Polymer/Silicate Nanocomposites Used to Manufacture Gas Storage Tanks With Reduced Permeability

Over the past decade, there has been considerable research in the area of polymer-layered silicate nanocomposites. This research has shown that the dispersion of small amounts of an organically modified layered silicate improves the polymer strength, modulus, thermal stability, and barrier properties (ref. 1). There have been several reports on the dispersion of layered silicates in an epoxy matrix (ref. 2). Potential enhancements to the barrier properties of epoxy/silicate nanocomposites make this material attractive for low permeability tankage.

Polymer/silicate nanocomposite tanks tested for helium permeability.
Long description.

Polymer matrix composites (PMCs) have several advantages for cryogenic storage tanks. They are lightweight, strong, and stiff; therefore, a smaller fraction of a vehicle's potential payload capacity is used for propellant storage. Unfortunately, the resins typically used to make PMC tanks have higher gas permeability than metals. This can lead to hydrogen loss through the body of the tank instead of just at welds and fittings. One approach to eliminate this problem is to build composite tanks with thin metal liners. However, although these tanks provide good permeability performance, they suffer from a substantial mismatch in the coefficient of thermal expansion, which can lead to failure of the bond between the liner and the body of the tank. Both problems could be addressed with polymersilicate nanocomposites, which exhibit reduced hydrogen permeability, making them potential candidates for linerless PMC tanks.

Through collaboration with Northrop Grumman and Michigan State University, nanocomposite test tanks were manufactured for the NASA Glenn Research Center, and the helium permeability was measured. An organically modified silicate was prepared at Michigan State University and dispersed in an epoxy matrix (EPON 826/JeffamineD230).

The epoxy/silicate nanocomposites contained either 0 or 5 wt% of the organically modified silicate. The tanks were made by filament winding carbon fibers with the nanocomposite resin. Helium permeability was measured by Northrop Grumman, showing that the leak rate/day of the nanocomposite matrix tank was approximately 80-percent less than that of the neat epoxy matrix tank.

References

1. Burnside, S.D.; and Giannelis, E.P.: Synthesis and Properties of New Poly(Dimethylsiloxane). Chem. Mat., vol. 7, no. 9, 1995, pp. 1597-1600.

2. Shi, H.Z.; Lan, T.; and Pinnavaia, T.J.: Interfacila Effects on the Reinforcement Properties of Polymer-Organoclay Nanocomposites. Chem. Mat., vol. 8, no. 8, 1996, pp. 1584-1587.

Find out more about this research:
http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html

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