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Facile fabrication of superhydrophobic coating based on polysiloxane emulsion

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ABSTRACT

We fabricated superhydrophobic coating by casting the alkoxy polysiloxane copolymerization emulsion containing fumed silica and phenyltrimethoxysilane (PhTMS)/ γ -(2,3-epoxypropoxy) propyltrimethoxysilane (EPTMS) on the glass slide. The copolymerization emulsion was prepared by methyl triethoxysilane (MTES), *n*-propyltrimethoxysilane (PTMS), polydimethyl siloxane (PDMS) and EPTMS. The morphology, wettability and thermostability of the prepared composite coating films were investigated by scanning electron microscopy (SEM), atomic force microscopy (AFM), the water contact angle measurement and thermal gravimetric analysis (TGA). The results indicated that the contact angles of coating surface increased first and then decreased with the increase of the amount of fumed silica, while the sliding angle first decreased and then increased. Under the mass of fumed silica keeping constant, the sliding angle of coating surface decreased obviously with the increase of the total of mixture silanes, but the contact angle had no significant change. When the content of fumes silica was 23 wt% and the total mass of PhTMS and EPTMS was 15 wt%, the contact angle was 156.1° and sliding angle was 3°, and the thermostability of as-prepared surface coating was good. The superhydrophobic polysiloxane coating was excepted for waterproof application.

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1. Introduction

Surfaces with an apparent contact angle greater than 150° are called superhydrophobic surfaces, and those surfaces with a contact angle greater than 150° and a sliding angle less than 10° generally referred to as self-cleaning surfaces [1,2]. It is well known that superhydrophobic surfaces have attracted tremendous attention due to their great importance in fundamental research and their wide applications in self-cleaning, anti-adhesion, anti-icing, anti-corrosion, antifouling, and microfluidic devices in the past decades [3–9]. High surface roughness and low surface energy are the prerequisites to achieve superhydrophobicity, and two strategies are generally adopted for the fabrication of superhydrophobic surfaces: roughening of a hydrophobic surface, and modifying that rough surface with low surface energy materials [10–14]. Up to know, fabrication of the superhydrophobic surfaces has employed many methods, such as lithography [15–17], self-assembly [18], template

method [19], chemical etching [20–23], sol–gel methods [24,25], electrochemical methods [26,27], layer-by-layer methods [28,29], etc.

Organosilicone is of interest in the fabrication of superhydrophobic surface because of its low surface free energy. As reported in the literature, superhydrophobic surfaces could be obtained by casting organosilicone or organopolymer coating on the substrate surface. Fang et al. prepared nanosilica superhydrophobic surface using glycidoxypropyltrimethoxysilane as monomer, dodecylamine as treatment agents in toluene solvent [30]. Polizos et al. fabricated superhydrophobic surface based on polydimethyl siloxane (PDMS) using a 50:50 PDMS–poly (ethylene glycol) (PEG) blend [31]. PDMS was mixed with PEG, and the PDMS/PEG mixture yielded a hierarchic structure through phase separation. Superhydrophobic surface also could be fabricated using organosilicone and inorganics. Rao et al. prepared superhydrophobic surface using methyltrimethoxysilane precursor, methanol solvent and ammonium hydroxide catalyst [32]. Ke and his workers reported a facile preparation method of superhydrophobic biomimetic surface based on octadecyltrichlorosilane and silica nanoparticles [33]. The one-step fabrication of a superhydrophobic surface based on tetra-ethylorthosilicate and fluorinated

