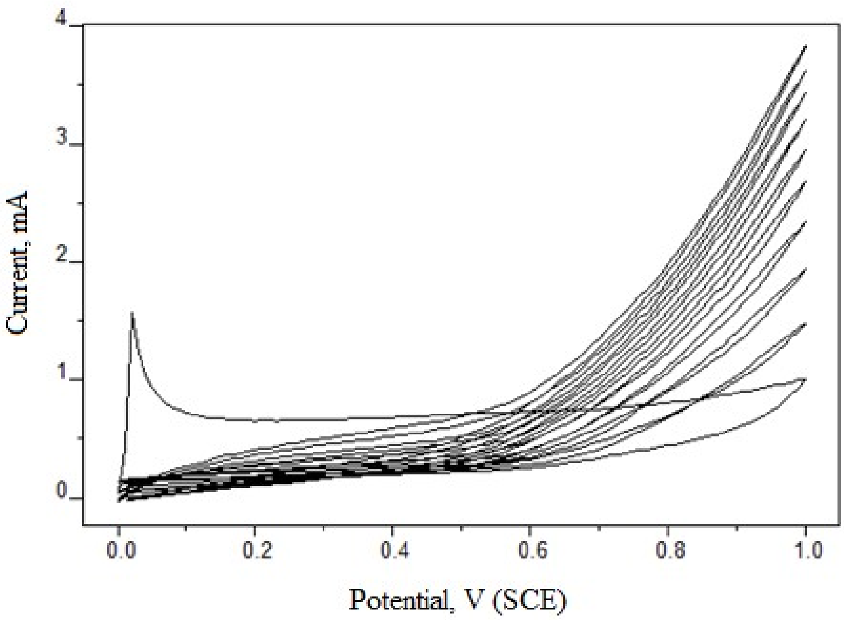

Figure 1. PPy coating curves obtained on Mild Steel surface.

PANI coating curves obtained at scan rate 100 mV / s in the range of 0.0 V to 1.2 V. It can be seen in Figure 2. It shows the aniline oxidation potential is higher than that of pyrrole. After about 1.0 V a big increase in potential has occurred.

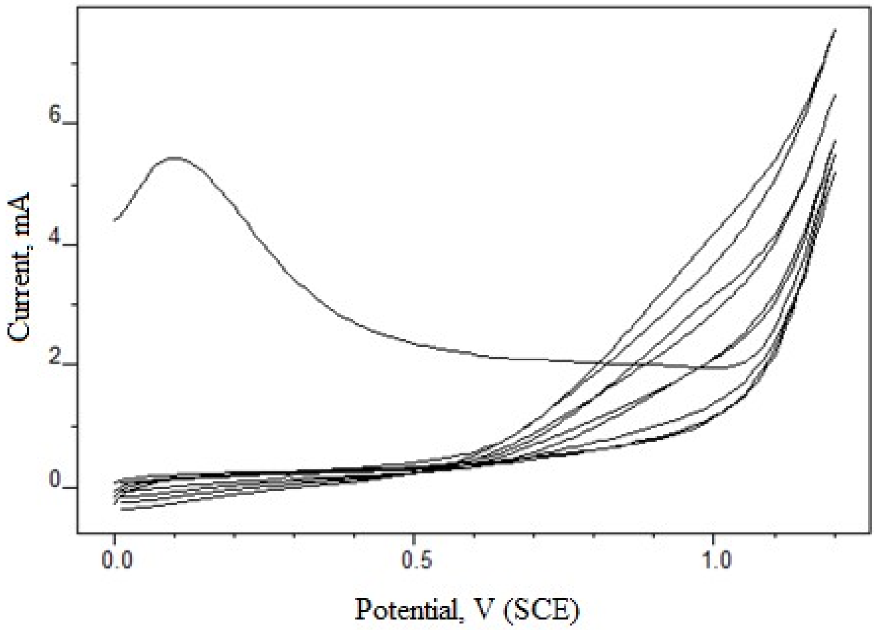

Figure 2. PANI coating obtained curves on the surface of steel.

