High-efficiency water treatment using light using a novel UV-light system

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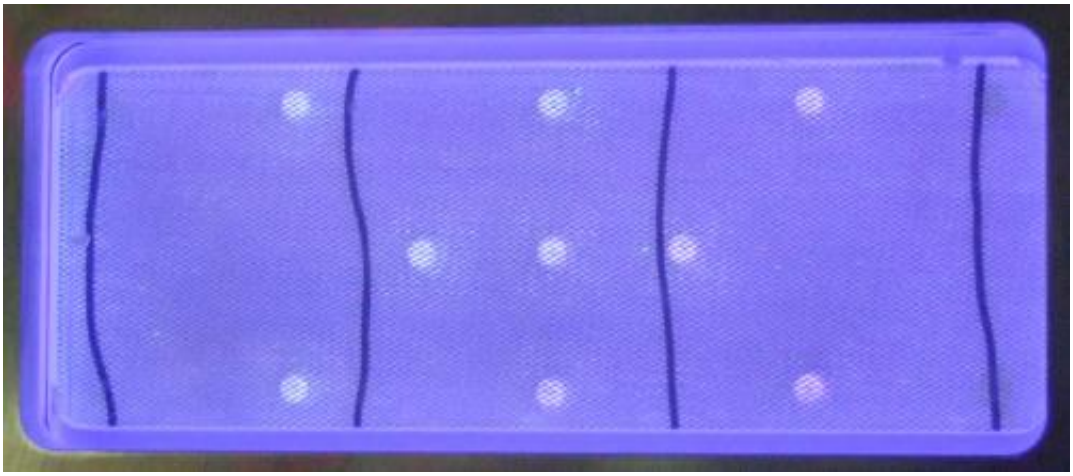

172 nm UV radiation element. Credit: Fraunhofer

Many harmful substances in waste water stubbornly resist being broken down by biological waste water treatment plants. Fraunhofer researchers have developed a photochemical reaction system in which water can be reliably treated at high flow rates by UV light without having to add chemical catalysts. They will be presenting an initial industrial prototype at this year's IFAT in Munich, 5-9 May.

There are numerous things in our waste water that should not find their way into the environment – yet waste water treatment plants only remove a portion of these contaminants. In particular, bacteria commonly employed in the biological treatment stage have no effect on persistent

substances, which include highly stable hydrocarbon compounds. The result: cleaning agent residuals and pesticides as well as pharmacological substances are reaching environmental waters. The loading from these kinds of harmful substances in the North Sea, for instance, is already clearly measurable today.

Researchers of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart together with international industrial partners have now developed a new chemical reaction system that breaks down these kinds of resilient and harmful molecules thoroughly and efficiently – without having to add chemicals like hydrogen peroxide, for instance. Instead, the researchers are essentially utilizing the "self-healing" power of water aided by photolysis (a.k.a. photochemical dissociation). The principle of photolysis is based on splitting water molecules using photons. The shorter the wavelength of light, the higher the photons' energy. Researchers therefore use light sources in this system that emit UV light exclusively in the region of 172 nanometers – i.e. extremely energetic photons. As soon as these photons enter water, they split the H2O molecules, forming highly reactive hydroxyl radials as a result. "These hydroxyl compounds have an even higher reaction potential than atomic oxygen, for example. They are therefore able to decompose even very stable hydrocarbon compounds contained in harmful residues," explains Siegfried Egner, head of the Physical Process Technology department at IGB.

Controlling the movement of the water

There is a catch, however: this process takes place only in the immediate vicinity of the UV emitter – a rectangular, flat glass element that is positioned in the reactor vessel. When power is applied to the element, the hydroxyl radicals form a thin reactive boundary layer only about 50 micrometers deep surrounding the external surface of the glass. In order to be sure no harmful particles escape untreated, the water must be

controllably and verifiably directed through this boundary layer – a genuinely tricky task. On the one hand, you have to make sure the entire contents of the reactor vessel is treated. On the other, the researchers would like to be as certain as possible that every single hydroxyl radical formed is also used for a chemical reaction. This is because the extremely reactive hydroxyl radicals are extremely short-lived. If no "fresh" molecules are found to react with during this time interval, the energy of the hydroxyl radicals goes unused. The experts in Stuttgart have been successful in controlling the movement of the water so exactly that all of the reactor vessel contents are reliably and highly efficiently treated.

The first industrial prototype, which has a through-put of 2.5 cubic meters per hour, will be shown by the researchers and their industry partners at the trade fair. "A certain amount of variation is normal, since the processing speed depends of course on the degree of contamination as well," explains Egner. To be sure the water is actually discharged only if its quality is impeccable, the unit is equipped with an additional safety mechanism. A sensor system is located right at the discharge port that monitors the water for harmful substances. The water is discharged only once impurities falls below a maximum permitted value. The entire unit is fully automatic and programmable – for instance, it can be switched on and off depending on the electrical power rates on offer.

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