

Preparation and Anticorrosion Properties of Polydimethylsiloxane(PDMS) Coating

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Abstract—In order to improve the corrosion resistance of the metal, polysiloxane (PDMS) coating was prepared on the metal by spin coating method. The chemical structure and micro surface morphology of PDMS coatings were analyzed by infrared spectroscopy and scanning electron microscopy. Using electrochemical workstation, the corrosion resistance of the PDMS coating was tested by Tafel polarization and impedance. It can be found that PDMS coating can obviously improve the corrosion resistance of the AA2024.

Keywords-PDMS ; corrosion resistance; AA2024

I. INTRODUCTION

The corrosion of metal brings huge economic loss to the society, accounting for about four percent of the national economy; this is a number that cannot be ignored, so the protection of metal is particularly important [1]. Aluminum alloy (AA2024) is widely used in aerospace, transportation and other fields due to its low density, high strength, electrical conductivity and easy processing [2-3]. However, Aluminum alloy contains aluminum, magnesium, copper and other major elements, due to uneven dispersion between the elements, aluminum alloy is vulnerable to corrosion, so the application of Aluminum Alloy is limited [4-5]. Therefore, more and more methods are used to improve the anticorrosion performance of the Aluminum Alloy, such as chromate conversion coatings, electrochemical deposition, etc. [6-7]. Chromate conversion coating is one of the most common protective coatings because of its strong binding force with the metal. However, the chromate ion is toxic, which limits its development [2]. So, finding environmentally friendly ways to protect aluminum is very important [8]. Organic coatings are one of the best choices for metal protection, which are widely used because of their simple preparation, low cost and wide range of applications. There are too many examples of hydrophobic materials applied to metal corrosion protection; they can provide a barrier between the metal and electrolyte [9-10]. Hence, polysiloxane (PDMS) is a material for organic coating with good chemical stability, environmental friendliness and strong interfacial adhesion: Its contact angle is about 105° [11-12]. So polysiloxane (PDMS) coatings are widely used in the fields of hydrophobic surface and metal corrosion and protection [11, 13]. For example, Ejenstam et al. fabricated PDMS hydrophobic coating with contact angle of 160° and the coating had a protective effect on the metal for up to 44 days [9]. Qing et al. discussed the influence of PDMS/TiO₂ composite coating on corrosion resistance [14].

In this article, T-PDMS coatings were prepared on the metal by spin coating, and the T-PDMS coatings were crosslinked and cured by heating. We investigated the structure and Micro morphology of the T-PDMS coatings by Fourier transform infrared spectroscopy (FT-IR) and scanning electron microscope (SEM). Meanwhile, the electrochemical method was used to evaluate the anticorrosion performance of T-PDMS coatings.

II. EXPERIMENT

A. Materials

The AA2024 alloy sheet with a size of 10 mm × 10 mm × 3 mm is polished through Sic papers (400/800/1200/2000 grit sizes). Next, aluminum alloy was treated with acetone, ethanol, water and sodium hydroxide solution.

B. Preparation of PDMS Coating

The hydroxyl-terminated polydimethylsiloxane (HO-PDMS-OH) (molecular weight of about 2500) was purchased from Jinan Xing fei long Chemical Company. Tetraethoxysilane (TEOS) and dibutyltin dilaurate (DBTDL) were acquired from Sinopharm Chemical Reagent Co. Ltd.

First, a certain amount of TEOS and DBTDL were added to the PDMS at a certain stirring speed, then, dried in vacuum drying oven for 2 hours. The coating was referred to as "T-PDMS". Fig. 1 showed the mechanism diagram of T-PDMS coating.

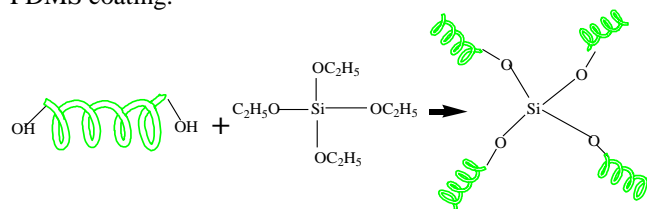


Figure 1. Mechanism diagram of T-PDMS coating.

