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Improvement of Nanoclay/Epoxy Composite Properties via Heat Treatment

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The current study shows that the properties of phase separated nanoclay/epoxy composites can be improved by heat treatment at elevated temperatures. Nanoclay/epoxy compounds containing 0, 2 and 10wt.% of Cloisite®30B nanoclay are prepared by copulverization of nanoclay with Bryte 250E-1 epoxy resin at -25°C. Five disk-shaped parts for each nanoclay content are fabricated by curing the nanoclay/epoxy compounds in APA2000 rheometer. Two rectangular samples are cut out from each disk and used to characterize mechanical and microstructural properties, before and after heat treatment.

Initial measurements of mechanical properties are carried out by three-point bending test. The results indicate up to 28% improvement in flexural stiffness with 57% deterioration in flexural strength over the range of nanoclay loading. Investigation of the composite microstructure by scanning electron microscopy indicates extensive nanoclay agglomeration. Transmission electron microscopy, on the other hand, indicates several nano-scale voids trapped in the intra-cluster regions. These nano-voids are quantified by density measurements. The average void content of the nanoclay clusters are determined to be as much as 11%.

The samples are subsequently subjected to treatment by increasing their temperature from ambient to 250°C at a rate of 1°C/min. The void content is characterized after heat treatment and observed to decrease substantially. The average void content of a cluster decreased from 10.4% to 3.8% for parts containing 2wt% nanoclay whereas the same value decreased from 10.6% to 7.6% for parts containing 10wt% nanoclay. The reduction of void content caused noticeable improvements in mechanical properties. After heat treatment, the three-point bending tests indicate up to 25% and 47% improvements in flexural strength and strain to failure, respectively, while maintaining the original level of improvement in flexural stiffness. It is believed that the softened polymer during heat treatment has penetrated into the clusters, thereby reducing the void content and improving the mechanical properties.