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STATISTICAL ANALYSIS OF INTERFACE AND ITS EFFECT ON PROPERTIES OF MICROINJECTION MOULDING NANOCOMPOSITES WITH FUNCTIONALIZED CARBON NANOTUBES

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KEYWORDS

Carbon nanotubes, functionalization, microinjection moulding.

ABSTRACT

Carbon nanotubes (CNT) exhibit unique thermal, electrical and mechanical properties and their nanocomposites have attracted the attention of many scientists due to the strong application potential in electronics, chemical and biological sensing and reinforced composite materials (Baughman et al, 2002). An effective process for the production of nanocomposites with CNT is microinjection moulding (μIM), the most efficient and cost-effective process for the large-scale production of thermoplastic nanocomposite microparts with low reinforcement content and exceptional electrical properties.

The present work reports, mainly, the dispersion, distribution and interface of CNT in polyamide 6 (PA 6) in nanocomposites with different CNT content produced using µIM.

EXPERIMENTAL

The CNT (Nanocyl NC 7000) were functionalized using the 1,3-dipolar cycloaddition reaction of an azomethine yilide to the CNT, generating pyrrolidine groups at the surface (Araújo et al, 2007), under solvent-free conditions.

The nanocomposites with polyamide 6 (Badamid®B70) and pure or functionalized CNT were prepared in a prototype mini-twin screw extruder under different processing conditions; small specimens were obtained by microinjection moulding in a Boy 12 equipment (Figure 1).

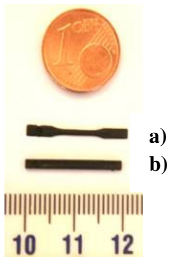
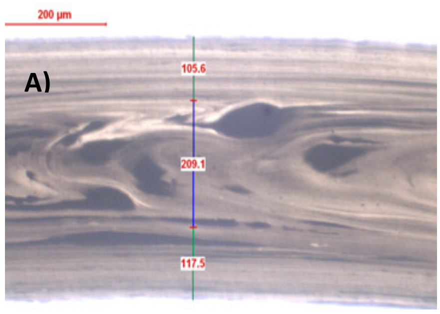


Figure 1 - Microinjection moulded composite specimens: a) tensile and b) impact.

The ratio skin/with, nanotube agglomerate size, distribution and dispersion were measured using optical microscopy (OM) and the CNT/polymer interface was observed by scanning electron microscope. The electrical resistivity of the composites was measured. The tensile specimens were tested using a microtester equipped with a load cell of 1 kN.

RESULTS and CONCLUSION

The statistical study of CNT agglomerate size, distribution and dispersion (Figure 2) in the images of the composites obtained by OM evidence that the ratio skin/with is lower and more relevant for functionalized CNT indicating a better distribution and dispersion also comproved by the lower ratio area/agglomerate.



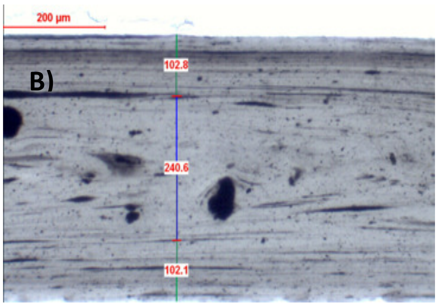
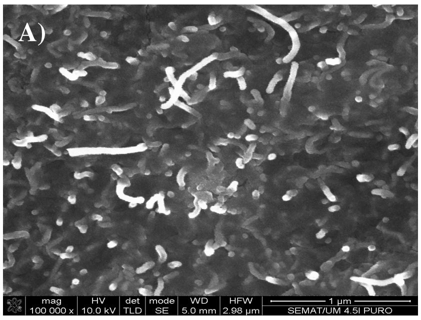


Figure 2 – Examples of optical microscope images and statistical study for pure A) and functionalized B) 1,5% CNT nanocomposites for tensile specimens.

The SEM images evidence the effect of the chemical modification of the CNT, illustrating the improvement of the CNT interface in PA 6 in the case of funcionalized CNT (Figure. 3).



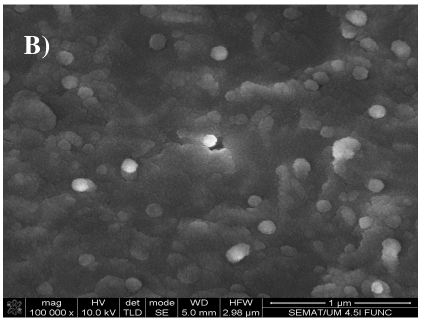


Figure 3 – SEM images for pure A) and functionalized B) 4,5% CNT nanocomposites.

The improvement in CNT dispersion affected the electrical and mechanical properties of the composites, as illustrated in Table 1 for the composites with 1,5% wt of as received and functionalized CNT.

Table 1 – CNT dispersion results and electrical and mechanical properties for the nanocomposites with 1,5% of pure CNT and functionalized CNT (FCNT).

Composite	CNT	FCNT*
Number of agglomerates	94	242
Average area (μm^2)	3017 ± 682	839 ± 151
Electrical conductivity ($S.m^{-1}$)	$7{,}3 \times 10^{-04}$	$1{,}7 \times 10^{-04}$
Elastic Modulus (GPa)	$2{,}66 \pm 0{,}42$	$3{,}99 \pm 0{,}64$

*The CNT content in FCNT nancomposites is 1,26%, the remaining weight is due to the functional groups at the CNT surface.

As expected, the composites of PA 6 with 1,5-4,5% CNT are semiconductors, and the condutivity increased with the CNT content. The addition of pure CNT to PA 6 increased the elastic modulus and the increase was proportional to the amount of CNT incorporation. Samples with functionalized CNT presented the higher values for elastic modulus.

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TÂNIA FERREIRA was born in Santo Tirso in 1980. She study Chemistry at Science University of Oporto and obtained her degree in 2003. Since then, she became a Physics and Chemistry teacher at a junior and high school. In 2007, she started PhD about microinjection moulding of polymer composites with functionalized carbon nanotubes.

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