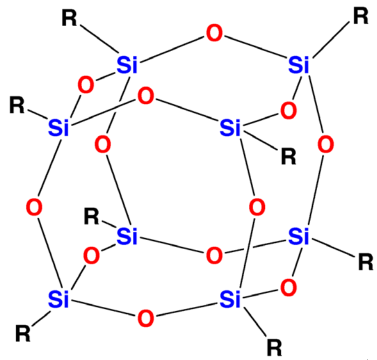
EXPANDED POSSIBILITIES

A Mississippi-based nanotechnology company finds a multitude of uses for a new polymer



When a Northrop Grumman Antares rocket blasted off from Wallops Island, Virginia, in November, 2018, it carried a promising nanotechnology that could help next-generation satellites and high-altitude airships keep critical telecommunication, surveillance, and weather monitoring technologies functioning in extreme environments.

Solar panels power these high-altitude craft. However the treacherous environments they operate in are filled with radiation that can quickly degrade the solar cells. To improve their efficacy, engineers have, for decades, covered the cells with an ultra-thin protective glass. But the glass is heavy, and complicated to install.

Hybrid Plastics, a nanotechnology company based in Hattiesburg, Mississippi, used Small Business Innovation Research (SBIR) contracts from the Air Force and Missile Defense Agency (MDA) to develop a protective cover for the solar cells. Markedly lighter than glass, this new protection can be simply sprayed on. The nanotechnology, commercially manufactured by NeXolve Materials and called CORIN XLS, is currently being tested on the International Space Station, and is showing excellent results, according to Brandon Farmer, the company's director of advanced materials.

"These solutions would not have been found to be viable without the support of the SBIR program," said Carl Hagstrom, Hybrid Plastics' Chief Operating Officer.

Steve Best, an engineer and physicist who worked with some of Hybrid Plastics' nanotechnologies at Alabama's Auburn University, said the cell panel coverings had to address two complex issues. One was brutal atmospheric conditions. At high altitude, atomic oxygen and ultraviolet radiation can mean, according to Best, "double the trouble." The other was the exacting technical demands of cutting-edge air and spacecraft.

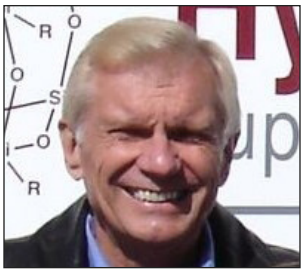
"In that business you are competing for every little fraction of a percent of efficiency," he said.

In the late 1980s, Joseph D. Lichtenhan, now the president of Hybrid Plastics and then a graduate student at the University of California-Irvine, came across a unique family of molecular cages that he thought could improve a diverse array of products. The cages were made up of silicon and carbon compounds—a hybrid of inorganic and organic elements. Some of them had been created a century earlier. In the 1960s a company had experimented with some of them to make a more biocompatible breast implant, but the expense of production proved too high.

Understanding the potential of hybrid plastics, in 1996 Lichtenhan won a National Institute of Standards and Technology Advance Technology Program grant to continue studying them at the Air Force Research Laboratory at Edwards Air Force Base in Palmdale, California. He wanted to learn if they could make aerospace plastics lighter, stronger, and more heat resistant. It was there that he invented and patented the nanotechnology called Polyhedral Oligomeric Silsesquioxane, better known as POSS®. Able

to be used in solid, semi-solid and liquid forms, POSS nanoparticles are 1,000 times smaller than a human hair.

Hagstrom added, "It's a platform technology, it can do all sorts of things."



Carl Hagstrom

POSS has shielded precision helicopter turbine engines from corrosive dust and it has strengthened ships' hulls. It has made dental materials more durable, improved electrical solders, and made white paints containing titanium dioxide release fewer pollutants. Other uses include improving cosmetics, building smaller microchips, making sausage casings, and enhancing rubber for oil and gas drilling. In laboratory tests, POSS has even showed promise in creating scaffolding for duplicates of human body parts that living cells can permeate and subsequently grow into tissue. POSS might one day help manufacture ears, noses, heart valves, blood vessels, intestinal lengths, and trachea; thereby decreasing dependency on human donors and eliminating risk of organ rejection.

For the solar cells of low earth orbit aircraft, POSS was used to make the transparent film coating. The coating created a layer of protection for the solar cells that could seamlessly connect to the frames bordering the solar panels. It was, "lighter weight and excellent protection from atomic oxygen, better than other polymeric coatings," said Garrett Poe, a polymer science engineer who helped develop the nanotechnology.

Brian K. Wells, a former senior research associate at Auburn who also worked on the POSS solar cell coatings, said it was a great example of an enabling technology.

"It's a technology that doesn't just benefit itself but it makes other products and other applications possible," Wells said. "That's what SBIRs are always looking for."

With a $2 million grant from the Department of Commerce in 1998, Hybrid Plastics soon grew beyond the Air Force Research Laboratory in California. Shortly afterward, President Bill Clinton was advised by cabinet members that nanotechnology's, "impact on the health, wealth and security of the world's people is expected to be at least as significant as the combined influences in this century of antibiotics, the integrated circuit, and human-made polymers."

Expecting growth, in 2004 Hybrid Plastics moved to a 35,000 square foot facility located on 15 acres in Hattiesburg, close to the renowned School of Polymer Science and Engineering at the University of Southern Mississippi.

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POSS represents the military's first new polymer feedstocks since the 1960s. In 2005, President George W. Bush determined that POSS products were in the strategic interest of the United States, allowing the company to receive funding under Title III of the Defense Production Act. That program "created POSS production capability at Hybrid Plastics to meet current and future warfighter needs," said John Crabill, a program manager at the Air Force Research Laboratory at Wright-Patterson Air Force Base in Ohio.

As the company grew from six to 20 employees, its manufacturing capacity grew also. Today it is one of the top 10 nanotechnology companies in the U.S. Hybrid Plastics has won three R&D Magazine Top 100 Award for its innovations, as well as an award for outstanding customer service from the market research company Frost & Sullivan. In 2015 it won the prestigious Tibbetts Award; the SBIR program's version of being inducted into the Hall of Fame.

"Hybrid Plastics has found the SBIR program exceedingly helpful, if not critical, to the development of many of the applications for which its POSS chemicals are used," Hagstrom said.

Hybrid Plastics
Hattiesburg, MS
Modernization Priority: General Warfighting Requirements (GWR)
SBIR contract: HQ0006-05-C-7227 • Agency: MDA • Topic: MDA04-036, POSS Nanochemical Technology for Radiation Hardened/Tolerant Systems SBIR contract: FA9453-06-C-0091 • Agency: Air Force • Topic: AF05-022, Radiation-Resistant Nanoscopically Enhanced Solar Cell Coverglass