Aerogel | World's Lightest Material | Aerogel Lighter Than Air | Aerogel Insulation

Aerogel is a very special type of foam which is 99.8% air. Aerogel is a low-density solid-state material derived from gel in which the liquid component of the gel has been replaced with gas. The result is an extremely low density solid with several remarkable properties, most notably its effectiveness as a thermal insulator. Aerogels are solid, but can be less dense then air. Despite their sparse molecular structure aerogels are strong.

It was first invented in the 1930s by Samuel Stephens Kistler, but was very brittle and could not be shaped. Aerogels are traditionally expensive and difficult to manufacture, and they are difficult to handle. Now a team of scientists have discovered how to make it flexible so that it does not break so easily. This means there are a lot of ways in which it can be used to solve problems.

It is nicknamed frozen smoke, solid smoke or blue smoke due to its translucent nature and the way light scatters in the material; however, it feels like exploded polystyrene (Styrofoam) to the touch.

Aerogels posses the lowest density and highest internal surface area of any known solid material, which makes them extremely high performance material for collision, damping, acoustic and thermal insulation, structural support and surface chemistry.

Properties:

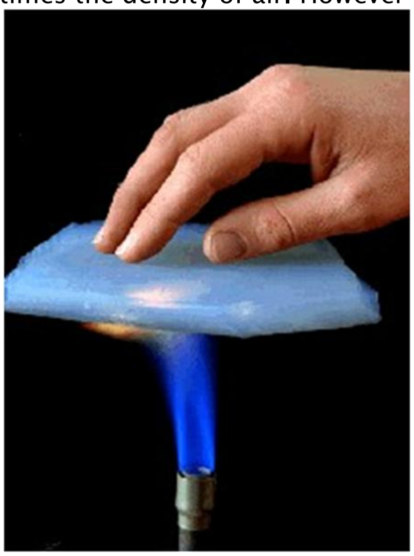
1. Extremely low density
2. Very good thermal insulator
3. High specific surface area
4. Lowest dielectric constant

Metal aerogel Properties:

1. High specific surface area (100-500m2/g)
2. Electrically conductive!
3. Enhanced catalytic activity
4. Surprisingly capable thermal insulator

Interesting Facts:

1. A paperclip has a mass of approximately one gram. A one gram sample of aerogel has an internal surface area of between 250 and 3000m2 per gram (when produced in a weightless environment).
2. Lowest solid density: The lightest man-made material is an Aerogel with a density of only three times the density of air. However industrial aerogels can be made denser, up to 0.6 g/cc or more.



1. Highest porosity: Perhaps the only material that can have over 95% porosity, and a very wide pore size distribution, ranging from Angstroms (10-10 meter) to microns (10-6 meter).
2. Very high surface area: For some Aerogels, one ounce can have a surface area equal to a football field (over 3000 square meters per one gram).
3. Versatile compositions: Aerogels can be made with a wide range of chemical compositions.
4. Functional properties by design: Combinations of the above features can lead to Aerogel materials with useful properties such as:
   - adsorbents,

- catalysts,
- insulators,
- semiconductors,
- piezoelectric,
- dielectric,
- ferroelectric,
- diffusion controllers,
- electric conductors,
- electric insulators,
- and optical features.

5. Can hold (theoretically) 500 to 4,000 times its weight in applied force.

Types of Aerogels:

1. Silica:

• Silica aerogel is the most common type of aerogel and the most extensively studied and used. It is a silica-based substance, derived from silica gel.

• The world's lowest-density solid is a silica Nano foam at 1 mg/cm3, which is the evacuated version of the record-aerogel of 1.9 mg/cm3.The density of air is 1.2 mg/cm3.

