CHARACTERIZATION OF FIBER/MATRIX INTERFACE FOR UPCYLCLING COMPOSITES

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Introduction

• Current composite waste disposal methods include downcycling composite materials or sending composite waste to landfills.
• Although these two methods are considerably cheaper and easier to perform, it results in high environmental damages. However, upcycling composite waste is both economically and environmentally favorable.

Materials

• Liquid Elium 188 O resin is supplied by Arkema. Elium 188 O resin is PMMA combined with a peroxide (Luperox AFR 40) also supplied by Arkema. The peroxide starts the free radical polymerization reaction.
• T700SC-12K-F0E sized fibers are supplied from Toray. These carbon fibers are currently used in pressure vessels such as natural gas vehicles and storage tanks.

DSC

• DSC is run on each polymerized preform to determine the thermal glass transition temperature (Tg). The Tg is directly correlated with molecular weight.
• Each sample is tested to determine the effect degree of polymerization has on the sample. A heat cool heat (HCH) process is used to test each sample.

Problem and Process Overview

• Elium 188 O resin evaporates at a fast rate under normal conditions. Because of this evaporation, normal fiber inserts cannot be done. To prevent evaporation during the fiber insertion process, Elium 188 O preforms are made.
• Residual reactions occur in the first heat that create a higher Tg in the second heat.

Fiber Pullout Testing

• Axiom can be used in the TUFF (fiber alignment) process. Since it can be used, it will be considered as a baseline for the Elium 188 O pullout testing.
• Fiber embedded length (Le) are calculated using:

\[
L_e = \frac{F_{\text{max}}}{\pi L \sigma_{\text{IFSS}}} 
\]

• The force required to displace the fiber from the matrix is used to calculate the maximum IFSS.

Second Heat of each Elium 188 O Sample

• The force required to pullout the FOE sized fiber is lower than expected due to a smaller embed length (Le).

• IFSS is calculated using:

\[
\text{IFSS} = \frac{\text{Force}}{\text{Area}} = \frac{F_{\max}}{W_d}
\]

References

For Elium Safety Data Sheet: Retrieved August 1, 2022 from Arkema.

Acknowledgements

A special thanks to Sagar M. Doshi, Ph.D., Steve Sauerbrunn, Ph.D., and Joshua Yu, JD-CHE, from the Center of Composite Materials and The University of Delaware for their help with this project.

This material is based upon work supported by the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE) under the Advanced Manufacturing Office Award Number DE-EE0009303

Figure 1: The Effects of Current Composite Waste Disposal Methods.

Figure 2: Elium 188 O made OFF-shore Windmills²

Figure 3: Bobbin of T700SC Carbon Fibers²

Figure 4: Elium 188 O Composition²

Figure 5: (Left) Preparing Pull Out Testing Samples with Elium 188 O resin. (Right) In-depth polymerization cycle provided from ARKEMA.

Figure 6: Elium 188 O resin made with 2 glass plates

Figure 7: (Left) Elium 188 O Pullout preform after Laser cutting. (Middle) Elium 188 O sample prepared for fiber insertion. (Right) Elium 188 O sample after fiber insertion.

Figure 8: DSC raw data after First heat of the samples. Room Temperature, Annealed, and Post annealed samples are run under the same conditions.

Figure 9: DSC raw data after second heat of the samples. Room Temperature, Annealed, and Post annealed samples are run under the same conditions.

Figure 10: Tg temperature range of each type of prepolished preform.

Figure 11: (left) Schematic of a typical pullout test². (Right) Elium 188 O Laser Cut Sample loaded in sample with FAX0607 for pullout test

Figure 12: (Left) Axiom IFSS Displacement Curve. 70-100 μm samples are compared since embed length affects IFSS. (Right) Elium 188 O IFSS Displacement Curve.

Figure 13: IFSS Database. The average IFSS of each sample composition is plotted.

Figure 14: SEM image of a T700S fiber after pullout testing

Figure 15: Current silicon mold for mild angle single fiber method creation.