Microalgae produced on a commercial scale

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180-liter reactor module installed at Fraunhofer CBP's outdoor facility in Leuna. Credit: Fraunhofer IGB

Many products, including food supplements, cosmetics and biodiesel, are made from substances derived from microalgae. A fully automated pilot plant operated by Fraunhofer in Leuna is capable of producing microalgae on pilot scale. The concentration of algae in its reactors is

five times higher than in conventional closed reactors. The researchers who designed the plant will be exhibiting it at the ACHEMA 2015 show in Frankfurt am Main from June 15 to 19 (Hall 9.2, Booth D64).

Microalgae are highly versatile organisms. Some strains, for instance, produce large quantities of omega-3 fatty acids that have important health-giving properties, and are therefore used in the composition of food supplements. Many ingredients in cosmetic products are also derived from algae, such as the red pigment astaxanthin which is extracted from the algal strain Haematococcus pluvialis. Other strains of microalgae produce oils or starch that can be used to manufacture biodiesel, ethanol or biogas. But the microalgae from which all of these products are derived are grown almost exclusively by American, Israeli or Asian companies – there are only few commercial production facilities in Europe. In Asia, the aquatic organisms are mainly cultivated in open ponds. But the quantity of algae that can be harvested from these ponds is limited because they need light to grow, and sunlight rarely penetrates beyond the first few inches deep in the water body. Finally, there is the constant risk that the algae might be contaminated by other microorganisms.

Fully automated production – under strictly controlled conditions

The fully automated plant at the Fraunhofer Center for Chemical-Biotechnological Processes CBP in Leuna was designed to produce microalgae on an industrial scale. It was built by Subitec GmbH hand in hand with researchers from the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB and Fraunhofer CBP. "The pilot plant enables us to produce microalgae under defined, strictly controlled conditions," says Fraunhofer IGB team leader Dr. Ulrike Schmid-Staiger. "We are able to achieve concentrations of algae that are up to

five times higher than those in other types of closed reactor – not to mention open ponds." As a result, the yield of algae is significantly greater than that of other commercial plants.

The main reason for this is light – a prime growing condition for algae. To ensure that sufficient light reaches all of the algae, the researchers chose to build their pilot plant using flat-panel reactors. These consist of arrays of panels measuring three or five centimeters in thickness, installed vertically to the ground. Over a slotted tube at ground level a mixture of air and CO2 is blown into the nutrient medium in which the algae are suspended. This has two effects: Firstly, the gas bubbles rise upward, supplying the algae with the carbon dioxide they need to grow, and secondly the flow of gas stirs up the algae and causes them to move about. In this way, each alga is propelled at regular intervals to the surface of the reactor, where it comes into contact with the light it needs to replenish its store of energy. This light comes from the sun: The reactors are installed either outdoors or in a greenhouse.

From laboratory to industrial scale

Before a particular strain of algae is cultivated in the reactor, the Fraunhofer IGB researchers conduct laboratory tests to determine the conditions that encourage its growth. Their colleagues at Fraunhofer CBP then reproduce these conditions in the full-scale pilot plant. "This might sound easy, but in fact it's a major challenge that requires a lot of know-how because the plant consists of several interconnected reactors," explains Schmid-Staiger. "The algae have to be introduced into all of them at the same time, and it's also important that the algae grow at the same rate in every reactor, so that they can be harvested at the same time." The researchers start out with small, 6-liter reactors, which they connect in series, and then scale up the results to larger reactors with a volume of 30 and finally 180 liters.

"The plant in Leuna is now producing sufficient biomass for us to be able to conduct further experiments on a pilot scale," says Fraunhofer CPB engineer Gordon Brinitzer. "This will also allow the operating team to gather hands-on experience of running a plant of this size. One day this could give rise to a new profession: algae farmer." In total, the pilot plant comprises 65 reactors with a capacity of 3.6 cubic meters installed in the greenhouse, and 45 reactors with a capacity of 8.1 cubic meters installed outdoors.

The harvested algae are transferred to an extraction unit to extract the fat-soluble substances they contain, such as omega-3 fatty acids. Alternatively, the biomass is sent to project partners and customers for further processing. Organic farmers, for instance, use the algae to protect their crops against fungal infections or for pest control. When algae are mixed in with a fertilizer, their odor repels insects such as the cabbage root fly, which prefer to lay their eggs elsewhere. As Schmid-Staiger explains, "an important aim of the project is to find as many uses for the microalgae as possible, because they are still relatively expensive to produce." The researchers will be exhibiting a 180-liter reactor module of their pilot plant at the ACHEMA show (Hall 9.2, Booth D64).

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