

Web Exclusive: Shedding New Light

by Bonnie MacLeod

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A material that can withstand the rigorous demands of both deep-space and deep-sea environments is now being used to create skylights that are revolutionizing the daylighting industry. The product of nanotechnology, the mind-boggling process of manipulating matter on an atomic or molecular scale, the material almost redefines the term high-performance. The innovation is aerogel, a "miracle material" that can significantly reduce -- and in some cases virtually eliminate -- the thermal disconnect associated with fenestration making it possible to manufacture skylights that are up to six times as energy efficient as their predecessors.



Wasco structural skylights with Nanogel translucent aerogel.

Wal-Mart, Lockheed Martin, Pennsylvania Power & Light and others have amply demonstrated the many benefits of daylighting for commercial applications -- namely, increased worker productivity, reduced absenteeism, increased sales and, of course, savings in lighting costs. Until recently, however, a loss in thermal protection was the accepted trade-off. But aerogel has dramatically changed those calculations. Now, it is possible to create a daylighting system that provides all of the advantages of natural light with an insulating value approaching that of an exterior wall.



Wasco unit skylights with Nanogel translucent aerogel.

An Innovative Insulation

Aerogel is considered to be the best solid insulator on the planet -- 39 times more effective than the highest-grade fiberglass insulation. It is made from a gelatinous form of silica, the principal component in glass, which is desiccated to produce a porous network of interconnected nanostrands of silicone dioxide, each of which measures a mere 1.5 nanometers (one nanometer equals one billionth of a meter) in diameter. Viewed under a microscope, aerogel resembles a field of quartzlike barbed wire. This tangle of glass nanostrands creates a navigational dilemma for air moving through it, impeding its flow and, consequently, stemming heat loss or solar gain. In fact, aerogel is such a good insulator it maintains its structure when subjected to heat from a blowtorch in excess of

1,300 degrees Celsius. NASA may eventually use it to insulate both spacecrafts and spacesuits.

Aerogel has been used to meet a number of diverse and exceedingly difficult technical challenges. In 2006, NASA's Stardust spacecraft landed in Utah having collected interstellar space dust particles 242 million miles from earth using an aerogel-filled collector. The material was chosen because it is the lowest density product known to man (it is comprised of 97-percent air and 3-percent solids) and has an enormous surface area (one gram flattened out would expose a surface area the size of a football field). Due to its capacity to function as a super sponge, it is also being considered for use in cleaning up oil spills and filtering wastewater.

The Benefits of Frozen Smoke

Although it was discovered in 1931, aerogel was not commercially available until the early 1990s when Cabot Corp. made a breakthrough in the manufacturing process allowing the material to be produced more economically. In 2002, the company engineered another advance -- a translucent aerogel -- that has revolutionized the design of skylights. When sealed inside double-wall translucent or transparent panels, the aerogel gives skylights high-performance properties while allowing for the transmission of glare-free, full-spectrum and diffused light. The nanotechnology permanently stops convective, conductive thermal transfer with no noticeable effect on light transmission and gives aerogel an R-value of R8 per inch. With an aerogel-improved panel 2.5 inches thick, it is possible to achieve an R-value of R20 and still provide sufficient daylight.



The matches resting on top of the aerogel are protected from the flame underneath. Photo courtesy of NASA/JPL-Caltech.

Aerogel's lightness, ethereal appearance and hazy-blue cast have earned it the nickname "frozen smoke." But the product is so durable it has been chosen to insulate a 39-kilometer subsea pipeline in the deepwater Gulf of Mexico; and its compressive strength (it can hold up to 4,000 times its own weight in compressive force) allows it to withstand a direct blast of 1 kilogram of dynamite.

In addition to its insulating value and durability, aerogel has other beneficial attributes. For one, skylighting systems insulated with aerogel reduce sound transmissions by 25 to 70 percent while increasing acoustic performance. The product is UV stable; its performance will not degrade over time. It is also completely moisture resistant. Aerogel repels water and resists vapor migration, which limits the build-up of condensation. And its chemical composition makes it unable to support the growth of mold, mildew and fungus.



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Illuminating Slumberland

CMA, a Minneapolis-based architectural firm, chose aerogel skylights for two Slumberland stores in Minnesota. The retail furniture chain installed 24 units at its Maple Grove location -- approximately 432 square feet of 16-mm polycarbonate aerogel-filled skylights -- to illuminate 30,600 square feet of retail space. The units were chosen in lieu of dome skylights, and according to Wasco, the Maine-based skylight manufacturer, they provide triple the R-value of standard polycarbonate skylights while offering UV protection, which is of particular concern for a furniture store.

Slumberland was so pleased with the results, the company decided to use the skylights for a second store and expanded the installation to include the warehouse section of the building. "Our client was most impressed with the uniform diffusion of natural light in the center of the building," said Gary Fagerstrom, CMA's project manager. "Slumberland has a sophisticated system of spotlights for its retail spaces, but in the stores where they have installed these skylights, they don't use them at all during the day."

Because aerogel is the lightest solid on earth, costs and greenhouse gas emissions associated with transportation are significantly reduced. The material is completely recyclable, reusable and earth friendly earning it the 2008 Silver Cradle to Cradle certification from MBDC and the company's assessment of aerogel as "an excellent technical nutrient" and "an elegant solution to the problem of thermal and sound insulation."

The ultra high-performance properties of aerogel make it seem like the stuff of science fiction. Described in superlatives, the material appears almost too good to be true -- a product for the future. However, in today's market where sustainability is the benchmark for good design and products are expected to satisfy multiple performance criteria, materials like aerogel -- once considered the domain of mad scientists -- may well become the norm.



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