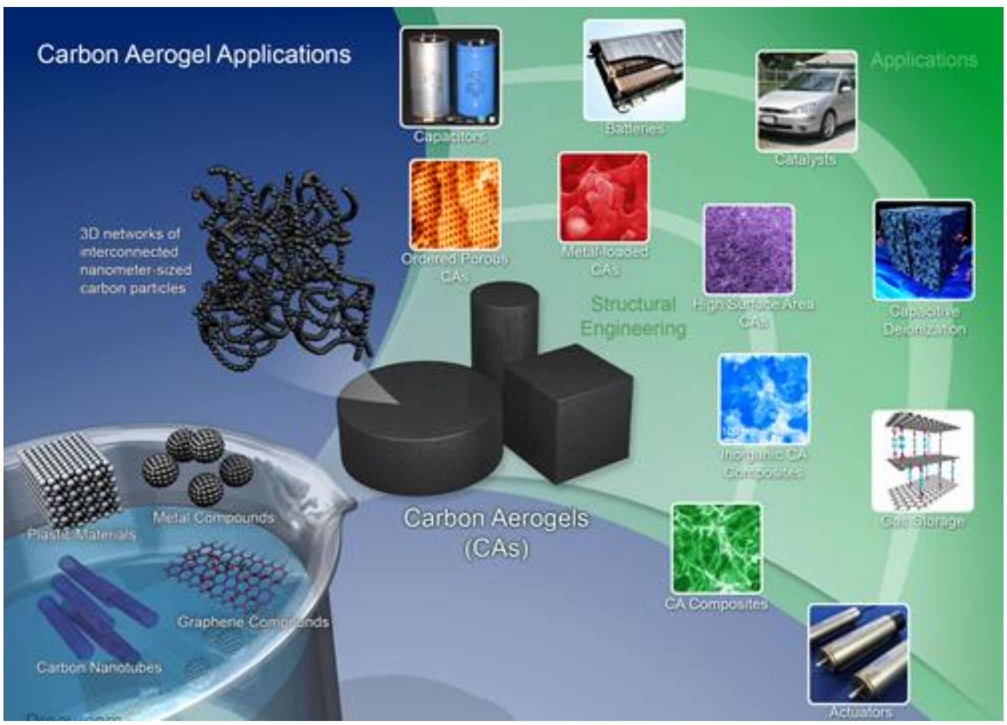
• Silica aerogel strongly absorbs infrared radiation. It allows the construction of materials that let light into buildings but trap heat for solar heating.

• It has remarkable thermal insulative properties, having an extremely low thermal conductivity: from 0.03 W/m·K down to 0.004 W/m·K, which correspond to R-values of 14 to 105 for 3.5 inch thickness. For comparison, typical wall insulation is 13 for 3.5 inch thickness. Its melting point is 1,473 K (1,200 °C or 2,192 °F).

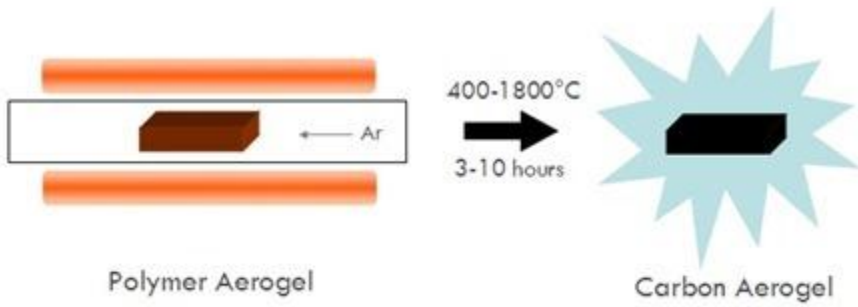
• Silica aerogel holds 15 entries in Guinness World Records for material properties, including best insulator and lowest-density solid.

2. Carbon:

• Carbon aerogels are composed of particles with sizes in the nanometre range, covalently bonded together. They have very high porosity (over 50%, with pore diameter under 100 nm) and surface areas ranging between 400–1000 m^2/g. They are often manufactured as composite paper: non-woven paper made of carbon fibres, impregnated with resorcinol-formaldehyde aerogel, and pyrolyzed.

