Announces the Ph.D. Dissertation Defense of

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“Enhancing Fracture Toughness and Thermo-Mechanical Properties of Vinyl-Ester Composites Using a Hybrid Inclusion of Both CNT and GNP”

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ABSTRACT OF DISSERTATION
Enhancing Fracture Toughness and Thermo-Mechanical Properties of Vinyl-Ester Composites Using a Hybrid Inclusion of Both CNT and GNP

We report a method of increasing fracture toughness (Kc) and strain energy release rate (Gc) of vinyl-ester (VE) matrix by adopting a hybrid (dual) reinforcement strategy. The idea of using this strategy was to trigger intrinsic polymer-nanoparticle interaction such as carbon nanotube (CNT) pull-out and interface sliding to enhance energy absorption during fracture. Additionally, we included a second reinforcement, graphene nanoplatelets (GNP), to promote crack-deflection, crack bridging and cross-linking density. Both reinforcements were dispersed into the polymer in three states: non-functionalized (n); functionalized with COOH (f); surface-treated with Triton X-100 (TX100). We embarked on numerous experiments with many combinations of these variables. We measured Kc and Gc using ASTM D5045-14. We conducted an exhaustive iterative investigation with three systems (f-CNT-VE; f-GNP-VE; f-CNT-f-GNP-VE) to determine the best weight-percentage for the nanocomposite system that produced the highest Kc and Gc values when compared to neat-VE. We found that 0.5wt% f-CNT with 0.25wt% f-GNP in the VE matrix resulted in the highest fracture toughness values and was termed the optimized hybrid nanocomposites (OHN) system. Subsequently, we explored further increasing the Kc and Gc of OHN through altering the nanoparticle surface characteristics, which led to four OHN groups: f-CNT-f-GNP-VE; f-CNT-f-GNP-TX100-VE; f-CNT-f-GNP-TX100-VE; f-CNT-f-GNP-TX100-VE. We discovered that the OHN group with non-functionalized nanofillers that were TX100 surface treated (0.5wt% f-CNT-0.25wt% f-GNP-TX100-VE) generated the greatest improvements in Kc and Gc. Ultimately, we observed that the Kc of neat-VE increased by 65%, from 1.14 to 1.88 MPa*(m)0.5. The improvement in Gc was even greater with an increase of 166%, from 370 to 985 J/m2. Differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA) studies showed a minor shift in glass transition temperature (Tg) by up to 8°C when comparing neat-VE specimens to OHN specimens. A similar increase in maximum thermal decomposition temperature (Td) of up to 8°C was observed through thermogravimetric analysis (TGA) and derivative TGA (DTG). Scanning electron microscope (SEM) studies revealed that the source of improvements in fracture toughness and thermal properties was primarily the three-dimensional hybrid nanostructures (3DHN) that were formed by binding CNT and GNP together, which caused an increase in nanoparticle surface area and inhibited agglomerations.

BIOGRAPHICAL SKETCH
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Published Papers:

