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The synthesis and antistatic, anticorrosive properties of polyaniline composite coating

Aiping Zhu[a,*], Hongsheng Wang[a], Shasha Sun[b], Chaoqun Zhang[a]

[a] College of Chemistry and Chemical Engineering, Yangzhou University, Yangzhou 225002, Jiangsu, China
[b] School of Environmental & Chemical Engineering, Jiangsu University of Science and Technology, Zhenjiang 212003, Jiangsu, China

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ABSTRACT

In this paper, acrylic ester grafting epoxy (A-g-EP) with —COOH functional groups was firstly designed and prepared. Then the PANI-A-g-EP composite was obtained through oxidation polymerization of aniline on A-g-EP macromolecular chains. PANI nanoparticles in the PANI-A-g-EP composite were dispersed uniformly due to the strong interactions between macromolecular carboxyl groups and PANI. The composite is characterized by FT-IR, UV–vis and cyclic voltammetry (CV). The effect of PANI content on the glass transition temperature (T_g) and the thermal decomposition temperature (T_d) were studied. PANI-A-g-EP composite coating was fabricated by the solution casting. The results of surface resistance, anticorrosion performances of the composite coating demonstrate that the good anticorrosion property of A-g-EP coating is caused by the good wet adhesion. The anticorrosion mechanism of PANI in the PANI-A-g-EP composite coating is revealed to be the electron transmission and passivation catalysis.

1. Introduction

In recent years, intrinsically conducting polymers (ICPs) have attracted a lot of attention due to their metal-like conductivity in a doped state [1,2]. The presence of large amounts of ions (which is a result of doping) in these polymers alters their structure and endow them completely new and unique properties, such as controllable electrical conductivity, reversible doping/dedoping (oxidation/reduction) process, optical activity and corrosion stability et al. [3–6]. Among the various conducting polymers, polyaniline (PANI) is one of the mostly studied and widely applied ICPs in biosensors, storage batteries, electrochromic devices and optical components, due to its low cost, easiness of synthesis, and good physicochemical stability [7]. Application of polyaniline in corrosion protection involves individual coatings and working as a primer layer in a coating system [8–11]. PANI has great potential to replace the toxic metal, such as chromates, in corrosion protection and realize “green” anticorrosion.

Polyaniline has various forms such as leucoemeraldine, emeraldine and pernigraniline, depending on the degree of oxidation. The only conducting form of polyaniline is half-oxidized emeraldine salt, obtained by doping or protonation of emeraldine base. Polyaniline coating can be prepared by several techniques, such as direct deposition from solvents, electrochemical deposition, and blending of polyaniline powders with various commercial polymeric materials like epoxy, polyester, acrylic and polyurethane et al. [12,13]. Among them, the blending method is the most simple and efficient one. There are many reports about preparation and characterization of nano-polyaniline composite [14–19]. However, due to the surface and interface effect between nano-polyaniline and polymer matrix, most of the studies showed that nanoscale polyaniline inevitably forms a state of aggregation in matrix polymers, which would affect anti-corrosion, conductivity and anti-fouling performance of the materials [20]. For example, Armelin and co-workers showed that as the PANI percentage in an epoxy paint formulation increased from 0.3 to 1.5 wt%, the surface defect of the coating occurred, which greatly affect the coating properties such as gloss and stain resistance [21]. Meanwhile, the low feeding ratio or significant particle aggregation of PANI is difficult to form a conductive network in the coating matrix, which is not suitable for anti-electrostatic coatings. To solve these problems, Wang et al. have prepared epoxy resin composite with organic phosphate doped polyaniline particles (PANI-OP), the amount of PANI-OP ranging from 0.1% to 1% can significantly improve the corrosion resistance of water-borne epoxy resin coating [20]. Qiu and coworkers prepared polyaniline-graphene oxide (PANI-GO) composite coating on the 316 stainless steel (SS) by a pulse current co-deposition method, the corrosion inhibition efficiency and protection efficiency of the PANI-GO composite coating reached 98.4% and 99.3%, respectively [21]. Moss et al. synthesized a set of polyaniline-graphene oxide (PANI-GO)

* Corresponding author.
E-mail address: apzhu@yzu.edu.cn (A. Zhu).

