New composite decking could reduce global warming effects of building materials

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Buildings and production of the materials used in their construction emit a lot of carbon dioxide (CO_2), a potent greenhouse gas that contributes to global warming and climate change. But storing CO_2 in building

materials could help make them more environmentally friendly.

Scientists report that they have designed a composite decking material that stores more CO_2 than is required to manufacture it, providing a "carbon-negative" option that meets building codes and is less expensive than standard composite decking.

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

Apart from a few types of cement, carbon-negative composites are scarce, according to David Heldebrant, an organic chemist who is one of the project's principal investigators. The composite decking his team has developed "is one of the first composite materials to be demonstrably CO_2 negative over its life cycle," he says.

The materials and processes that go into constructing buildings account for 11% of all energy-related carbon emissions, according to the World Green Building Council. Significant efforts have gone into developing building supplies that can offset these emissions, such as using recycled or plant-derived products. However, in many cases, these sustainable alternatives are more expensive than traditional materials or can't match their properties, such as strength or durability.

One type of construction material—decking—is a multibillion-dollar industry. Decking boards made from a wood plastic composite are a popular alternative to lumber boards because they are less prone to damage from ultraviolet radiation and can last longer.

Composite decking is typically made from a blend of wood chips or sawdust and plastic, such as high-density polyethylene (HDPE). To make these composites more sustainable, one alternative is to use fillers that are waste products or would otherwise be burned.

That's an approach Heldebrant's colleague Keerti Kappagantula was taking: using low-quality brown coal and lignin, a wood-derived product left over from papermaking, as the filler in decking composites.

To make the pulverized coal and lignin particles mix with and stick to plastics, the research team needed to add ester functional groups to the particles' surfaces. Heldebrant, who works at Pacific Northwest National Laboratory (PNNL) and develops specialized liquids to capture CO_2, found out about this work while chatting over coffee with Kappagantula.

Satish Nune, another project investigator, and Heldebrant were excited when they heard about this. "Esters are essentially carboxylic acids, which are a captured form of CO_2," Heldebrant explains. So, the team wanted to do the same thing and put CO_2 onto the surface of the particles in the composite to make the material even more environmentally friendly while improving the composites' mechanical performance.

To test the feasibility of this approach, the team turned to a classic chemical reaction to form a new chemical bond between CO_2 and a functional group called a phenol, which is abundant in wood products like coal and lignin. After undergoing the reaction, the lignin and coal particles contained 2–5% CO_2 by weight.

The team then mixed varying ratios of these particles with HDPE to form brownish-black composites, and they tested the resulting properties. A composite containing 80% filler maximized the amount of CO_2 content while demonstrating strength and durability that meet international building codes for decking materials.

It was manufactured via friction extrusion using PNNL's shear assisted processing and extrusion (ShAPE^{TM}) machine. The researchers used this material to form 10-foot-long composites that look and feel similar to

any standard wood composites found in decking or lawn furniture.

In addition to their favorable physical properties, the new composite boards offer a substantial price and sustainability advantage. They are 18% cheaper than standard decking composite boards. They also store more CO_2 than is released during their manufacture and lifetime, Heldebrant says. If the 3.55 billion feet of decking sold in the U.S. every year were replaced with the researchers' CO_2-negative composite decking, he says, 250,000 tons of CO_2 could be sequestered annually, which is equivalent to the yearly emissions from 54,000 cars.

Next, the researchers plan to make additional composite formulations and test the properties. They envision that carbon-negative composites could be developed for a range of building materials, such as fencing and siding. In the meantime, the team is working to commercialize its decking boards. This new carbon-negative decking could be available at building supply retailers as soon as next summer.

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