Pioneering new process creates versatile moldable wood

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Natural wood already boasts an inherently lower life cycle cost than other materials and is a naturally strong, lightweight, and durable composite material that could offer an attractive alternative to commonly used polymers, metals and alloys, if its properties and

functionality could be improved.

Previous approaches, such as delignification and densification, have been tried and so far failed to provide the same formability offered by metals and plastics.

That's why the development of an innovative new technique, using a rapid 'water-shock' process, able to create strong and moldable wood is so exciting and made the cover story of Science.

After extracting the lignin—a polymer which binds the cell walls inside wood that give it strength—which softens it, and then closing the fibers via evaporation, the research team, involving the University of Bristol, re-swelled the wood by "shocking" it with water.

"The rapid water-shock process forms a distinct partially open, wrinkled cell wall structure that provides space for compression as well as the ability to support high strain, allowing the material to be easily folded and molded," said lead author Professor Liangbig Hu, Director of the Center of Materials Innovation, University of Maryland.

"The resulting 3D-Molded Wood is six-times stronger than the starting wood and comparable to widely used lightweight materials like aluminum alloys."

This 'moldable wood' can then be folded into different shapes and then set to dry before forming the final product. The remarkable foldability of the processed wood originates in its wrinkled cell wall structure, which can sustain severe folding without fracture.

The study, was a collaborative effort between the University of Maryland, Yale University, Ohio State University, USDA Forest Service, University of Bristol, University of North Texas, ETH Zurich,

and the Center for Materials Innovation.

Co-author Professor Stephen Eichhorn, Professor of Materials and Science Engineering at the University of Bristol, provided some of the mechanistic understanding of how the wood is able to deform in the way it does. He is an expert on cellulosic materials and has spent more than 20 years studying cellulose fibers, wood, composites, and plant-based materials.

Professor Eichhorn recalls a childhood memory of his father building his own plane out of wood.

Professor Eichhorn said: "He bent the wood to be used in the wings of the plane using steam. To see now that it is possible to make this flexible wood, while also enhancing the mechanical properties makes this a truly amazing material, and who knows—it could be used as a future material in aerospace!"

"Moldable wood significantly broadens the potential applications of wood as a sustainable structural material, while reducing the environmental impact for buildings and transportation applications," said co-author Professor Teng Li, of the University of Maryland.

"This out-of-the-box approach to developing advanced wood materials will drive wood product and market innovation as a sustainable solution to replace many unsustainable structure materials and combat climate change," said JY Zhu at the USDA Forest Products Lab. "It will also facilitate mitigating forest thinning cost for healthy forest management to reduce wild catastrophic forest fires. We at the U.S. Forest Service Forest Products Laboratory are very excited to collaborate with Professor Hu on this research."

Professor Hu founded InventWood LLC in 2016 to commercialize the

advanced wood technologies invented at his lab, including this 3D moldable wood.

"The researchers introduce a clever means to transform the naturally occurring, straight-walled cellular structures of wood into wavy, accordion-like geometries, at the microscale," said co-author Professor John Rogers, of Northwestern University. "The result is an unusual, high-strength form of wood that is both flexible and moldable, in ways that open up new applications for this very old class of material."

More information: Shaoliang Xiao et al, Lightweight, strong, moldable wood via cell wall engineering as a sustainable structural material, *Science* (2021). DOI: 10.1126/science.abg9556

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