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REINFORCEMENT EFFICIENCY OF CARBON NANOTUBES - MYTH AND REALITY

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Due to their outstanding electrical, thermal and mechanical properties, carbon nanotubes (CNTs) have many potential applications and are considered to be ideally suited for the next generation of nanocomposite materials. Probably the most widely used application of CNTs is as reinforcing agents for polymers. The key issues for transferring the CNTs properties to composites are: i) homogeneous dispersion and distribution of CNTs in the matrix; and ii) interaction between CNTs and the surrounding medium. Due to their large specific surface area, CNTs tend to agglomerate, making their dispersion a real challenge. As a consequence, the reported results on mechanical properties of polymer composites are still far from satisfactory and are in contradiction with the expected simulated values. As a matter of fact, different micromechanical models as the widely known Halpin-Tsai or the rule of mixtures, predict a continuous increase of the composite modulus with the addition of CNTs. However, experimental results have shown that the enhancement of properties takes place up to a certain concentration of fillers, after which the reinforcement efficiency decreases. Not surprisingly, most of the literature reports results for CNT concentrations lower than 2-5 wt%. This 'turning point' in the reinforcement efficiency usually takes place at volume fractions coincident with the percolation threshold. In this study, we derive different mechanical models taking into account the presence of agglomerated CNTs and the effect of percolation on the elastic modulus of the composite. The suitability of these models is verified by comparing simulated values with experimental data from literature. The results show that some models are able to predict mechanical properties over a wide range of testing conditions. Overall the findings of this study strongly suggest that, despite of the exceptional properties of CNTs, their efficient use may be bound to limited concentrations.