Rheological Behavior of Graphene Suspensions in Polymer/Graphene Nanocomposites for Coating Applications

O. M. Istrate[1], S.R. Gibbon[2], J. Moghal[3], P. M. Budd[4], and I. A. Kinloch[1*]

[1] School of Materials, University of Manchester, Manchester, United Kingdom, M13 9PL
[2] AkzoNobel RD&I, Felling, Tyne & Wear, United Kingdom, NE10 0JY
[3] Crown Packaging UK Plc, Downsview Road, Wantage, United Kingdom, OX12 9BP
[4] School of Chemistry, University of Manchester, Manchester, United Kingdom, M13 9PL
[1*] School of Materials, University of Manchester, Manchester, United Kingdom, M13 9PL
Ian.Kinloch@machester.ac.uk

Graphene based coatings are rapidly becoming a field of great interest due to their unique properties and applications [1-3]. So far, the manufacture of graphene based materials has been limited by the small amounts of graphene available. However, new methods for preparing exfoliated graphene nanoparticles [4, 5] opened the door to production of polymer/graphene nanocomposites with remarkable properties [6, 7]. The current study investigates the preparation and rheological behavior of polymer/graphene nanocomposites for coating applications. Rheology has been previously used as a complementary technique to characterize the dispersion of nanofillers into the polymer matrix [8].

Polymer/graphene nanocomposite suspensions were prepared using graphene nanoparticles, XGnP® 25M (XG Sciences, Inc., Lansing, Michigan, USA), and a thermosetting matrix, i.e., BPA free coating, Gold Lacquer (AkzoNobel, Packaging Coatings Ltd., Birmingham, UK). Two processing techniques were employed to synthesize BPA free resin/graphene dispersions, i.e., direct mixing and solvent mixing. In the direct mixing approach the lacquer and the graphene nanoplatelets were directly mixed. Whilst, in the solvent mixing approach a solvent, propylene glycol monomethyl ether acetate (Sigma-Aldrich Co Limited, UK), was used to disperse the graphene nanoplatelets into the lacquer.

Rheological measurements were performed at 25°C using a TA Discovery HR-3 rheometer with parallel-plate geometry (60 mm diameter and 1 mm gap). The frequency sweeps (Figure 1) performed between 0.1 and 628 rad/s show that storage modulus and loss modulus increase with increasing frequency. The amount of graphene nanoplatelets dispersed into the polymer matrix is reflected in the storage modulus measured at low frequencies. The terminal slope of the elastic modulus curves depreciated with increasing the graphene nanoparticles content. The slope reduced further when solvent was used during the preparation process. This was found to be in good agreement with previous work and implied that the nanoplatelets presented a better delamination when solvent was present [9]. The changes in the elastic and viscous moduli reflected in the complex viscosity. The steady-shear measurements showed changes in the viscosity of the suspensions. The polymer/graphene nanocomposite suspensions were used to coat steel surfaces (Crown Packaging UK Plc).

References

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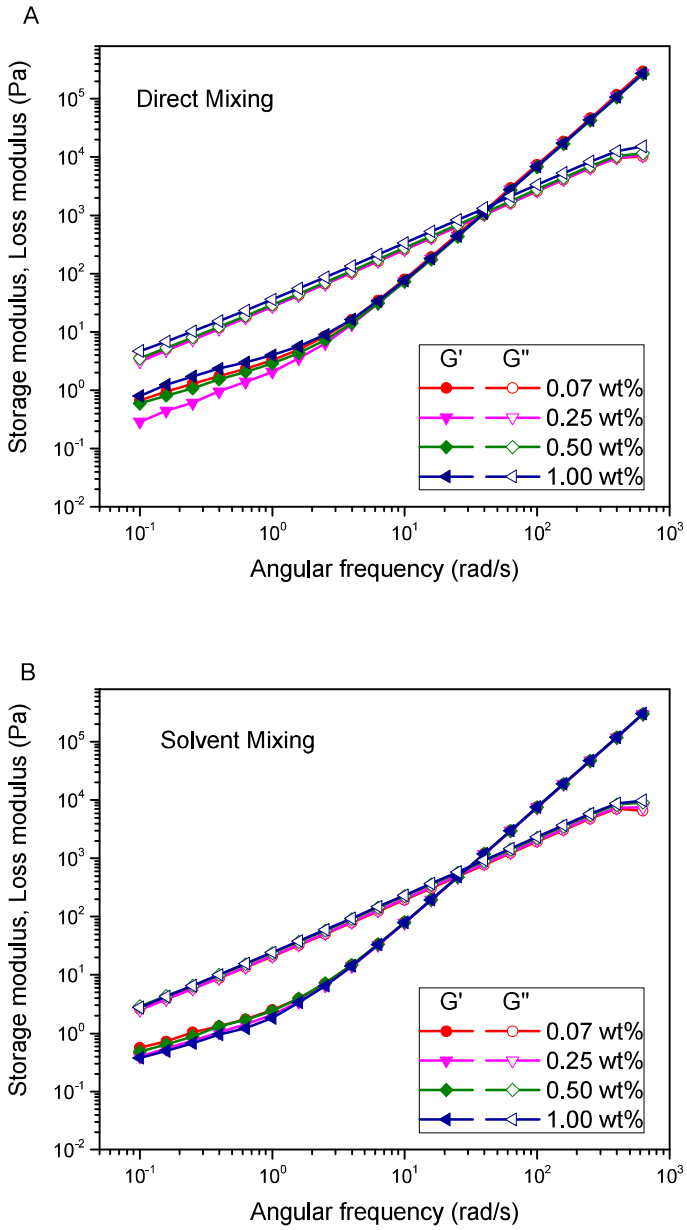

Figure 1: Storage modulus (G') and loss modulus (G") versus frequency of non-intent BPA/graphene nanocomposites