One of the most effective strategies for making construction more sustainable is to change the materials we build with. Shifting away from carbon-intensive steel and concrete toward naturally-abundant renewable materials like mycelium and hemp is a good start. Science, however, has given birth to a variety of high-tech materials that can boost construction even further down the path of sustainability, opening up novel ways to make our buildings more energy-efficient and less environmentally destructive.

In this article, we'll take a look at five high-tech building materials dreamt up in the lab that promise a greener tomorrow for the construction industry.

1. The World's Whitest Paint
2. Chameleon Skin
3. Self-Healing Concrete
4. Solar Glass
5. Transparent Wood

THE WORLD'S WHITEST PAINT

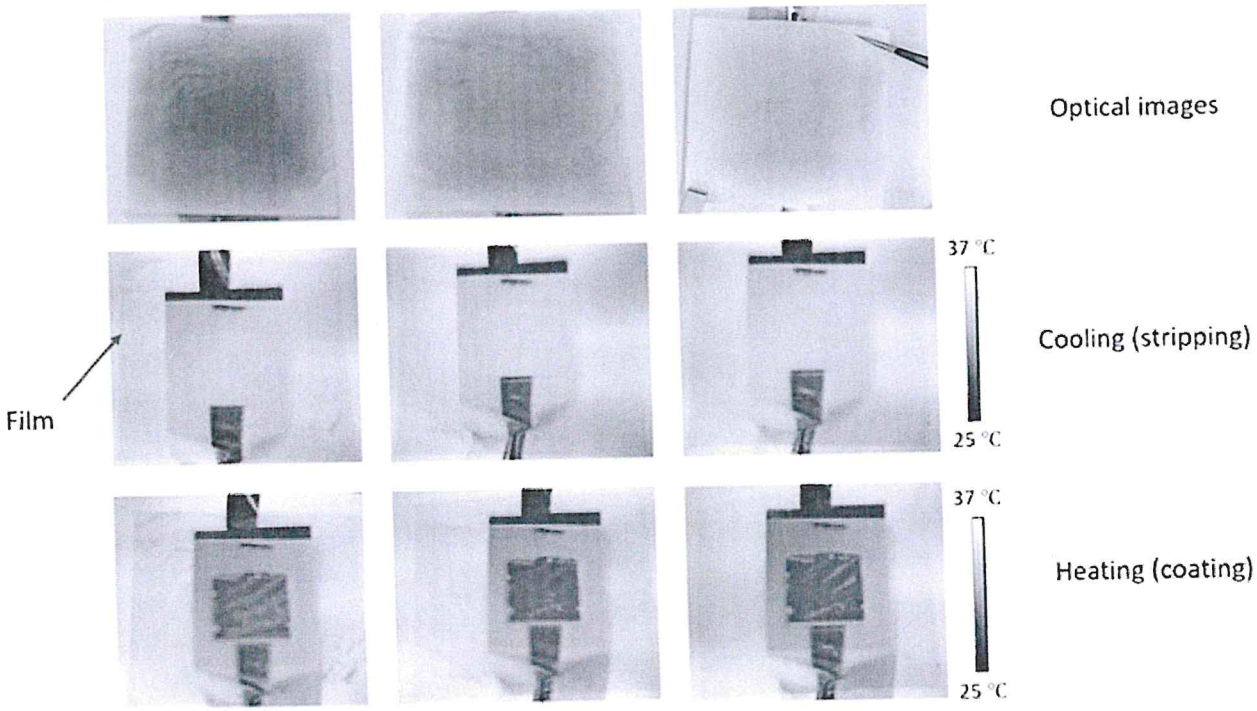
Imagine being able to cool a building simply by putting a coat of paint on it.

This is the promise of the world's whitest paint, unveiled in 2021 by researchers at Purdue University. The paint—created with a blend of light-scattering barium sulfate particles—is so glaringly white that it's capable of reflecting more than 98% of the sunlight that hits it, keeping buildings up to 19 degrees Fahrenheit cooler at night.

