Novel Ultra-Low-Density Nickel Aerogel

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Aerogels are the least-dense class of solid material available today, with an enormous surface area relative to their weight and volume due to their porous nature. This makes aerogels attractive in many fields, from particle physics and medicine to the clean-up of oil spills and Mars exploration. Aerogels can be made from a wide range of materials, including metals. However, despite their industrial potential, metallic aerogels have been held back by cumbersome, expensive, and limited procedures. Herein, I have created the very first aerogel made of nickel, through freeze-casting an aqueous suspension of nickel nanowires, followed by a process analogous to freeze-substitution in cellular biology. This technique is fairly simple, inexpensive, and addresses many of the issues with the production of metal aerogels. The aerogel's density is ultra-low, even compared to that of other aerogels, at 0.0441 g/L (only 0.495% the density of bulk nickel). It has a high surface area, 99.5% porosity, eminent magnetic properties, and a uniform structure that is moldable via a magnetic field during casting. While the initial aerogel had a very high electrical resistivity, I introduced a sintering procedure, which maintained the aerogel's features while resulting in an extremely low resistivity. The sintering also improved the aerogel's structure and chemical purity. Beyond its novelty, the nickel aerogel has great potential as a hydrogenator in catalytic processes, and as an efficient solid-state storage material for hydrogen. The latter is an important step towards the adaptation of hydrogen into a renewable, clean, and reliable fuel for transportation.

Awards Won:

First Award of $5,000

American Chemical Society: Certificate of Honorable Mention