Conducting Poly (Aniline-Co-O-Anisidine) Coatings on Low Carbon Steel: Synthesis, Characterization and Corrosion Protection Studies

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Abstract:- *Conducting poly (aniline-co-o-anisidine) coating are obtained on low carbon steel sample by galvanostatic deposition method using oxalic acid as supporting electrolyte. The coating is characterized by UV-vis absorption spectroscopy. The corrosion protection aspects of poly (aniline-co-o-anisidine) co-polymer coatings on low carbon steel were investigated in aqueous 3.5% NaCl solution by potentiodynamic polarization studies, open circuit potential measurements, electrochemical impedance spectroscopy and alternate immersion testing. The results of the potentiodynamic polarization measurement showed that the corrosion rate of co-polymer coated steel is 1.477 mpy which is about 3 times lower than that of uncoated low carbon steel. The electrochemical studies reveal protective nature of electrodeposited conducting poly (aniline-co-o-anisidine) copolymer coating even after 144 hours of immersion. Conducting poly (aniline-co-o-anisidine) coating protects low carbon steel in neutral medium by preventing cathodic reduction process.*

Key Words: PANI- Polyaniline.

1. INTRODUCTION

Metals and alloys corrode in environments encountered during their service. Corrosion can be defined as the destruction or deterioration of a material because of reaction with its environment [1]. Perhaps, the most common corrosion prevention method is the use of paint coatings. Effective paint coatings contain environmentally hazardous and toxic pigments such as strontium chromates. There is a need to replace conventional toxic coatings by environmental friendly and non toxic formulations. Corrosion, being an electrochemical phenomenon, can be tackled through the use of electrochemistry and conducting polymers [2]. Within family of conducting polymers, conducting polyaniline occupies an important place due to its ease of synthesis, stability and low cost economics.

Conducting polyaniline either in the form of electrodeposited primer or in the form of paint has shown promise for corrosion protection of active metals [3]. However, the extent of using this polymer is limited to the exclusivity of the monomers that are required for its synthesis. Also, its electrochemical activity is limited due to low pH conditions (pH < 4) required for its synthesis. Presently three methods are used to overcome this situation – 1) The first approach is concerned with the use of derivatives such as poly(o-anisidine), 2) The second technique involves the formation of bi layer coatings which either consists of a top coat conducting polyaniline on the layer of the other conducting polymer such as polypyrrole or a top coat of conducting polyaniline on the metallic coating such as nickel and 3) The third method is based on co polymerization of two conducting polymers [4]. The aim of present work is to synthesize conducting poly (aniline-co-o-anisidine) coatings on low carbon steel samples by galvanostatic method, to characterize these coatings by UV- visible spectroscopy to study their corrosion protection performance in neutral solution by using electrochemical methods.

2. EXPERIMENTAL WORK

Chemicals:

All chemicals required for electro deposition of conducting poly (aniline-co-o-anisidine) copolymer coating on low carbon steel were analytical reagents (AR Grade, supplied by Loba Chemicals, Mumbai , India) and used as received (Table 1).

Table 1: Chemicals used for coating on conducting poly (aniline-co-o-anisidine) copolymer coating on low carbon steel sample.

Material	Chemical formula	Molecular weight (g/mol)
Aniline	$C_6H_5NH_2$	93.13
o-anisidine	C_7H_9NO	123.16
Oxalic acid	$C_2H_2O_4$	90.03
Low carbon steel	AISI 1015	475.25

Specimen preparation

The samples for the experiments were cut from the sheet of low carbon steel (AISI 1015). Before each experiment, the specimen was dry polished by using a series of emery papers. The final approximation to a flat scratch free surface was obtained by use of the lapping machine. The specimen was then washed under running water and dried.

Galvanostatic deposition

The electrochemical deposition of conducting poly (aniline-co-o-anisidine) coating on low carbon steel samples (AISI 1015) is carried out at room temperature in a simple one compartment glass cell under galvanostatic conditions. A three electrode geometry is employed during electro-copolymerization of aniline and o-anisidine on low carbon steel as working electrode (8 cm^2), stainless steel as counter electrode and saturated calomel electrode (SCE) as a reference electrode as shown in the figure 1.

