RESEARCH NEWS

Residue-free and sustainable removal of contaminants

Remediation of contaminated wooden structures

In Germany, there are around three million buildings that are contaminated with the toxic wood preservatives lindane and pentachlorophenol (PCP). Previous measures for minimizing contamination include insulating contaminated areas or disposing of treated wooden building materials as hazardous waste. However, these measures are neither sustainable nor cost-efficient. In the CycloPlasma project, researchers at the Fraunhofer Institute for Building Physics IBP are developing a new type of process to remove these decades-old contaminants — in the air as well as in contaminated wooden structures — in a way that is residue-free, sustainable and does not pose a health risk. For this purpose, the scientists have combined an innovative adsorber material with plasma technology.

In the 1970s and 1980s, wooden structures in buildings were massively treated with the wood preservatives lindane and pentachlorophenol (PCP) to protect them against fungus and insect infestation. These substances proved to be carcinogenic and neurotoxic — they have been banned in Germany since 1989. However, these toxic substances have a low volatility. This causes them to adhere to material, and contaminated wooden beams, wood paneling and roof trusses therefore still pose a health risk today. Historic and buildings are particularly affected, as well as public buildings from this period such as government offices, kindergartens and schools. Previous solutions for contaminant removal have a negative effect on the conservation of existing buildings in terms of resources, energy, and heritage preservation. They can also result in high disposal costs. With the CycloPlasma technology, researchers at Fraunhofer IBP in Valley, Germany are developing a solution that allows dangerous contaminants to be removed in an environmentally friendly, sustainable way without any residue and without any loss of construction substance. In the CycloPlasma project, which is supported by the Fraunhofer Future Foundation, researchers from the Department of Environment, Hygiene and Sensor Technology and the Business Unit Cultural Heritage Research of Fraunhofer IBP are combining the adsorption technology for decontaminating wood and the plasma method for purifying indoor air of contaminants that have already released.

New cyclodextrine formula encapsulates contaminants

The researchers are using cyclodextrine (CD) as an adsorber material, which is applied to wood like a varnish. These molecules can capture and bind contaminants such as lin-

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dane and PCP. They were discovered a hundred years ago and are used to decontaminate soil polluted with heavy metals or oil. CDs are also used in medicine for the delayed release of active ingredients. "The cyclodextrines are ring-shaped dextrose molecule chains that are enzymatically obtained from starch. The ring structures of sugar chains enclose the lindane and PCP in a cavity, thereby encapsulating them completely," says Dr. Andrea Burdack-Freitag, deputy head of department and group leader of the Analysis and Applied Sensor Systems. The scientist and her team have developed a new gel-like formula from the cyclodextrines, which are available as a white powder. The gel can be applied to wood in a non-destructive manner. The colorless texture does not change the wood structure and is not visible on the wood surface. It does not cause mold growth and is non-toxic, colorless, biodegradable and washable. "The formula penetrate into the pores of the wood, where it soaks up the contaminants like a sponge. Depending on the contaminant concentration, these remain bound in the CD layer," the scientist explains. If too many toxic substances are present, however, they cannot be completely adsorbed by the formula. The excess contaminants are then released into the indoor air. This is where plasma technology comes in. A plasma device, which can be attached to the ceiling, for example, soaks up the hazardous substances and renders them harmless. "Electrodes in the housing generate a plasma gas through which the air flow containing the contaminants is drawn. The plasma gas chemically degrades the lindane and PCP. In addition, active carbon filters prevent gaseous degradation products from escaping from the device," Burdack-Freitag explains the principle.

Tests in an open-air museum

The first laboratory tests have been successfully completed. The technology is currently undergoing practical testing with extensive measuring technology in the contaminated attic of the historic Thürlmühle mill, which is located on the premises of the project partner "Freilichtmuseum Glentleiten" (an open-air museum). "Especially the roof trusses of historical buildings as well as museum exhibits frequently contain dangerous contaminants from wood preservatives, which were used in the past to conserve cultural assets for as long as possible," Prof. Ralf Kilian from Cultural Heritage Research explains. Occupational safety examinations had revealed high loads in the rooms there.

With the laboratory method, it was possible to completely degrade the existing contaminants; in the experiments in the Thürlmühle mill of the Glentleiten open-air museum, it has been possible to reduce the contaminant concentration by two thirds so far. However, the formula has only been thinly applied to visible wood surfaces in previous tests. If the varnish is applied more thickly, the contaminant concentration can be reduced even more. After the tests, there was no mold formation and the formula had not damaged the wood either. In long-term testing, the IBP researchers are now investigating how long the CD layer remains stable and whether any contaminants escape over the long term. Tests with the combined adsorber and plasma technology are also now starting. In addition, tests are being carried out with compresses soaked in the CD

formula (a classic restoration technique) that are wrapped around the wooden beams and then removed.

Technology for renovators and property developers

Depending on the pollution load and room size, the adsorber and the plasma technology can be used in combination. "The renovation measures are taking place according to a modular principle. We have submitted a patent application for our formula in the renovation and construction sector. The restoration of wooden furniture and wooden objects is also conceivable," according to the scientist. The solution could also be suitable for other building materials such as concrete and screeds if they also contain lindane and PCP. Tests with potential industrial partners are still pending though.

Fig. 1 Cyclodextrine gels as adsorber material enclose the toxic wood preservatives and completely encapsulate them.

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Fig. 2 Dr. Burdack-Freitag of Fraunhofer IBP applies the cyclodextrine formula to a contaminated wooden beam.

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Fig. 3 Indoor air sampling in the historic Thürlmühle mill on the premises of the Glentleiten open-air museum.

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