PhD Student

Improvement of Composite Thermal and Mechanical Properties via GO/POSS Hybrid Additives and Discussion Regarding the Importance of Additive Compatibility

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This work aimed to study effects of incorporating functionalized hybrid GO/POSS additives in epoxy, polyester, and vinyl ester resin/fiber reinforced composites. Changes in T_G were characterized via DMA. 3-point flexural and DCB tests were performed to analyze improvements in flexural and toughness properties. Some testing results displayed behaviors which were not anticipated based on data from previous studies. These findings demonstrate the importance of understanding and characterization of additive compatibility for the composites industry.

Materials of Interest

Epoxy resins (E):
- Superior strength
- Most expensive

Vinyl ester resins (VE):
- Generally good properties
- Less expensive than epoxy resins

Polyester resins (PE):
- Generally poor properties
- Very cheap

Additives of Interest

Reduced Graphene oxide (rGO):
- Cheap to produce
- Variety of functional groups
- Excellent dispersion properties

Polyhedral oligomeric silsesquioxane (POSS):
- Unique cage structure
- Organic and inorganic moieties

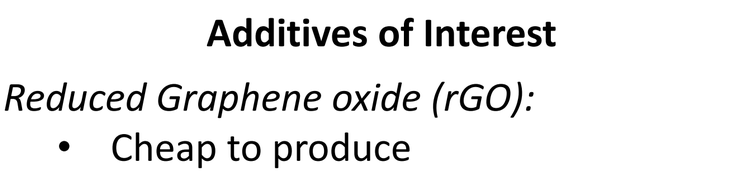
rGO-POSS hybrid additive:
- High compatibility in resin systems
- Improves thermal properties
- Improves mechanical properties

MITO Additives Currently in Study:

E-GO: Epoxide functionalized additive

A-GO: Acrylate functionalized additive

SMITO: Starch-based functionalized additive



Hybrid additives created by MITO consist of rGO, cage structure POSS, and various functional groups which allow for the additives to be tailored for a variety of resin systems and applications.

Reduced graphene oxide image is licensed under CC BY, Jacek Wychowaniec. POSS image credit to https://www.reade.com/.

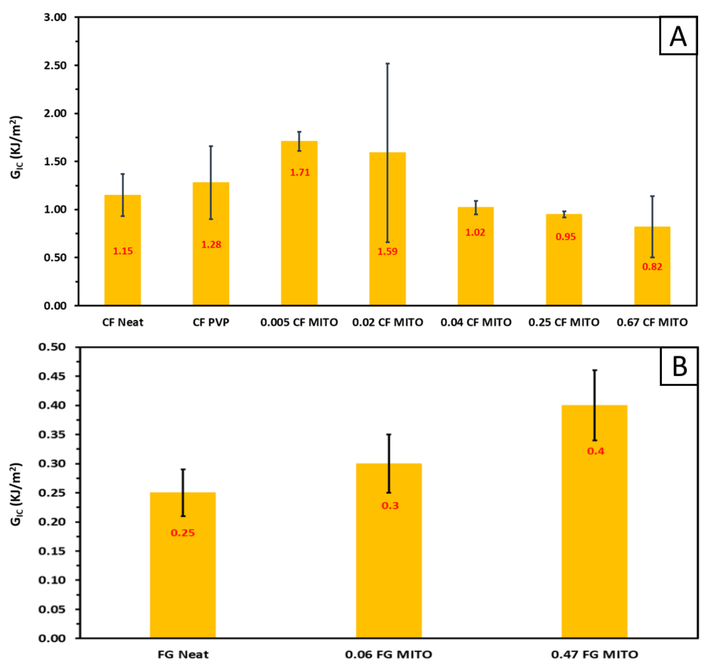
Previous Study

- Create fiber-reinforced composites with inclusion of E-GO
- Improve mode I interlaminar fracture toughness (G_{IC})
- Show improvements within a variety of resin systems

Previous Study Results

Dynamic Mechanical Analysis (DMA):
- Tan δ of bulk polymer decreased
- T_G:
  - 5 °C increase in epoxy
  - 8 °C increase in polyester
  - 12 °C increase in vinyl ester
- Good fiber/additive/resin interactions

Double Cantilever Beam (DCB):
- G_{IC} increased:
  - Glass Fiber/PE: 60% (0.47wt% E-GO)
  - Carbon Fiber/E: 48% (0.005wt% E-GO)



G_{IC} values of carbon fiber fabric/epoxy (A) and fiber glass fabric/polyester (B) composite samples of varying E-GO additive composition. The numbers represent final percentage of additives in the composites.

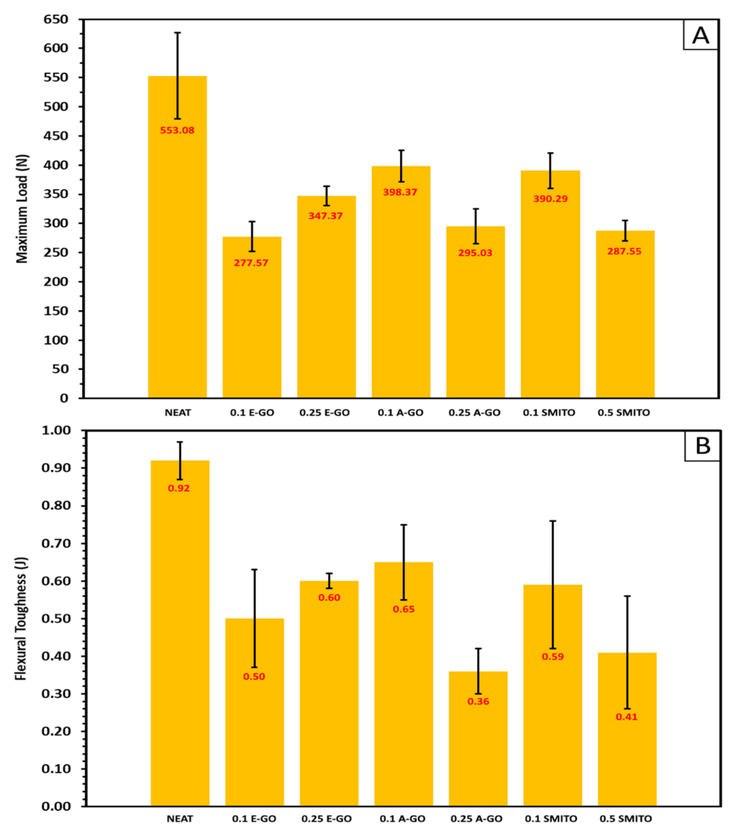
Current Study Purpose

- Create fiber-reinforced VE composites with the inclusion of various additives
- Improve flexural strength and toughness

Current Study Results

Dynamic Mechanical Analysis (DMA):
- *Tan* δ of fiber-reinforced VE composites:
  - Decrease in E-GO
  - Increase in A-GO
  - No change in SMITO
- T_G in fiber-reinforced VE composites:
  - No change in E-GO, A-GO, or SMITO

Flexural Testing (Three Point Bend):
- Decreased flex. max. strength up to -50%
- Decreased flex. toughness up to -61%



Maximum flexural load (A) and flexural toughness (B) results of fiber glass fabric/vinyl ester composite samples of varying additive composition. The numbers represent final percentage of additives in the composites.

Comparison between these two studies shows the significance of resin/additive compatibility. While the previous study showed evidence of positive material interactions in epoxy, vinyl ester, and polyester resins, the current study shows that this is not evident across all individual resin formulations. Future works will be conducted to identify details regarding chemical interactions between MITO additives and the varieties within resin systems.

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