COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

The Effects of POSS Surface Treatment on the Interlaminar Property of Marine Composites

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The fiber/matrix (F/M) interface of carbon/vinyl ester composites has been modified by treating the carbon fiber with polyhedral oligomeric silsesquioxane (POSS). The objective was to improve the durability of the F/M interface in various environments. POSS has hydrophobicity characteristics that decrease the water uptake, swelling and corrosion degradation of composites, which is ideal for marine applications. Two POSS systems with different functionalities, namely octaisobutyl and trisilanolphenyl, have been investigated. Surface treatment involved de-agglomerating the POSS into a solvent by sonication, soaking the fibers for three hours, and then removing the solvent in an oven. Treated and untreated carbon fibers were then used to make composites using Derakane 8084 vinyl ester resin. Composites samples were immersed in three different environments: seawater at room temperature (SWRT), seawater at 40°C (SW40), and in 85% relative humidity at 50°C (HM50). Over a period of six weeks, POSS modified samples absorbed less water reducing absorption by 20-32% compared to control specimens. Short beam shear tests of samples after exposure to environmental conditions have shown that there is no degradation in interlaminar shear strength. Instead there was improvement of about 7-32%. This observation suggests that while under environmental exposure the resin was still curing, especially at elevated temperature.

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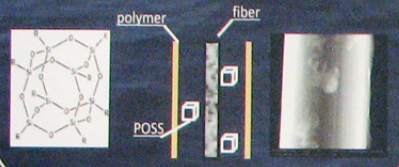
Introduction

The fiber/matrix (F/M) interface of carbon/vinyl ester composites has been modified by surface treating the carbon fiber with polyhedral oligomeric silsesquioxane (POSS). The objective was to improve the durability of the F/M interface in marine environments.



Fabrication

Acetone Treatment

Fiber: uni-directional carbon fiber
Soak: 16 hrs
Dry: 30 min in cooling oven

POSS Dispersion

POSS: octaisobutly 1.0 wt%
trisilanolphenyl 0.2 wt%
Solvent: hexane or ethanol
Homogenize: 5 min
Sonicate: 1 hr 30 min

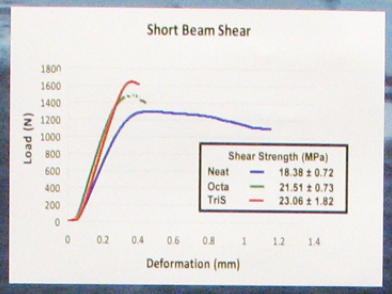
Fiber Surface Treatment

Dispersion: 40 (140) mL
Ply: individual 6(12) in² in Ziploc® bag
Soak: 3 hrs with agitation
Dry: 30 min in cooling oven

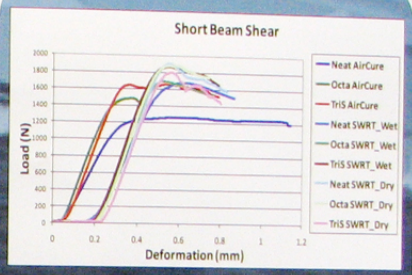
Composite Fabrication

Resin: Derakane 8084
Promoters:
0.30 phr CoNap6%
0.05 phr DMA
Catalyst: 1.50 phr MEKP

Dry Conditions



Moist Conditions



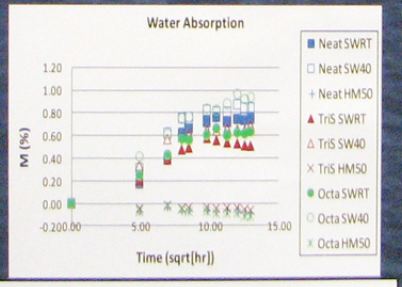
Wet Shear Strength (MPa)

Specimen	SWRT	SW40	HM50
Neat	26.08 ± 0.49	29.29 ± 1.35	31.66 ± 1.41
Octa	24.30 ± 0.81	28.02 ± 0.80	28.76 ± 0.32
G/L (%)	-0.29	14.98	18.01
TriS	26.60 ± 1.58	28.64 ± 1.56	32.15 ± 1.91
G/L (%)	9.15	17.52	31.92

Dry Shear Strength (MPa)

Specimen	SWRT	SW40	HM50
Neat	28.03 ± 1.12	29.58 ± 1.07	31.97 ± 0.99
Octa	26.19 ± 1.15	28.98 ± 1.03	30.03 ± 1.69
G/L (%)	7.47	18.92	23.23
TriS	26.06 ± 1.20	30.30 ± 2.16	31.33 ± 1.13
G/L (%)	6.93	24.33	28.56

Moist Conditions



Percentage of Weight Change (%)

Envir.	Neat	Octa	G/L (%)	TriS	G/L (%)
SWRT	0.75	0.64	15	0.51	32
SW40	0.85	0.94	-11	0.68	20
HM50	-0.08	-0.11	-38	-0.06	25

Conclusion

- POSS systems, like trisilanolphenyl, functionalized with vinyl ester compatible silanol, promotes better adhesion with carbon fiber than unfunctionalized Octa.
- Under dry conditions, POSS fiber surface treatment improved the composite interlaminar shear strength by 17-25%.
- Although water absorption was insignificant at less than 1%, it has been shown that composites with trisilanolphenyl performed the best, under each of the exposure conditions, reducing absorption by 20-32% compared to neat specimens.
- Short beam shear testing of samples after exposure to environmental conditions have shown that there is no degradation in interlaminar shear strength. Instead there was improvement of about 7-32%.
- This was true with neat as well as POSS reinforced composites. This observation suggests that while under environmental exposure, the resin was in fact curing rather than deteriorating within the six week time, especially at elevated temperatures.