Blue-sky material | Mark Miodownik

From curiosity to space-age material and architect's dream, aerogels have taken a strangely haphazard journey.

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In the 1930s, a chemist called Samuel Kistler conjured into existence a new type of material solely to satisfy his curiosity on a purely academic question. The scientific community applauded briefly and then forgot all about it. This is how one of the most beautiful materials in the universe was almost lost forever.

Silica aerogel is essentially a transparent form of sand whose nanostructure contains up to 99.8% air, making it the world's lightest solid. Kistler had been interested in understanding the structure of gels and in proving whether a gel contained a continuous network of solid material. He decided to find a method to remove the liquid from a gel without collapsing the solid pore walls and, in succeeding, created the most highly porous material on the planet. First he did it with silica and then went on in a virtuoso performance to make alumina, tungsten oxide, and nickel tartrate aerogels. As an encore, he created what must now be regarded as the fluffiest omelet that has ever existed, egg aerogel.

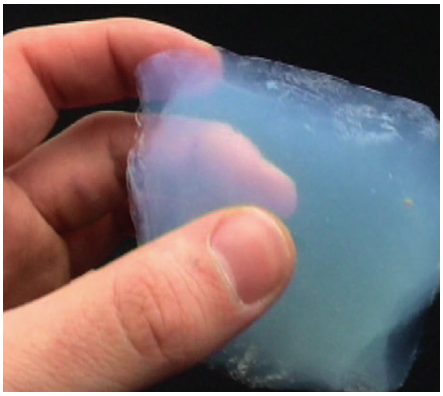
But applications of aerogels didn't take off. Their properties of extreme low density and thermal insulation were ahead of their time, and so more than 50 years went by without aerogels really finding a place in the world. Then in the 1980s, NASA started playing around with them and decided that perhaps aerogels were not really suited for planet Earth. The result was the Stardust mission to send an aerogel capsule on a close approach to the comet Wild 2, collect space dust, and return to Earth.

What made aerogel ideal for the mission was that the ultrafine foam can gradually decelerate and capture dust particles in pristine condition. Since the dust particles impact the aerogel at six times the speed of a rifle bullet, this is no mean feat. Imagine jumping from a jet plane and landing on a foam mattress that breaks your fall so gently that you emerge on the ground perfectly unruffled. This is how aerogel handles space dust, and by doing so prevents its microstructure and chemistry from being changed through heating.

The return capsule containing the stardust successfully re-entered the Earth's atmosphere and landed on the 15th January 2006. Now the process of sifting through the aerogel, micron by micron, to identify and collect the space dust has started. This is set to be the world's largest collaborative microscopy activity: it is has been shared out to anyone willing to help and having access to the internet (see http://stardust.jpl.nasa.gov).

In the meantime, environmental concerns have finally become a high enough priority that aerogel's extraordinary thermal insulation properties can be commercially exploited. The big problem is how to deal with the brittleness of aerogels. Aspen Aerogel's solution is to incorporate aerogels into a fabric, making them much easier to handle and install. The applications are as various as insulation for oil pipelines, arctic expedition footwear, and NASA spacesuits. Another solution, by the company Cabot, is to produce aerogel in a granular form so that it can be pumped into building cavities. This has also allowed the development of transparent aerogel skylights, now much beloved of architects, for their quality of light combined with ultra-insulating credentials.

The 70 year journey of aerogels from their birth as a result of curiosity-driven chemistry to being the centerpiece of NASA space missions, and then hailed as a miracle design material, appears haphazard



Silica aerogel produced by Steve M. Jones, NASA Jet Propulsion Laboratory. (Courtesy of Zoe Laughlin.)

because the material was written off so many times. However, anyone who has ever held a piece of aerogel in their hand will understand why it has never been forgotten. They do not look like anything else you have ever seen. If someone told you that they had been discovered in a crashed space ship, you would believe them; everything about them is alien. The material has the ability like no other to compel you to search your brain for some excuse to be involved with it. Like an enigmatic party guest, you just want to be near it, even if you can't think of anything to say.

Its allure is difficult to describe. The material appears to be much more invisible than glass despite being less transparent. This is because there is no hint of reflection on its surfaces giving it the appearance of not being fully solid. Its azure color is not the result of any pigmentation, but is caused by the same phenomenon that gives color to our atmosphere, namely Raleigh scattering of light. For this, and many other reasons, aerogel really is the ultimate blue-sky material.