Universidade do Minho

Escola de Engenharia

Semana da Escola de Engenharia

October 24 - 27, 2011

THE EFFECT OF MICROINJECTION MOULDING ON THE DISPERSION OF CARBON NANOTUBES IN POLYAMIDE 6

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KEYWORDS

Carbon nanotubes, functionalization, microinjection moulding.

ABSTRACT

The excellent performance of carbon nanotubes (CNT) that combines unique electrical, thermal and mechanical properties defines them as excellent fillers for polymer matrices. The nanocomposites produced are expected to be suitable for applications in electronics, chemical and biological sensing and reinforced composite materials.
The present work compares the dispersion, distribution and interface of CNT in polyamide 6 (PA 6) in nanocomposites, varying the CNT content, produced by twin screw extrusion on a bench-top equipment, followed by microinjection moulding (μIM). The later process is the most efficient and cost-effective for the large-scale production of thermoplastic nanocomposite microparts (Baughman et al, 2002).

EXPERIMENTAL

The CNT were provided by Nanocyl (NC7000). They were functionalized trough 1,3 – dipolar cycloaddition reaction, generating pyrrolidine groups at the surface (Araújo et al, 2007), under solvent-free conditions.
The nanocomposites with PA 6 (Badamid®B70 from Bada AG) 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.
The dispersion level of the CNT in the polymer was analysed by the measurement of CNT agglomerate size and number using optical microscopy.
To quantify the amount of non-dispersed CNT, area ratio (d) was calculated: $d = \frac{A_i}{A_t} \times 100$ where A_i is the cumulative area fraction of all agglomerates and A_t the total area of the micrograph.
The CNT/polymer interface was analyzed by scanning electron microscopy. Tensile tests were carried out on a universal testing machine INSTRON 4505 equipped with a load cell of 1 kN.

RESULTS and CONCLUSION

Samples with PA 6 and functionalized CNT (f-CNT) mixed by extrusion and injection moulded by μIM presented better nanotube dispersion, originating lower area ratio (d), of 1.86 and 3.22, compared with non-functionalized CNT. The dispersion level was also improved after μIM as compared to the extruded composite that presented d values of 2.26 and 5.45.
The cumulative agglomerate area was plot against agglomerate area for the nanocomposites with 1% and 3% of pure CNT (p-CNT) and functionalized CNT (f-CNT), extruded, and extruded followed by μIM. (figure 1), illustrating the particle size distribution for the composites prepared.

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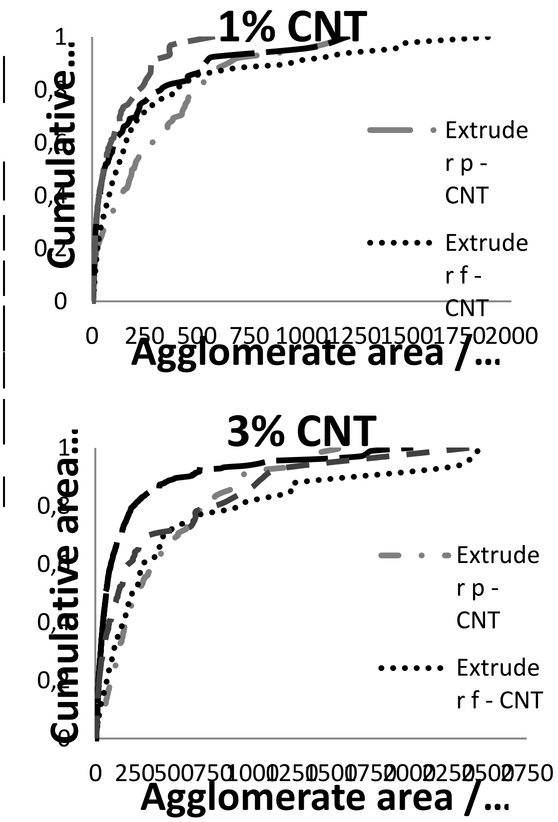

Figure 1 – Evolution of cumulative area ratio with agglomerate area for samples with 1% and 3% at different conditions.

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).

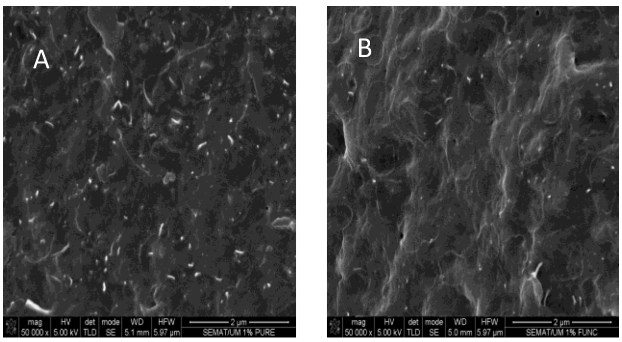

Figure 2 – SEM images for pure A) and functionalized B) 1% CNT nanocomposites.

The Young´s modulus and tensile strength were higher for the nanocomposites with CNT compared to PA 6, as observed in Table 1.

Table 1 – Tensile properties of PA and PA/CNT nanocomposites

Sample		Young´s Modulus (MPa)	Tensile strength (MPa)	Strain to breack (%)
Pure PA6		754.6 ± 30.2	52.0 ± 1.2	81.0 ± 24.1
1% CNT	P	952.8 ± 51.2	91.8 ± 17.5	111.9 ± 10.8
	F	875.9 ± 42.1	113.0 ± 17.8	91.8 ± 17.5
3% CNT	P	1046.3 ± 34.7	89.0 ± 20.6	99.4 ± 15.0
	F	952.4 ± 65.1	101.4 ± 27.2	89.0 ± 20.6

The results revealed, in all cases, most agglomerates are of small size and this fact is more evident for microinjected and functionalized CNT. The remaining agglomerates are very few in number but with large area. The CNT-PA6 interface was better for the f-CNT nanocomposites, exhibiting better CNT adhesion to the PA6. The addition of pure CNT to PA 6 increased the elastic modulus and the increase was proportional to the amount of CNT incorporation.

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AUTHOR BIOGRAPHIES

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

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