New aerospace and building materials could repair themselves thanks to fungi and bacteria

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Credit: Faksawat Poohphajai (InnoRenew CoE)

Researchers are using biological matter to create unique new materials that can adapt to their environment and repair themselves.

The science fiction writer Arthur C. Clarke famously said that "any sufficiently advanced technology is indistinguishable from magic."

For Dr. Kunal Masania, an associate professor of aerospace structures and materials at the Delft University of Technology in the Netherlands, Clarke made a huge impression.

"I've always been greatly inspired by this," said Masania. "Through my research, I try to bring a kind of magic to people's lives."

Living materials

Masania is developing what he calls "living materials," for use in the aerospace and transportation sectors. These living materials are, precisely as they sound, literally alive. They contain microorganisms such as fungi and bacteria, which give them the capacity to sustain their integrity and self-healing.

His work may seem like magic, but it is very real and advancing well.

It is part of a five-year project called AM-IMATE, for which Masania was awarded a grant from the European Union in January 2023. The research team are looking at the potential of biological organisms to be integrated into innovative new materials for use in industry and engineering.

"The goal is to make engineered structures that can behave like living organisms, able to sense and adapt to mechanical stresses," said Masania.

3D printed fungi

The material Masania is developing is a composite that combines living

fungi cells and wood. It consists of a hydrogel and mycelium, a root-like structure of a fungus that normally lives underground.

"We chose to work with fungi because fungus is a really robust organism, it is tolerant to harsh conditions and is relatively easy to cultivate," said Masania.

Moreover, fungal cells have a great ability to connect. Mycelium can grow a vast sensing network that allows it to send signals throughout the organism. That means the scientists can distribute only a few cells throughout the material, and these cells will reconnect and form a sensing network.

To produce these living materials, Masania has developed a special 3D printing method and a new 3D printing ink.

"We are making good progress in this regard, and we are already able to 3D print our material," he said.

Sustainable space

Biological materials could help to improve the performance and durability of critical structures used in areas like aerospace and transportation. For example, Masania and his team are exploring using their composites as the core material for the interior of airplanes.

"Our materials are very lightweight and more sustainable than currently used materials," said Masania. "Right now, the interior of aircraft is made largely of plastic and metal. If we replace these, we no longer have to rely on fossil fuels and we can offer better end-of-life solutions. If we use living materials, the aircraft components could be dismantled and returned to nature."

Masania's research may even be looking to make what seems like sci-fi a reality.

"It could be very interesting for building in space and on other planets," he said. "Our living materials could form the basis of new habitats because you could use the local materials and bind them together using the fungi."

Bio-based building skin

Closer to home, bio-based materials are also being used to develop a new ally for sustainable construction. Dr. Anna Sandak is an expert in materials science with a special focus on wood. She is an associate professor at the University of Primorska, in Koper, Slovenia, and deputy director and head of the materials department at the Slovenian InnoRenew Centre of Excellence.

InnoRenew was set up in 2017 with the help of EU, international and national funding to build on Slovenia's strengths in forestry and wood research. The aim was to investigate innovative renewable materials for sustainable building.

In 2022, Sandak and her InnoRenew research team were awarded a five-year EU grant to further develop the concept of a bio-active living coating system for use in the construction industry. Thanks to this funding, they are developing a "live" biofilm able to protect various built surfaces, including concrete, plastic and metal.

The idea is that this living skin could be applied to protect construction materials and make buildings more resilient and sustainable.

"Instead of using synthetic chemicals, biocides and mineral oils that are not always environmentally friendly, we are focussing on developing

natural solutions," said Sandak.

By using living organisms, scientists are creating new functionalities that cannot be found in conventional materials.

"We are adding a new dimension to materials that has not existed before—life," said Sandak. "In nature, cells have many fantastic properties which are very difficult and costly to achieve in synthetic materials. Living materials are more environmentally friendly, they can self-heal, have the potential to clean air and come at a lower cost."

Fun fungi

Like the AM-IMATE project, Sandak's team works primarily with fungi.

"They have a huge potential," she said. "They grow fantastically, have a high survival rate and don't need many nutrients. Fungi are fun."

Fungi already occur on construction sites, but are usually not desirable because they can damage materials. Sandak's team, however, works with a specific fungus that isn't harmful and doesn't degrade materials.

"We are using the "good guys" to stop the "bad guys" from spreading."

To ensure their research makes it to practice, the scientists are creating a biocoating that is not only effective, but also visually appealing. They are testing it on a variety of materials and working on adding different colors.

"Because aesthetics is important in architecture," said Sandak.

The resulting product is envisaged to be a water-based coating that can

be sprayed, brushed or rolled onto a wide range of surfaces.

ARCHI-SKIN runs until 2027, and according to Sandak, the research is progressing quite fast, and it won't be too long before their coating can be applied to the first buildings.

"I believe it will be possible to use our solution within the next decade," she said.

Societal impact

In the case of both projects, scientists are gaining valuable fundamental knowledge about microorganisms, but as both project coordinators say, the main outcome of the research should be real-life applications.

"We want to make our world a better place," said Sandak.

"I believe we will definitely start to see many more applications for bio-based materials, such as in buildings and the built environment, as well as consumer products," said Masania. "As our understanding of these materials develops, more and more applications will follow."

More information:

- AM-IMATE
- ARCHISKIN
- EU research and innovation for chemicals and advanced materials

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