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Strange but True: Gossamer Gel Stands Up to Flame, Speeding Space Particles

The next time you want protection from a blowtorch--or space dust--consider an aerogel

By Alison Snyder

Almost as light as air, capable of withstanding a direct flame or catching speeding comet dust like a baseball mitt stops a hardball, aerogels are some of the strangest solids in the world. This "Space Age Styrofoam" was developed in a chemistry lab decades ago but is now appearing in snowsuits, explosives and even energy storage technology.

Aerogels are the lightest and lowest-density class of materials in the world. Up to 99 percent of the dry, rigid gels are air, while the rest consists of silica, carbon, metals and other substances; it feels like a Styrofoam peanut. Yet, some formulations can support close to two thousand times their weight (if it is lowered onto them slowly). "Enough force to crush a Rice Krispie will crush an aerogel," states Stephen Steiner, a nanomaterials graduate student at the Massachusetts Institute of Technology and aerogel researcher.

But when NASA needed something to safely capture particles from Comet Wild 2 traveling at 6,000 meters per second as part of its recent Stardust Mission, the agency turned to the airy substance. A grid of silica aerogel within the spacecraft was able to catch the minuscule particles (smaller than a grain of sand) without damaging them in any way.

In addition, NASA's Mars Rovers were lined with the ultrainsulating material. Silica and carbon aerogels are poor thermal conductors, because there "isn't much matter there to do the job," according to Steiner. The porous, kitchen-sponge-like structure of aerogel forms a labyrinth through which it is nearly impossible for air molecules--and sound waves--to travel. Therefore, silica aerogel can protect a human hand from the direct heat of a blowtorch as well as dampen its roaring sound.

Modern scientific legend has it that the supersubstances were discovered by chemist Steven Kistler at the College of the Pacific in Stockton, Calif., when he accepted a bet that he couldn't replace the liquid inside a jelly jar without causing any shrinkage. Kistler exchanged the liquid in the jelly with methanol, then heated and pressurized the gel past the compound's supercritical point, where the liquid becomes a gas. Rather than evaporating, which causes the methanol to pull away from the gel and shrink it, supercritical drying pulls the solvent out of the gel without stressing it much. Bet or no bet, Kistler invented the first "aerojelly" and published his results in *Nature* in 1931. The chemist went on to experiment with making aerogels from silica, nitrocellulose and rubber.

Although Kistler's process was effective, it also required the dangerous heating and pressurization of flammable--and toxic--methanol. But a few key tweaks over the next 70 years have brought the materials out of the lab and onto the market. Chemists have found that they can create aerogels with different silica-starting materials and replace methanol with liquid carbon dioxide.

Modern aerogels do, however, have some flaws; one of which is that many share a ghostly blue cast thanks to silica nanoparticles scattering short wavelengths of visible light. This is a problem in window and optical applications that require transparency. M.I.T.'s Steiner and his colleagues are running experiments on NASA's Vomit Comet--an airplane used to train astronauts and perform experiments in microgravity conditions--to see whether eliminating convection and buoyancy when forming the gels can create a nanostructure of particles that do not scatter short light and thus create a more transparent aerogel.

Back on Earth aerogels may have many other applications. The material is already being crushed up and used as insulation in extreme weather gear like snowsuits as well as spacesuits. Another possibility is developing aerogel-based capacitors--energy storage devices--for powering cell phones and cars; the large surface areas of carbon aerogels could store enormous amounts of electric charge compared with their traditional battery counterparts. In addition, researchers at Lawrence Livermore National Laboratory have made iron oxide aerogels embedded with nanoparticles of aluminum that react with the oxidizing gel, releasing an immense amount of heat that could be useful as rocket propellants, in explosives or for pyrotechnics. Similarly, carbon aerogels impregnated with nanosize particles of precious metals like platinum could serve as catalytic converters in cars that would require a fraction of the rare metal to perform the same function. For such a lightweight substance, aerogels have a lot of heavy-duty applications.