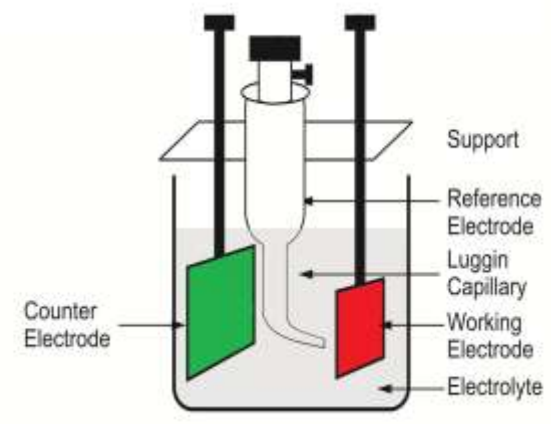

Figure 1: Electrochemical Cell: A line diagram

CHARACTERIZATIONS:

The UV-Visible absorption study of electrochemically deposited conducting co polymer coating will be carried out ex situ in the wavelength range 200 – 1200 nm using microprocessor controlled double beam UV-Visible spectrophotometer (Model V 520, Jasco, Japan) to determine conducting phase obtained. Schematic diagram of double beam.

UV-visible spectra of the Poly (aniline-co-o-anisidine) copolymer were recorded at room temperature in N-Methyl-2-pyrrolidone (NMP) solution.

CORROSION PROTECTION PERFORMANCE:

A corrosion cell having three electrode geometry of paint coated sample as working electrode (8 cm^2), stainless steel as counter electrode and saturated calomel electrode (SCE) as a reference electrode was used. The cell was coupled with Gamry Reference system 600 (Wilmington, USA) for corrosion studies.

RESULTS AND DISCUSSION:

Galvanostatic deposition of conducting poly (aniline-co-o-anisidine) coating on low carbon steel sample. The UV-vis spectrum of poly (aniline-co-o-anisidine) copolymer is shown in the figure 2 . The copolymerization of aniline and o-anisidine was performed under the galvanostatic conditions. The reactivity of o anisidine is higher than aniline, hence it seems that when the mixture of these two monomers are polymerized more o-anisidine monomers take part in the polymerization compared to the aniline monomers. Consequently, there are more o-anisidine monomeric units compared to aniline in the electrodeposited copolymer [5].

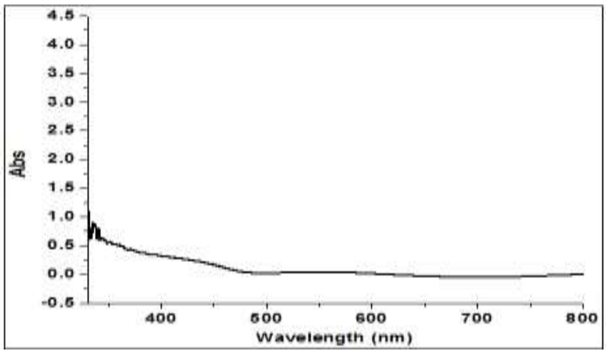

Figure 2: UV-vis scan of conducting poly (aniline-co-o-anisidine) copolymer electrodeposited coating.

The UV-vis spectra of poly (aniline-co-o-anisidine) copolymer exhibit more resemblance to the spectral features of o-anisidine. The spectrum of copolymer is dominated by two bands; a strong absorption band at 330- 350 nm (peak 1) and a broad band at 500-600 nm (peak 2). According to the general practice of peak assignment, first peak is attributed to the π-π* transition of the benzenoid moieties in the poly (aniline-co-o-anisidine) copolymer linear structure or simply to the band gap of the copolymer. The second peak closely resembles the benzenoid-quinoid transition in the copolymer. G. Bereket et.al. and Mohammad Reza Nabid et.al has noted similar observations [5, 7]

CORROSION STUDIES

The Potentiodynamic polarization

Tafel curve for uncoated low carbon steel is shown in the figure 3.

