CONTROLLING ELECTRICAL PERCOLATION IN THERMOPLASTIC-NANOCARBON COMPOSITES

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Carbonaceous nanomaterials, including graphene, carbon nanotube (CNT) and carbon black (CB), have been proven to be excellent reinforcements in conductive polymer composites due to their low density, high aspect ratio, high electrical conductivity, and good mechanical properties[1,2]. However, the nature of the percolated networks formed within these nanocarbon composites is still relatively poorly understood due to the complex interdependencies between the filler morphology, processing conditions, network structure and final conductivity. Herein, we present our latest understanding of these interdependencies based upon a detailed combined modelling and experimental approach.

Four types of carbon nanomaterials (graphenes, nanotubes and carbon black) were used as reinforcements in polycarbonate composites with over 100 different masterbatches being produced. The electrical percolation curves were established for both singular reinforcements and hybrid systems where different combinations of reinforcements (e.g. graphene-CB, CB-CNT etc) were used. For the hybrid systems it was found that the higher aspect ratio reinforcement dominated the electrical behaviour. The hybrid combinations of filler were also used to understand how one can control the percolation threshold, exponent of the percolation curve and ultimate electrical conductivity. The nature of the networks were explored through Transmission Electron Microscopy which allowed the aggregate formation to be visualised (Fig. 1A). Conductive AFM was used to establish the fraction of the nanocarbon which connected to the percolated network and the dimensionality of the network (Fig.1A). The experimental work was supported by Monte-Carlo simulations where we have focussed on understanding the role of clustering and secondary aggregate formation. In particular, the modelling allowed us to interpret the conductive AFM micrographs as sections cut through the percolated network and the role of branching in the aggregate formation.

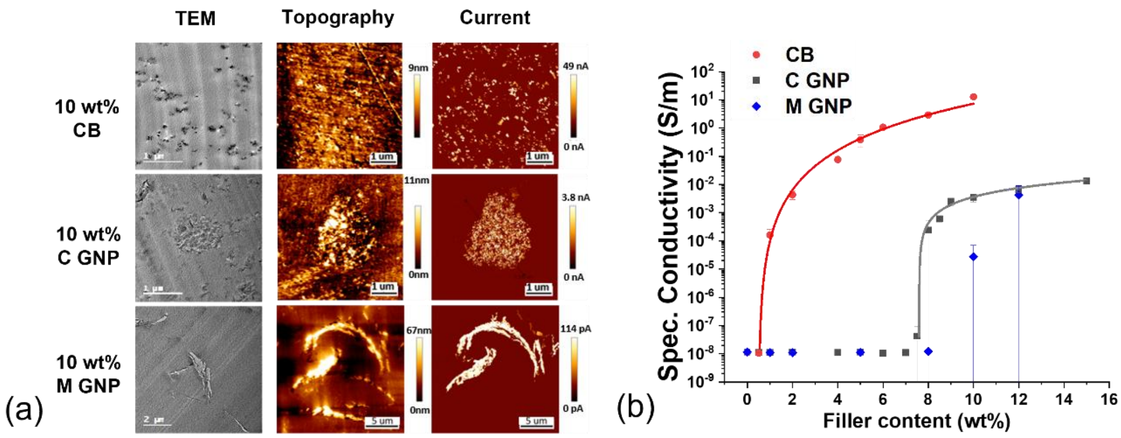

Fig. 1 (a) TEM image as well as topography and current mapping obtained from CAFM of composites and (b) the percolation curves for these systems. The comparison between the topography and current maps allows the connectivity of the percolated networks to be calaculated.

References

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