C. Characterization

The structure of T-PDMS coating was characterized by FT-IR (Nicolet iN10). The scanning electron microscope (HitachiS-4800) was used to characterize the micro morphology of T-PDMS coating. And the corrosion resistance of T-PDMS coating was carried out by Tafel polarization and electrochemical impedance spectroscopy (EIS). Three-electrode method was used for electrochemical testing.

III. RESULTS AND DISCUSSIONS

A. FTIR Spectra of Samples

In order to detect whether PDMS reacted with TEOS, infrared analysis of T-PDMS in the range of 4000-500 cm^{-1} before and after curing was carried out and the results were shown in Fig. 2. The dip at 3288 cm^{-1} in T-PDMS was the stretching vibration peak of hydroxyl group (O-H) [15]. However, the stretching vibration dip of O-H disappeared in T-PDMS, indicating that PDMS reacted TEOS.

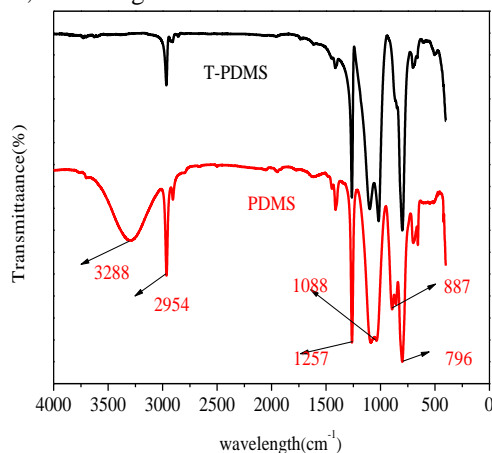


Figure 2. FTIR spectra of T-PDMS and PDMS.

B. Scanning Electron Microscope Analysis

Fig. 3a was the microscopic surface morphology of the AA2024. It can be seen from Fig. 3a that the surface of the AA2024 was slightly rough, which was the result of NaOH solution treatment. The rough surface structure made it easy for T-PDMS to combine with the substrate. Fig. 3b was the microscopic surface morphology of T-PDMS coating. As

seen in Fig. 3b, the surface of the T- PDMS coating was smooth and uniform and without cracks. In addition, due to the lower surface energy of T- PDMS, there was a good isolation effect on corrosive ions.

C. Corrosion Resistance of Coatings

1) EIS Results

Fig. 4 showed the corrosion resistance of AA2024 and T-PDMS. Fig. 4a was Nyquist plot, it can be seen from the figure that the capacitance arc of T-PDMS coating was greater than AA2024. Fig. 4b was a Bode diagram. As we can see, the modulus of the low frequency impedance of the T-PDMS was larger than that of the AA2024. Compared with AA2024, the low frequency impedance modulus of T-PDMS coating was increased by an order of magnitude. It can be concluded that T-PDMS coating can obviously improve the corrosion resistance of the AA2024.

TABLE I. TAFEL POLARIZATION PARAMETERS FOR AA2024 AND T-PDMS COATING

Sample	E_{corr} (V)	I_{corr} (A cm^{-2})	R_p
Bare	-1.175	2.714×10^{-5}	1523
T-PDMS	-0.9966	4.920×10^{-7}	82181

2) Tafel Polarization

Fig. 5 showed the Tafel polarization curves of AA2024 and T-PDMS coatings, and Table 1 was the Tafel polarization curve parameters for AA2024 and T-PDMS coating. It can be seen from Fig. 5 and Table 1, compared with the AA2024, the corrosion potential of T-PDMS coating was obviously shifted by 0.178V towards positive potential, and the corrosion current density was reduced by two orders of magnitude. Therefore, T-PDMS coating has a good protective effect on the AA2024.