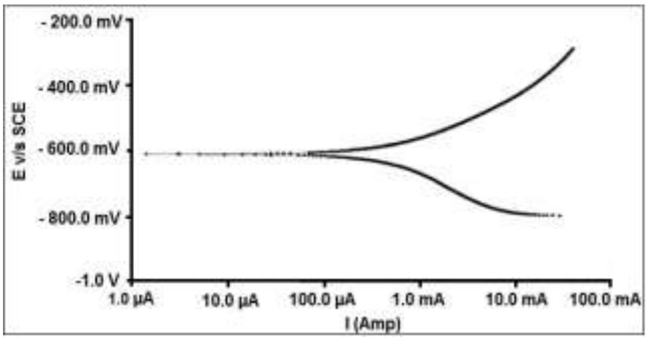

Figure 3: Tafel plot for low carbon steel sample in 3.5 wt% NaCl.

Potentiodynamic polarization behavior of electrodeposited conducting co-polymer (0.05M Aniline + 0.05M o-Anisidine) coating on low carbon steel in 3.5 wt % NaCl solution is depicted in the figure 4.

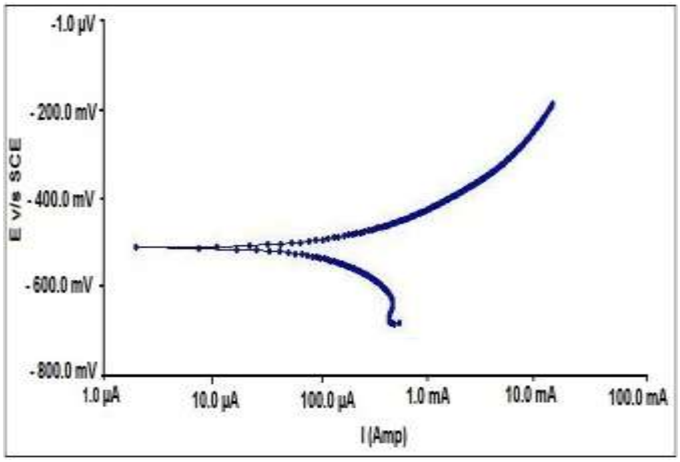

Figure 4: Tafel plot for of electrodeposited conducting co-polymer (0.05M Aniline + 0.05M o-Anisidine) coating on low carbon steel in 3.5 wt % NaCl solution.

The values of the corrosion potentials, corrosion current densities and corrosion rates obtained from the figures 3 & 4 are recorded in Table 2.

Table 2- Corrosion rates for unpainted low carbon steel and epoxy coated steel.

Sample	E_{corr} mV	I_{corr} per cm^2	Corrosion rate mpy
Uncoated low carbon steel	-680.0 mV	87 µA	5
Co-polymer (0.05M Aniline + 0.05 M o-anisidine) coated low carbon steel	-519.0 mV	64 µA	1.477

Corrosion potential is found to be increased from – 680 mV for uncoated low carbon steel to -519 mV for co-polymer coated steel in noble direction. This reveals anodic type of protection offered by co polymer. It should also be noted that the corrosion rate is substantially reduced due to decrease in current density from 87 µA/ cm^2 to 64 µA/ cm^2 for co-polymer coated steel. The corrosion rate of co-polymer coated steel in 3.5 wt% NaCl is found to be 1.477 mpy which is about 3 times lower than that of uncoated low carbon steel. These results are in good agreement with the previous work [4].

3. CONCLUSION

It is possible to obtain conducting poly (aniline-co-o-anisidine) coatings on low carbon steel sample by galvanostatic deposition method. UV-vis spectra confirm the copolymerization of aniline-co-o-anisidine and its conducting phase. The corrosion rate of co-polymer coated steel in 3.5 wt% NaCl is found to be 1.477 mpy which is about 3 times lower than that of uncoated low carbon steel.

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