THE EFFECT OF GRAPHENE AS ADDITIVE ON THE ANTI-CORROSION OF POLYURETHANE COATINGS

TRACK OR CATEGORY
Surface Engineering I 3066791

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INTRODUCTION

Corrosion of metal could be considered as a serious threat for the safety of the equipment, especially the equipment worked in the sea-water [1-2]. To increase equipment life, spraying coating is always an effective method to enhance the anti-corrosion performance [3-5]. With the development of the nano-science, many nano-materials, such as carbon nanotubes [6], was added into the traditional coatings. Graphene with the high chemical inertness is the ideal candidate to be added into the coatings.

In this paper, a commercial electrochemical workstation was used to study the corrosion behaviors of medium carbon steel with and without coatings. The surface characterization techniques were introduced to discuss the mechanism of the anti-corrosion of coatings.

1. Test materials

In the experiment, the coupons was medium carbon steel and purchased from the Corrtest Instruments Co. Ltd. (Wuhan, China) and the chemical compositions of the alloy steels are given in Table 1. The working area for the coupons was 0.5 cm^2 and for other parts, it was encapsulated by epoxy resin.

Table 1 Chemical composition of the alloy steel (mass fraction, wt. %).

Components	C	Mn	P	S	Si	Ni	Cr	Cu	Fe
Content	0.31	0.52	0.017	0.022	0.31	0.019	0.96	0.015	Bal.

2. Artificial sea-water

To ensure the repeatability of the test, the corrosive medium was configurated according to the standard of ASTM D 1141-98 and with the pH of 8.2. The concentration (g/L) was as follows: NaCl 24.53, $MgCl_2$ 5.2, Na_2SO_4 4.09, $CaCl_2$ 1.16, KCl 0.695, $NaHCO_3$ 0.201, KBr 0.101, H_3BO_3 0.027, NaF 0.025 and $SrCl_2$ 0.003.

3. Coating preparation

The hydroxyl number of solids of the hydroxyl functional acrylic polyol (Thyon Ox787) was about 90. The hexamethylene diisocyanate (HMDI) was used as crosslinker. The solvent was dimethylbenzene (Sinopharm Chemical Reagent Co., Ltd.). The graphene was made by ourselves using arc-discharge method. The mass fraction of graphene compared with hydroxyl functional acrylic polyol was 0.6%.

4. Electrochemical test

The electrochemical test experiments conducted in this paper shown in Figure 1, three cell system of electrochemical workstation (ParStat 4000, America) was introduced. The medium carbon steel and the graphite rod were used as work electrode (WE) and counter electrode (CE), respectively. A saturated calomel electrode

(SCE) was used as reference electrode (RE). This RE was placed into a luggin capillary and the distance between the luggin capillary tip and WE was about 1mm to decrease the IR drop.

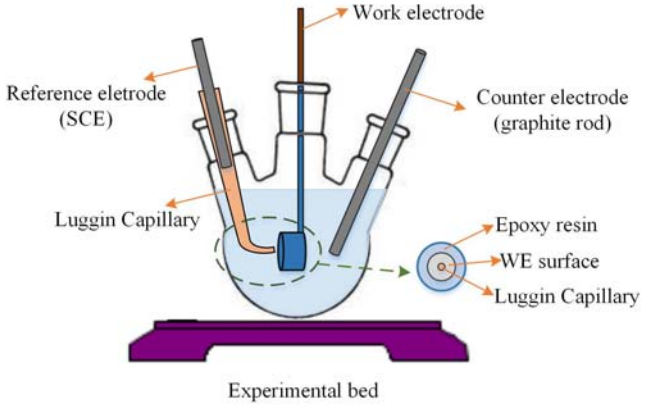

Figure 1. Electrochemical test set-up.

4.1 Tafel curve

The corrosion rate can be calculated by the tafel curve. The tafel curves for the coupons with and without coatings were showed in Figure 2. As we can see that the corrosion potential was the most negative for the coupon without coating. With the PU coating, the corrosion potential was moved positively. When the graphene was added, the corrosion potential further decreased which showed that the coupons with PU/Graphene possessed the best anti-corrosion performance.

