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ORIGINAL PAPER

Thermal stability and abrasion resistance of polyacrylate/nano-silica hybrid coatings

Cheng-Fu Zheng · Zhi-Fang Yang · Chen-Chen Lv · Xing-Ping Zhou · Xiao-Lin Xie

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Abstract Polyacrylate (PAE)/nano-silica (SiO_2) hybrids were prepared by an in situ sol–gel process of tetraethyl orthosilicate in the presence of PAE toluene solution. The hybrid coatings were fabricated using a PAE/SiO_2 suspension by the traditional casting. Their intermolecular interaction and morphology, as well as thermal, mechanical, and optical properties, were investigated using Fourier transform infrared spectroscopy, field-emission scanning electron microscope, differential scanning calorimetry and TG/DTA thermogravimetric analysis, coating impact testing, and UV–Vis spectroscopy, respectively. At the same time, their abrasive properties were carried out by abrasion resistance and nanoindentation tests. The results indicate that silica nanoparticles, with diameter about 30 nm, can disperse homogeneously in the PAE matrix, where hydrogen bonds between the PAE and nano-silica are formed. Therefore, homogeneous dispersion of nano-silica particles provides high transparency for the PAE/SiO_2 hybrid coating as the size of nano-silica phase is much smaller than the wavelength (390–770 nm) of visible light. PAE/nano-silica hybrid coatings have increased T_g and thermal stability including the onset decomposition temperature, 10 % weight loss temperature, and char at 700 °C. Additionally, the incorporation of nano-silica particles improves the glossiness of the PAE/nano-silica hybrid coatings and enhances their abrasion resistance and surface hardness. The nano-silica content has obvious effect on the thermal, mechanical, optical, and anti-abrasion properties of PAE/SiO_2 hybrid coatings. With the consideration of all the properties of hybrid coatings, the PAE/SiO_2 hybrid containing 10 phr of nano-silica has the optimal composition. These PAE/nano-silica hybrid coatings have potential applications in high-performance hologram image recording.

Keywords Polyacrylate · Silica · Hybrid coating · Thermal stability · Abrasion resistance

Introduction

Laser holography has been widely employed in security and anti-counterfeiting. Copies can be made from an original hologram using the simple, but important, process of embossing; this can be carried out with a simple heating press [1]. Polyacrylate (PAE) is one of the most common resins for recording the image in the hologram layer due to its thermoplastic, optical transparence, and low cost. However, its low glass transition temperature and poor ability to withstand abrasion limit certain special applications it can be used with, such as banknotes, identical cards, passports, and tax bills. Therefore, it is necessary to improve the thermal and abrasion resistance of PAE coatings. Silica nanoparticles can significantly improve the mechanical and thermal properties of the polymer matrix [2, 3], but it is essential to enhance the dispersion of silica in the PAE matrix in order to ensure that the size of the silica phase is smaller than the wavelength of visible light

C.-F. Zheng · Z.-F. Yang · C.-C. Lv · X.-P. Zhou (✉) · X.-L. Xie
Key Laboratory for Large-Format Battery Materials and System, Ministry of Education, School of Chemistry and Chemical Engineering, Huazhong University of Science and Technology, Wuhan 430074, China
e-mail: xpzhou@mail.hust.edu.cn

C.-F. Zheng · Z.-F. Yang · X.-L. Xie
National Anti-counterfeit Engineering Research Center, Huazhong University of Science and Technology, Wuhan 430074, China