



STUDY ON CARBON FIBER SURFACE MODIFIED BY Γ -RAY IRRADIATION

Li Junqing*, [Huang Yudong]** Huangyd@hrbeu.edu.cn

*Harbin Engineering University, **Harbin Institute of Technology

Keywords: carbon fiber; γ -ray; irradiation; surface modification; interlaminar shear strength

1 Introduction

Carbon fiber has already widely used as reinforced material in composite because of its unique merits such as low density, high specific strength, high specific modulus, resistance to elevated temperature and so on. But its smooth surface and the lower surface energy is the bottle neck element which unable to form strong adhesive bonds between their surfaces and the matrix [1]. In order to improve the overall adherence, various surface treatments were carried out such as wet chemical oxidation or electrochemical methods [2-5], plasma [6-7], dry chemical oxidation or gas phase oxidation [8-9], *et al.* A suitable modified method should be high-efficient, save energy, environmental protection. Irradiation treated method was not only satisfied with these conditions but also could induce chemical reactions at any temperature in the solid, liquid and gas phase without any catalyst. Irradiation treatment has already widely used in fields of materials modification such as polymer, fibers, powders films, composites [10-13], *et al.* In this paper, the modification method of using γ -ray irradiation treated on the surface of carbon fiber was introduced which was according to the mechanics of free radical reaction. The effect of the carbon fiber surface performance were analyzed which treated by irradiation.

2 Experimental

2.1 Materials

The polyacrylonitrile (PAN) based carbon fibers investigated in current studies were manufactured by Jilin Carbon Factory of China (average diameter was 7 μ m, 3 \times 10³ single filaments per tow, linear mass was 0.161 gm-1). The matrix was an epoxy resin from Wuxi, China (E-618).

2.2 Irradiation instrument

Mutual irradiation grafting was introduced in this paper. Several bundles of carbon fiber were wound up on a frame and placed in a glass container; which was full of chloroepoxy propane. The irradiation device has two vent holes, the one for vacuuming the other for inflating argon.

2.3 Characterization methods

The fiber surface composition and surface functional groups were examined by X-ray photoelectron spectroscopy (XPS). Deconvoluted peaks of the C1s spectrum were also used to determine the surface oxygen functional groups content of the carbon fiber. The surface morphology of the fibers were observed by scanning electronic microscopy (SEM) and the surface roughness was calculated by atomic force microscopy (AFM). Different absorption dose influence on the interlaminar shear strengths (ILSS) of the carbon fiber/epoxy composites were also analyzed by three-points short beam shear.

3 Results and discussion

3.1 XPS analysis

After widely scan by XPS, it could be found that C and O are the major elements on the surface of carbon fiber as well as minute quantity N elements. The result of elements percentage content was shown in Table 1.

The data from Table 1 shows that the value of O/C was increasing as enhanced the adsorption dose in the range of 0~2000kGy. The C1s spectroscopy of each sample was fitted by the function of Gaussian-Lorentzian, the result was shown in Fig. 3.

The Table 2 showed the parameters of each peak, the peaks corresponded to the kinds of the functional groups and their ratio content.

3.2 Surface topography analysis

The surface topography of carbon fiber was observed by SEM before and after irradiation, they were shown in Fig. 4.

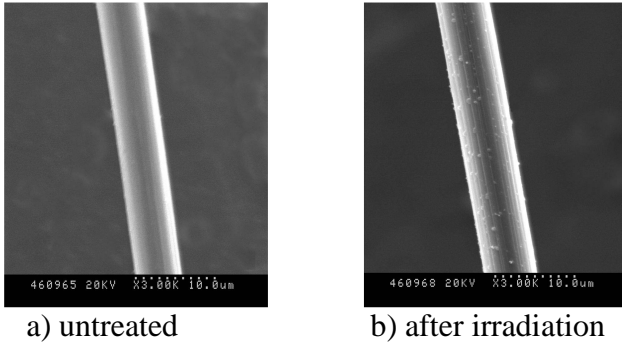


Fig. 4. The carbon fiber surface pictures of SEM

It also could be observed the similar results from the AFM pictures in Fig5 which were detected on the surface area of $2\mu\text{m}^2$.

