THERMAL DEGRADATION OF CARBON FIBER/CYANATE ESTER RESIN COMPOSITES FILLED WITH CLAY SILICATE NANOPARTICLES

S. Doherty, A Shah (Triton Systems), and J. Deitzel

University of Delaware . Center for Composite Materials

INTRODUCTION

- Polymer matrix composites are being used in high-temperature applications such as engine components and aircraft structures
- Cyanate ester based composites are promising due to excellent properties (High T_g, low shrinkage, thermally stable)
- Long term use in extreme environments leads to decrease in composite properties
- Project Goal:
  - Use nanoclay particles to reduce the rate of thermo-oxidative decomposition and microcracking of cyanate ester resins composites

PRIOR FINDINGS

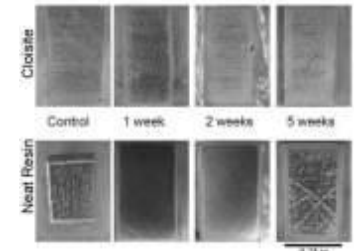
- Nanoclays act as catalysts, increasing the rate of cure and decreasing the maximum cure temperature
- Nanoclay composites have less weight loss and higher fracture toughness after thermal aging than neat system

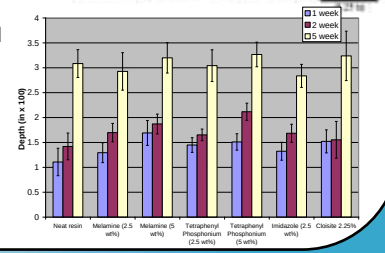
PREPARATION OF MATERIALS

- Resin mixture:
  - Modified cyanate ester resin (RS-9D) mixed with organically modified montmorillonite clay by high shear mixer
- Composites:
  - Uni-directional and Quasi-isotropic panels made from prepreg of IM7 carbon fiber and resin mixtures
- Thermal Aging:
  - Samples were aged in air at 260 ºC

EFFECTS OF NANOCLAYS – OXIDATION DEPTHS

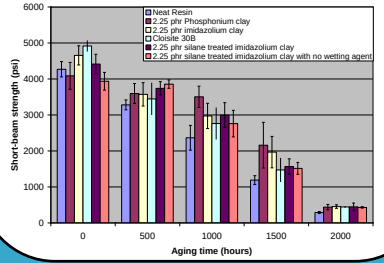
- During aging, cross-sectional samples were cut perpendicular to fiber direction, after 1, 2, and 5 weeks.
- Discoloration ring indicated depth of oxidation.
- Longer times had greater oxidation depth, however no significant correlation between clay particles and oxidation.





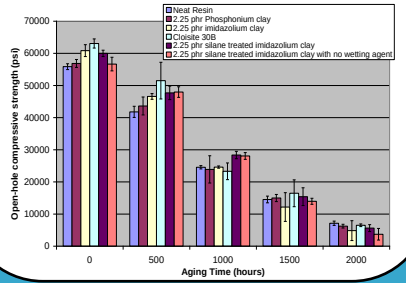
EFFECTS OF NANOCLAYS – SHORT BEAM SHEAR

- Phosphonium and Imidazoluim had highest strength retention post-aging
- By 2000 hrs, all samples had lost most shear strength, although neat resin samples was lowest



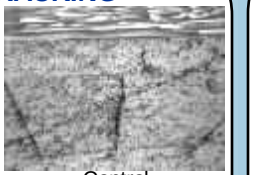
EFFECTS OF NANOCLAYS – OPEN-HOLE COMPRESSION

- For each system, the compressive strength decreased with increased aging
- Clays have no significant impact on thermal degradation



EFFECTS OF NANOCLAYS - MICROCRACKING

- Unaged samples had transverse cracks in center due to residual thermal stresses
- Microcracks more prevalent in clay samples than neat
- Cracks form in surface layers due to thermal degradation
- Control sample most resistant to crack penetration


Control


2.25% Phosphonium

CONCLUSIONS

- Short beam shear results showed modest improvement in property retention for imidazolium and phosphonium nanoclay.
- Open hole compression testing showed that all had similar decline in properties, with no clear benefit for clay systems.
- Transverse microcracks present at center of unaged control composite samples.
- Composites containing nanoclays have higher crack density at center layer than the unfilled control system, suggesting that agglomerates of clay filler may act as flaws that initiate transverse cracking.

ACKNOWLEDGEMENTS

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