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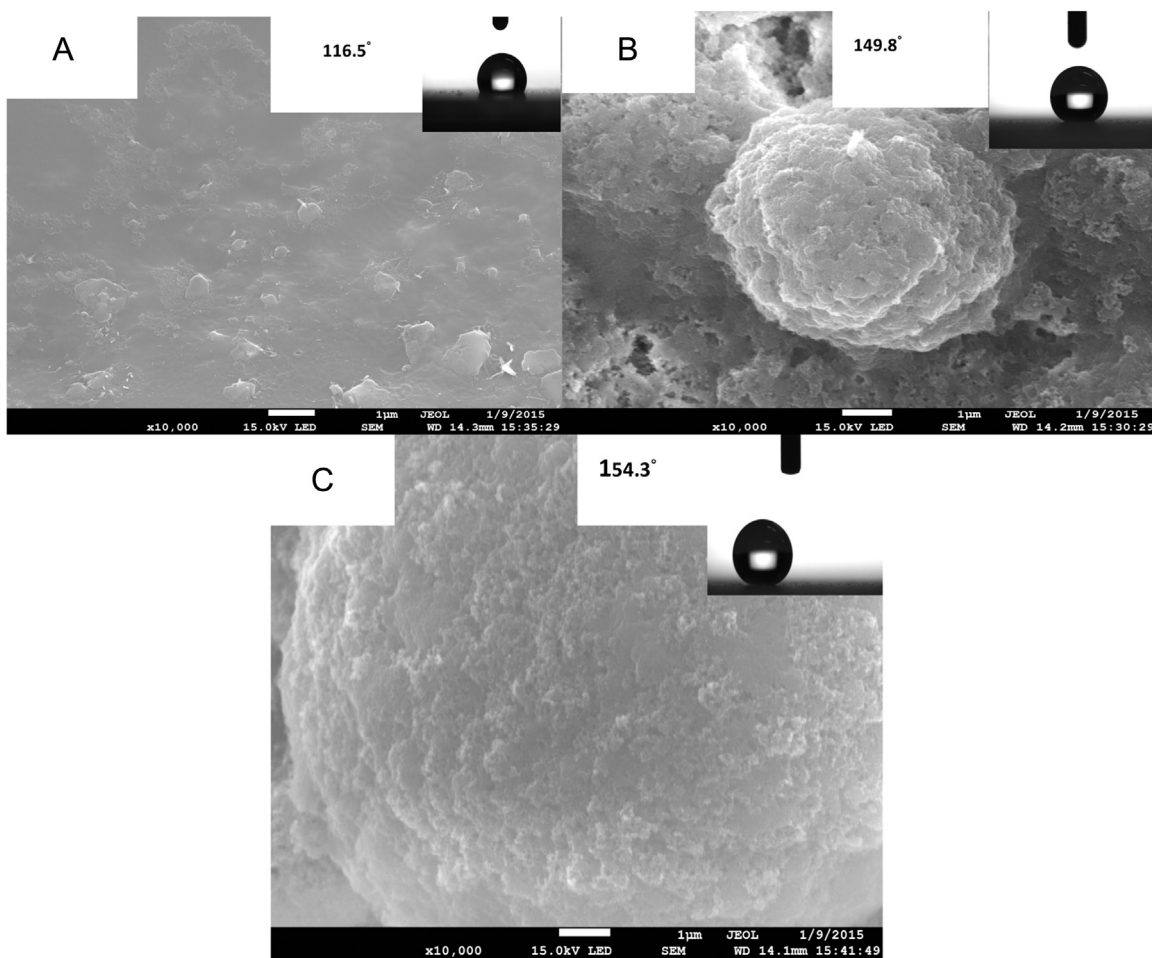


Fig. 1. The SEM images and the water contact angle images of various sample surfaces containing different amount of fumed silica: (A) 0; (B) 17 wt%; (C) 23 wt%.

alkyl silcane was also recently reported [34,35]. Zhang et al. presented a facile approach for the preparation of durable and robust superhydrophobic textiles by simply dip coating in a nanocomposite solution of fluoro-free organosilanes [36a]. Ramakrishna et al. prepared self-recoverable superhydrophobic coatings using water-rolling oligomer wrapped silica particles (OWS) which was synthesized using a one-step method by employing the quick and efficient silanol- isocyanate surface reaction [36b]. The OWS superhydrophobic particles with an incorporated cross-linked PDMS coating displayed excellent pH and stress resistance. They also demonstrated a unique class of melt-processable, bulk superhydrophobic coating by grafting long alkyl chains on silica nanoparticle surface by a facile one-step method [36c]. The well-defined nanomaterial showed superhydrophobic and self-cleaning properties in the bulk and was found to heal macro-cracks on gentle heating.

Though the preparing methods and wetting behaviors of silicone-containing coatings have been widely studied, there were a few reports on preparation of superhydrophobic surface based on polysiloxane emulsion. As a sort of environment-free material, preparation of polymer emulsion on a large scale is facile and safe relatively. In this work, based on extensive research work in terms of organic silicone emulsion [37,38], we presented one method of facile fabrication of superhydrophobic surface based on alkoxy polysiloxane hybrid emulsion. The effect of silica and silane content on wetting behaviors of coating was investigated; the thermostability of coating was discussed.

2. Experimental

2.1. Materials

Methyltriethoxysilane (MTES) (99.2%), *n*-propyltrimethoxysilane (PTMS) (99.2%), phenyltrimethoxysilane (PhTMS) (99.5%) and γ -(2, 3-epoxypropoxy) propyltrimethoxysilane (EPTMS) (98.4%) were purchased from Jingzhou Jiangnan Fine Chemical Co., (China). Hydroxyl-terminated polydimethylsiloxane (PDMS, 28cs) was provided by Zaoyang Jinpeng Chemical Co., China. Fumed silica (LM150, 8000 mesh, 1.25 μm) was supplied by Shenzhen Tian Sheng Wei Ye Chemical Co., (China). Hexamethylene was provided by Sinopharm Chemical Reagent Co., (China). Sodium dodecylsulfate (SDS) (CP) was purchased from Shanghai Maxam Co., (China). Sodium dodecylbenzenesulfonate (SDBS) (CP) was obtained from Nanjing Tianxi Fine Chemical Co., (China). Polyoxyethylene octylphenol ether (OP-10) (CP) was purchased from Sinopharm Chemical Reagent Co., (China). Deionized water was homemade.

2.2. Synthesis of quaternary copolymerization emulsion

The hybrid quaternary copolymerization emulsion was synthesized using MTES, PTMS, PDMS and EPTMS; the correlation research has been reported before [37,38]. In a typical experiment, emulsifiers (SDS, mass fraction of total system $w = 0.23$ wt%; SDBS, 0.13 wt%; OP-10, 0.29 wt%) were mixed in a 250 ml four-neck flask at room temperature for 0.5 h. The pH value of system was about

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