4.2 Electrochemical impedance spectroscopy (EIS)

The Nyquist curve can be used to state the degree of difficulty to be corroded of the coupons. The much bigger the semicircle diameter are, the more difficult of the coupons to be corroded. It can be seen (Figure 3) clearly that the coupon without coating has the smallest value of the semicircle diameter which dedicated the coupon without coating was much easiest.

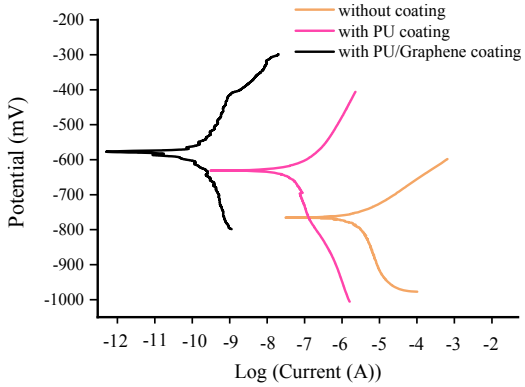

Figure 2. Tafel curve of coupons

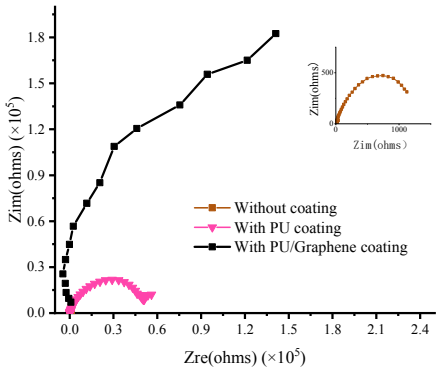

Figure 3. Nyquist curve of coupons

5. Immersing test

To verify the date collected from the electrochemical workstation, the coupons were immersed in the artificial sea-water for 45 days. As we can see in Figure 4 that the coupon without PU coating suffered the worst corrosion.

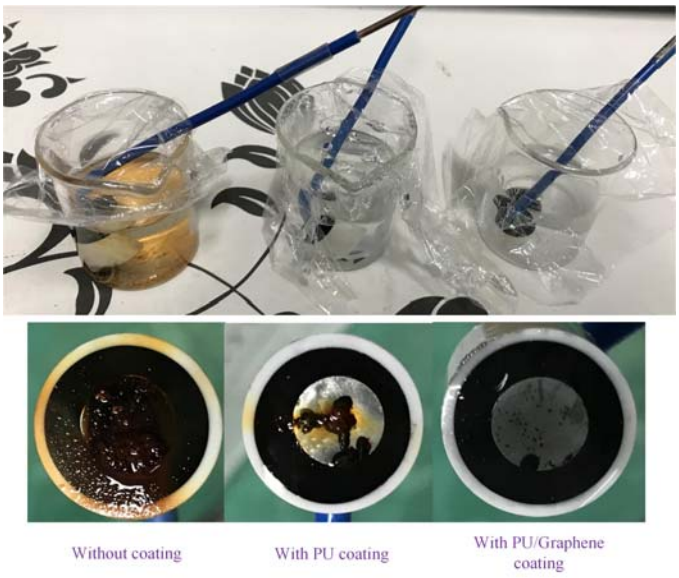

Figure 4. Macro morphologies of specimens after immersing test.

6. Mechanism

The mechanism was discussed through detect the contact angles when the coatings were sprayed on the medium carbon steel, the bonding strength of coatings and the isolated performance of PU and PU/Graphene coatings with corrosive solution.

7. Results

In this paper, the anti-corrosion performance of the coupons was mainly studied by electrochemical method. Through the Tafel curve (Figure 2) and Nyquist curve (Figure 3), we can indicate the graphene additive can effectively increase the anti-corrosion performance of the bare steel which can also shown in Figure 4. The mechanism was also discussed.

ACKNOWLEDGMENTS

This research is funded by the National Natural Science Foundation of China (No.51675534), the Tribology Science Fund of State Key Laboratory of Tribology, and the Science Foundation of China University of Petroleum, Beijing (No. 2462017BJB06, C 201602).

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KEYWORDS

Carbon, Graphite, Polymers (solid), Optical Microscopy