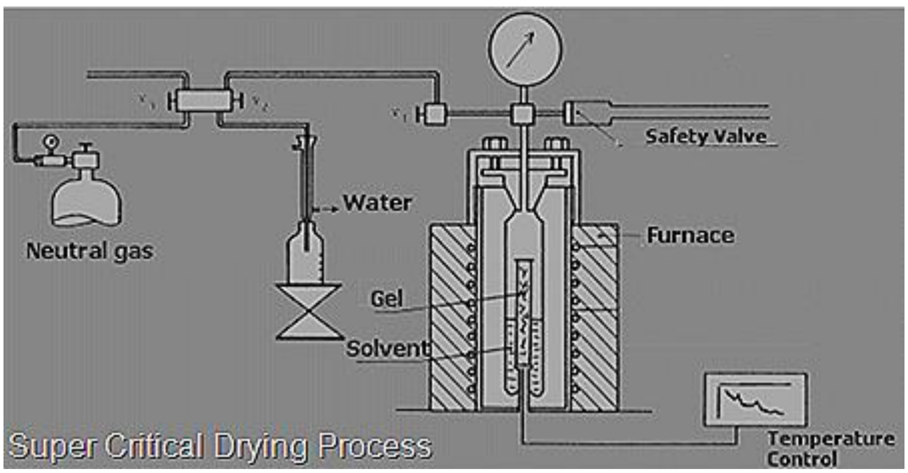


• Depending on the density, carbon aerogels may be electrically conductive, making composite aerogel paper useful for electrodes in capacitors or deionization electrodes. Due to their extremely high surface area, carbon aerogels are used to create super capacitors, with values ranging up to thousands of farads based on a capacitance of 104 F/g and 77 F/cm^3.



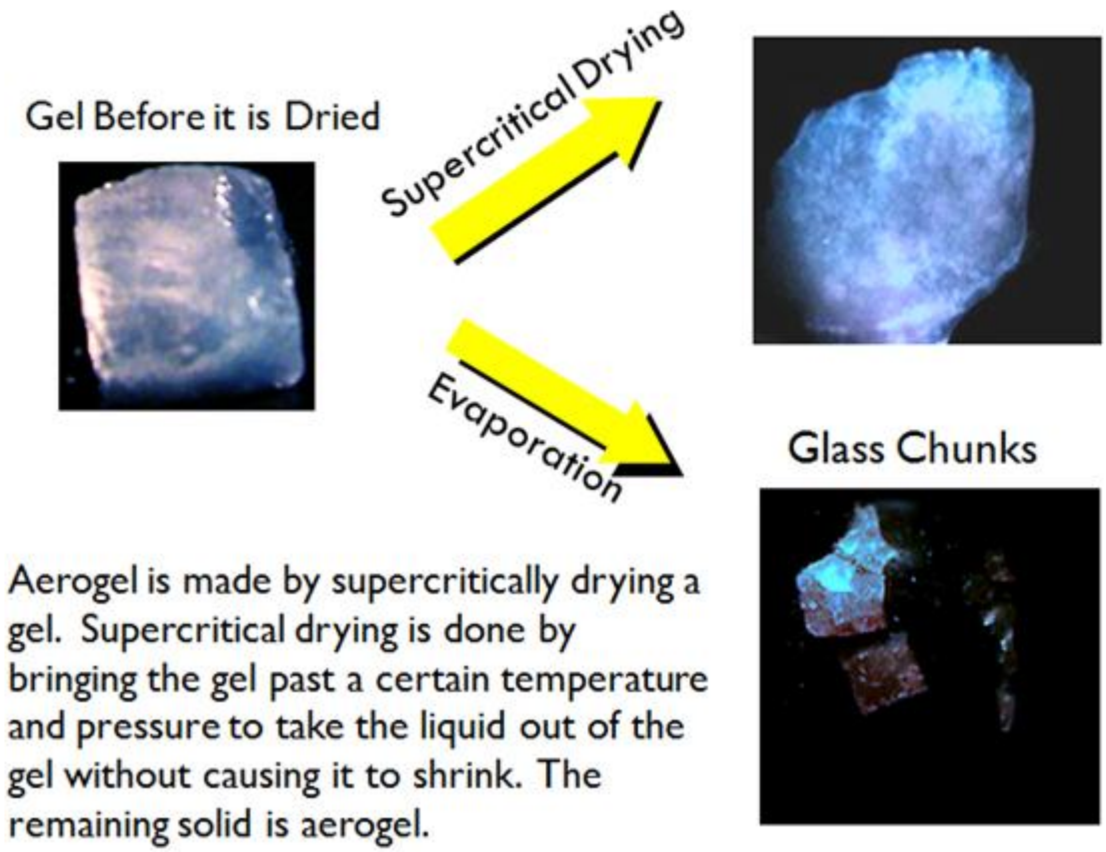
•Carbon aerogels are also extremely "black" in the infrared spectrum, reflecting only 0.3% of radiation between 250 nm and 14.3 μm, making them efficient for solar energy collectors.

