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SENT TO LSU AGCENTER/LOUISIANA FOREST PRODUCTS DEVELOPMENT CENTER - FOREST SECTOR / FORESTY PRODUCTS INTEREST GROUP

Nice article sent from Bill Wieger. It was published in Sport Aviation Magazine.

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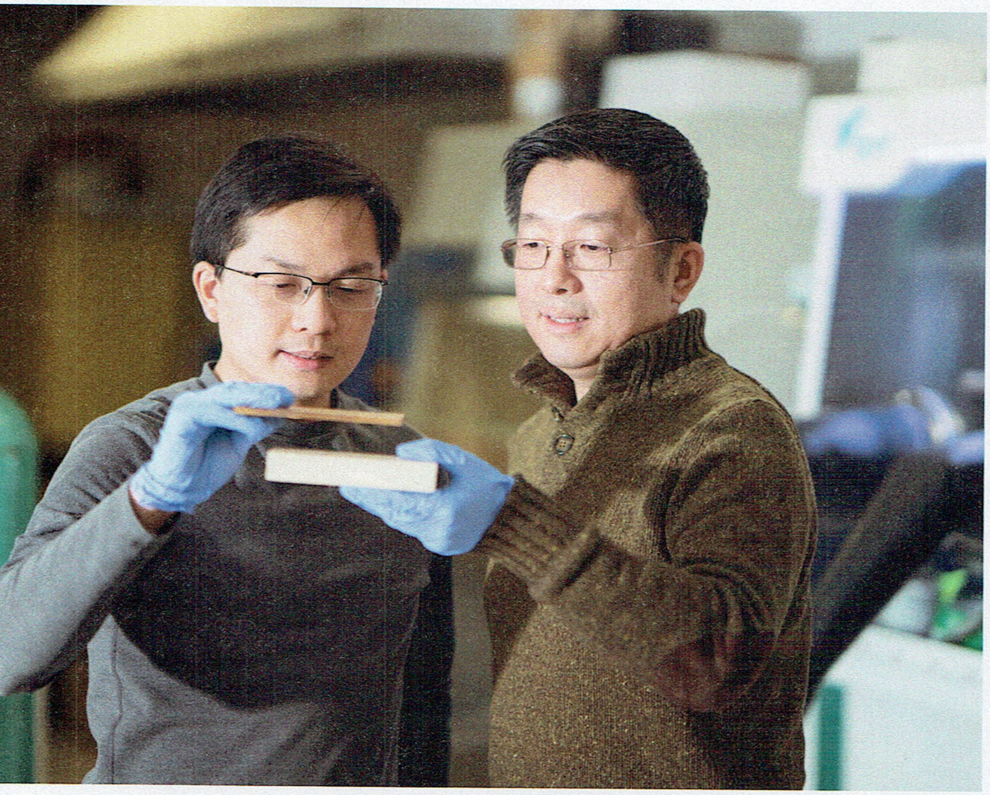
Super Wood

Transforming natural wood into high-performance material

BY BETH E. STANTON

QUALITIES SUCH AS STRONG, lightweight, and inexpensive can be mutually exclusive. What possibilities might exist if wood could somehow be made as strong and durable as steel or carbon fiber but at a fraction of the weight and cost? Researchers at the University of Maryland have discovered a process to engineer wood into a product that is more than 10 times stronger and tougher than natural wood, creating a material that is as strong as steel but six times lighter.



TOTALLY TUBULAR

Liangbing Hu is an associate professor of materials science and engineering at the University of Maryland in College Park. While conducting research for his doctorate degree in physics, he worked extensively with carbon nanotubes (CNT), cylindrical tubes with a diameter 10,000 times smaller than a human hair. The bonding between the atoms of CNT make it stronger than steel, and it's one of the most popular nanomaterials. However, CNT is exceedingly expensive, worth about 50 times more than gold.

While talking to a colleague, Professor Lars Wågberg from the Royal Institute of Technology in Stockholm, Sweden, one day about trees and paper, Liangbing realized that wood fibers are very similar to CNT.

"A tree is actually made out of these tiny tubes of fibers," Liangbing said. "Nature is producing many tons of these kinds of fibers every day."

He began to get excited about this plentiful, renewable, and cheap material.

"Even though I am a physicist, I work with wood because to me it is an amazing material," Liangbing said.

> **"Hot pressing the wood removes the pores (open channels) that are mechanical defects in terms of strength and toughness."**
>
> – Liangbing Hu

HIGH PERFORMANCE

Rather than working with wood in the same ways as other scientists in the wood research community, Liangbing began experimenting with high-performance applications. Current methods to increase the mechanical performance of wood, such as treatment with ammonia, heat, steam, or cold rolling, create a product that can expand and weaken when exposed to humidity. By looking at wood from a physicist's perspective, Liangbing asked, "What is wood made of, and what do we need it to do?"

Liangbing and his team came up with a solution that seemed very simple: wood densification.

"It became very clear to us that we may want to try this," he said. "We tried it, and it worked."

