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ATOMIC OXYGEN EXPOSURE TESTING OF NOVEL LAYERED POSS THERMOSET NANOCOMPOSITES

Abstract

Weight is of primary importance for space vehicles. With high strength-to-weight ratios, thermoset matrix carbon fiber composites are appealing structural materials. However, the low Earth orbit (LEO) environment contains hazards including atomic oxygen (AO) and UV radiation. These degradants weaken polymers, limiting the use of such composites in orbit. Common protective schemes utilize thin coatings of oxides, which are difficult to apply, or use heavy metal shielding. Thermoplastic polyimide has shown protective potential, but still degrades in LEO and thermoplastics are more difficult to use than thermosets in fiber composites.

A class of promising alternatives is polyhedral oligomeric silsesquioxanes (POSS) nanocomposites. The POSS particle is a silica cage (RSiO1.5) with eight organic pendants. Depending on the type of pendant and the surrounding polymer, POSS will solubilize or form a layer of aggregates at a surface or interface. This layering could create an effective protective barrier over underlying polymers, allowing for minimal mass loss during exposure. Ultraviolet and AO protection has been demonstrated with POSS-polyimide nanocomposites. However, current literature is extremely limited on POSS in LEO when used in thermosets including cyanate esters or epoxies.

This study will review the results of atomic oxygen exposure on POSS-epoxy-amine nanocomposites including mass loss, surface morphology, and thermal behavor. A neat thermoset of diglycidyl ether of bisphenol-A (DGEBA) and 4,4'-diaminodiphenylsulfone (44DDS), and three DGEBA-44DDS nanocomposites of 2.5 wt% octamethyl, octaphenyl or glycidyl POSS were exposed to atomic oxygen at the POSS-rich face only at NASA Glenn Research Center. This took 68 hours at an average flux of 5e15 atoms/(cm^2*s). Mass loss per area was 6.57e-3 +/ -5.99e-4, 7.43e-3 +/- 1.58e-4, 9.02e-3 +/- 2.58e-4, and 8.07e-3 +/- 3.98e-4 g/cm^2 for neat, octamethyl, octaphenyl, and glycidyl samples, respectively. Neat and glycidyl samples darkened upon exposure, whereas octamethyl and octaphenyl samples were lighter. Microscopy revealed deep cracking on octamethyl and octaphenyl-rich surfaces. Texturing but less severe cracking was seen on neat and glycidyl filled samples. Although the contrast between neat and POSS filled samples was not strong as desired, surface phase domain size examined by AFM will be compared to mass loss to identify any correlations. Coefficient of thermal expansion and glass transition temperature will

also be measured. Glass transition temperature did increase with POSS, but it remains to be seen if this trend will survive AO exposure. In conclusion, results will enhance understanding of POSS aggregations and their behavior in thermosets in an AO environment.