Manufacturing:
Aerogels a formed by a process known as supercritical drying, in which the liquid from the gel base is removed and replaced by a gas, leaving a solid structure.



It is prepared like gelatine by mixing a liquid silicon compound and a fast-evaporating liquid solvent, forming a gel that is then dried in an instrument similar to a pressure cooker.

The mixture thickens, and then careful heating and depressurizing produce a glassy sponge of silicon.



Recent Development:

NASA's Glenn Research Centre developed a polymer Aerogel which is strong, flexible, and robust against folding, creasing, crushing, and being stepped upon. These aerogels are among the least dense solids, possess compressive specific strength similar to aerospace grade graphite composite, and provide the smallest thermal conductivity for any solid.

The new aerogels are up to 500 times stronger than their silica counterparts. A thick piece actually can support the weight of a car.

Silica aerogels would crush to powder if placed under a car tire. As seen above, the same is not true of the new polymer aerogels, even if the car is only a Smart car. Overall, the mechanical properties are rather like those of a synthetic rubber, save that the aerogel has the same properties (and far smaller thermal conductivity) with only about 10 per cent of the weight.The new class of polymer aerogels also have superior mechanical properties. For example silica aerogels of a similar density have a resistance to compression and tensile limit more than 100 times smaller than the new polymer aerogels. And they can be produced in a thin form, a film so flexible that a wide variety of commercial and industrial uses are possible.

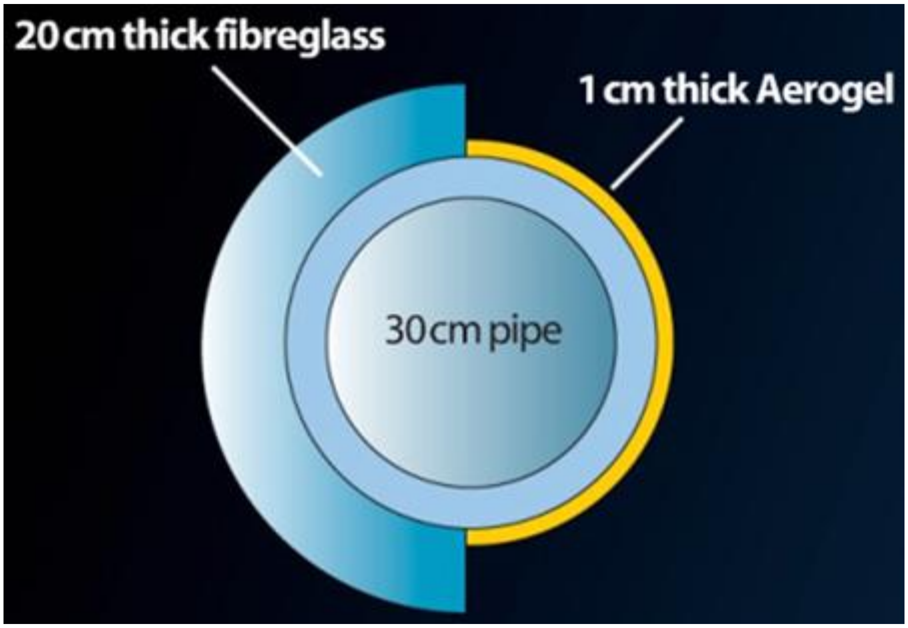
Applications:

Example 1:

Military aeroplane and helicopter engines produce a lot of heat. This means they can be attacked by heat-seeking missiles. If the engine is surrounded by a layer of Aerogel, then less heat escapes for the missiles to detect.

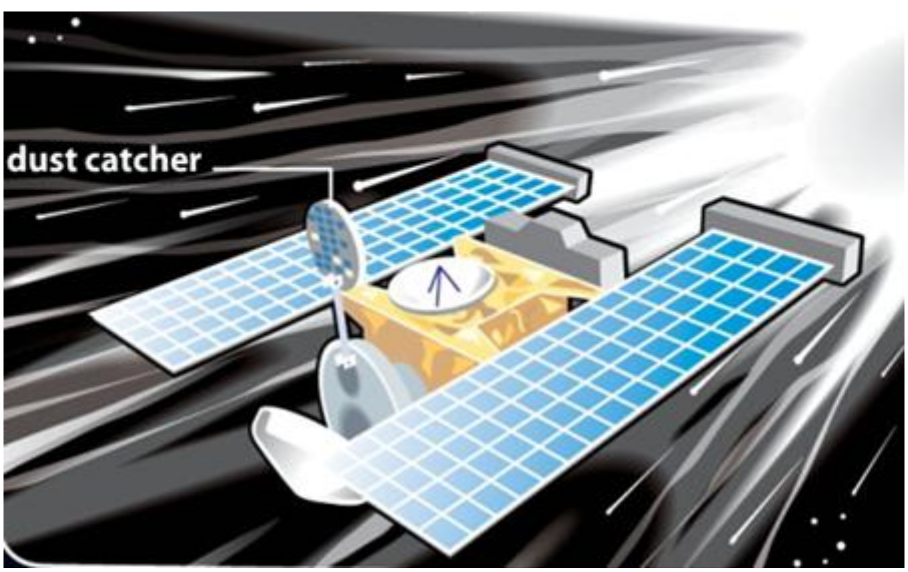
Example 2:

Aerogel can also be used to stop heat from escaping from hot water pipes. When heat escapes energy is wasted, which means more of the earth's energy supplies are used up. Lots of other materials can be used to stop heat escaping, so that aerogel was used.



Example 3:

Scientists look at the dust from comets to find out what the Solar system was like when it was first formed. They want to know what the dust is made of and what shape it is. But it is hard to catch the fast moving dust. If the dust rubs against anything, friction makes the dust hot which can change it. If the dust hits anything hard, that can also change its shape. So scientists use Aerogel in a dust collector on the Stardust spacecraft. As the very small dust particles go through the Aerogel they leave little paths. These paths are used to find the dust particles when the probe comes back to Earth.



More Applications:

1. Fire retardant

1. Oven (regular, pizza, etc.)
2. Grill

3. Furnace
4. Blacksmith forge

2. Insulation (hot or cold):

a. Auto

1. Air intake
2. Engine
3. Exhaust
4. Manifolds

b. Clothing – Only for cold, not warm, since it'll trap body heat!

c. Home

1. Furnace
2. Grill
3. Kitchen
1. Oven
2. Pot holders
3. Pots and pans
4. Coolers and refrigerator's
4. Pipes & air ducts
5. Walls & Roof
6. Windows

3. Blacksmith forge

4. Pulling water out of materials

5. Shock absorption

6. Sound insulation

Source:

http://www.mechanicalengineeringblog.com/category/latest-automobile-technology/aerogel/