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DENSIFICATION PROCESS

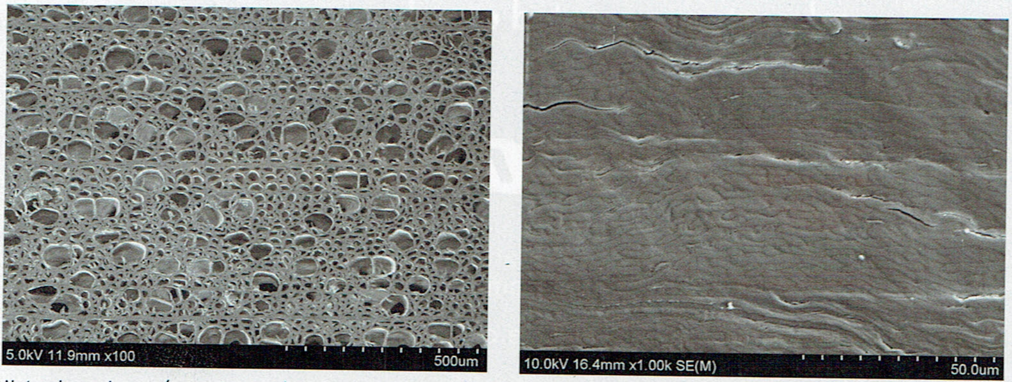
Liangbing explained the two-part wood densification process.

"You take a piece of wood and basically press it," he said. Hot pressing the wood removes the pores (open channels) that are mechanical defects in terms of strength and toughness. Once the wood fibers are crushed together, the defects are removed and the aligned cellulose nanofibers form hydrogen bonds that are connected at a much higher strength. The compression makes the wood five times thinner than its original size.

The key step before pressing is the partial removal of lignin, the yellowish glue that binds the wood fibers of a tree together to allow it to grow tall.

"The important thing is that we are the first ones to come up with the idea of taking something out first and then pressing," Liangbing said.

Removing the lignin allows the wood to become more compressible, but remove too much and there is not enough to hold the fibers together. Removing approximately 50 percent of the lignin is the optimal sweet spot for compressibility and integrity.



Natural wood pores (open channels) are crushed together during the desification process, aligning cellulose nanofibers to form stronger bonds.

STRENGTH

Teng Li, co-leader of the team and associate professor of mechanical engineering at UMD, measured the mechanical properties of the densified wood versus natural wood by shooting it with projectiles. The projectiles pierced clear through the natural wood, while the densified wood stopped projectiles partway through. Teng's experiments measured an increase of greater than 10 times the strength, toughness, and ballistic resistance in the densified wood, along with greater dimensional stability.

"The specific strength of a material is its strength divided by weight," Liangbing said. "When you have a very high specific strength, it means you have a high strength and a low density."

Strength is measured as a force per unit area, with the unit being a megapascal (MPa). Steels with strength levels above 550 MPa are called advanced high-strength steels (AHSS), and the majority of steel used in automobiles measures about 800 MPa. The strength of the densified wood equals this automotive steel strength. Metals such as steel and aluminum alloys could potentially be replaced with this densified wood and used in buildings, cars, and airplanes.

RENEWABLE RESOURCE

Hardwoods take decades to grow. Faster-growing softwoods that are mechanically densified by Liangbing's process exceed the strength of any wood found in nature. Different species of wood vary in density and shape due to unique growth rates and environments.

"There are so many different kinds of wood, but to me they're all the same," Liangbing said. "It's a material that has the same components — cellulose, hemicellulose, and lignin and channel structure."

The densification process is generic and universally effective for different species. The wood may be bent, shaped, and cut.

"At the end of the day, it's still a piece of wood," he said.

WOOD NANOTECHNOLOGY

Liangbing and his team are researching other uses of wood nanotechnology, including strong, clear paper for replacing plastic, transparent wood for energy-efficient buildings, photonic paper for increasing solar-cell efficiency, and a battery and super capacitor made from wood.

> **"At the end of the day, it's still a piece of wood."** – Liangbing Hu

"Paper in one sense is very stable and lasts thousands of years in a library, but at the same time it will decompose within weeks when exposed to the elements," Liangbing said. "This material is fully biodegradable and sustainable with amazing properties and can be used in our everyday life."

The trend now is to use biomaterials to replace human-made materials.

"Steel, glass, and plastic are wonderful, and that's why they're used everywhere," he said. "But for some applications, we can gradually replace many of them so that we can have a better sustainable future."

INVENTWOOD

The UMD spinoff company Inventwood is a startup founded in 2016 to study these new wood technologies. It has funding from the U.S. Department of Agriculture and is actively engaging with investors to get products to market. While the densified wood performs well in university studies, it is now being tested in the real world. Replacing structural materials for transportation or construction applications requires extensive fatigue, duration, and lifetime testing.

"We're on the path and want to take the time and be patient," Liangbing said. Companies in the automotive, building, and furniture industries have approached Inventwood about product possibilities.

"They all want something that is strong and lightweight," he said. "My mission is to replace a lot of existing materials with wood-based materials for better sustainability, better performance, and lower cost." EAA

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