WASTED WOOD

ENGINEERS SEEK A MORE SUSTAINABLE BUILDING MATERIAL

Professors Craig Criddle and Sarah Billington develop and test biocomposites for building.

BY DAVID ORENSTEIN

A home builder can use a wide variety of materials to build a house that is durable, but virtually none of those choices will build a house that is sustainable. At a time of bulging landfills, record construction and enormous third-world needs for housing, a group of Stanford engineers is rethinking the life cycle of today's building materials.

They are demonstrating how new "biocomposite" materials could cycle through landfills much more quickly than wood, minimizing waste, providing energy, preserving perhaps thousands of acres of trees, and maybe even helping slow global warming.

"Materials that are used in a building are often eventually sent to a landfill, not just the structural materials but the non-structural ones as well," says Sarah Billington, an associate professor of civil and environmental engineering (CEE). She leads a team of five professors and three graduate students who think the solution might be in developing biocomposites: strong but quickly biodegrading sheets of natural resins reinforced by fibers, such as hemp or jute. "From what we know so far about their mechanical properties, our materials could be a replacement for wood. Housing definitely is something to which this can be applied."

Housing has a huge environmental impact. In 2005, U.S. homebuilders used an all-time high 27.6 billion board feet (165.6 million cubic meters) of lumber for residential construction, according to the Western Wood Products Association. Overseas demand is significant as well. In fact, an estimated 500 million people around the world lack adequate housing. Meanwhile, wood makes up a quarter of all debris from construction and demolition, accounting for 35.1 million tons in 1998, according to the Environmental Protection Agency.

CHANGING THE LANDFILL LANDSCAPE

When lumber and plywood go to the landfill—tons did after Hurricane Katrina destroyed about 200,000 homes—they biodegrade in an anaerobic process that emits methane. If not collected, this gas can seep into the atmosphere, contributing to the greenhouse effect and global warming, says CEE Professor Craig Criddle, who is working with Billington on the project. Although methane is useful as an energy source, it just isn't economical for small landfill owners to invest in harvesting it, because decaying wood and other landfilled materials release methane so slowly.

Biocomposites, by contrast, degrade much faster than wood and could therefore make recapturing methane a profitable energy practice. Alternatively, because methane can be used to make the resin that is used in the biocomposites, much of the material's mass could be chemically recycled into new biocomposite materials of similarly high quality. In either case, landfills would become productive parts of a sustainable, "closed-loop" process, rather than just dumps.

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The most promising materials the group has tested so far are made by fusing together many layers of a plastic-like material made from hemp fibers in a polyhydroxy-butyrate (PHB) resin. The resin, produced commercially by Procter & Gamble under the brand name Nodax, is made naturally by a number of microbes as their way of storing excess food. These microbes thrive in oxygen-rich environments, using a variety of food supplies. The Stanford team is focusing particularly on microbes that consume methane. When they are fed extra methane but deprived of the other chemicals, Criddle says, they store away the carbon from the methane in the form of PHB granules. These can be extracted and made into a very strong resin either for plastics or for biocomposite building materials.

In lab tests, the group has found that hemp-reinforced PHB resin has almost exactly the same tensile strength as wood. The material has been able to withstand loads causing between 30 and 55 million Pascals (a unit of pressure), while common framing woods such as Douglas fir typically rate between 28 and 55 million Pascals. Other tests have shown that the material biodegrades in the right environment not only much faster than wood, but also much faster than any other biocomposite.

"It has two things going for it," Criddle says, "fast biodegradation and strength."

OPEN QUESTIONS, OPEN FUTURE

While the biocomposites and a sustainable process for making them, using them and then reusing them, seem promising, Billington and Criddle readily acknowledge questions remain to be studied. One is whether the material would biodegrade at an undesirable pace while it is still "in service." Clearly no one wants structural elements of their house to start breaking down. The group also hasn't yet tested how the material would best be sawed, drilled, routed or planed. In other words, it is as strong as wood, but might not be worked in the same way.

For all the open questions, the researchers are optimistic that they are on to something that could lessen the environmental costs of the vital human need for shelter. The team is composed of Billington, Criddle, aeronautics and astronautics Professor George Springer, chemical engineering Professor Curt Frank, CEE Professor Emeritus Perry McCarty and CEE graduate students Molly Morse, Alison Pieja and Sarah Christian. The project is funded by a grant from the Woods Institute for the Environment at Stanford.

Fundamentally their contribution has been not only to test promising materials but also to study their environmental impact during their entire life cycle of use, disposal and reuse.

"We are excited to be developing an integrated cycle," Criddle says. Adds Billington: "This is a great opportunity to make building products that serve a societal need and respect and protect the natural environment. We're engineering materials to be used and then removed from service to generate energy and re-create the substance needed to make them all over again, closing the loop."