The creation has set a Guinness World Record and won numerous awards, including the South by Southwest (SXSW) 2023 Innovation Award in sustainability and recognition by the 2023 Gizmodo Science Fair.

Xiulin Ruan is the Purdue professor who spearheaded the project. According to him, conventional white paint from the hardware store only reflects roughly 80 to 90% of light. Buildings painted with his team's ultra-white paint, he claimed, could potentially eliminate the need for air conditioning.

The electrochromic film developed by Assistant Professor Po-Chun Hsu and his team of researchers follows the same principle: Sensing and responding automatically to outside temperatures, the material can switch between two infrared states, each of which has a different effect on the interior temperature of the building. When it's cold out, the material morphs into a solid copper state that absorbs heat. When it's hot out, the material will shift into a liquid state that instead deflects heat.



The material contains a layer that can take on two conformations: solid copper that retains most infrared heat, which helps keep the building warm; or a watery solution that emits infrared, which can help cool the building. (Image courtesy of Hsu Group*)*

A very small amount of electricity is used to induce this chemical transformation. The researchers found that in an average commercial building, the material would require less than 0.2% of the structure's year-to-year electricity and could save roughly 8.4% on annual HVAC energy consumption.

"We've essentially figured out a low-energy way to treat a building like a person; you add a layer when you're cold and take off a layer when you're hot," said Asst. Prof. Po-Chun Hsu, who led the research published in *Nature Sustainability*. "This kind of smart material lets us maintain the temperature in a building without huge amounts of energy.

As of this writing, the chameleon material can only be produced in small batches, in pieces that measure roughly six centimeters across. If Hsu and his team can successfully scale up their creation, you may someday be able to purchase chameleon shingles and siding at your local hardware store.

SELF-HEALING CONCRETE

This next high-tech building material hails from ancient times.

Self-healing concrete is exactly what it sounds like: Concrete that can repair itself from cracks, damage, and other forms of erosion.

Traditional concrete is strong, but it isn't without its drawbacks. As one of the most common building materials of the modern era, concrete has an enormous carbon footprint, accounting for about 8% of CO2 emissions worldwide. What's more, for all its strength and durability, modern concrete tends to break down, placing the lifespan of even steel-reinforced concrete within the range of 50 to 100 years.

This might seem like a long time until you realize that many ancient unreinforced concrete structures like the dome of the Roman Pantheon remain standing more than 2,000 years later. How is this possible?

The answer is self-healing concrete. Now, all forms of concrete have some amount of "self-healing" power: even in conventional concrete, hairline cracks and fissures are able to partially mend themselves due to the ongoing hydration of innate clinker materials, for example. But the self-healing ability of modern concrete pales in comparison to the cementitious stuff of ancient times. Roman engineers "hot mixed" their concrete with quick lime in a unique process that scientists at MIT recently identified as the key to the resiliency of structures like the Pantheon. Water entering into cracks reacts with the quick lime, forming calcium-rich deposits called "lime clasts" that fill the cracks and re-strengthen the structure.

"We can use AuREUS instead of typical glass windows so that whole buildings can become solar energy farms," Maigue said in an interview with Dyson. "AuREUS could become part of our clothes, our cars, buildings, and our houses."

TRANSPARENT WOOD

That's right, transparent wood.

It may sound like the stuff of solarpunk sci-fi, but recent research has demonstrated that transparent wood is very much a real world technology that could someday replace glass as the preferred material for windows and other see-through surfaces.

In a 2016 paper, scientists described removing the lignin (the polymer that gives plants their rigidity) from a 1.22 millimeter thick sample of dehydrated balsa wood and replacing it with a solution of prepolymerized methyl methacrylate, an acrylic alternative to glass. The result was a product similar to glass, albeit hazier, ideal—the study said—for transmitting natural light while maintaining privacy. Another paper from 2020 describes a similar process with similar results.

Invented in 1992 by German scientist Siegfreid Fink, transparent wood has many qualities to recommend it. Compared to glass, transparent wood is much lighter and more durable, bending and splintering rather than shattering on impact.