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Biorefinery for the field edge: catalysts made from rice straw in a BMBF project

Billions of tons of rice ripen in fields around the world, especially in Asia. After harvesting, the farmers burn the waste directly on site and spread the ashes on their fields. Rice straw is a valuable raw material in this process. The LIKAT in Rostock has developed a process that can be used to produce high-quality products: Catalysts for basic reactions in organic chemistry and antibacterial coatings on surfaces, for example for so-called smart clothes.

The BMBF project intends to help farmers in Vietnam to avoid the gigantic emission of CO_2 and to secure their livelihood with additional sources of income.

Only for this year, the global rice production is estimated at 496 million tonnes. Rice husks and straw are mostly incinerated. The climate-damaging CO_2 is produced by oxidation of the carbonaceous components sugar and lignin. In addition, the atmosphere is massively polluted by fine dust. During the harvest, the sky is veiled in grey, as chemists at the Leibniz Institute for Catalysis in Rostock (LIKAT) experienced during their business trips to Vietnam.

The state of the art offers a climate-friendly alternative: the biorefinery. This process can convert sugar and lignin into activated carbon, e.g. for filter processes, and into fertiliser. Furthermore, the refinery's range of products could be considerably expanded.

Fig. 1: Burning rice fields in Vietnam – „The sky is hidden behind a grey veil."

Interesting Substance: Silicon

The crucial idea came from Dr. Esteban Mejia, head of a junior research group at the Leibniz Institute for Catalysis in Rostock (LIKAT). He remembered from research that rice plants contain silicon dioxide - finest grains of sand that are also found in harvest waste.

„For us chemists silicon is an interesting substance," says Dr. Mejia. In catalysis, it serves as a carrier material. The actual catalyst, usually a metal compound, is stabilized on this carrier material. For this purpose, molecules of the metal compound are applied to fine-grained silicon dioxide. The resulting powder accelerates reactions such as hydrogenation, a basic reaction in organic chemistry, for example in the production of margarine.

Esteban Mejia's idea was the production of such catalysts in the biorefinery on the basis of rice straw. Together with his colleague Felix Unglaube, Mejia developed the process for a project funded by the German Federal Ministry of Education and Research (BMBF). In the end, a rural community in the Vietnamese province of An Giang will be able to refine harvest waste in a biorefinery nearby their field.

The basic concept for the refinery was developed by the Faculty of Agricultural and Environmental Sciences at the University of Rostock. Mejia's idea added an innovative flair and also convinced the BMBF, which is funding the work with €300,000 until the end of 2021. The partners are the University of Rostock, LIKAT and colleagues from TU Dresden.

Stabilizer for Smart Clothes

Dr. Mejia transferd the search for a suitable metal for the catalyst to his PhD student Felix Unglaube, who had already convinced him with his achievements in his master's degree. Unglaube began to experiment with copper, cobalt and silver in the laboratory. The substances commonly used in catalysis, such as platinum and rhodium, are too expensive for the project. "For a successful implementation of our process in rural areas, it must be simple and must not cost a lot," explains Dr. Mejia.

The laboratory tests with silver brought Mejia and Unglaube to her second product idea. Silver has an antibacterial effect. That´s why clothing in the medical and sports sector are coated with silver. This is to prevent the spread of germs or sweat odor. But at sometimes the silver particles lose their adhesion to the clothing, as Dr. Mejia explains. "So they get into the environment, which is problematic because of their cell-damaging effect.“

In the lab, the two LIKAT chemists discovered that silicon dioxide binds the silver particles extremely tightly. Esteban Mejia: "Our carrier fixes the silver particles and would therefore be suitable for coating smart clothes, for example. Colleagues at the Institute of Biochemistry at the University of Greifswald have analyzed these materials and confirmed their germicidal effect. "It can thus increase the durability of antibacterial layers, and the silver would no longer pose a danger to the environment.“

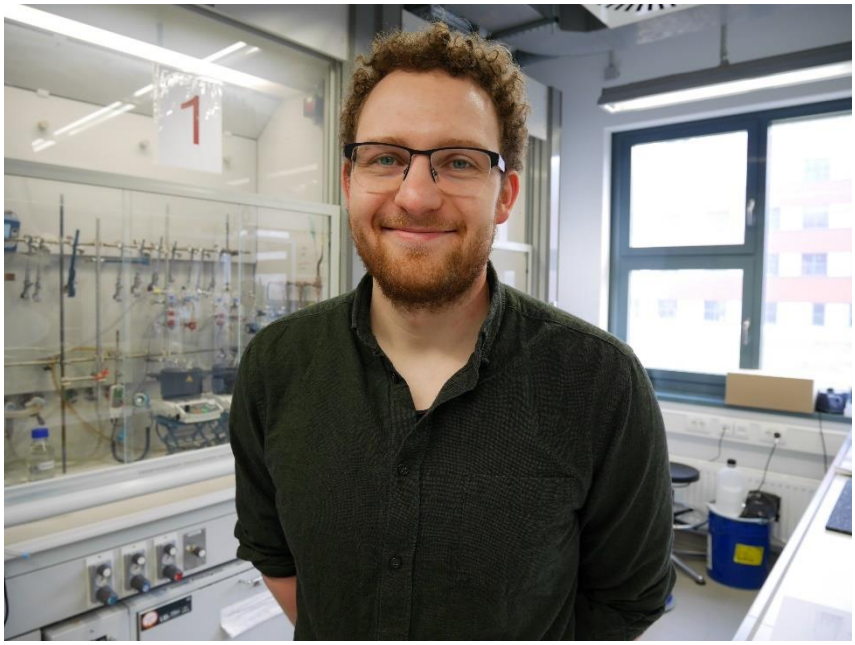

Fig. 2: Felix Unglaube, PhD student at the Leibniz Institute for Catalysis

Vietnamese Partners are Convinced

And how is the process working in the biorefinery? Rice straw and rice husks are ground to a superfine size and pyrolysed in the biorefinery, that means they are burned at high temperatures without oxygen and hence almost without CO_2 emissions. On the one hand, this produces carbon-like substances that can be used as filter material or fertilizer, among other things. On the other hand a fine powder of silicon dioxide is produced. Dr. Mejia: "When we add silver nitrate to the reaction, nanoparticles of this metal are deposited on the granules of the powdered silicon dioxide. That's it! Ready ist he catalyst“

Their Vietnamese cooperation partners at the universities in Hanoi and An Giang are enthusiastic about the work. The provincial authorities gave their “go” for the biorefinery. "The plant will be operated by farmers. We will train them in workshops," says Esteban Mejia. The success of the project also depends on how well this is done. And it will also help to make the biorefinery concept attractive to other rice producers in India, Thailand and China.