In Figure 3, Tafel polarization coating curves obtained are given collectively to see the effect of the coating on mild steel corrosion. All of the coatings on the steel surface have increased the corrosion potential of the steel to more positive potentials and reduced the corrosion current density.

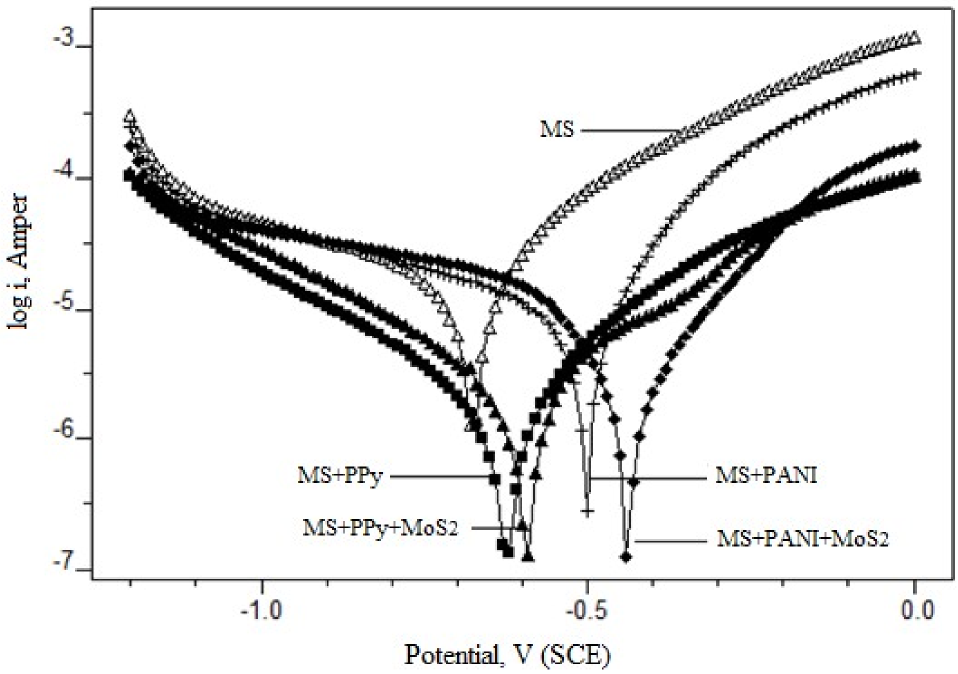

Figure 3. Tafel Polarization curves for all coatings on the mild steel surface.

PPy coatings have shifted their corrosion potential to positive values, approximately 100 mV, while PANI coatings shifted to more than 200 mV. The doped MoS_2 positively affected the corrosion potential for both coatings. This contribution of MoS_2 can be explained by closing gaps in the micro level that can occur in the coating and forming a more stable impermeable layer. It is seen that PANI coatings decreased the cathodic reaction rate more than PPy coatings.

The lower corrosion current density of the PPy coating compared to the PANI coating showed that the PPy coating is more effective on the anodic reaction. MoS_2 added a positive contribution to the decrease of anodic current in both coatings.

Table 1. Corrosion Parameters.

	Ecor (mV)	Rp (ohm)	Corrosion Rate(mm/year)	Coating Efficiency %
Mild Steel (MS)	-685	9289	0.210	-
MS+PANI	-497	11525	0.115	45.2
MS+PANI+MoS_2	-432	12047	0.064	69.5
MS+PPy	-637	12825	0.023	89.0
MS+PPy+MoS_2	-591	13267	0.007	96.7

Corrosion potentials, polarization resistance, and corrosion rate calculated from corrosion current density, and coating efficiency are given in Table 1. Polarization resistance results for mild steel and MoS_2 doped PPy / PANI coatings are compatible with corrosion rates. The coating efficiency was determined for PANI, PANI+MoS2, PPy, and PPy+MoS2 45.2, 69.5, 89.0 and 96.7 respectively.

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