Aerogels

Vicky Wong

It has a ghostly appearance like a hologram, but aerogel is a solid.

Key words
materials
structure
density
comet

They were made as the result of a bet and ended up going into space to capture comet dust. Aerogels are the lightest solids which exist and have some unusual properties.

Two scientists, Samuel Stephens Kistler and Charles Learned, had a bet to see who could replace the liquid in a 'jelly' with air without loss of volume. Samuel Stephens Kistler made the first aerogel and won the bet. The work was published in a paper in 1931 but there were not many applications for the material as it was difficult and expensive to manufacture.

In a gel or jelly there is a network of a solid which surrounds pockets of liquid. This is a bit like a sponge where there is a network of solid surrounding a gas. The majority of the mass in a gel is due to the water – the solid is like a cross-linked mesh holding it together. Kistler managed to remove the water from a jelly and so remove most of the mass. Usually this would result in the collapse of the structure – the same is if you leave edible jelly out and it dries up. The structure collapses and the volume reduces.

States of matter

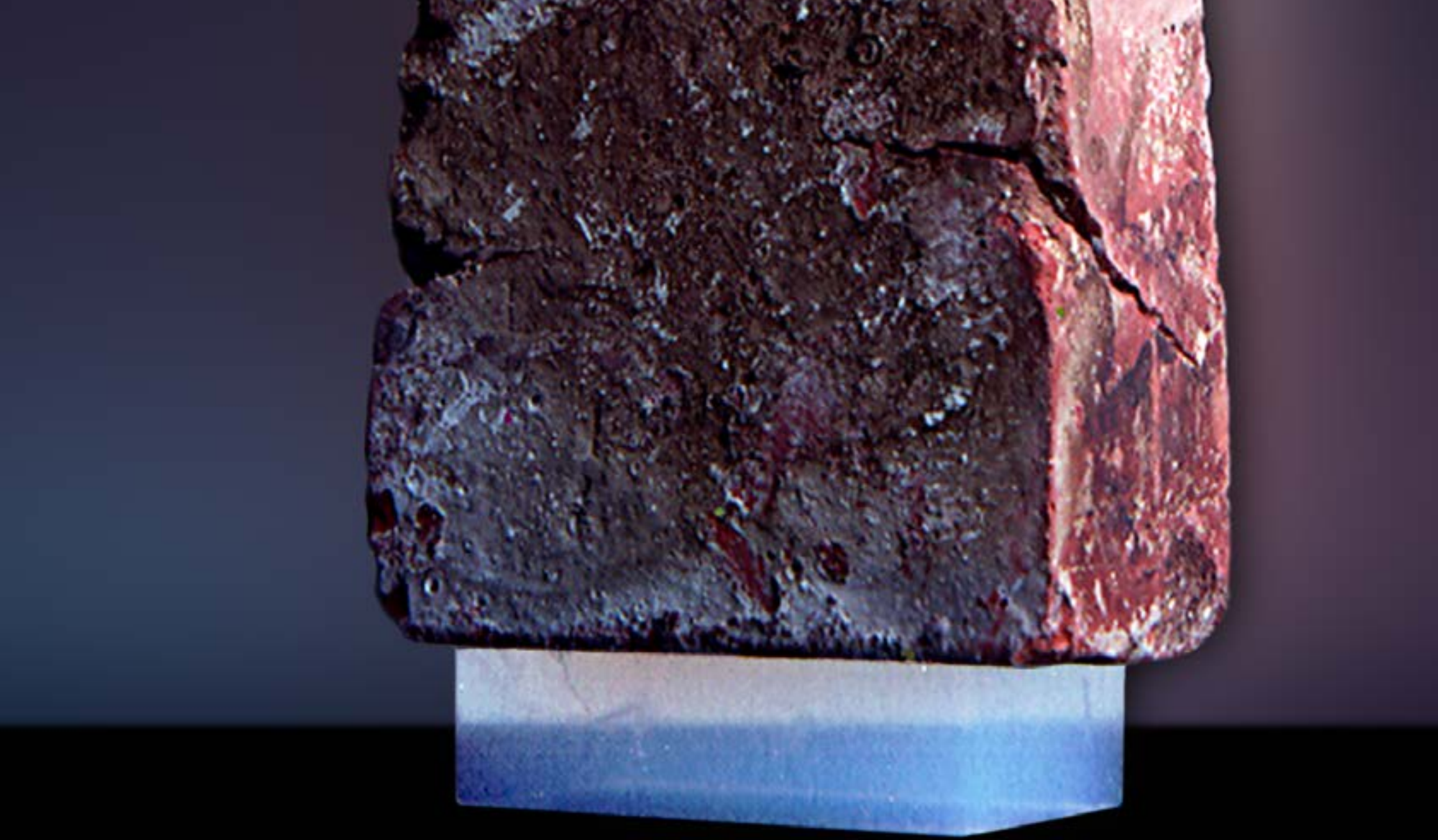
Kistler wanted to remove the liquid without causing this collapse so he used a method called supercritical drying. He used a gel (or jelly) made of silica with liquid alcohol and subjected it to high temperatures and pressures. This causes the liquid to turn into what is called a supercritical fluid. This is a strange state of matter which is neither liquid nor gas. When the pressure is suddenly reduced, the supercritical fluid turns to a gas which can escape from the solid network of the gel, producing the aerogel.

The aerogel has extremely low density and looks like frozen smoke. When touched, it feels like hard expanded polystyrene and will spring back like expanded polystyrene when pushed gently. If poked hard it can dent or shatter. The lightest aerogels have a density of only 4 kg/m^3, about 3 times that of air, and a block the size of an adult has a mass of only about 500 g. The image in the centre spread shows a small piece of aerogel, weighing only 2 g, supporting the weight of a 2.5 kg brick.

