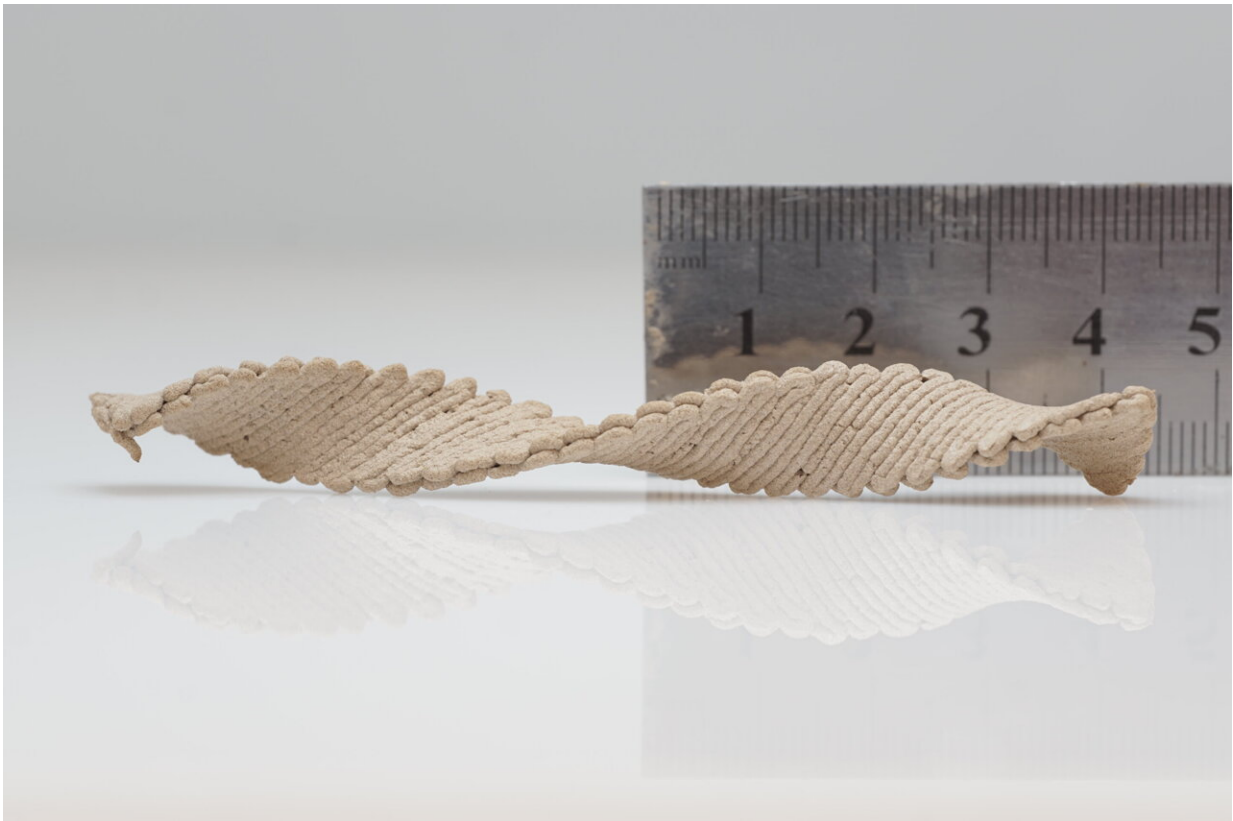


Your next wooden chair could arrive flat, then dry into a 3D shape

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Wood ink printed as a flat rectangle is programmed to form a complex shape after drying and solidifying. (Ruler is marked in centimeters.). Credit: Doron Kam

Wooden objects are usually made by sawing, carving, bending or

pressing. That's so old school! Today, scientists will describe how flat wooden shapes extruded by a 3D printer can be programmed to self-morph into complex 3D shapes. In the future, this technique could be used to make furniture or other wooden products that could be shipped flat to a destination and then dried to form the desired final shape.

The researchers will present their results at the fall meeting of the American Chemical Society (ACS).

In nature, plants and some animals can alter their own shapes or textures. Even after a tree is cut down, its wood can change shape as it dries. It shrinks unevenly and warps because of variations in fiber orientation within the wood. "Warping can be an obstacle," says Doron Kam, a graduate student who is presenting the work at the meeting, "but we thought we could try to understand this phenomenon and harness it into a desirable morphing."

Unlike some natural objects, [artificial structures](#) can't typically shape themselves, says Eran Sharon, Ph.D., one of the project's principal investigators. But scientists in recent years have begun printing flat sheets that could form themselves into 3D shapes after a stimulus, such as a change in temperature, pH or moisture content, says Sharon. However, these self-morphing sheets were made from [synthetic materials](#), such as gels and elastomers, he notes.

"We wanted to go back to the origin of this concept, to nature, and do it with wood," says Sharon. He and Kam—as well as Shlomo Magdassi, Ph.D., and Oded Shoseyov, Ph.D., the other [principal investigators](#) who took on this challenge with Ido Levin, Ph.D., who was a graduate student at the time—are at The Hebrew University of Jerusalem.

A few years ago, the team developed an environmentally friendly water-based ink composed of wood-waste microparticles known as "wood

flour" mixed with cellulose nanocrystals and xyloglucan, which are natural binders extracted from plants. The researchers then began using the ink in a 3D printer. They recently discovered that the way the ink is laid down, or the "pathway," dictates the morphing behavior as the [moisture content](#) evaporates from the printed piece. For instance, a flat disk printed as a series of concentric circles dries and shrinks to form a saddle-like structure reminiscent of a Pringles potato chip, and a disk printed as a series of rays emanating from a central point turns into a dome or cone-like structure.

The ultimate shape of the object can also be controlled by adjusting print speed, the team found. That's because shrinkage occurs perpendicular to the wood fibers in the ink, and print speed changes the degree of alignment of those fibers. A slower rate leaves the particles more randomly oriented, so shrinkage occurs in all directions. Faster printing aligns the fibers with one another, so shrinkage is more directional.

The scientists learned how to program the print speed and pathway to achieve a variety of final shapes. They found that stacking two rectangular layers that are printed in different orientations yields a helix after drying. In their latest work, they found that they can program the printing pathway, speed and stacking to control the specific direction of shape change, such as whether rectangles twist into a helix that spirals clockwise or counterclockwise.

Further refinement will allow the team to combine the saddles, domes, helices and other design motifs to produce objects with complicated final shapes, such as a chair. Ultimately, it could be possible to make [wood products](#) that are shipped flat to the end user, which could reduce shipping volume and costs, Kam says. "Then, at the destination, the object could warp into the structure you want." Eventually, it might be feasible to license the technology for home use so consumers could design and print their own wooden objects with a regular 3D printer,

Sharon says.

The team is also exploring whether the morphing process could be made reversible. "We hope to show that under some conditions we can make these elements responsive—to humidity, for example—when we want to change the [shape](#) of an object again," Sharon says.

More information: Wood warping by 3D printing, ACS Fall 2022.
[www.acs.org/content/acs/en/mee ... tings/fall-2022.html](http://www.acs.org/content/acs/en/mee...tings/fall-2022.html)

Provided by American Chemical Society

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