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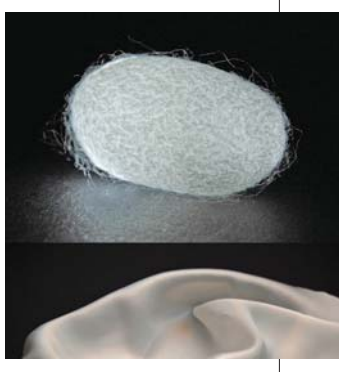
New Research on High-Tech Metamaterials Made from Silk Fibers. by Kathlyn Swantko

Ancient Innovation

A fascination with silk's natural properties led researchers at Purdue University to new discoveries about this age-old fiber. For example, Purdue's research into the physical properties of silk fiber provided a better understanding of silk's inherent self-cooling quality. (It's interesting that even some ancient Asian writings mentioned that silk underwear would keep the body temperature cool in the summer and warm in winter.)

The research also demonstrated that silk could be hybridized with photocatalyst-like biomaterials (such as fluorescent proteins). This hybrid silk could be used as a "natural" metamaterial in biomedical and environmental applications that would protect people from exposure to ionized radiation and for remediation against potential harmful pathogens in the environment. (Metamaterial is a nanomaterial, engineered with properties not usually found in natural materials).



The light strongly scattering from a natural silk cocoon, indicating that silk fibers are natural metamaterials with densely packed nanostructures. Bottom: The brilliantly "white" and "lustrous" reflection of natural silk fabrics without any chemical treatments.

Under the direction of Young Kim, associate professor of biomedical engineering at Purdue, the research team is supported by the Korean National Institute of Agricultural Sciences, which produces silk and fluorescent silk; and the U.S. Air Force Research Lab at Wright-Patterson Air Force Base, which is theoretically characterizing the thermal properties of silk.

Through their research, the team became interested in the "brightly white" or "silvery" qualities provided by natural silk fibers, which create a "lustrous" or "sparkling" reflection. It was discovered that natural silk fibers have densely packed nanostructures. Each silk fiber is 10-20 micron in diameter and is made up of more than 3,000 tiny nanofibrils, each less than 100 nanometers wide. An important finding was that this nanostructure is beyond what can be manufactured using conventional nanoscience technologies.

"Our findings have shown that silk scatters light strongly, and that silk dissipates heat to the surroundings," states Kim. "Among several physical measurements of natural silk, we have characterized the optical and thermal properties of natural silk, while reflecting sunlight and dissipating heat to a cooler space. This means that silk can cool down the temperature without using any external energy, such as electricity," continues Kim. "Even though this result could be used directly in such applications as combat uniforms and thermal camouflage, we also discovered a new design principle for the synthetic materials."

The Purdue team found that fluorescent silk can break down organic containments and kill harmful pathogens upon green (visible) light irradiation. "We discovered that silk, produced by silkworms, can directly be used as fabrics or can be processed into materials and structures to host other functional nanomaterials," explains Kim. "The introduction of far-red fluorescent proteins from silk provides a photosensitizer hybridization platform for immediate, usable and scalable biomaterials."

Recent advances in nanotechnologies and nanophotonics have already shown a variety of possibilities for engineering nanomaterials and nanostructures to possess properties that don't exist naturally in the silk fiber. However, these nanomaterials are often intrinsically limited for large-scale, sustainable, economical, and eco-friendly production. Therefore, it was important to use natural products like silk as the basis for the research.

Looking Ahead Optimistically

Kim is confident that the team can develop advanced nanotechnologies using existing textile methods that are currently being used to weave silk into fabrics. Kim says, "Our findings provide the groundwork for exploiting natural silk as photonic nanomaterial hybridization platforms to implement embedded functionalities into the silk fiber, which can be then woven into large-area fabrics."

Kim's team believes they have just scratched the surface regarding the future use of silk fibers as high-tech 'natural' metamaterials for medical, military, and first responder applications. ●

For more information on Purdue's research on "High-Tech Metamaterials Made from Silk Fibers," contact Dr. Young Kim, Associate Professor of Biomedical Engineering: youngkim@purdue.edu, 765-496-2445.

Kathlyn Swantko, president of the FabricLink Network, created TheTechnicalCenter.com for Industry networking and marketing of specialty textiles, and FabricLink.com for consumer education involving everything fabric.