MASTERBOND®
CASE STUDY

EP21DCHT Used as a Sealant for the Spectroscopic Determination of Uranium Dioxide Weathering

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Overview of EP21TDCHT

Master Bond EP21TDCHT is a two-component epoxy adhesive, coating, and sealant that can withstand aggressive thermal cycling. It meets the requirements of MIL-STD-883J Section 3.5.2 for thermal stability and can be used to bond materials with different coefficients of thermal expansion. It has been used in a variety of industries, including the aerospace, electrical, electronic, and medical fields. As shown by the case study below, it is ideal for bonding dissimilar substrates, such as stainless steel and fused silica, which were used in a sample container to measure the weathering of uranium dioxide (UO_2) particles.

Application

UO_2 is a radioactive compound used as a fuel in nuclear fission reactors. During use, some UO_2 particles may escape into the environment, where they are exposed to ambient atmospheric conditions such as UV light, heat, oxygen, and humidity. Exposure to these environmental factors can oxidize and erode UO_2 particles via a process called weathering. This process changes the oxidation state of U in UO_2 particles, allowing the age of the particles to be determined via spectroscopy, which may ultimately help monitor nuclear weapon proliferation. Researchers at the Air Force Institute of Technology developed a weathering apparatus for the controlled analysis of the oxidation of UO_2 particles using diffuse reflectance Fourier-transform spectroscopy (DRIFTS), photoluminescence spectroscopy, and Raman scattering. This apparatus needed a sample cell capable of containing the UO_2 particles while allowing only specific gases to flow through the cell. EP21TDCHT was used to soundly bond various dissimilar components of the sample cell together.

Key Parameters and Requirements

A weathering apparatus was designed to analyze the weathering of UO_2 by spectroscopically determining changes in the oxidation state of uranium. In this apparatus, two fused silica capillary tubes were used as the sample cells, one for DRIFTS and one for Raman/fluorescence. The sample cells were required to contain the fine UO_2 particles (1–20 μm) while also allowing exposure to environmental conditions, such as different humidities, gases, and UV light. This was accomplished by using EP21TDCHT to bond 0.5 μm frits to the ends of the fused silica capillary sample cells after UO_2 particles were added. These frits allowed only specific gases—and not the uranium particles—to flow into and out of the sample cell. A quartz window for UV exposure was also bonded to the stainless steel cell using EP21TDCHT. All connections between Teflon tubing and glass components required the use of a Teflon stopper. These Teflon stoppers were sealed into place using EP21TDCHT, which was used on all connections to prevent the diffusion of unwanted gases into the weathering apparatus. (Note: Teflon is highly unreactive and must be chemically etched before applying EP21TDCHT.) Although EP21TDCHT can be cured completely at ambient temperature, curing can be accelerated by using an overnight cure at room temperature, followed by around 3-5 hours at 150–200°F.

Results

The developed apparatus provided a proof-of-concept device and method for monitoring the weathering of UO_2 particles. By exposing the UO_2 particles to different gas compositions, humidities, temperatures, and UV light, the researchers spectroscopically measured changes in the oxidation state of U in the UO_2 particles. The sample cells successfully contained

the UO_2 particles while allowing only specific gases to enter and exit the cell, which permitted the in situ weathering and analysis of particles without needing to remove the sample. EP21TDCHT was critical to ensuring that both sample cells contained the UO_2 particles while preventing the inward diffusion of unwanted ambient gases. Preventing the intrusion of these gases was critical to accurately assessing the weathering of UO_2 particles, as these gases may have altered the weathering process or interfered with spectroscopic measurements. As noted by the researchers, EP21TDCHT sealed various dissimilar components to the fused-silica capillaries. This ensured excellent sample containment in both sample cells, which was critical to preventing interference by ambient gases to obtain accurate spectroscopic measurements.

References

Zickafoose, M. S. *Analysis of uranium oxide weathering by molecular spectroscopy. Final Report.* 1997.