Asian Journal of Chemistry; Vol. 26, No. 6 (2014), 1800-1802

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2014.17360

Effect of Functionalized SiO_2 Nanoparticles on the Performance of Polyurethane Coatings†

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Published online: 10 March 2014; AJC-14901

In this paper, based on the pristine polyurethane coatings, four groups of coatings composite which had different mass ratio of functionalized SiO_2 nanoparticles suspending liquid were tested. The result was that polyurethane coatings composite modified with (1.2 wt %) functionalized SiO_2 nanoparticles suspending liquid could significantly increase their resistance to chemical corrosion. More interestingly, it has little influence on the transparency of polyurethane coatings film and thermal stability.

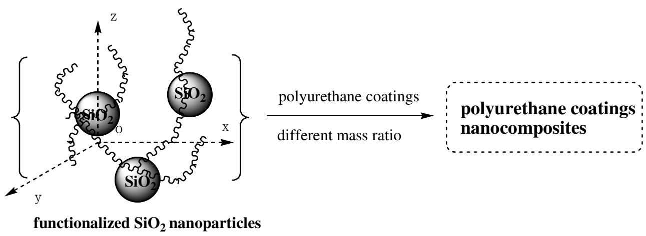
Keywords: Polyurethane coatings, Functionalized SiO_2, Chemical corrosion.

INTRODUCTION

Polymer nanocomposites are a progressively large category of hybrid composites[1,2]. Since the introduction of SiO_2 nanoparticles, their nanocomposites have attracted a major interest from both scientific and technological viewpoints. It is well-known that SiO_2 nanoparticles have unusual structural, mechanical and optical properties, which provide great potential in a wide range of applications as reinforcing fillers in nanocomposites[3-6].

One of the major challenges is actually to easily and individually disperse these SiO_2 nanoparticles in polymer matrix to obtain materials with improved properties for different applications. Thus, many research groups have focused on the functionalization of SiO_2 nanoparticles with various inorganic and organic structures using covalent approaches to improve the compatibility with polymer matrix[7-9]. When SiO_2 nanoparticles are applied in preparing nanocomposites such as polymer nanocomposites, they must be available in large volumes at low cost and dispersible in polymer matrix, also the strong interactions between SiO_2 nanoparticles and the surrounding matrix should be formed.

In this study, we have prepared functionalized SiO_2 nanoparticles *via* a novel crosslinking reaction to study its dispersion stability and effect for polyurethane coatings. The whole research process is divided into two parts containing the preparation of polyurethane coatings nanocomposites and effect of functionalized SiO_2 nanoparticles on the performance of polyurethane coatings. The first part, in accordance with established programme and steps (**Scheme-I**), we have prepared industrial polyurethane coatings nanocomposites with different concentration of SiO_2 nanoparticles suspending liquid. The second part is to study its effect for polyurethane coatings and develop a simple preparation procedure for preparing polymer nanocomposites.



Scheme-I: Preparation route of polyurethane coatings nanocomposites

EXPERIMENTAL

Functionalized SiO_2 nanoparticles suspending liquid was prepared in our Lab. All solvents employed and pristine polyurethane coatings were commercially available and used without further purification.

Preparation of industrial polyurethane coatings nanocomposites: Scheme-I shows the progress of industrial polyurethane coatings nanocomposites. Table-1 shows the

†Presented at The 7th International Conference on Multi-functional Materials and Applications, held on 22-24 November 2013, Anhui University of Science & Technology, Huainan, Anhui Province, P.R. China

TABLE-1
PRESCRIPTION OF INDUSTRIAL POLYURETHANE COATINGS NANOCOMPOSITES WITH DIFFERENT CONCENTRATION OF SiO_2 NANOPARTICLES SUSPENDING LIQUID

Sample (%)	Main coatings	Curing agent	Diluent	Functionalized SiO_2 nanoparticles suspending liquid
0.0	20	10	12	0.000
0.3	20	10	12	0.126
0.6	20	10	12	0.252
0.9	20	10	12	0.378
1.2	20	10	12	0.504

formulation of industrial polyurethane coatings nanocomposites with different concentration of SiO_2 nanoparticles suspending liquid.

RESULTS AND DISCUSSION

Thermogravimetric analysis: In Fig.1(1a), the thermal decomposition temperature range of original SiO_2 nanoparticles is 60-450 ºC. Surface functionalized SiO_2 nanoparticles was washed by butyl acetate and dried. When compared decomposition curves of functionalized SiO_2 nanoparticles (Fig. 1c) with original nanoparticles, it is easy to find that there is a little decomposition when temperature is below 200 ºC due to small molecule. From 300 to 600 ºC, SiO_2 nanoparticles decompose quickly, mainly because of the decomposition of grafted polymer. Therefore, the comprehensive comparison between original SiO_2 nanoparticles and functionalized SiO_2 nanoparticles in heat stability approves that we succeeded in grafting polyurethane onto the surface of SiO_2 nanoparticles.

