Self-Healing Nanocomposites for Reusable Composite Cryotanks

Applications for COPVs include storage of natural gas and liquid hydrogen fuel in vehicles, and marine transport of propane via tanker ships.

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Incorporating a novel, self-healing, epoxy-based resin into the manufacture of COPVs allows repeatable self-healing of microcracks to be performed through the simple application of a low-temperature heat source. This permits COPVs to be reparable and reusable with a high degree of reliability, as microcracks will be remediated. The unique phase-separated morphology that was imparted during COPV manufacture allows for multiple self-healing cycles.

Unlike single-target approaches where one material property is often improved at the expense of another, robustness has been introduced to a COPV by a combination of a modified resin and nanoparticle additives. Unique nanoparticles were used that have been surface-functionalized to be compatible with the resin. Both organic and inorganic components toughen the matrix and result in a more impact-resistant COPV.

In one resin system containing an inorganic nanomaterial additive, a significant improvement in burst performance was observed after the COPV was cryo-impact-damaged and then self-healed, with a greater than 10% improvement in burst pressure after the self-healing process was performed. Initial cross-sectional analysis via microscopy showed good resin infiltration of the carbon fibers and without voids. To further enhance the capability between the nanomaterial additives and the resin, a surface modification was successfully performed. A second specialty epoxy resin was prepared using a surface-modified nanomaterial additive, and COPVs were fabricated. Steps were taken to improve the mechanical properties of the COPVs by using a low-viscosity resin system that contained a different curing agent. This lower viscosity improves the processing of the COPV, and preliminary results show that the burst pressure of these new vessels is 20 to 25% higher than that of the original.

The self-healing concept demonstrated in this research and development effort represents a platform technology, and the self-healing property is neither restricted to the particular epoxy system used here, nor to the COPV application. Self-healing is a direct result of a unique phase separated morphology created via the resin and is aided by the nanoparticles. The self-healing function can be introduced to other customer-specific resin systems in coating, bulk, or composite applications provided that the unique phase separated morphology can be enabled in those systems.

This work was done by Daniel Eberly, Runqing Ou, Adam Karcz, and Ganesh Skandan of NEI Corporation for Marshall Space Flight Center. For more information, contact Sammy Nabor, MSFC Commercialization Assistance Lead, at sammy.a.nabor@nasa.gov. Refer to MPS-32995-1.

This work was done by James A. Riedell and Timothy E. Easler of ATK COI Ceramics, Inc. for Johnson Space Center. Further information is contained in a TSP (see page 1).

Title to this invention, covered by U.S. Patent Nos. 7,628,878 and 7,888,277, has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)). Inquiries concerning licenses for its commercial development should be addressed to: ATK COI Ceramics, Inc. 9617 Distribution Avenue San Diego, California, 92121 Phone No.: (858) 621-5700 Refer to MTC-23996-1/5218-1, volume and number of this NASA Tech Briefs issue, and the page number.