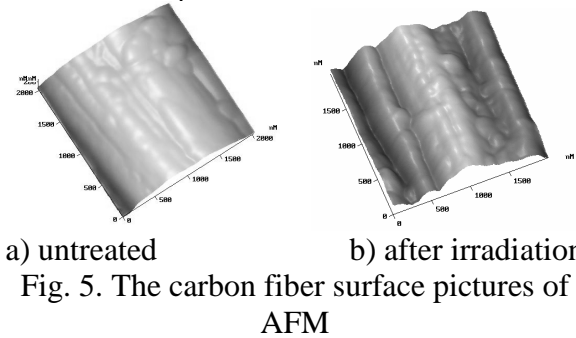


Fig. 5. The carbon fiber surface pictures of AFM

3.3 The effect on the ILSS of CFRC

The relationship between graft rate and absorption dose was shown in Fig. 6.

The ILSS of carbon fiber reinforced epoxy resin composite was measured by the universal material testing machine which the results were shown in Fig. 7.

Grafting shape had already changed whose schematic as shown in Fig. 8.

4. Conclusion

- (1) The O/C value of CF surface was increasing after irradiated treatment by γ -ray, the ratio content of oxygen functional groups were increased such as C-O-C, COOH or COOR;
- (2) The grafting particles on the CF surface were observed obviously by SEM and the CF surface roughness was much higher after irradiation;

- (3) The graft rate was increasing as enhancing the absorption dose. The irradiation technique could improve the ILSS of CFRC in suitable treatment conditions. The excessive absorption dose and graft rate were not benefit for forming excellent interface when fabricate composite.

Reference

1. Li Junqing, Huang Yudong, Xu Zhiwei, *et al.* "High-energy radiation technique treat on the surface of carbon fiber". *Materials Chemistry and Physics*, Vol. 94, No. (2-3), pp315-321, 2005.
2. Yue Z R, Jiang W, Wang L, *et al.* "Surface characterization of electrochemically oxidized carbon fibers", *Carbon*, Vol. 37, pp 1785-1796, 1999.
3. Yumitori S, Nakanishi Y. "Effect of anodic oxidation of coal tar pitch-based carbon fiber on adhesion in epoxy matrix. Part 2. Comparative study of three alkaline solutions". *Composites*, Vol. 27A, No. 11, pp1059-1066, 1996.
4. Gulyás J, Földes E, Lázár A, *et al.* "Electrochemical oxidation of carbon fibres: surface chemistry and adhesion". *Composites*, Vol. 32A, pp353-360, 2001.
5. Fukunaga A, Ueda S, Nagumo M. "Air-oxidation and anodization of pitch-based carbon fibers". *Carbon*, Vol. 37, pp1081-1085, 1999.
6. Montes-Morán M A, Martínez-Alonso A, Tascón J M D, *et al.* "Effects of plasma oxidation on the surface and interfacial properties of ultra-high modulus carbon fibres". *Composites*, Vol. 32, pp361-371, 2001.
7. Dilsiz N, Erinc NK, Bayramli E, *et al.* "Surface energy and mechanical properties of plasma-modified carbon fibers". *Carbon*, Vol. 33, No. 6, pp853-858, 1995.
8. Xuli F, Weiming L, Chung D L. "Ozone treatment of carbon fiber for reinforcing cement". *Carbon*, Vol. 36, No. 9, pp1337-1345, 1998.
9. Xu C, Mark F, Yuming G, *et al.* "Mechanisms of surfactant adsorption on non-polar, air-oxidized and ozone-treated carbon surfaces". *Carbon*, Vol. 41, pp1489-1500, 2003.
10. Clough R L. "High-energy radiation and polymers: A review of commercial processes and emerging applications". *Nuclear Instruments and Methods in Physics Research B*, Vol. 185, pp8-33, 2001.
11. Sueo M. "New trends of radiation processing applications". *Radiation Physics and Chemistry*, Vol. 47, No. 3, pp333-336, 1996.
12. Ajit S. "Radiation processing of carbon fibre-reinforced advanced composites". *Nuclear Instruments and Methods in Physics Research B*, Vol. 185, pp50-54,.
13. Machi S. "Radiation technology for sustainable development", *Radiation Physics and Chemistry*, Vol. 46, No. 4-6, pp399-410, 1995.