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Aqueous dispersion of submicron-sized diamond particles for thermally conductive polyurethane coating

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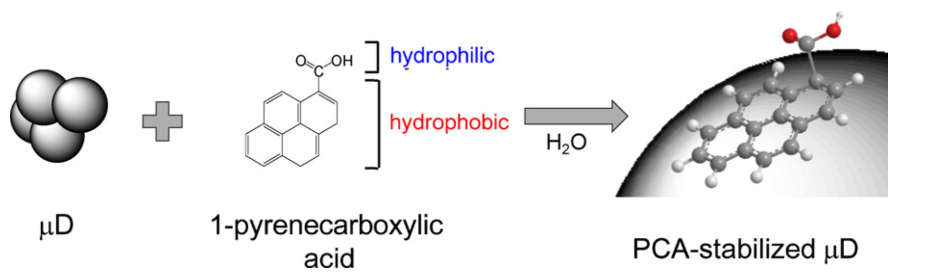
HIGHLIGHTS

- ► Diamond particles were dispersed in water using ionic and nonionic surfactants.
- ► 1-Pyrenecarboxylic acid significantly improved dispersion stability of diamond particles in an aqueous phase.
- ► Diamond particles increased the thermal conductivity of polyurethane coating layer.
- ► Anti-corrosion capability of the PU coating layer was not deteriorated.

GRAPHICAL ABSTRACT



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ABSTRACT

To improve corrosion resistance of steel sheet, polymeric resin coating has been practiced in steel industry. However, this method has a drawback to use because polymeric coating layer decreases the thermal conductivity. With an aim to enhance the thermal conductivity of the polymeric coating layer on steel sheet, submicron-sized diamond (µD) particles were employed as a thermally conductive material. Various anionic and non-ionic surfactants were tested in order to stabilize heavy µD particles in aqueous phase. Among them, 1-pyrenecarboxylic acid (PCA) endowed the best stability to µD particles. The polyurethane-based coating layer containing PCA-stabilized µD particles was applied on the steel sheet. The thermal conductivity of the coating layer effectively increased from 0.351 W/(m K) (0 wt% µD) to 0.434 W/(m K) (for 1.0 wt% µD). Furthermore, the corrosion behavior was not observed upon salt spray test for 144 h.

1. Introduction

Traditionally, iron steel sheet has been modified by chromate conversion coating. But this chromate coating releases hexavalent chromium when it is disposed or recycled. The hexavalent chromium is toxic and causes water and air pollution [1]. Because of this problem, an alternative coating using polymeric resins has been practiced. However, this suggestion also has the limitation to use because polymeric resin coating with 20–30 µm thickness makes steel sheet poor at electrical conductivity and thermal conductivity. However, the literatures reporting the method to improve the thermal conductivity of polymeric coating layer on steel sheets are still very rare.

Diamond particles having the average size below 1 µm (µD) are a new type of carbon material with nanometer-scale size [2]. Recently, such diamond particles have gained interest for improving properties of polymer composite due to its excellent properties, such as chemical and mechanical stability, low electrical conductivity, high thermal conductivity of 1300 W/(m K), and extreme hardness [3,4]. These properties would enable µD to be used for polymer composites [5], biomedical [6], and electrochemical applications [7]. However, there is a main obstacle to overcome for

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