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Preparation and characterization of a new low infrared-emissivity coating based on modified aluminum

Guangwen Wu, Demei Yu*

Department of Applied Chemistry School of Science, Xi'an Jiaotong University, Xi'an 710049, PR China

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ABSTRACT

A low infrared-emissivity coating was prepared using modified Al powder and polyurethane as metallic pigment and adhesive. Al powder was coated with polyethylene wax by the flux-capping method to reduce the emissivity and gloss of the coating. The surface morphology and chemical composition of pure and modified Al powders were characterized by scanning electron microscopy and X-ray diffraction. The infrared emissivity of the product was measured by an infrared emissometer. The influences of the modified Al powder content, substrate material, coating thickness, and aging time on infrared emissivity were systematically investigated. The results indicate that modified Al powder decreases not only the gloss of the coating, but also its emissivity within the wavelength range of 8–14 μm. The polyethylene wax/Al composites have a homogenous sheet structure at 30 wt.% Al content, and a lower infrared emissivity. The optimum content of modified Al powder is around 18 wt.%. The coating exhibits a lower emissivity value and excellent optical properties. The infrared emissivity of the composite coating significantly increases with increased thickness, and approaches a constant value when the thickness is more than 80 μm. Accelerated aging test results show that with increased aging time, the coating with modified Al powder has a better aging resistance and lower infrared emissivity than that with pure Al powder.

1. Introduction

Low infrared-emissivity coatings are widely used in military engineering and civil applications, including camouflaging military tactical equipment and aircraft, as well as protecting vehicles from infrared detection [1,2]. Over the past decade, a few studies focused on decreasing coating infrared emissivity have employed such materials as polyurethane/titania nanocomposites [3], collagen-g-poly(methyl methacrylate)/indium oxide nanocomposites [4], composite ceramics [5,6], organic/inorganic composite coatings [7–9], as well as silver and Al [10]. Among them, aluminum powder has received considerable attention because of its low price and good performance in reducing coating emissivity. However, high glossiness has constrained the application range of Al powder [11], resulting in compatibility problems with visible and near-infrared light. The flux-capping method can effectively solve this problem, and Al powder has been coated with organic film to decrease its emissivity and gloss. In recent years, the application of polyethylene wax in infrared camouflage has been intensively studied because of its excellent extinction performance and low emissivity [12]. Superficial pretreatment using polyethylene wax may decrease the gloss and emissivity of Al power.

Among organic adhesives, polyurethanes dominate the market given their excellent outdoor stability, as well as resistance to chemicals, water, abrasion, corrosion, and scratches. Polyurethanes are the chief components of high-performance coatings, such as those suitable for military applications. These polymers can also be used in material requiring for high tensile and impact strengths, as well as excellent low-temperature flexibility [13–19]. However, polyurethanes contain the two groups N—C═O and C—O—C, which have strong photoabsorptive abilities within 8–12 μm. Consequently, polyurethanes have rather high infrared emissivities, which may limit their applications in low infrared-emissivity coatings [20,21]. Therefore, some special metallic pigments need to be added to decrease the coating emissivity. Modified Al powder composites can be used for this purpose.

In the present study, modified Al powder was prepared with polyethylene wax via the flux-capping method. Low infrared-emissivity coatings were obtained using modified Al powder and polyurethane. The influences of modified Al powder content, thickness, substrates, and aging time on the infrared emissivity of the composite coating were systematically investigated.

* Corresponding author. Tel.: +86 29 82668019; fax: +86 29 82668559.
E-mail address: dmyu@mail.xjtu.edu.cn (D. Yu).