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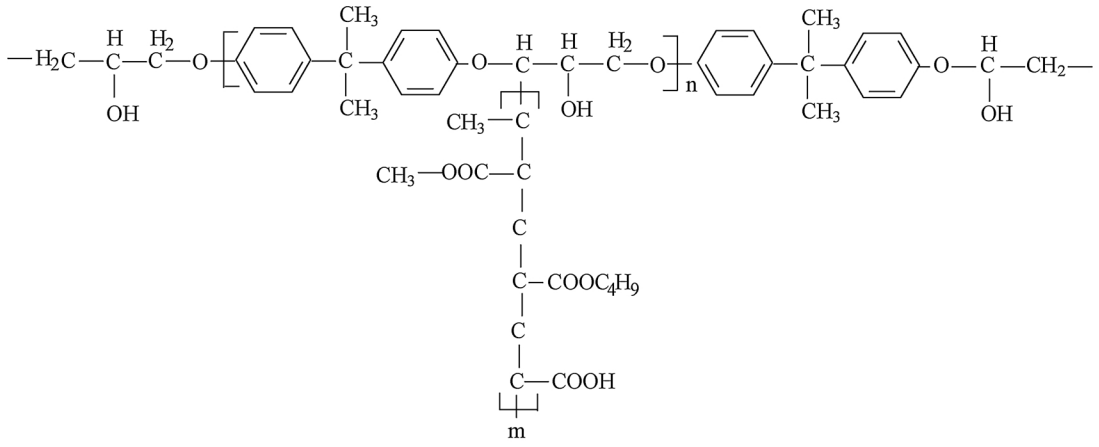
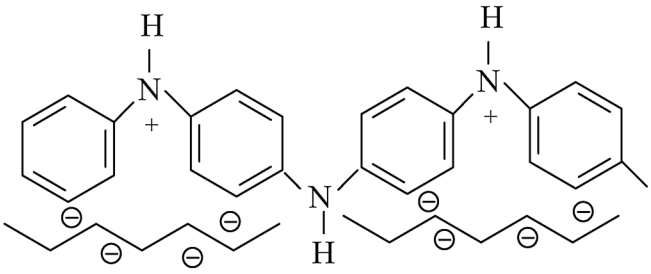
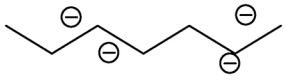


(a) A-g-EP



PANI-A-g-EP

A-g-EP 

(b)

Scheme 1. (a) The structure of the acrylic ester grafting epoxy; (b) The synthesis of PANI -A-g-EP composite by macromolecular acid.

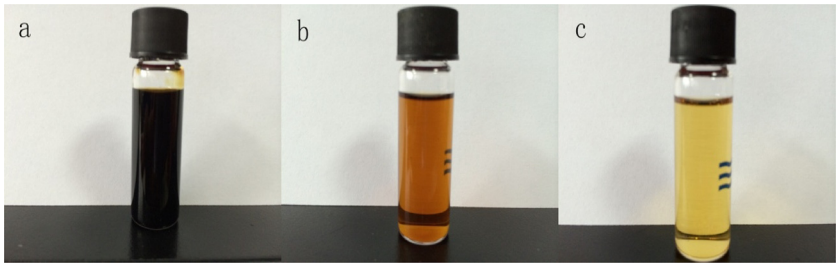


Fig. 1. Images of PANI (12%)-A-g-EP in solvents (toluene/butanone = 85/15) with a concentration of a) 40 wt%, b) 0.4 wt%, and c) 0.004 wt%. (For interpretation of the references to colour in the figure text, the reader is referred to the web version of this article).

nanocomposites which exhibit superior properties in terms of shelf life, processability and conductivity due to the synergistic effect of GO and PANI by varying the concentration of highly non-conducting GO with respect to aniline, the potentiodynamic results reveal that PANI nanocomposites with 1% GO exhibited long-term anti-corrosion behavior which is much lower than its individual components and commercial-grade red oxide [22]. Farag et al. synthesized Polyaniline (PANI) and its composites with multiwalled carbon nanotubes (MWCNTs) by chemical oxidative polymerization, the encapsulation and dispersion of MWCNTs into the PANI matrix promoted the anticorrosive efficiency of the alkyd coating [23]. Zhao et al. synthesized Graphene-based polyaniline (PANI/RGO) which used as conductive filler through a new one-pot