Summary of Minor Research Project

Development of Supertough Thermosets from Self Assembled Nanostructured Block copolymer/ Epoxy Resin Blends

UGC Reference No: MRP(S) - 0805/13-14/KLMG027/UGC-SWRO

Submitted to

UGC- New Delhi

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July 2016

The goal of this work is to investigate how to modify the epoxy matrix by the addition of poly(styrene-*block*-butadiene-*block*-styrene) (SBS) triblock copolymers and also to investigate the effect of epoxidation on polybutadiene in SBS on the network structure of the epoxy matrix.The materials epoxy resin and styrene-block-butadiene-block-styrene (SBS) triblockcopolymer were procured and prepared the blends. To improve the compatibility of SBS the epoxidation reaction was done and characterized. Epoxidation reaction is carried out using H_2O_2 in the presence of in situ prepared methyltrioctylammoniumtetrakis(diperoxotungstate)phosphate as the catalyst system in a water/dichloroethane biphasic system. The epoxidation is confirmed by FTIR and the main reaction occurs at 1,4-butadiene units. The epoxidation reaction was carried at different epoxidation degrees. From the characterization, the maximum epoxidation was found to be 47mol%.

Epoxy/eSBS triblock copolymer blended resin mixtures at different epoxidation degrees were prepared by solvent casting method and the characterization of these blends was done by morphological and mechanical studies. The properties of these blends were compared. A series of blends with varying compositions (5, 10, 15, 20 and 30wt%) at highest epoxidation degrees were prepared. At high epoxidation degrees ie; at 47mol% the blends obtained are transparent before and after the curing process, shows the phase separation in the nanoscale. The FTIR studies showed that there could be interactions (ie; hydrogen bonding) between the hydroxyl group of the growing epoxy thermoset and epoxy groups of the epoxidised butadiene. The morphological and mechanical studies were done. The analysis of the prepared blends was carried out using a variety of techniques like SEM, optical, TEM, SAXS etc.

The presence of macroscopic phase separation is obviously visible in cured blends containing unmodified SBS; moreover the cured blends are opaque. Hence it is an indication of immiscibility of SBS in epoxy resin. The blends with eSBS26 copolymer are microphase separates, forming a heterogeneous morphology, where block copolymers of around 2µm size are dispersed in a continuous epoxy matrix. The TEM images of 39 and 47 mol% of epoxy/eSBS blends show nanostructuring with phase separation in nanometer range, i.e.; unepoxidised PB blocks surround the PS core and the matrix of epoxy resin containing epoxidised PB. The worm-like micelles with spherical nanodomains morphologies have been observed when epoxidation degree reaches 39mol%. The average size of the micelle is around 10-15 nm in diameter. These micelles are interconnected each other and arranged in the epoxy matrix containing epoxidised PB segments, which shows merely partial miscibility of epoxidised PB block in epoxy matrix due to the presence of unepoxidised PB. Once the epoxidation degree reaches 47mol% the worm- like morphologies are changed to long range ordered spherical micelles with an average diameter of around 10-15 nm in size, which are dispersed continuously in the epoxy matrix. It was found that at highest epoxidation degrees the blends showed improvement in the properties like fracture toughness and impact strength and nanostructures in the epoxy matrix.