Development of low cost polymeric nanocomposite materials with high mechanical performances

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Introduction

Composites use is increased worldwide quickly [1-6] because they present significant advantages over traditional materials, as metals. It is able to get improved and tailored properties to each application by means the formulation [2-4]. Initially, composites were used in advanced technologically sectors as aeronautical, although the technological advance and manufacturing cost reduction have promoted their use in different industrial sectors as building, renewable energies, automotive, sports, nautic,…[2,4,7]. In all cases there are needs to reduce weight, to improve the resistance in aggressive environments and to keep high performances during the life-span in more demanding applications.

The objective in this work has been to develop thermoset multiscale composites with improved properties. They consist of glass fibers as reinforcement, carbon based nanostructures (mainly multiwall carbon nanotubes-MWCNTs-, although too it has used carbon nanofibers –CNTs- and carbon nanoparticles from tire recycled [8]) as nanoreinforcement. MWCNTs and CNFs have a huge potential as nanoreinforcements polymeric matrices because they present unique and excellent mechanical, thermal and electrical properties with a competitive cost. Moreover, currently in the market there is enough availability of these nanomaterials for using in industrial scale [11]. As polymeric matrix has been used polyester resin. These new low cost polymer composite/nanocomposite materials improved with nanoreinforcements opens new market opportunities in large-volume applications as structural composites: civil engineering works [6, 7], transport sector, etc.

The main challenge has been to transfer the MWCNTs (or CNFs) excellent properties to the polymeric matrix. It requires dispersing the nanoreinforcements as individual particles in the polymeric matrix, to avoid agglomerates [2, 12]. For this reason, it has studied and implemented an advanced dispersion techniques of high shear forces called Three Roll Mills. On the other hand surface functionalisation of the nanoreinforcements by chemical treatment has been done in order to improve the dispersion within the matrix.

Following, it has been performed a novel and detailed quality and quantity characterisation of the dispersion rate combining different techniques: viscosity measurements (VM), Confocal Ramam spectroscopy (CRS) and Atomic Force Microscopy (AFM). Finally the samples was characterised from mechanical point of view.

Results and conclusions

It has been obtained a high MWCNTs/CNFs dispersion rate within the matrix by using 3-roll-milling process. It has permitted to work with nanoreinforcements low content: from 0.1 wt% to 1 wt%, obtaining good results with 0.1 wt%. Moreover, it is a process easy to industrial scale up.

MWCNT's distribution map based on intensity RAMAN spectra (at G band) has been obtained. All samples present a high dispersion rate of the nanoreinforcements. Surface area where there are not nanoreinforcements is below 3%, where there are nanoreinforcements is above 90% and where there are nanoreinforcements aggregates is below 14%.

Furthermore, correlation between viscosity increasing and nanoreinforcements content and dispersion rate has been observed.

From mechanical point of view, the samples present better behavior than original sample (without nanoreinforcements). Depending of nanoreinforcements content and parameters during the dispersion process, the mechanical improvements can be:

Tensile test

Up to 13% in tensile strenght (σ) and 15% in Young module (E)

Flexural test

Up to 26% (σ) and 84 % (E)

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