INTERPHASE CHARACTERIZATION OF GLASS FIBER REINFORCED VINYL ESTER COMPOSITES

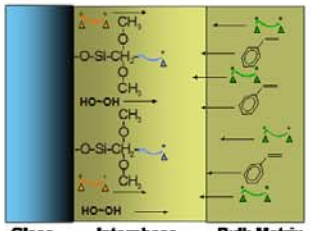
M. E. Foley (PhDMSE), A. Abu Obaid, and J. W. Gillespie, Jr.

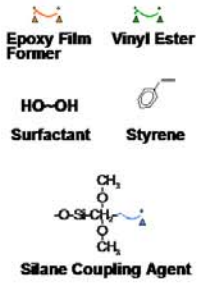
University of Delaware • Center for Composite Materials • Department of Materials Science and Engineering

INTRODUCTION

- There is a trade off when designing a composite part for ballistic purposes:
  - Structural strength requirements call for less than 1% voids with strong adhesion between fiber and matrix
  - Ballistic energy absorbing requirements call for resin lean composites with weak fiber-matrix interphases.
- The energy-absorbing properties may be tailored through the sizings applied to the fiber or through control of the resin infiltration of the composite part.
- Interphase characterization process developed for the Dynamic Interphase Loading Apparatus (DILA) was used to characterize a glass fiber reinforced vinyl ester system.

INTERPHASE FORMATION



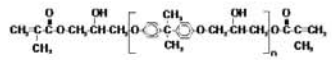


The interphase region is formed by the diffusion of the vinyl ester matrix and styrene towards the glass fiber surface and the surfactant and film former away from the surface.

MATERIALS AND SAMPLE PREP

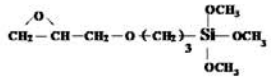
- Specimen Preparation
  - Matrix: Vinyl Ester
  - Fiber: E-glass fiber
- Curing cycle: at RT for 24 hours, Post cure at 130°C for 2 Hours
- Slicing and polishing to thickness of ~100 mm

Vinyl Ester

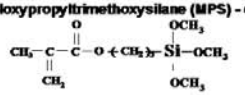


Styrene

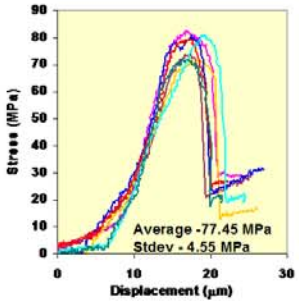
γ-Glycidoxypropyltrimethoxysilane (GPS) - incompatible



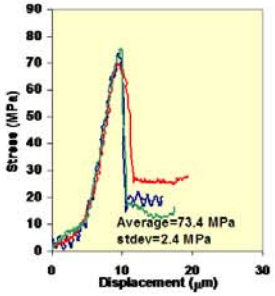
γ-Methacryloxypropyltrimethoxysilane (MPS) - compatible



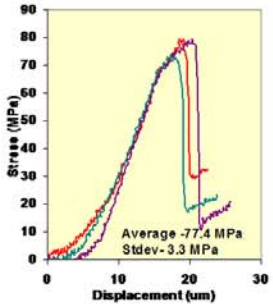
AS-MANUFACTURED COMPATIBLE



AS-MANUFACTURED INCOMPATIBLE

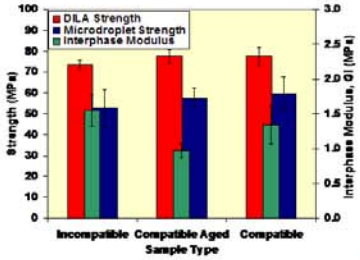


AGED COMPATIBLE

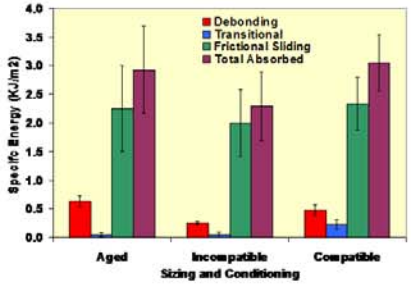


Aged in Water 849 days at RT

STRENGTH AND MODULUS RESULTS



SPECIFIC ABSORBED ENERGIES



- Absorbed energies were greater for the compatible sizing.
- The total absorbed energy for the as-manufactured and aged specimens was similar but the aged specimens exhibited less transitional energy

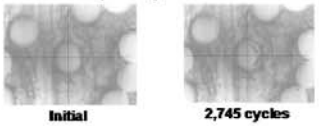
EFFECT OF INDENTER GEOMETRY ON CONTACT STRESSES

8 μm 60° Conical Tip

6 μm Displacement

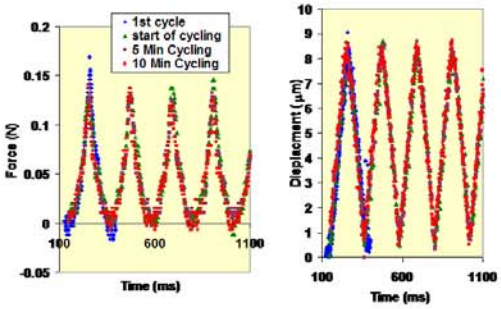
12 μm 40° Flat Tip

12 μm Displacement

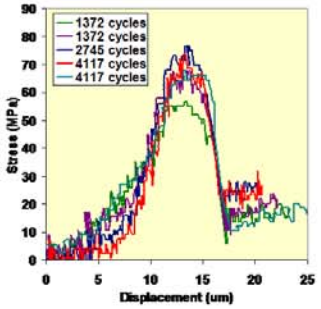


- Conical Tip has much higher contact stresses, which cause excessive damage during fatigue cycling

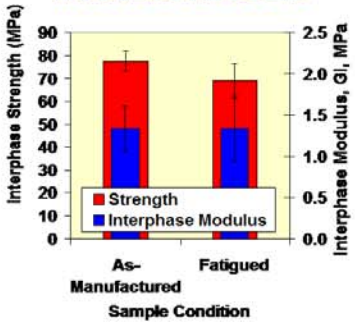
INITIAL FATIGUE TESTING



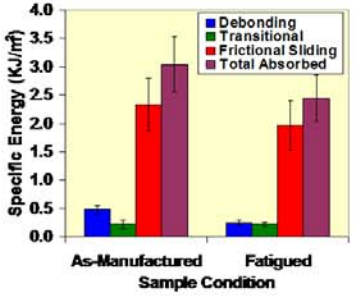
RESIDUAL STRENGTH



POST FATIGUE STRENGTH AND MODULUS RESULTS



POST FATIGUE SPECIFIC ABSORBED ENERGIES



CONCLUSIONS

- Incompatible sizing exhibits similar strength and interphase modulus as compatible sizing.
- Long term aging in water caused a 27.6% decrease in interphase modulus.
- Initial fatigue studies showed a minimal effect on the strength and modulus, but a 19% decrease in absorbed energy

ACKNOWLEDGEMENTS

This work is supported by the Army Research Laboratory through the Composite Materials Research program.