Nanocomposites based on carbon nanotubes oxidized by solar energy

M Blanco, M López, E Aranzabe, A Marcaide

Fundación Tekniker, Av Otaola 20, 20600 Eibar Gipuzkoa, Spain
mblanco@tekniker.es

Carbon nanotubes (CNT) have attracted considerable attention in some potential applications due to their remarkable properties, such as mechanical and electrical properties. Therefore, they have been expected to be excellent fillers for polymer composites. In order to obtain nanocomposites with enhanced properties, it is necessary to oxidize or functionalize their surface in order to improve CNT-matrix interaction and CNT dispersion in the matrix. Chemical treatments, above all acid treatments, are being widely employed to oxidize CNT [1]. However, the high consume of solvents and energy required for these oxidation processes and the fact that morphology of carbon nanotubes can be highly damaged during this process point out the necessity of more environmentally friendly processes.

In the present work, the oxidation of CNT by the photoFenton process assisted by solar energy is proved that overcomes main problems associated to conventional processes. The Fenton process consists on the generation of hydroxyl radicals, which have a high oxidation potential, using H_2O_2 as source of OH• radicals and Fe^{2+} salt as catalyser in an aqueous medium (pH=2.7) [2]. When the process rate is enhanced by UV radiation, it is call photoFenton process. The process conditions such as reactive concentration, reactant ratio and time of reaction have been optimized using a parabolic collector (Figure 1) to concentrate solar radiation. The process promotes the generation of carboxylic (-COOH), carbonylic (C=O) and/or hydroxylic (-OH) groups onto CNT surfaces without affecting their structural integrity as was shown by Fourier transform infrared (FTIR) spectroscopy and thermogravimetric analysis (TGA) in Figure 2 and by scanning electron microscopy (SEM). The photoFenton process achieves an increase in the oxidation degree in comparison with a usual oxidation method, the oxidation in HNO_3 concentrated acid.

In a second step, carbon nanotubes (pristine and oxidized by the photoFenton process assisted by solar energy and by HNO_3) were incorporated into a thermoplastic matrix, polyamide 6 (PA 6), by a twin screw corrotating microextruder. SEM micrographs show that a good CNT dispersion into the matrix was obtained with the applied processing conditions for the three types of CNT, as it is shown in Figure 3. The effect of CNT content and CNT oxidation treatment in thermal and mechanical behavior of nanocomposites were analyzed by dynamic mechanical analyzer (DMA), differential scanning calorimetry (DSC) and TGA. The obtained results show a similar performance of nanocomposites based on CNT oxidized by both methods.

In summary, CNT oxidation by the photoFenton process assisted by solar energy is proved a suitable alternative environmentally friendlier and less costly to conventional chemical oxidation processes. Composites obtained by the incorporation of CNT oxidized with the photoFenton process into polyamide 6 show a similar behaviour than the obtained by the incorporation of CNT oxidized with common chemical methods.

References

[1] V. Datsyuk, M. Kalyva, K. Papagelis, J. Parthenios, D. Tasis, A. Siokou, I. Kallitsis, C. Galiotis, Carbon **46** (2008) 833–840
[2] L. Zhang, J. Li, Z. Chen, Y. Tang, Y. Yu, Applied Catalysis A: General **299** (2006) 292–297

Figures

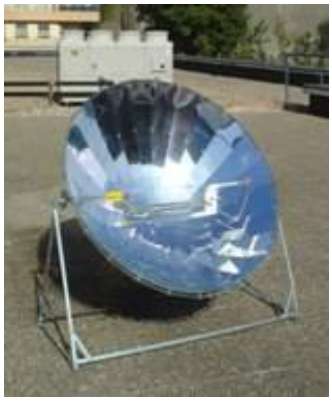

Figure 1. Parabolic collector

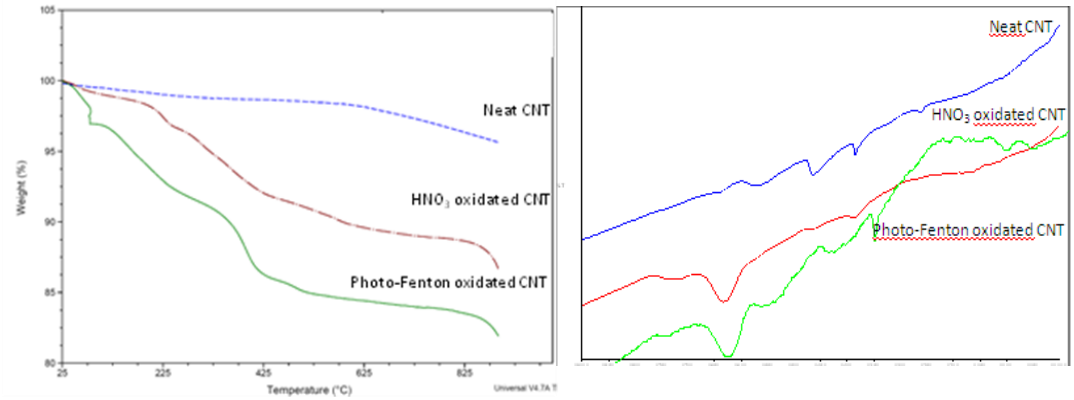

Figure 2. TGA thermograms and FTIR spectra of MWCNT pristine and oxidized with HNO_3 and photoFenton treatment

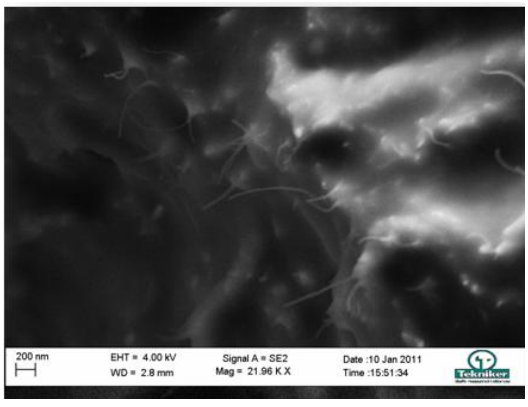

Figure 3. SEM micrograph of photoFenton oxidized CNT in PA 6 matrix.