Morphology and properties of polyamide 12/mwcnt nanocomposites

N. Aranburu, J. I. Eguiazabal

Department of Polymer Science and Technology and Institute for Polymeric Materials (POLYMAT), Faculty of Chemistry, University of the Basque Country, Paseo Manuel de Lardizabal 3, Donostia, Spain
nora.aramburu@ehu.es

The introduction of nanofillers into polymer matrices creates a class of novel materials (nanocomposites) exhibiting superior overall properties, which are suitable for replacing many existing materials in engineering applications [1-3]. In this field, carbon nanotubes (CNT´s) are highly interesting fillers because of their high aspect ratio, nanometer scale diameter, mechanical strength and electrical properties. The dispersion of low CNT amounts in polymer matrices enables electrical conductivity together with substantial improvements in mechanical properties [4]. Among the processing methods used for the production of polymer/CNT nanocomposites, melt mixing offers significant advantages with respect to solution processing methods or in-situ polymerization, due to the absence of solvents, monomers, contaminants, etc.

Polyamide 12 (PA12) is an engineering thermoplastic which shows, among other properties, excellent toughness and good chemical resistence. Potential application areas for PA12 nanocomposites containing CNT´s are, for instance, antistatic fuel pipes and parts in fuel pumps for the use in the automotive industry. Even if several studies have been carried out comprising PA12/CNT nanocomposites [5-7], it does not exist, to our knowledge, any work that analyses the effect of the addition of multi-walled CNT´s (MWCNT´s) on the phase behaviour, morphology, mechanical properties, and the electrical conductivity of PA12/CNT nanocomposites.

The polymer used in this work as the matrix of the nanocomposites was a PA12, Rilsan AMNO TLD, from Arkema. MWCNT´s with an outside diameter of 20-30 nm and >95% purity (Cheaptubes) were used as fillers. The blending of PA12 with 3, 6 and 9% CNT´s was carried out in a twin-screw extruder. Standard tensile and impact specimens were obtained by injection molding. The caracterisation of the nanocomposites was performed by dynamic-mechanical analysis (DMTA), differential scanning calorimetry (DSC), scanning electron microscopy (SEM), electrical conductivity measurements and tensile and impact tests.

The DSC thermograms showed no variation in the T_m of the PA12. However, the T_c of the nanocomposites increased 10ºC with respect to the neat PA12 indicating a nucleating effect of the CNT´s. With respect to the crystallinity, it decreased slightly with increasing the CNT content. The T_g´s of the 3 and 6% CNT containing nanocomposites were similar to that of the neat PA12, while the T_g of the PA12-9% CNT nanocomposite decreased sligthly. The SEM micrographs of the nanocomposites (Figure 1) showed a relatively well dispersed morphology, with no observable agglomerates.

The tensile properties of the nanocomposites are plotted in Figure 2. The incorporation of the CNT´s to the PA12 matrix led to a linear increase in the elastic modulus and the yield strength. The addition of 9% CNT caused a 42% increase in the Young´s modulus of the PA12. Besides, although a slight decrease was observed in the ductility, the nanocomposites showed high elongation at break. The impact strength of the PA12 remained unchanged even at 9% CNT content.

The electrical conductivity values of the nanocomposites are summarized in Table 1. As can be observed, the nanocomposites were non-conductive, even at 9% CNT concentration. Thus, the percolation threshold concentration is beyond the CNT contents used in this work. The latter results suggest that the CNT dispersion was not good enough to enable the formation of a three-dimensional network.

Taking into account the results observed for the PA12 nanocomposites with unmodified MWCNT´s, our future work includes the incorporation of modified nanotubes to PA12, with the aim of obtaining a new reinforced and conductive material.

References

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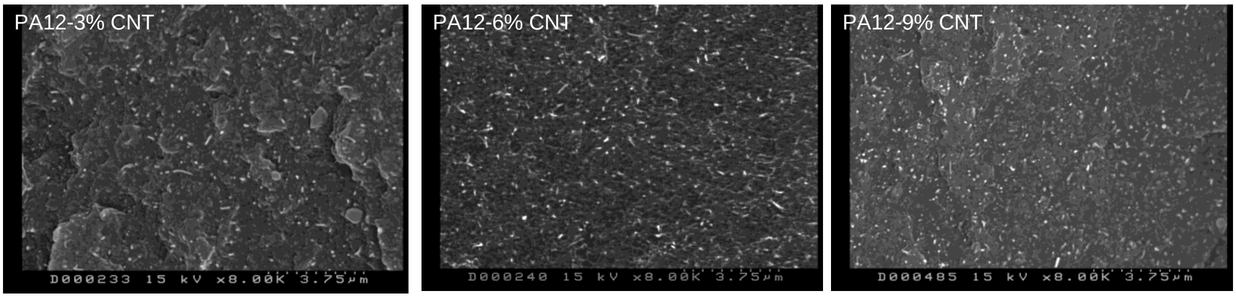

Figure 1. SEM micrographs of 3, 6 and 9% CNT containing PA12 nanocomposites.

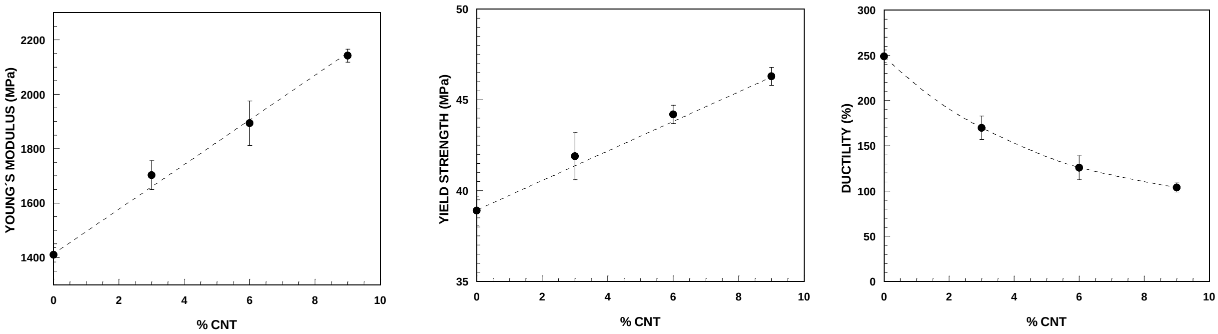

Figure 2. Mechanical properties of the PA12 nanocomposites as a function of the CNT concentration.

Table 1. Electrical conductivity of the PA12/CNT nanocomposites.

SAMPLE	CONDUCTIVITY (S/cm)
PA12-3% CNT	$5 \cdot 10^{-11}$
PA12-6% CNT	$3.5 \cdot 10^{-10}$
PA12-9% CNT	$7.5 \cdot 10^{-6}$

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