olet (NUV) and vacuum ultraviolet (VUV) wavelengths. UV radiation also causes damage to the seal, with different wavelengths causing different levels of damage.

Low-wavelength VUV radiation attenuates rapidly; it is absorbed quickly and does not penetrate deeply into solids or gases. VUV is absorbed by air, thus does not reach the surface of Earth. Seals exposed to near-VUV radiation achieve the desired level of adhesion reduction without raising the seal leakage level. The radiation likely breaks weaker atomic bonds on long polymer molecules near the surface, which can then cross-link with other molecules, thereby absorbing the weaker bonds and preventing adhesive bonds.

The novel feature of the innovation is that it uses near-VUV wavelength radiation to control and decrease the level of adhesion of silicone-based elastomers without significantly damaging the elastomer. It is expected that the innovation can be implemented using handheld radiation sources, thereby enabling the technique to be used on odd-shaped and very large parts.

The innovation has the potential to use off-the-shelf radiation sources in air, thus circumventing the need for a vacuum chamber. Exposures could be done, for example, using a radiation "oven" through which a conveyor belt passes.

This work was done by Henry C. de Groh III, Bernadette J. Puleo, and Deborah L. Waters of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18948-1.

High-Temperature Adhesives for Thermally Stable Aero-Assist Technologies

These adhesives feature high thermal conductivity and increased thermal decomposition temperature.

Marshall Space Flight Center, Alabama

Aero-assist technologies are used to control the velocity of exploration vehicles (EVs) when entering Earth or other planetary atmospheres. Since entry of EVs in planetary atmospheres results in significant heating, thermally stable aero-assist technologies are required to avoid the high heating rates while maintaining low mass. Polymer adhesives are used in aero-assist structures because of the need for high flexibility and good bonding between layers of polymer films or fabrics. However, current polymer adhesives cannot withstand temperatures above 400 °C.

This innovation utilizes nanotechnology capabilities to address this need, leading to the development of high-temperature adhesives that exhibit high thermal conductivity in addition to increased thermal decomposition temperature. Enhanced thermal conductivity will help to dissipate heat quickly and effectively to avoid temperature rising to harmful levels. This, together with increased thermal decomposition temperature, will enable the adhesives to sustain transient high-temperature conditions.

A first principle analysis showed that enhancing the thermal conductivity of the adhesive can have a beneficial impact on the high-temperature stability of aeroshells and inflatable structures. Silicones and polyimides are used as high-temperature adhesives, and prior efforts have been made to incorporate thermally conductive ceramic powders such as aluminum oxide and boron nitride into silicone formulations to increase thermal conductivity. These high loading levels of ceramic particles present several problems. Viscosity rises, necessitating the use of a solvent, which then needs to be removed at a later stage. Adhesive and mechanical properties deteriorate. A way to decrease the additive loading level while achieving the desired thermal performance was needed.

For conventional composite structures, a three-dimensional percolative network is required to achieve significant performance enhancement, which typically results in a high-volume loading of particles. In contrast, advances were made in creating a new paradigm in non-three-dimensional percolative composites. The emphasis is on nanoparticulate composites, but the concept applies equally well to all particulate composites (i.e., both nanoscale and microscale). As a result, the desired thermal properties can be obtained at relatively low loading levels of nanoparticles, without the detrimental effect on processing and other properties, such as mechanical strength and bonding.

The thermal conductivity of silicone material can be significantly enhanced by adding high-aspect-ratio nanoparticles at relatively low levels. For example, the thermal conductivity is drastically increased by a factor of 3.7 when 10 wt % of high-aspect-ratio nanoparticles is added to a commercial silicone adhesive. In addition, it was shown that there is a synergistic effect when spherical nanoparticles and high-aspect-ratio particles are present. An array of samples that had unique nanoparticle characteristics and nanocomposite morphology was fabricated, and a set of characterization protocols was developed.

This work was done by Kenneth Eberts and Runqing Ou of NEI Corp. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32899-1.