PREPARING NANOCOMPOSITES VIA MELT PROCESSING: CURRENT DIFFICULTIES AND PERSPECTIVES

J. A. Covas, F. van Hattum, C. A. Bernardo
I3 / University of Minho, 4800-058 Guimarães, Portugal
jcovas@dep.uminho.pt

Nanocomposites are expected to exhibit excellent mechanical and thermal properties, even at very low filler contents. In the particular case of Carbon nanotubes, CNTs, Young's modulus, tensile strength and thermal conductivity should reach up to 100, 200 and 2000 times the value of the polymeric matrix, respectively, thus making these materials suitable for sophisticated applications, e.g., in the automotive, aeronautics, textile and medical industries. However, in practice, performances only two or threefold those of the base polymer have been reported [1], this being often attributed to difficulties in preparing sufficiently homogeneous materials. A number of techniques has been used to prepare (reportedly) well dispersed nanocomposites [2,3], including solvent-based (solution/dispersion, followed by sonication), in-situ polymerization, combination of free radical reaction and water-crosslinking reaction, latex technology and melt compounding.

In principle, melt processing is an attractive route to prepare nanocomposites, given the wide range of available shear intensive equipment, its capacity for continuous production with significant output levels and the readiness for scale-up to industrial environment. Co-rotating twin screw extruders seem particularly fit for this purpose, given their flexible construction, adjustable distributive and dispersive mixing characteristics, possibility of combining several operations in a single run (e.g., polymer feeding and melting, CNT feeding, melt mixing, devolatilization, and extrusion) and relatively easy operation. However, and despite the current research on this topic, nanocomposite preparation via melt processing is far from being well understood, conflicting results having been reported.

This work discusses some of the approaches taken by the authors to obtain meaningful compounding-morphology-properties relationships for CNTs / thermoplastic composites. Micro-processing [4] using specially designed equipment (Figure 1 illustrates a micro twin-screw extrusion line, complete with feeding) allows the preparation of composites using very small amounts of CNTs, and thus to investigate topics such as the effect of CNT surface functionalization. On-line sensors [5] (Figure 2) provide the opportunity to follow (via rheological response) the evolution of dispersion along the extruder screw and correlate it with operational variables. Finally, rheometrical set-ups create controlled flow conditions to investigate the effect of extensional flow on dispersion efficiency. In spite of still being far from the ultimate targets, the results obtained so far seem indeed promising.

References:

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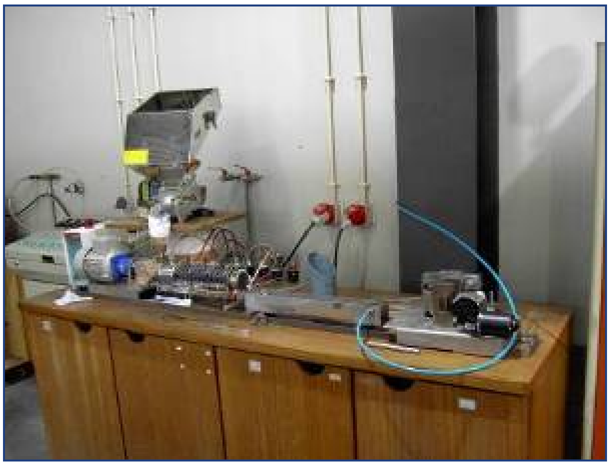

Figure 1- Micro-compounding line

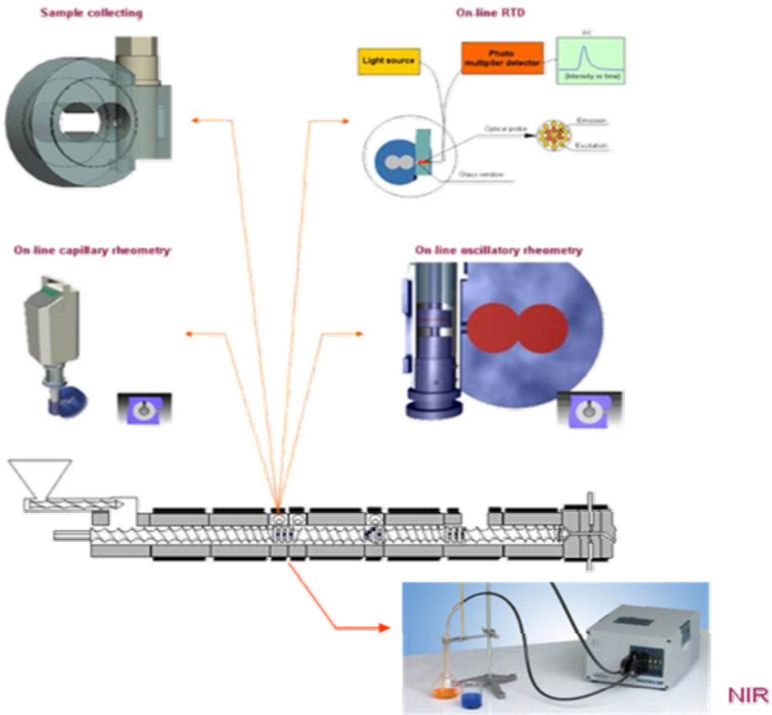

Figure 2 – Available on-line instrumentation

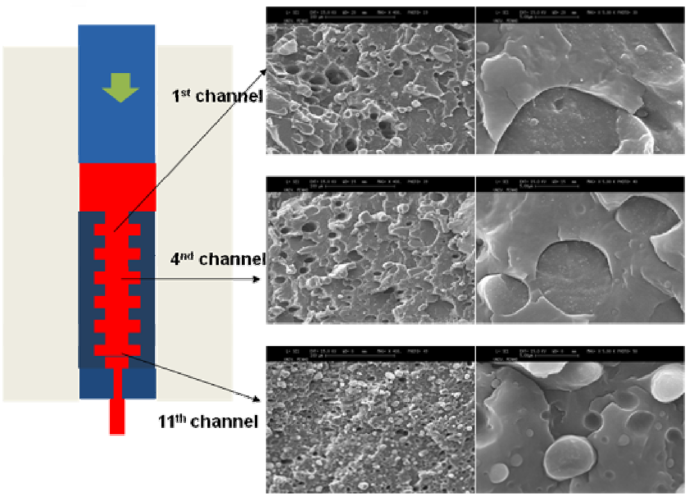

Figure 3 – Effect of extensional stresses (induced by repetitive convergent flows) on the dispersion of CNTs in a polymer blend