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Enhancement of barrier and corrosion protection performance of an epoxy coating through wet transfer of amino functionalized graphene oxide

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ABSTRACT

An amino functionalized graphene oxide (FGO) was synthesized and characterized by Fourier transform infrared spectroscopy (FTIR) and X-Ray diffraction analysis (XRD). Then, FGO/epoxy composite was prepared through dispersing 0.1 wt.% of FGO in an epoxy coating through wet transfer method (WTM). The GO/epoxy and FGO/epoxy composites were applied on the mild steel substrates and their barrier and corrosion protection performance were characterized by salt spray test and electrochemical impedance spectroscopy (EIS). Incorporation of 0.1 wt.% of FGO nanosheets into the epoxy coating significantly enhanced the corrosion resistance of the coating through improving its ionic resistance as well as barrier properties.

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1. Introduction

Organic coatings have been widely used to protect metals against corrosion through playing as a physical barrier between the metal surface and the corrosive environment. However, the corrosive species such as oxygen, water and chloride ions can reach the metal/coating interface through diffusion into the coating porosities [1]. These may result in the coating barrier performance decline as a result of hydrolytic degradation. In addition, the corrosion of metal beneath the coating can accelerate the adhesion loss and coating blistering.

Attempts have been done to enhance the barrier performance and corrosion protection properties of the polymer coatings through addition of various additives and/or anticorrosive pigments [2]. Jiang et al. [3,4] studied the corrosion protection performance of the epoxy coatings reinforced with active (aminopropyltrimethoxy) and non-active (bis-1,2-[triethoxysilyl]ethane) silane precursors on the alloy (AA2024). They found that incorporation of such silane coupling agents into the epoxy coating resulted in the interfacial adhesion bonds promotion and the increase of corrosion resistance of the coating. Liu et al. [5] investigated the effect of grinding temperature on the surface treatment of iron oxide and its effect on the corrosion resistance of the epoxy coating. They found that the increase of graft density of iron oxide particles resulted in the improvement of the coating corrosion protection performance. Doğru Mert et al. [6] revealed that TiO_2 doped polypyrrole coating can significantly increase the corrosion resistance of aluminum substrate. Hiromoto et al. [7] revealed that hydroxyapatite and octacalcium phosphate coatings provided good corrosion protection performance on the Mg AZ31 alloy.

In recent years, the researchers' attentions have been directed toward using nano size materials in the polymer coating to enhance its protection properties. Owing smaller particle size and greater specific surface area than conventional fillers, they can provide good barrier performance against corrosive electrolyte diffusion. In this regard, various nanoparticles i.e. SiO_2 [8–13], Al_2O_3 [23,14], Cr_2O_3 [15], Fe_2O_3 [16,17], ZnO [18–21], TiO_2 [22–25] and Clay [26–29] have been investigated. The benefits of using such nanoparticles in improving the corrosion protection properties of the coatings have been shown in these studies. Pour-Ali et al. [30] investigated the corrosion resistance of steels in chloride-laden concrete environment in the presence and absence of an epoxy/polyaniline–camphorsulfonate nanocomposite coating.

