Researchers derive naturally occurring melanin at a massive scale from mushrooms

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Empa researcher Tine Kalac applies melanin as a varnish to Norway spruce wood. Credit: Empa

The pigment melanin protects human skin from harmful UV light (and gives us a summer tan), and is a veritable treasure trove for new materials and technologies. Although melanin occurs naturally, the complex biopolymer can only be produced artificially at an industrial scale through expensive and complex processes, during which some of the compound's properties are lost. To date, processes for extracting natural melanin from microorganisms have low yields. It is therefore not surprising that melanin is many times more expensive than gold.

Empa researchers have now developed a method to produce melanin in a simple and highly scalable process. "Melanin is extremely stable when exposed to environmental influences and is interesting not only as a pigment, but also far beyond for the development of innovative composite materials," says Empa researcher Francis Schwarze from Empa's Cellulose & Wood Materials lab.

In their quest for simpler, cheaper processes for the production of natural melanin in large quantities, Schwarze and his team came across a common saprophytic fungus that grows in the forest: Armillaria cepistipes. Its amazing metabolism enables the fungus to bind heavy metals, make wood glow in the dark, and produce melanin on a massive scale. "We have selected a promising strain of A. cepistipes that allows us to produce around 1,000 times more melanin than with other fungi," says Schwarze. The trick: A. cepistipes is cultivated in a nutrient fluid, and in the presence of a precursor, tyrosine, releases melanin into the environment. "In this way, we have developed a sustainable production method, which no longer requires time-consuming extraction steps used in previous microbiological processes," explains the Empa researcher. In three months, A. cepistipes produces around 20 grams of melanin.

The scalable and sustainable production of melanin now enables Empa researchers to advance projects to develop innovative materials for a range of industrial applications. These include, for example, a system for water purification: Since melanin is able to bind heavy metals, it can be used to develop new types of water filters. "We have integrated melanin into artificial polymers such as polyurethane," explains Empa researcher Anh Tran-Ly. Using electrospinning, the polymer mixture was spun into ultra-fine fibers to form membranes. The Empa team found that these melanin-based composite membranescan remove up to 94% of lead from polluted water.

