

## ABSTRACT

The objective of the present work is the development and characterization of siliconized epoxy-bismaleimides matrix systems using hydroxyl-terminated polydimethylsiloxane and bismaleimides namely N,N'-bis(maleimido)4,4'-diphenylmethane (BMI-1), 1,3-bis(maleimido)benzene (BMI-2), 1,2-bis(maleimido)ethane (BMI-3) and 1,6-bis(maleimido)hexane (BMI-4) as chemical modifiers for epoxy resin with  $\gamma$ -aminopropyltriethoxysilane ( $\gamma$ -APS) as crosslinking agent and dibutyltindilaurate as catalyst.

Hydroxyl-terminated polydimethylsiloxane prepolymer was synthesized from octamethylcyclotetrasiloxane through controlled equilibration reaction using alkaline catalyst. Siliconized epoxy prepolymer was prepared from epoxy resin and hydroxyl-terminated polydimethylsiloxane (HTPDMS) using  $\gamma$ -APS as crosslinking agent and dibutyltindilaurate as catalyst. Bismaleimides BMI-1, BMI-2, BMI-3 and BMI-4 were prepared from reported procedure, their purity and structural conformation were ascertained from FTIR and NMR spectral studies. The prepared siliconized epoxy prepolymer was blended with varying percentages of bismaleimides BMI-1, BMI-2, BMI-3 and BMI-4 and cured with diaminodiphenylmethane (DDM).

The siliconized epoxy and bismaleimides modified siliconized epoxy matrix materials developed were characterized by their physico-chemical, mechanical (tensile strength, flexural strength, tensile modulus, flexural modulus and plain strain fracture toughness), electrical (dielectric strength, surface resistivity, volume resistivity and arc resistance) thermal (cure reaction behaviour, glass transition temperature and thermal degradation temperature), morphological (SEM) and water absorption properties.

The formation of siliconized epoxy graft IPN had been ascertained from FTIR spectra. The increase in viscosity of epoxy resin with increasing siloxane content further confirmed the influence of the effect of siloxane incorporation into epoxy resin. The homopolymerization of bismaleimides (BMIs) in the presence of epoxy resin, occurred at much lower temperature (130-140°C) and was confirmed by FTIR spectra.

The mechanical study reveals that the siloxane incorporation into epoxy resin decreased the tensile and flexural properties. This may be explained due to the presence of flexible -Si-O-Si- linkage and weak interface boundary between HTPDMS and epoxy resin. The tensile and flexural properties of both epoxy and siliconized epoxy systems increased with incorporation of bismaleimides according to their nature and percentage concentrations. This is due to the formation of intercrosslinking network between bismaleimides and epoxy systems. The plain strain fracture toughness of epoxy and siliconized epoxy systems decreased with increasing bismaleimides concentration. The

reduction in the value of toughness was higher in the case of aliphatic bismaleimides (BMI-3 and BMI-4) modified systems than that of aromatic bismaleimides modified systems (BMI-1 and BMI-2).

The cure reaction behaviour of epoxy-DDM,  $\gamma$ -APS-epoxy-DDM and bismaleimides modified epoxy systems had been studied by DSC. The increase in the peak maximum temperature with increasing bismaleimides concentration for BMI-1, BMI-2, and BMI-3 modified epoxy systems confirmed that the homopolymerization reaction of bismaleimides would predominate over Michael addition reaction. In the case of BMI-4 modified systems, the decreased peak maximum temperature with increasing BMI-4 concentration confirmed that the rate of Michael addition reaction was slightly higher than that of homopolymerization reaction. Incorporation of HTPDMS into epoxy resin had no significant effect on T<sub>g</sub>. However, a slight decreasing trend was observed with increase in HTPDMS concentration, due to the presence of flexible -Si-O-Si- linkage. The T<sub>g</sub> of epoxy and siliconized epoxy systems increased with the incorporation of bismaleimides (BMI-1, BMI-2 and BMI-3), whereas the introduction of BMI-4 decreased the T<sub>g</sub>.

Incorporation of HTPDMS into epoxy resin improved thermal stability and enhanced degradation temperature according to its percentage concentration. The bismaleimides incorporation into epoxy and siliconized epoxy systems also enhanced 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, whereas, siliconized epoxy systems and bismaleimides modified siliconized epoxy systems showed heterogeneous morphology. Siloxane and bismaleimides incorporation into epoxy resin decreased the water absorption behaviour. This was due to the inherent water-repellent nature of siloxane moiety and negligible water absorption behaviour of bismaleimides. The electrical properties like dielectric strength, surface resistivity, volume resistivity and arc resistance of epoxy were improved with the introduction of siloxane and bismaleimides.

Data resulted from different studies revealed that the siliconized epoxy, bismaleimides modified epoxy and bismaleimides modified siliconized 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.