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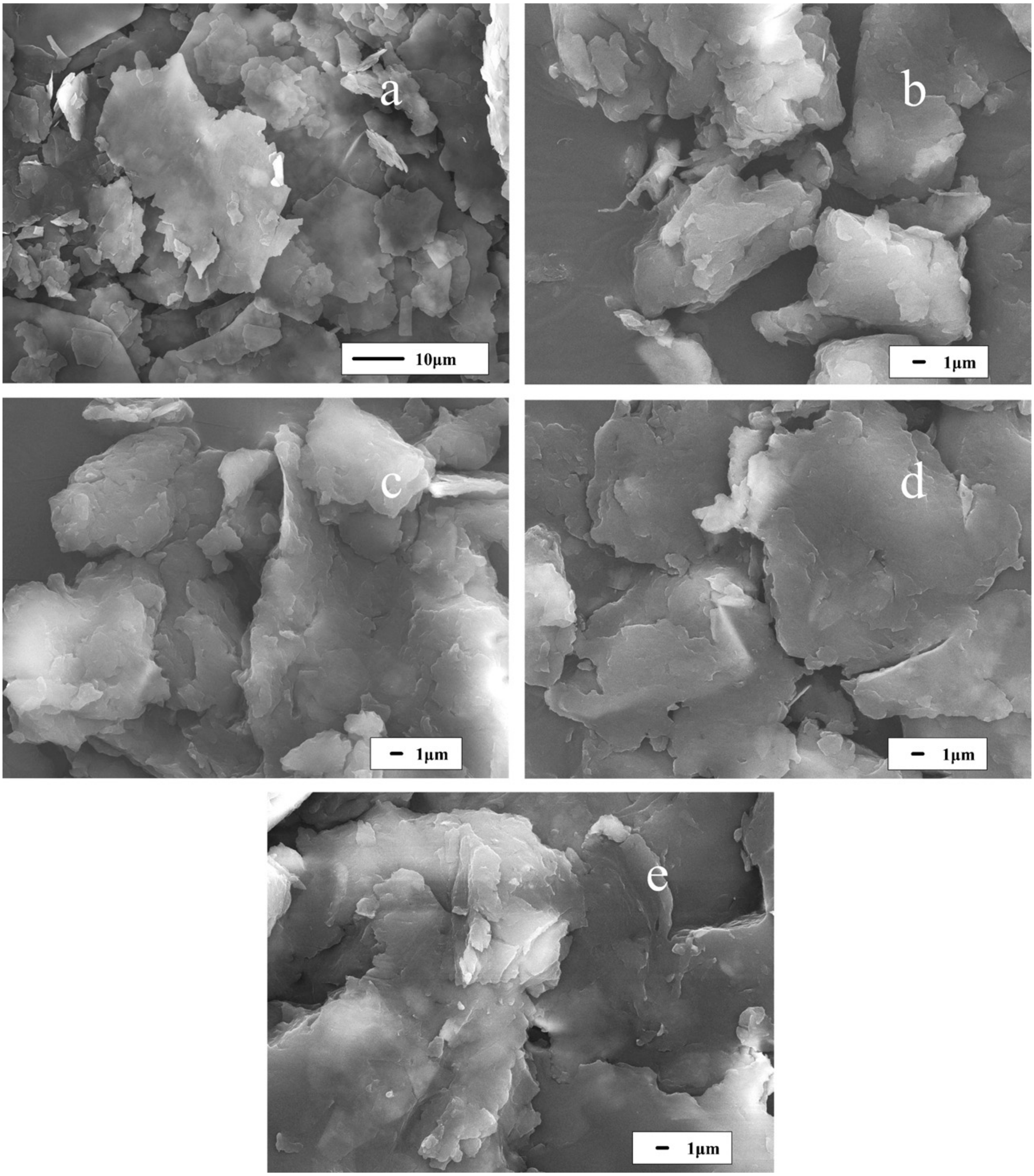

Fig. 1. SEM images of Al powder (a) and the polyethylene wax/Al composites with different Al contents: 10% (b), 20% (c), 30% (d), and 40% (e).

2. Experimental

2.1. Materials

Al powder, polyester polyol (polyterephthalate ester) and TDI (mixture of 20% 2,6 and 80% 2,4 toluene diiosocyanate) were kindly supplied by Xi'an Chemical Agent Co., Ltd. And the polyurethane resin was prepared from the chemical reaction of polyester polyol with toluene diiosocyanate (TDI) in a ratio NCO/OH equal to 1.1:1.0. Polyethylene wax was purchased from Shanghai Wenhua Chemical Pigment Co., Ltd. All other chemicals were reagent grade and used as received without further treatment.

2.2. Preparation of polyurethane/polyethylene wax/Al composite coating

Al powder was modified by polyethylene wax using the flux-capping method. First, fixed amounts of polyethylene wax and Al powder were mixed at different ratios (9:1, 4:1, 7:3, and 3:2, w/w) and smashed in a high-speed disintegrator. The mixture was heated for 10 min at 110 °C under constant stirring in the crucible until the mixture solidified. The homogenized and cooled mixture was refined in the high-speed disintegrator, and the polyethylene wax/Al composites were obtained.