

Mechanically Strong Aerogels Formed by Templated Growth of Polymer Cross-Linkers on Inorganic Nanoparticles

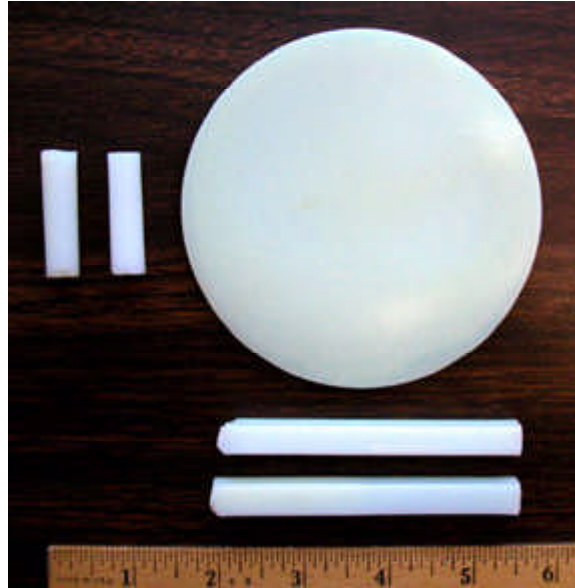
In the search for materials with better mechanical, thermal, and electrical properties, it is becoming evident that oftentimes dispersing ceramic nanoparticles in plastics improves performance. Along these lines, chemical bonding (both covalent and noncovalent) between a filler and a polymer improves their compatibility, and thus enhances certain properties of the polymeric matrix above and beyond what is accomplished by simple doping with the filler. When a similarly sized dopant and matrix are used, elementary building blocks may also have certain distinct advantages (e.g., in catalysis). In this context, researchers at the NASA Glenn Research Center reasoned that in the extreme case, where the dopant and the matrix (e.g., a filler and a polymer) are not only sized similarly, but their relative amounts are comparable, the relative roles of the dopant and matrix can be reversed. Then, if the "filler," or a certain form thereof, possesses desirable properties of its own, such properties could be magnified by cross-linking with a polymer. We at Glenn have identified silica as such a filler in its lowest-density form, namely the silica aerogel.

Aerogels are used primarily in space applications as collectors of hypervelocity particles (STARDUST Program) or for thermal insulation in extreme environments (refer to the *Sojourner* Rover in 1997 or the two Mars Exploratory Rovers, *Spirit* and *Opportunity*, in 2003). For instance, it has been reported that if conventional thermal insulation had been used on the *Sojourner* Rover, 6 lb of the total 25-lb weight of the rover would have been lost for thermal insulation. Thus, it was reasoned that if the thermal insulator--the aerogel--was strong enough to comprise the building material of the entire space vehicle, more weight would be freed for useful payload.

With this in mind, we were able to "glue" together the nanoparticle building blocks of a conventional silica aerogel, by templated, directed growth of the polymer on those particles. Thus, the resulting material is ~3 times more dense than the underlying silica aerogel framework but takes more than 300 times the force to break. The preceding photograph shows such a cross-linked silica aerogel monolith just before its break point.



A cross-linked silica aerogel undergoing a three-point flexural bending test. The density of the monolith is $\sim 0.55 \text{ g/cm}^3$. The density of the underlying silica is $\sim 0.18 \text{ g/cm}^3$, and the



Aerogels produced by ambient pressure drying from pentane.

Find out more about this research:

<http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html>

Glenn contact: Dr. Nicholas Leventis, 216-433-3202, Nicholas.Leventis@nasa.gov

Authors: Dr. Nicholas Leventis, Dr. Eve F. Fabrizio, Dr. Chris Johnston, and Dr. Maryann Meador

Headquarters program office: OAT

Programs/Projects: PR&T