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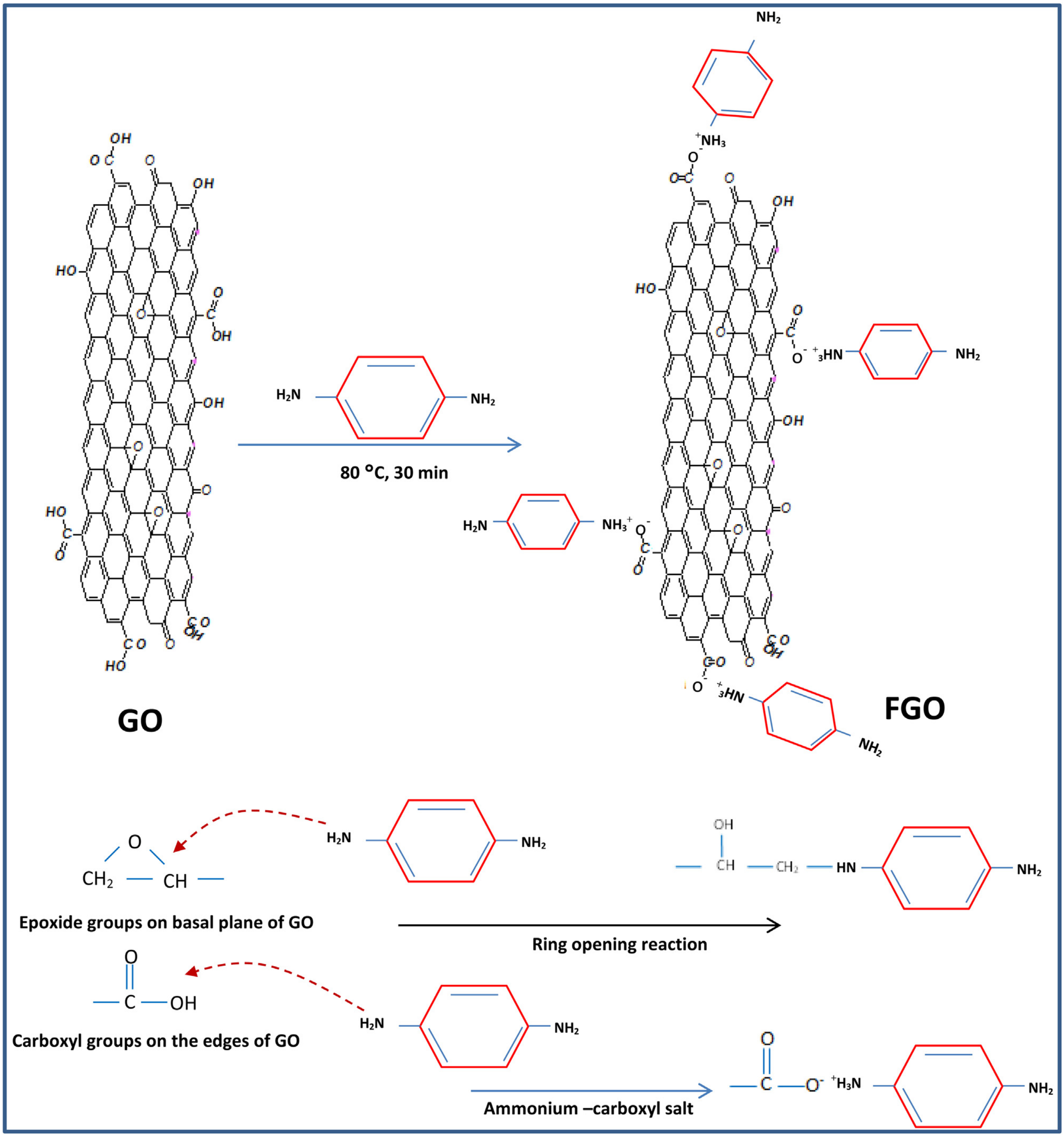

Fig. 1. Schematic illustration of diamine bonding reactions to the GO surface at 80 °C for 30 min.

They found that utilizing such a coating provided good corrosion protection properties for steel in concrete environment. Recently, researchers have attempted to find nanoparticles with superficial properties against corrosive electrolyte to provide extended corrosion protection properties for the organic coatings. Graphene nanosheets and its derivatives have been considered in this regard.

The effectiveness of graphene oxide as a filler in corrosion protective coatings is still subject to controversy. There are several reports stating good protection behavior of the graphene-based coatings [30–32]. However, Schriver et al. reported that the unfunctionalized graphene may accelerate oxidation of metals when exposed to corrosive environments over long periods of time [33]. Singh et al. [34] studied the corrosion resistant of graphene reinforced composite coating on copper by electrophoretic deposition. They revealed that GO composite coating on cupper surface acts as a barrier to electrons and ions transport between the substrate and corrosive electrolyte. There are various reports regarding the use of chemical vapor deposition (CVD) method for deposition of graphene coating on the metals [35–40]. They found that graphene coating behaves as a passive layer and prevent the oxidation of metals.

Very recently, Yu et al. [41] loaded titanium dioxide on graphene oxide sheets by using 3-aminopropyltriethoxysilane and dispersed hybrid TiO_2-GO sheets in an epoxy resin to enhance its corrosion protection performance. Qian et al. [42] successfully functionalized GO particles with amine-terminated polyether and then introduced

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