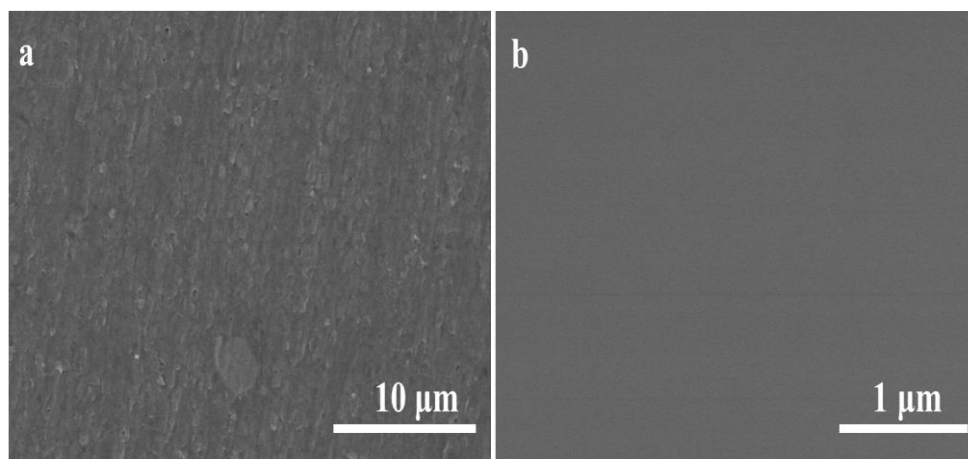


Figure 3. SEM images of (a) AA2024; (b) T-PDMS

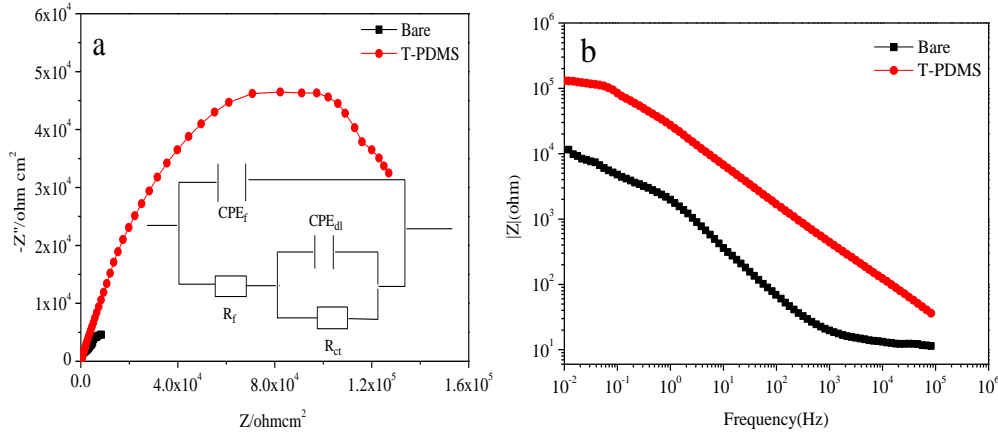


Figure 4. Electrochemical impedance plot for coatings (a) Nyquist plot; (b) Bode plot.

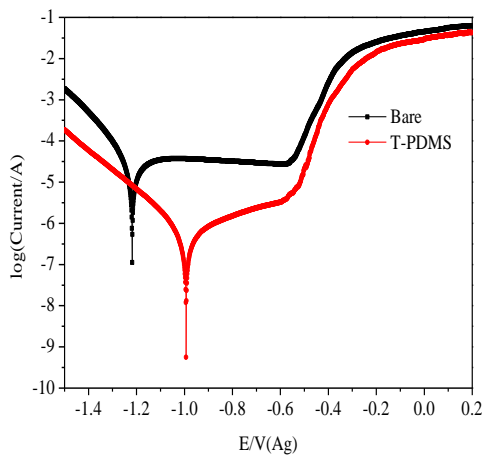


Figure 5. Tafel polarization curves of AA2024 and T-PDMS coating.

IV. CONCLUSION

T-PDMS coating was prepared on metal surface by spin coating method. Through scanning electron microscope, it can be found from Fig. 3b that the T-PDMS coating surface was smooth, without cracks and other defects, which can effectively hinder the corrosion of ions. Through electrochemical impedance polarization test, it was found that the T-PDMS coating had obvious protective effect on the metal, the low frequency impedance modulus increased by an order of magnitude, and the corrosion current density dropped by nearly two orders of magnitude, reaching $4.920 \times 10^{-7} \text{ A} \cdot \text{cm}^{-2}$.

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