Electrical conductivity of polymer/polymer/graphene hybrid composites

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Abstract

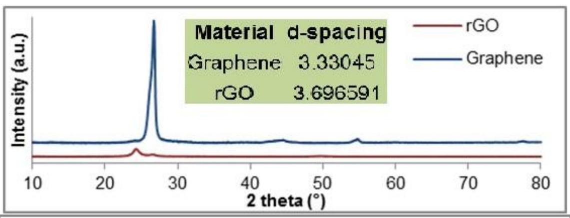
Electrical conductivity can be introduced in conventional non-conductive thermoplastics by the right choice of additional conductive polymers and components using a melt blending process through a systematic approach [1]. Conducting polymers such as polyaniline (PANI) and polypyrrole (PPY) can be blended with thermoplastics even at temperatures of 280ºC. Hence, hybrids of polypropylene (PP- non-polar), polymethyl methacrylate (PMMA- polar) and polyoxymethylene (POM- highly polar) as primary polymer matrices with polypyrrole and polyaniline as secondary conducting polymer matrices reinforced with graphene (G) have been developed. Techniques such as XRD, SEM and tensile testing have been used to characterise the blends. A Taguchi analysis has been performed for the blends to identify the optimal combination with respect to electrical conductivity and also to control the amount of graphene/secondary polymer loading (wt %). It has been found that both electrical and mechanical properties are improved by the addition of conducting polymers and graphene. Interestingly, a maximum electrical conductivity of 0.8 S/cm has been achieved with POM/PPY/G blend with 4 wt% and 3 wt% of polypyrrole and graphene loadings, respectively. A subsequent simplex model has been used to sub-optimise the blend which to show that the 0.8 S/cm could be achieved with 3.25% of G and 2.25% of PPY addition. Reduced graphene oxide (rGO) has been synthesised (by the Hummer's method and hydroiodic reduction) and compared with the graphene powder to understand their effect on the electrical and mechanical properties of the hybrids. This comparative study showed that the electrical conductivity and tensile strength are improved with graphene. From elemental (XPS) and physical characterisation (Raman spectroscopy, XRD and particle size analysis), it has been identified that the interlayer defects, crystalline structure, purity and particle size are the main factors that influence the electrical as well as the mechanical properties of the rGO/G samples it selves and the hybrid composites. Raman spectroscopy and XRD studies revealed that G has much oriented and crystalline structure than that of rGO, which is an indication of its improved properties. The purity of the graphene materials was determined by XPS which showed that rGO has relatively high amount of oxygen functional groups compared to that of graphene. The presence of large number of oxygen containing functional groups lead to partially obstructed π–stacking in rGO layers which decreases electrical conductivity [2].Figures- (A, B & C) compares different and elemental characteristics of graphene and rGO and the Figure (D) shows the properties of the improved hybrids.

References

[1] K Sadasivuni, D Ponnamma, J Kim, S Thomas, Graphene-Based Polymer Nanocomposites in Electronics, Springer (2015).
[2] VB Mohan, R Brown, K Jayaraman, D Bhattacharyya, Materials Science and Engineering B, **193** (2015) 49-60.

Figures

A



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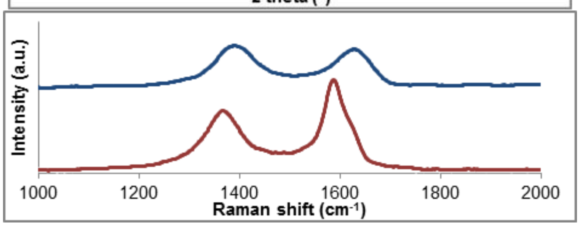

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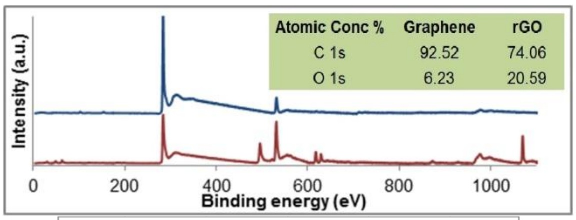

D