Engineered Superwood Stronger Than Steel

Researchers at the University of Maryland are transforming wood by modifying its cellular structure. They've made it squishy and bouncy like rubber, transparent like glass, and as strong as steel and titanium alloys.

Since 2013, Dr. Liangbing Hu's lab has been reengineering wood at the nanoscale. The researchers utilize various chemical, mechanical and thermo technologies to create the new types of wood.

Hu started working with wood after noticing the similarities between cellulose nanofibers and carbon nanotubes. In fact, the cellulose nanocrystal is stronger than a carbon fiber. A key difference is the lower cost and sustainability of wood compared to lab-produced carbon fiber.

Over the next several years, he modified the wood to create transparent paper and a glass-like material. He also developed a type of wood that was flexible and could bounce like a Superball.

The version of wood that has attracted the most attention is Superwood. It's five times thinner but has four times the density of regular wood. It's 4 to 20 times stronger and stiffer, with 3 to 10 times higher dent resistance. It boasts 50% greater tensile strength than steel and has 10 times the strength-to-weight ratio.

Superwood offers excellent UV and weather resistance and experiences minimal dimensional changes, such as swelling and warping. Exterior-grade Superwood withstands freeze-thaw cycles and temperature fluctuations.

It has a Class A fire rating, is resistant to moisture, termites and fungi, and has even demonstrated bullet resistance. In one test, a bullet penetrated through untreated wood but lodged halfway through a same-sized block of Superwood.

To produce it, Hu uses food-grade chemicals to modify lignin and selectively remove hemicellulose, then applies heat and pressure. This causes the wood's structure to collapse and the cellulose fibers to realign, forming new chemical bonds.

Hu licensed Superwood to InventWood. This summer, the company began commercial production of interior finishing materials using woodchips as the cellulose source. This fall, InventWood plans to introduce exterior-grade panels for siding and roofing. In the next few years, the company aims to begin producing structural beams and columns. That's only awaiting certification.

You don't need special tools to work with Superwood. Regular woodworking tools work well, although its density might call for slightly different techniques. Like wood, it can be treated with most standard finishes.

Superwood's initial pricing is described as competitive with high-quality tropical hardwoods and hybrid woods, such as wood fiber composites, steel or concrete.

Although it's much more expensive than steel on a pound-for-pound basis, other factors are important. The 10-fold higher strength-to-weight ratio means a 10-lb. Superwood beam can match the load capacity of a 100-lb. steel beam. This can bring the effective cost closer to steel. As production increases and costs decrease, the price difference will narrow.

Superwood is five times thinner, but has four times the density of wood. It's 4 to 20 times stronger.

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Renovator Helps With Pasture Compaction

"I noticed compaction was starting in my pastures, often the water was ponding after a large rain, and thin spots were appearing where cattle traveled more frequently," says Ryan Preul of Truxton, Mo. "I wanted to be proactive and do something about combating the problem."

Preul originally hoped to use an old cultivator frame and toolbar to build his own renovator. He tried to buy only DMI 4200 NH3 applicator openers to attach to his cultivator frame, but he could only find entire pieces of equipment for sale. After agreeing to purchase an older DMI applicator, he was offered a second unit when he arrived to pick up the first.

"I'm glad I went this route instead, as the DMI has a lot of weight and that's what I needed to do a nice job," he says. "They're heavy-duty and put together right."

Preul cut the wings off one of the units to use only the center section. He spaced the 17 20 1/2-in. fluted opener blades from the two applicators at 9-in. centers. Each opener has a 45-degree side-to-side radius and a stop to allow for turning corners without lifting out of the ground.

Behind the modified applicator, he attached an adjustable Deere 2200 tine harrow. To make the machine even heavier, he added Deere slab weights to the center and rear. In the future, he'd like to add an extra 600 lbs. to the back of the machine.

"The harrow was also added for weight and to better see exactly where I've been," Preul adds. "It does a great job pulling dead grass up and breaking up manure piles because I'm easily getting the blades in the ground up to 8 in., leaving very little disturbance to the ground."

The renovator pulls about the same as a 15-ft. no-till drill and can be operated at higher speeds to cover more acres. Preul says it's great for following the manure spreader, breaking up and smoothing out any clumps. He tested the machine in April and could clearly see where he had gone. He notes that the grass is greener in those locations.

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He would like to run over some hay ground this fall to evaluate its impact, but because of the dry conditions in his area, he'll need to wait for rain.

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Robotic Weeder Serves As Teaching Aid

Agricultural engineers at North Dakota State University (NDSU) have created a robotic weeder, but it's not available for purchase. Its purpose is to educate students and farmers about new technologies like AI, robotics and imagery that can help automate weed control.

"We're using the robot to educate the next generation of farmers," says Dr. Xin Sun, Agricultural and Biosystems Engineering, NDSU. "We want our students to have the opportunity to learn these technologies and bring them back to the farm."

Sun's research team is creating multiple prototypes for weed control in small grains, row crops and specialty crops. Essential to this work is developing algorithms to improve the robot's efficiency and AI models to identify specific crop and weed species in the field.

"Our team has collected over 20 million images of crops and weeds in different formats of imagery data to train and test our AI models to recognize the specific crop and weed species in the field," he said. "Our goal is to use AI to recognize the weeds and treat them automatically, chemically and mechanically, without human interaction.

"Right now, we're proud to say we've established some amazing weed/crop algorithms, and currently we're in the stage of making some final products for farmers to test the technology," adds Sun.

One of the prototypes uses AI deep learning and machine vision for spot spraying weeds. Arjun Upadhyay, a doctoral graduate research assistant, developed it.

Other prototypes include a 3-row mechanical weeding system with side-specific weed control based on a predefined weed map for targeted weed removal.

All of the prototypes are based on a robot developed at NDSU. They utilize drone-collected field maps, advanced camera systems, and AI-powered decision-making to make split-second decisions on weed-control actions and precise targeted treatments.

The research team is also exploring ways to partner with the private sector.

"We're looking for ways to share our research and for mutual ways to collaborate," says Sun. "We've had discussions with one robotics company on tackling problems in wheat production."

Developing the robots and using the various technologies is just the first step for Sun. Transferring the knowledge to the end user is the primary goal.

"We're demonstrating the robot and the technologies to our farmers so they gain confidence and trust," says Sun. "At farmer meetings, round tables and extension meetings, they show interest and ask how they can adapt it to their farm."

Sun notes that, as researchers, his team is interested in communicating with farmers to evaluate how applicable their research is to their operations.

"Regardless of where you live, don't hesitate to reach out to your university researchers with your questions," says Sun. "It was farmer questions that started my research in this area."

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