Exposure Study On UV-induced Degradation Of White Diffusers

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Motivation

UV imaging has seen recent growth in applications and increased product availability. These applications include astronomy, photolithography, material inspection, forensics, chemical detection, and skin reflectance. Increased growth and product availability will likely drive an increase in demand for reliable optical references that are stable in the UV spectral region.

One factor that could potentially change the characteristics of reference or calibration standards is UV-induced degradation. For example, in onboard space calibrations, UV exposure from the sun can result in errors in the calibration of space-flight instruments.

The objective of this study is to assess the UV exposure effects on materials commonly used as reflectance standards.

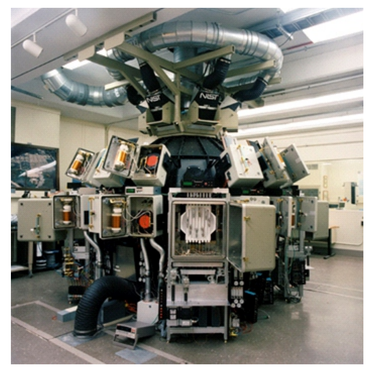
Method

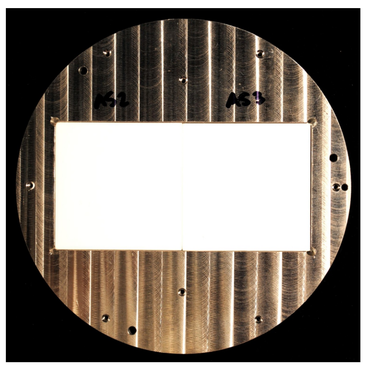
Reflectance standards:

- Sintered polytetrafluoroethylene (PTFE)
- White matte ceramic

NIST facility: Simulated Photodegration via High Energy Radiation Exposure (SPHERE)

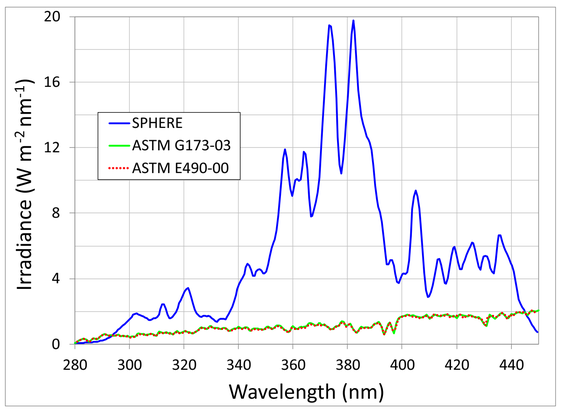
- Expose standards for equivalent of 4.35 solar years
- Measure reflectance and fluorescence before and after exposure
- Measure reflectance every 12 weeks during exposure





Results

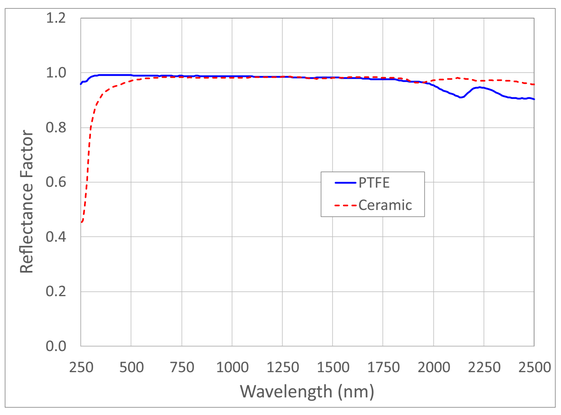
Comparison of UV Exposure



	Integrated Irradiance 275 nm to 450 nm
SPHERE	901.7 W m^{-2}
ASTM E490	190.3 W m^{-2}
ASTM G173	189.8 W m^{-2}

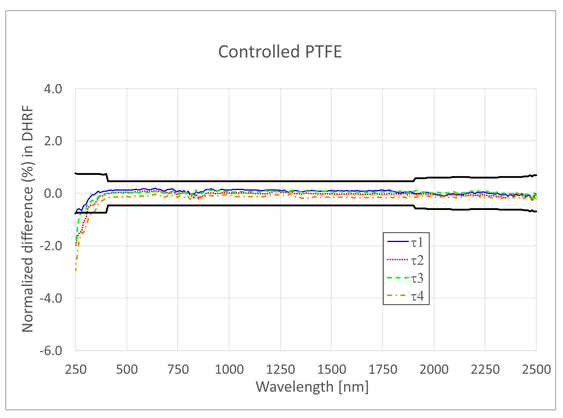
Irradiance spectra of SPHERE output compared to ASTM solar spectra. The integrated irradiance of each spectra is provided in the table.

Reflectance Before UV Exposure

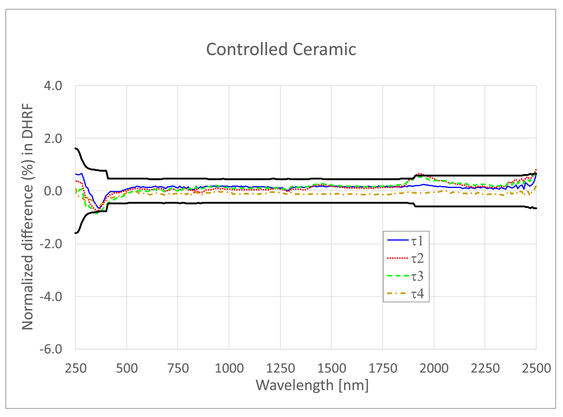


Directional-hemispherical reflectance factor (DHRF) of PTFE and ceramic samples before UV exposure. The expanded uncertainty ($k = 2$) for these measurements is 0.005.

Reflectance After UV Exposure



Normalized difference (%) in DHRF for the control (left) and UV exposed (right) PTFE samples at each characterization time during the exposure period.



Normalized difference (%) in DHRF for the control (left) and UV exposed (right) ceramic samples at each characterization time during the exposure period.

Conclusions

1. Ceramic samples showed significant decrease in reflectance (approx. 6% at 350 nm) upon UV exposure.
2. Decrease occurred within the first 12 weeks of UV exposure.
3. Neither control or exposed PTFE samples showed change in reflectance for wavelengths greater than 350 nm.
4. No discernible changes in fluorescence for PTFE or ceramic samples following UV exposure.
5. Results represent scenario for long-term terrestial UV solar exposure.

Publications

"Accelerated UV weathering device based on integrating sphere technology," J. Chin, E. Byrd, N. Embree, J. Garver, B. Dickens, T. Finn, J. Martin, Rev. Sci. Instrum. 75, 4951- (2004).

"Exposure study on UV-induced degradation of PTFE and ceramic optical filters," B. K. Tsai, C. C. Cooksey, D. W. Allen, C. C. White, E. Byrd, D. Jacobs, Applied Optics 58 1215-1222 (2019).

Acknowledgments

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