MASTERBOND®
CASE STUDY

EP30HT-LO: Utilized by NASA to bond components in lunar exploration vehicles

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Overview of EP30HT-LO

Master Bond EP30HT-LO is a moderate-viscosity, two-component, epoxy system that can be cured at room temperature, or at elevated temperatures for a faster cure. It can bond to various substrates, including metals, composites, glass, ceramics, and many rubbers and plastics. When cured, it remains rigid without becoming brittle and meets NASA's low outgassing specifications. In fact, NASA used silver-doped EP30HT-LO to study the effect of gamma radiation on titanium-water thermosyphons that may be used in vehicles for future missions to the moon or Mars.

Application

Fission power systems are being investigated for powering the exploration vehicles used in missions to the moon and Mars. In order for these vehicles to function properly, the heat generated by the fission power systems must be dispersed into the surrounding environment by pipes (i.e., thermosyphons) embedded in radiator panels. Titanium-water thermosyphons spread heat across these radiator panels, but because they are located so close to the reactor, they are exposed to gamma radiation. The radiolytic decomposition of water inside the thermosyphons may produce non-condensable gases that decrease the thermosyphon's cooling performance.

To investigate the production of non-condensable gases inside the thermosyphons, researchers at NASA Glenn Research Center conducted an accelerated radiation experiment in which thermosyphons were irradiated with the equivalent of 8 years of gamma radiation. As part of their experimental setup, the authors doped EP30HT-LO with silver and then used it to bond titanium thermosyphons to a graphite substrate, as well as graphite/isocyanate composite cooling fins.

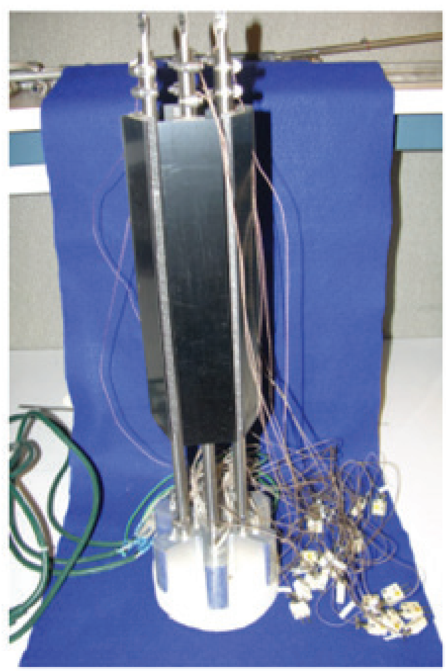

Figure 1. Thermosyphon setup bonded with silver-doped EP30HT-LO and used to assess the generation of non-condensable gases by irradiating water with gamma radiation.

Key Parameters and Requirements

To probe the generation of non-condensable gases inside the titanium-water thermosyphons induced by gamma radiolysis, the authors built an electrically-heated block to hold six hexagonally-arranged thermosyphons (***Figure 1***).

The authors doped Master Bond's EP30HT-LO with silver to likely improve its thermal conductivity and then used it to bond each of these thermosyphons to graphite foam saddles within the heating block. Silver-doped EP30HT-LO was also used to bond graphite fiber—RS–3 isocyanate resin polymer matrix composite heat-rejecting fins for cooling. The authors developed 10 identical titanium-water thermosyphons and replaced them in pairs to obtain samples with different gamma radiation exposure times.

Results

After using silver-doped EP30HT-LO to bond the thermosyphons to the graphite foam saddle and to attach the graphite-based cooling fins, the authors measured the temperature during gamma exposure at three locations on each thermosyphon (evaporator, condenser, and condenser end cap). They used the temperature difference between the evaporator to condenser to indicate the formation of a non-condensable gas and observed a temperature difference of only 2 K, indicating that a small amount of non-condensable gas formed. However, this gas was compressed at the fill tube at the top of the thermosyphon, away from the heat-rejecting fin, so the thermosyphon performance was unaffected. The authors did, however, observe an increase in non-condensable gas formation upon increasing the gamma radiation dose. This gas may have been hydrogen, which is expected to diffuse out of the system faster than it can accumulate under actual working conditions due to its small size.

Although the duration of this experiment was short (on the order of hours), it was designed to simulate up to 8 years of gamma irradiation, indicating that silver-doped EP30HT-LO could withstand large doses of gamma irradiation and still maintain its bonding performance. Importantly, it also maintained its bonding performance even after the authors doped it with silver. In fact, in a presentation given by the authors, they noted that "All aspects of the thermosyphon radiator, *including the epoxy with silver filler used for bonding*...appeared durable to the exposure environment." Thus, silver-doped EP30HT-LO played a key role in ensuring that all components of the gamma irradiation setup were securely bonded throughout the accelerated radiolysis experiment without affecting the thermosyphons' thermal performance.

References

Sanzi, J. L.; Jaworske, D. A.; Goodenow, D. A. *Titanium-Water Thermosyphon Gamma Radiation Exposure and Results*; 10th International Energy Conversion Engineering Conference (IECEC); Atlanta, GA, 2012.