

Nanocomposites and nanomaterials

Toughening of epoxy/benzoxazine hybrids with nanoillite

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Benzoxazines (BOX) are a novel class of thermosetting resins being under spotlight of interest due to their excellent thermal properties, low flammability, high stiffness, low water uptake, and shrinkageless curing. However, they require high polymerization temperature ($T > 200^{\circ}\text{C}$) and are inherently brittle.

The work related to toughness improvement of BOX mostly followed the strategy that was proven for epoxy (EP) based systems. This strategy is directed to manipulate the crosslinked structure via co-crosslinking [1], and to incorporate or create a second, dispersed phase in the matrix [2]. Co-crosslinking of BOX with EP was always favored because the phenolic $-\text{OH}$ groups of the ring-opened BOX could react with epoxy groups of EP. Nevertheless, copolymerization of BOX with EP usually requires even higher polymerization temperature compared to neat BOX. In addition, the fracture mechanical performance could not be markedly improved by this way.

In this work amine-cured EP was used for hybridization of BOX in order to develop nanoheterogeneous EP/BOX co-networks. Note that primary diamines, being usual hardeners for EPs, also react with BOX and accelerate the BOX homopolymerization at the same time [3]. Efficient toughening of the EP/BOX-hybrids was achieved using nanoillite in relative low concentrations.

1. *Rimduisit S., Pirstpindvong S., Tanthapanichakoon W., Damrongsakkul S.* Toughening of polybenzoxazine by alloying with urethane prepolymer and flexible epoxy: A comparative study // *Polymer Eng Sci.*-2005.-**45**.-P. 288-296.
2. *Gietl T., Lengsfeld H., Altstädt V.* The efficiency of various toughening agents in novel phenolic type thermoset resin systems // *J Mater Sci.*-2006.-**41**.-P. 8226-8243.
3. *Grishchuk S., Mbhele Z., Schmitt, S., Karger-Kocsis J.* Structure, thermal and fracture mechanical properties of benzoxazine-modified amine-cured DGEBA epoxy resins // *Expr Polymer Lett.*-2011.- **5**.-P. 273-282.