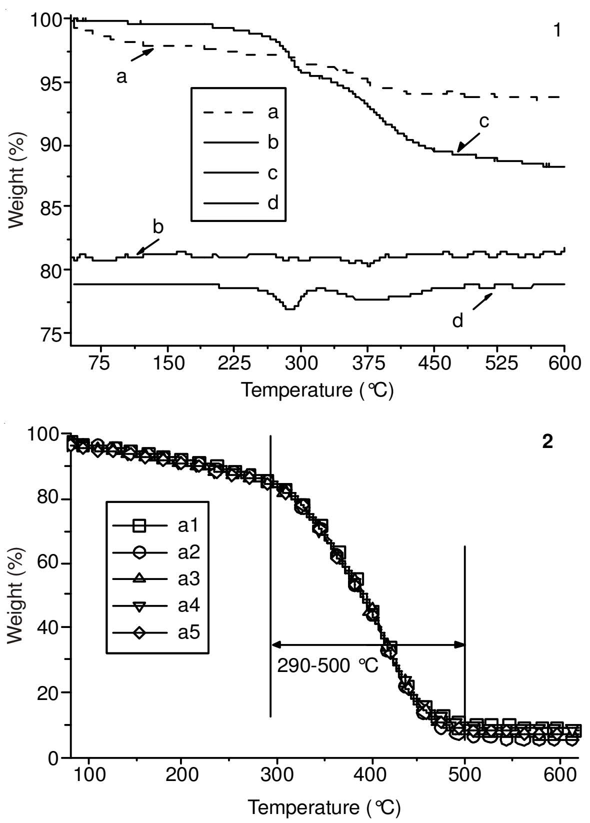


Fig. 1. Comprehensive comparison between original SiO_2 nanoparticles and functionalized SiO_2 nanoparticles (a and c. TGA curves, b and d. DTG differential curve); (4) the thermal decomposition of polyurethane coatings nanocomposites with different concentration of SiO_2 nanoparticles (a1) 0 % (a2) 0.3 % (a3) 0.6 % (a4) 0.9 % (a5) 1.2 %

As shown in Fig. 1(2), there are TG curves of polyurethane coatings nanocomposites with different content of functionalized SiO_2 nanoparticles suspending liquid in thermal decomposition performance. As can be seen from the Fig. 1, the decomposition temperature of original polyurethane coatings and polyurethane coatings nanocomposites ranges from 290 to 500 ºC. After adding nanoparticles, the impact on the thermal decomposition of the coatings become less and the weight loss is around 80 %, possibly due to smaller proportion of nanoparticles (0.3-1.2 %).

Analysis of corrosion resistance: Anticorrosion coatings not only has common properties of the regular coatings, but also has good stability against aggressive media, good permeability, excellent electrical insulation[10]. Results shown in Fig. 2, original polyurethane coatings film picture (a_0), that is, don't add functional additives and are not receiving strong alkali corrosion. a_1 is the sample that didn't add functional additives and received an alkali corrosion. It can be seen from the figure that polyurethane coatings surface presents flower-shaped morphology and has suffered serious corrosion. It can be seen from the comparison between Fig. $a_{(2-5)}$, a_3 and a_4 present small flower-shaped morphology showing suffered minor corrosion. In addition, a_5 (1.2 wt %) presents little flower-shape, showing a high level of corrosion resistance.

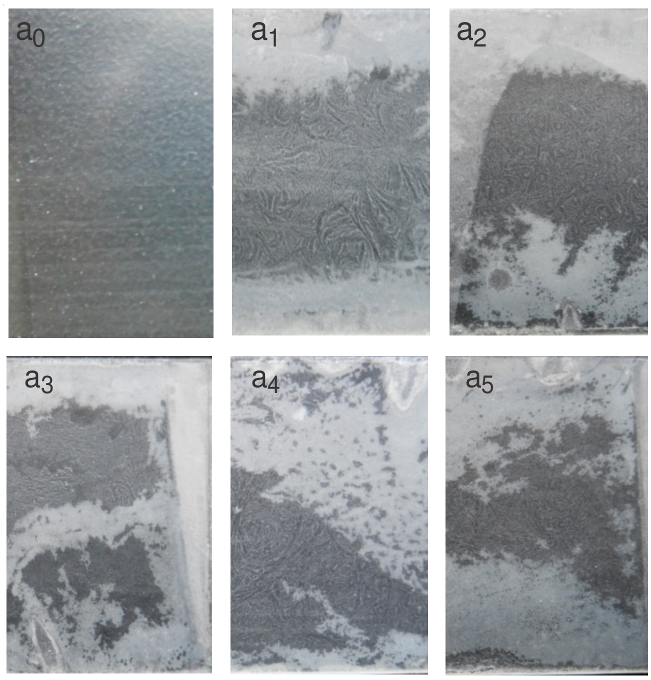


Fig. 2. Anticorrosion photos of the original polyurethane coatings film (a_0) and polyurethane coatings film doped with functionalized SiO_2 nanoparticles (a_1: 0.0 %, a_2: 0.3 %, a_3: 0.6 %, a_4: 0.9 %, a_5: 1.2 %)

Conclusion

In summary, this work studies on thermal stability of polyurethane chains functionalized SiO_2 nanoparticles suspending liquid and the anticorrosion effect in the industrial polyurethane coatings. Processed SiO_2 nanoparticles dispersed in butyl acetate clearly prevent the reunion of nanoparticles and have less impact on the transparency on polymer films. In addition, TGA and alkali resistance test show that when industrial polyurethane coatings nanocomposites compared with the original product can significantly increase their resistance to chemical corrosion and has less impact on its thermal stability.

ACKNOWLEDGEMENTS

The authors thank the "Talents Programme" from Hefei University (No. 13RC07), Natural Science Research Project of Anhui Provincial Education Department (No. KJ2013B228), National Science Foundation of China (No. 51102073), Research fund of Key Laboratory for Advanced Technology in Environmental Protection of Jiangsu Province (AE201361) and the College Students' Innovation and Entrepreneurship Training Program of China (No. 201311059022, 201311059024, 201311059017, 201311059018).

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