Aerogels have very low thermal conductivity. These wax crayons can be heated with a very hot flame without coming to any harm if insulated by aerogel.

Catalyst

www.catalyststudent.org.uk

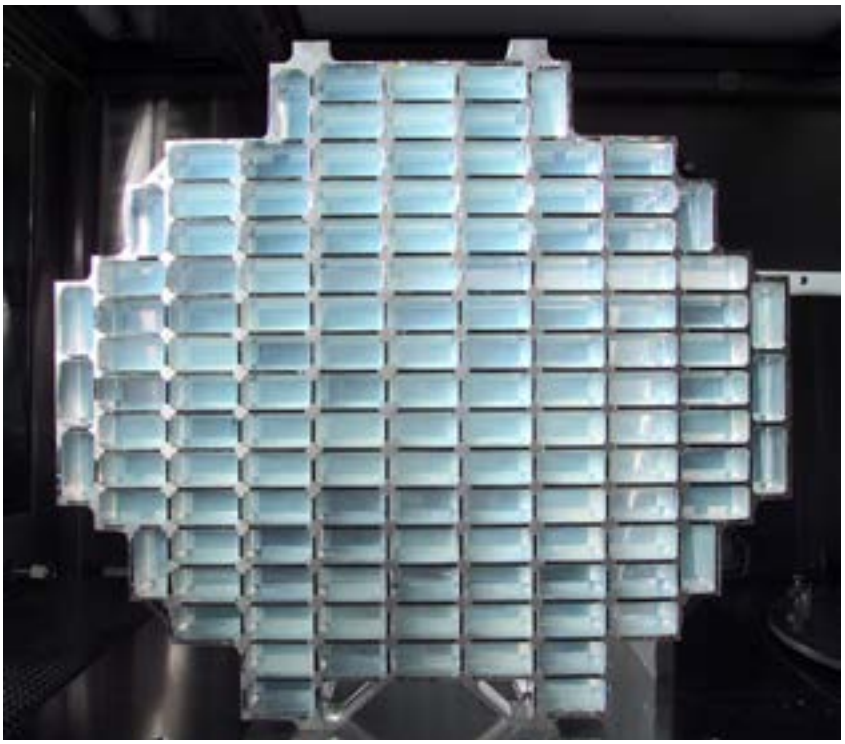


A block of aerogel is strong enough to support a brick.

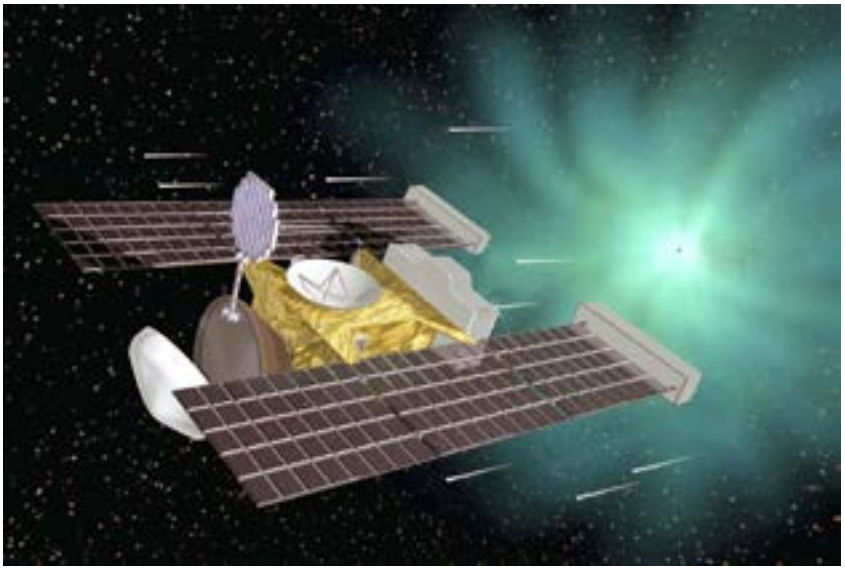
Aerogels in space

In the 1970s more efficient methods of making aerogels were developed. This allowed the number of applications for aerogel to increase.

NASA, the US government's National Aeronautics and Space Administration, used aerogel in its Stardust mission to explore a comet. The aim was to capture particles from the comet and return them to Earth. The main challenge with this is that the particles in the comet travel at up to 6 times the speed of a bullet. The particles are smaller than sand grains and high speed capture could alter their shape or chemical composition – or even completely vaporise them. Capturing them without damaging them requires that they are slowed down with minimal heating.



The dust collector containing aerogel to trap particles from the comet looks like a large tennis racket, as you can see in the artist's impression below.



The Stardust craft, collecting particles left in the trail of a comet

Aerogel, which is 99.8% empty space, is ideal for this. The aerogel is put into an array which looks like a large tennis racket. When a particle hits the aerogel, it buries itself in the material, leaving a carrot-shaped track up to 200 times its own length. This slows it down and brings it to a relatively gradual stop. Aerogel is mainly transparent so scientists can use the tracks to find the particles and view them with microscopes.

In a test of the material, particles were fired into a block of aerogel to mimic how comet dust will be captured in the Stardust mission.

By analysing the aerogel, scientists have found out more about the materials in the comet. They are more complex than had been realised, containing a range of minerals and materials including organic materials, showing that comets are not just lumps of ice.

Making something on Earth for the sake of it, for a bet, has resulted in a highly unusual material that has facilitated the study of a comet. Research often leads to applications which are undreamt of by the scientists originally involved.

Vicky Wong is chemistry editor of Catalyst.

Look here!

For more information about the Stardust mission and how aerogel was used see: *http://tinyurl.com/ot4ce2v*