Armillaria cepistipes culture: Dark areas contain melanin. Credit: Empa

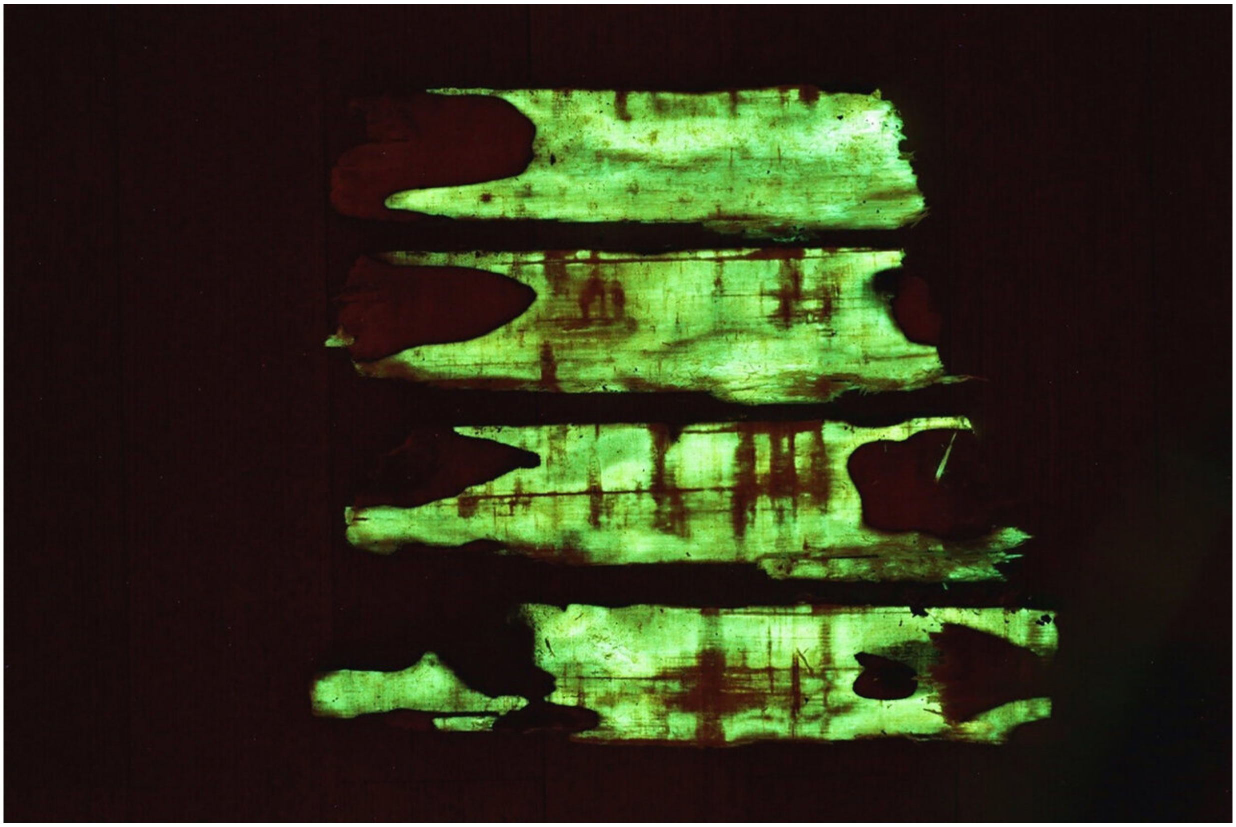
As black as ebony

In nature, fungi use melanin to protect themselves against other organisms that compete for nutrients and space in the environment. With the new technology, the pigment can now also be used to protect much larger communities from human influence: Melanin can be used to conserve tropical forests where highly priced and much sought after ebony grows.

Tropical ebony wood is particularly precious because of its unique dark color. A sustainable method that upgrades native Norway spruce wood to a visually equivalent product could preserve vulnerable tropical forests. "When spruce wood is impregnated with a melanin suspension, a deep, dark wood can be produced that is comparable to ebony," says Empa researcher Tine Kalac.

Using melanin to preserve rare musical instruments

Since Armillaria fungi use melanin as a weapon against competitors, it is only logical to use melanin to protect wood from fungi. In order to develop a melanin-based wood preservative, Empa researchers are participating in a recently launched interdisciplinary project supported by Innosuisse, the Swiss Innovation Agency. The goal is to reconstruct a historical wind instrument, the serpentino (in English: small snake).



The Armillaria fungus colonizes wood and makes it glow brightly in the dark with its own bioluminescence. Credit: Empa

Together with the University of Applied Sciences and Arts Northwestern Switzerland and the Basel Historical Museum, the industrial partner in the project is the company SBerger Serpents in Le Bois (JU), which is responsible for the practical implementation of the research project—the reconstruction of the instrument. Company founder Stephan Berger is enthusiastic about the rebirth of this rare instrument: "The serpentino was used over 400 years ago, and was the godfather of modern instruments such as the saxophone and the tuba," he explains. Although it is a technical challenge for musicians to master the instrument, the sound is incomparable, says Berger. "The serpentino creates sounds that are rich in overtones and deeply touching."

Originally, the wind instrument was used in churches to support singing because it covers the registers of the human voice and can thus "carry" a choir.

The Serpentino: a peculiar shape with a touching sound. Image: Xavier Voirol

Although today's trend towards historically informed performances means that the serpentino is in great demand, Berger is unable to supply its customers with instruments: The peculiarly curved original instruments have become rare. Because the snake-shaped instrument, which is made of walnut wood, not only creates an incomparable sound, condensation from the musicians' breath creates a humid microclimate that provides excellent conditions for the growth of all kinds of microorganisms. Thus, the conditions for bacteria and fungi are favorable for the decomposition of the centuries-old instruments, gradually destroying the last original specimens.

The research project's faithful serpentino replicas are to be protected from this damage. This is where Empa's melanin comes in: "If we can use a melanin-based wood preservative, not only the newly built serpentinos can be protected against decay," says Berger. Other woodwind instruments built today using domestic, less resistant woods could also benefit from such an environmentally friendly wood treatment. Thus, the collaboration with the Empa team is exciting in more ways than one.

Provided by Swiss Federal Laboratories for Materials Science and Technology

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