ABSTRACT

The objective of the present work is the development and characterisation of epoxy-cyanate ester - bismaleimides matrix systems using cyanate esters, 4,4'-dicyanato-2,2-diphenylpropane (CE-1), 1,1-bis(3-methyl-4-cyanatophenyl) cyclohexane (CE-2) and 1,3 dicyanatobenzene (CE-3), and bismaleimides namely N,N'-bis(maleimido)4,4'-diphenylmethane (BMI-1), N,N'-bis(maleimido)4,4'-diphenylsulphone (BMI-2) as chemical modifiers for epoxy resin. Cyanate esters were synthesised from cyanogen bromide and appropriate diol, using triethylamine catalyst. Bismaleimides BMI-1 and BMI-2 were prepared from reported procedure, their purity and structural confirmation were ascertained by FTIR and NMR spectral studies.

The formation of intercrosslinked network structure between epoxy and cyanate ester and the formation of isocyanurate and oxazolidinone by the reaction of epoxide with cyanurate were confirmed by FTIR. The homopolymerisation of bismaleimides (BMIs) in the presence of epoxy resin, occurred at much lower temperature (130-140 °C) and was confirmed by FTIR spectra. Varying amounts of bismaleimides were incorporated into the cyanate ester-epoxy blends and cured with diaminodiphenylmethane.

The matrices prepared in the form of castings were characterised for their physico-chemical, mechanical (tensile strength, flexural strength, tensile modulus, flexural modulus and Izod impact strength), electrical (dielectric strength, surface resistivity, and arc resistance), thermal (cure reaction...
behaviour, glass transition temperature and thermal degradation temperature), morphological (SEM) and water absorption properties.

The cyanate ester incorporation into epoxy resin decreases the tensile strength and improves the flexural properties and impact strength. This may be explained due to the formation of oxazolidinone ring structure during cure and this exhibits flexible and resistant to bending stress and improved toughness. Tensile and flexural properties of both epoxy and CE modified epoxy systems increased with the incorporation of bismaleimides according to its percentage concentration. This is due to the formation of intercrosslinking network between bismaleimides and epoxy systems. Impact strength of epoxy and cyanate ester-epoxy systems decreased with increasing bismaleimides concentration. The restricted chain mobility due to the formation of network structure and reduced free volume may be explained for the cause of the lowering of impact strength.

The cure reaction behaviour of epoxy-DDM, CE-epoxy-DDM and bismaleimides modified epoxy systems has been studied by DSC. The increase in the peak maximum temperature with increasing bismaleimides concentration for BMI-1 and BMI-2 modified epoxy systems confirmed and the homopolymerisation reaction of bismaleimides would predominate over Michael addition reaction. In the case of CE modified systems, the decreased peak maximum temperature with increasing CE concentration confirmed that the reaction between epoxy and cyanates which accelerates the reaction rate and reduces the curing temperature. The incorporation of cyanate ester into epoxy resin had no significant effect on Tg. However, a marginal decreasing trend was observed with increase in CE concentration. The Tg of epoxy and CE-epoxy systems increased with the incorporation of bismaleimides (BMI-1 and BMI-2).
The incorporation of CE into epoxy resin improves thermal stability and enhances the thermal degradation temperature according to its percentage concentration. The bismaleimides incorporation into epoxy and CE-epoxy systems also enhances the thermal degradation temperature due to the formation of intercrosslinking network between epoxy and bismaleimides and rigid heterocyclic ring structure of bismaleimides. SEM micrograph of fractured surface of unmodified epoxy system and bismaleimides modified epoxy systems showed homogeneous morphology. The incorporation of cyanate ester and bismaleimides into epoxy resin decreased the water absorption behaviour due to hydrophobic character imparted by bismaleimides and cyanate esters. The electrical properties such as dielectric strength, surface resistivity, and arc resistance of epoxy resin were improved with the introduction of cyanate ester and bismaleimides.

The organophilic montmorillonite clay - epoxy and cyanate ester-epoxy nanocomposites were prepared and the formation of nanocomposite was confirmed by XRD, DMA and SEM. The nanocomposites exhibit significant improvement in mechanical properties and negligible tendency to water absorption than that of the unmodified matrices.

The results obtained from different studies indicated that the cyanate ester epoxy, bismaleimides modified epoxy and bismaleimides modified cyanate ester-epoxy matrix systems could be effectively used for the fabrication of aerospace hardware components, filament wound pressure vessels as well as for high voltage insulating applications under adverse humid environments and high temperature service conditions.