Investigation into Silicone-Silicate Conversion Threshold During Atomic Oxygen Exposure in Low Earth Orbit

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Abstract

Optical reflectance and absorbance are vital material properties that affect many thermal and optical systems in spacecraft. In Low Earth Orbit (LEO), outgassed silicone species from commonly-used adhesives can collect on other surfaces and interact with the neutral environment, which may lead to reduced spectral reflectance and absorbance of critical spacecraft systems. Although the conversion from silicone to a glassy silicate surface layer during exposure to atomic oxygen (AO) has been documented in flight and ground-based tests, there is a need to investigate this conversion threshold as a function of AO fluence. This work aims to characterize the silicone to silicate conversion threshold for two commonly-used RTV silicone products: RTV-S-691 and CV-2960, through ground-based laboratory testing. The experiment allows exposed silicone to outgas onto several gold-coated glass microscope slide covers, which are then exposed to atomic oxygen using a capacitively-coupled plasma asher vacuum chamber at roughly 125 mTorr for twenty-four hours. The AO fluence achieved in this ground-based system over a twenty-four hour period agrees with AO exposure flight data for the International Space Station altitude and inclination over a 4-6 month mission. To achieve a realistic contamination mechanism, an effusion cell was developed that helped increase the transport factor for outgassed species to collect on the sample substrate during the contamination phase. Analysis on pristine (dehydrated), pre-AO exposure, and AO-exposed substrates are being performed using ATR-FTIR (Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy). Scanning electron microscope (SEM), atomic force microscopy (AFM), and possibly X-ray photoelectron spectroscopy (XPS) will be used for analysis in future tests. Early contamination tests resulted in visible contamination on the substrate, but ATR-FTIR spectra did not indicate the presence of silicone species. Using gold-sputtered substrates reduces background noise in pristine substrates

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and further analysis methods will be included as testing progresses. XPS analysis may be available for this work and is expected to help verify the presence and composition of SiO_x silicates in the exposed samples with correlation to AO fluence levels and test times. Probability of layer formation by AO fluence level will be presented using logistic regression methods. Model fit evaluation will be performed using the Hosmer-Lemeshow method.