HIGHLY FILLED MAGNETIC POLYMERIC COMPOSITES

By

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CERTIFICATE

This is to certify that the thesis entitled 'Highly Filled Magnetic Polymeric Composites' being submitted by Mr. D.R. Saini to the Indian Institute of Technology, Delhi for the award of the degree of 'Doctor of Philosophy' is a record of bonafide research work carried out by him. Mr. D.R. Saini worked under our guidance for the submission of this thesis which to our knowledge has reached the requisite standard.

The thesis or any part thereof has not been submitted to any other university or institution for the award of any degree or diploma.

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ABSTRACT

Magnetic polymer composites are commercially relevant due to their wide range of applications. These composites represent highly filled systems, containing greater than 75% by weight of ferrites. There is very little published information on the rheology and mechanical performance of such highly filled polymeric systems.

The scope of the present investigation includes studies on the melt rheology, mechanical properties, viscoelastic characterization in solid and molten phase, electrical and magnetic properties of these highly filled composites. The use of various thermoplastic elastomers as a matrix material has been explored. These include styrene-isoprene-styrene block copolymer, thermoplastic polyurethane, polyester elastomer. Similarly, several coupling agents based on silane and titanate were studied in order to select the effective type, grade and quantity for better processibility and mechanical properties.

The temperature and deformation rate sensitivities of these composites have been characterized to select the correct processing and compounding conditions. The composites were prepared at three different barium ferrite loadings, namely, 75, 80, 85 by weight. The effect of amount of loading on melt rheology, viscoelastic characteristics, relaxation spectrum, glass transition temperature, mechanical, magnetic and electrical properties was investigated in both treated and untreated filler composites. The composite samples were produced by melt compounding and test specimens were prepared by compression molding as per ASTM standards.

It was observed that such high filler loadings significantly increase the steady and dynamic melt viscosity over the entire range of shear rate

or frequency (10^{-2} to 10^{3} sec^{-1}). The use of coupling agent was found to significantly reduce the viscosity via improved filler dispersion as evident by SEM fracture surface micrograph. A correlation has been sought between the complex viscosity $|\eta^*|$ and storage modulus G'. The activation energy for viscous flow and for α-transition showed a decreasing trend with filler percentage.

It was observed that the type of matrix has little effect on the magnetic properties but it significantly influenced the processibility and mechanical performance. It is seen that the static mechanical properties can be related to the dynamic mechanical properties and can be used for the selection of the polymer matrix for specific application. The models developed for conventional filled systems (upto 40% by wt) may not be directly applicable to estimate the mechanical performance of highly filled systems.

The Wiechert viscoelastic model using a single arm with a Cole-Cole parameter has been used to fit the Argand diagram. The glass transition temperature, the magnetic, electrical properties and storage modulus were found to increase with increasing filler level, whereas there was little change in damping characteristics and tensile properties relative to the unfilled materials.

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