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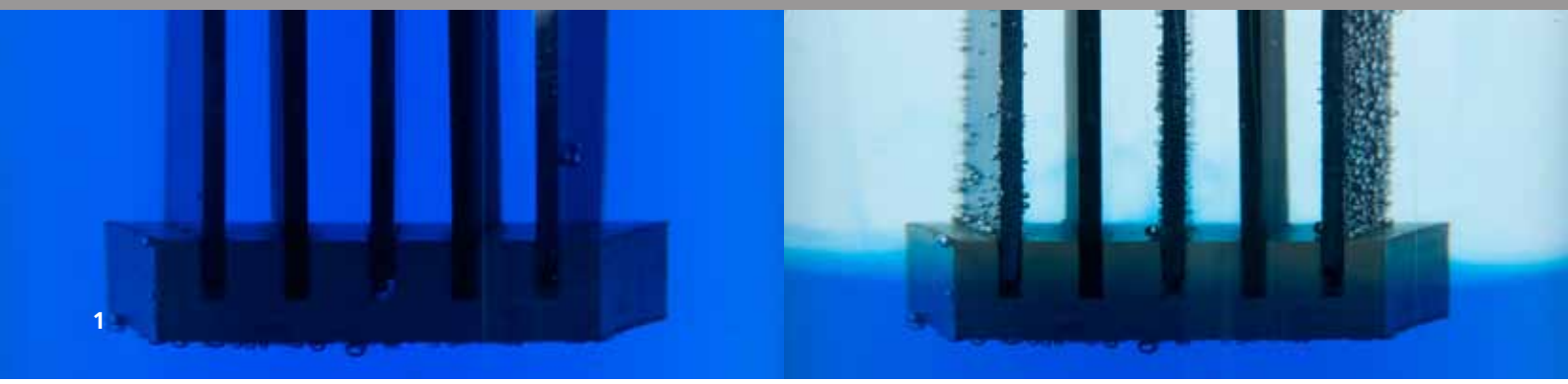
FRAUNHOFER WATER SYSTEMS ALLIANCE (SYSWASSER)



1 *Degradation of blue textile dye using diamond electrodes.*

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DIAMOND ELECTRODES: TREATMENT OF INDUSTRIAL WASTEWATER

Water is an important auxiliary material for many fields of industry. On the one hand it is used in a mostly defined quality as process water and on the other hand it is output as wastewater which may contain various residues from production.

In the case of highly purified process waters, such as are, for example, required for pharmaceuticals production or for cleaning purposes in the optics and semiconductors industries, contamination plays an important role. The problem here is that in most cases no chemicals can be used to carry out the disinfection necessary. Industrial wastewaters are frequently loaded with persistent, hard to degrade pollutants which can only be removed by conventional methods with a great deal of effort or even not at all.

The solution

Electrodes coated with polycrystalline conductive diamond films electrochemically generate oxidizing agents in the water without the use of chemical additives. On account of the extremely high overvoltage diamond electrodes provide for breaking water down into oxygen and hydrogen, not only are ozone (O_3) and hydrogen peroxide (H_2O_2) generated from the water molecules with a high current yield but also even hydroxyl radicals ($OH^{\bullet}$), which count as the strongest oxidizing agent. This means that no additional chemicals are required for the degradation of pollutants or to kill off bacteria. Furthermore, the oxidizing power, especially that of $OH^{\bullet}$ radicals, is strong enough to be sure to fully oxidize even persistent pollutants and thus render them harmless.

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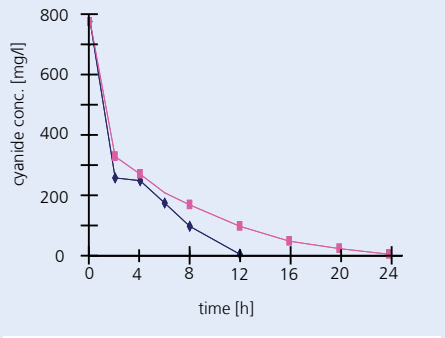
Degradation of cyanide compounds using lead-oxide and diamond electrodes in a wastewater from nickel electroplating.



For three different wavelengths the initial color values are given and also the color values reached in each case. For the purpose of comparison the color limits required for effluent water are listed.

	436 nm	*525 nm*	*620 nm*
Limit [m^{-1}]	*7.0*	*5.0*	*3.0*
Before [m^{-1}]	*81.2*	*7.7*	*0.0*
Diamond [m^{-1}]	*1.1*	*0.5*	*0.6*
PbO_2 [m^{-1}]	*29.5*	*29.5*	*3.3*

The Fraunhofer IST has been significantly involved in the development of the diamond electrodes and in testing them in different applications and is working on their further development and on implementation of the technology. In feasibility studies carried out at the Fraunhofer IST in test rigs and laboratory cells further development work is in progress on the electrochemical degradation of persistent pollutants (Fig. 2) and efficient ozone generation (Fig. 3) for disinfection using diamond electrodes. With positive results from the feasibility studies, investigations are underway to determine the electrical operating parameters and for the design of the diamond electrodes and electrochemical cells. Selected prototype cells are operated on site to obtain data regarding electrical and hydrodynamic operating parameters and also to secure information regarding integration into an overall system solution for a specific application case. Evaluation of these data makes it possible to assess the economic and technical feasibility of a system solution which includes electrochemical oxidation using diamond electrodes. In the event of a positive assessment the system solution will be implemented.

Advantages of the solution

The use of diamond electrodes makes possible the efficient removal of persistent and not readily degradable pollutants directly where they arise and without the need for additional chemicals. Current/voltage regulation means straightforward control of the systems. Heavily contaminated wastewaters no longer need to be expensively collected and transported away. The introduction of micropollutants into the water system can be considerably reduced or even prevented entirely. Furthermore, systems with diamond electrodes mean, for example, that production water can be prepared and then re-used, thereby permitting closed-loop water cycles. Only low energy levels are required to kill the bacteria and no chemical additives. Systems with diamond electrodes are thus suitable not only for water disinfection in areas with an autarchic, renewable energy supply but also for sterilizing ultra-clean process waters in production.

The Fraunhofer IST as a partner

The Fraunhofer IST participates in the Fraunhofer Water Systems Alliance (SysWasser) with its technology for the electrochemical treatment of water using diamond electrodes. This technology represents one module in the Alliance's technology portfolio. The aim of the Water Systems Alliance (SysWasser) is to research, develop and implement sustainable system solutions for the water supply, water infrastructures and wastewater treatment. The Fraunhofer IST is also a development partner of Condias GmbH, a spin-off company of the Fraunhofer IST, which markets diamond electrodes and which also in collaboration with partners develops system solutions.

2 *Test set-up for feasibility studies using a diamond bipolar cell.*
3 *Laboratory cell for investigating ozone generation using diamond electrodes.*