



1 *Diamond electrode, consisting of a niobium base body coated with a conductive polycrystalline diamond film.*

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DIAMOND ELECTRODES: DEGRADATION OF POLLUTANTS IN WATER

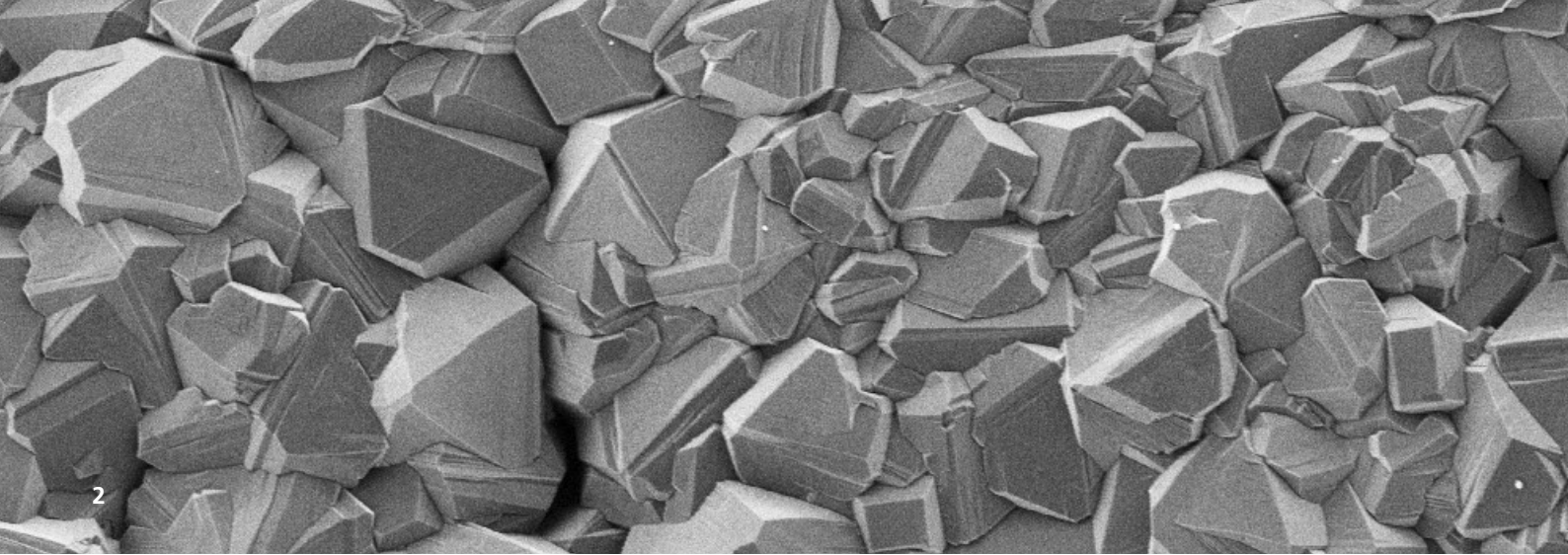
A number of very stable chemical pollutants, such as, for example, pharmaceuticals, pesticides and organic compounds from chemical production, get into our water in very low concentrations from various sources. These contaminants enter the water by different processes. They are found, for example, in surface water, in some types of groundwater as well as in wastewater from production facilities and hospitals.

Some of these compounds are as micropollutants a health hazard even in low concentrations. They may have a carcinogenic or even a mutagenic effect. However, due to their chemical stability they are difficult or even impossible to remove from the water by conventional methods.

The solution

At the Fraunhofer IST, persistent organic compounds are fully oxidized by electrochemical oxidation using diamond electrodes.

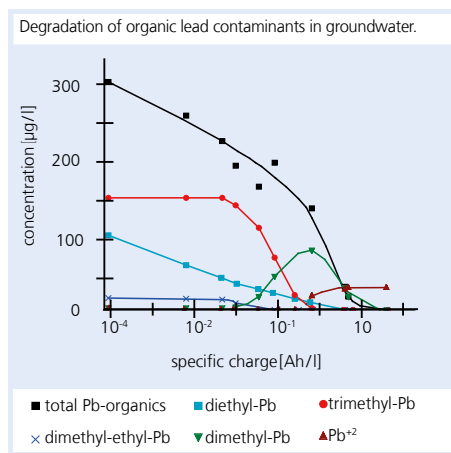
This method is based on the high over-voltage of conductive diamond in water which makes it possible for highly-reactive oxidizing agents, such as, for example, OH^{\bullet} radicals, to be generated directly in the water. The OH^{\bullet} radicals are able to fully oxidize all organic compounds up to and including CO_2 . Inorganic components are at the same time also oxidized to the highest oxidation level. The effectiveness of this technique has been demonstrated in a series of feasibility studies.



Example 1: Degradation of carcinogenic organic lead compounds

Pollutants of this kind are found in a number of groundwater reservoirs in concentrations up to a few hundred micrograms per liter.

These compounds and their intermediate products can be decomposed electrochemically to the point where only harmless residual concentrations of less than 20 nanograms per liter are left in the water (see graph below). This degree of degradation has not yet been achieved by any other conventional method.



Example 2: Degradation of pesticides in tank water

Contamination of the investigated tank water with pesticides results from rainwater being collected. The pesticides Diuron (initial concentration 0.28 µg/l) and terbutryn (initial concentration 0.6 µg/l) have been reduced to concentrations below the detection limit of 0.05 µg/l (right-hand graph).

Technical implementation requires the following application-specific developments:

- Adjustment of the electrical and hydrodynamic operating parameters to the water volumes to be treated and pollutant concentrations involved
- The intermediate products of oxidation to be taken into account
- Design of the electrochemical cell and the corresponding diamond electrodes
- Integration of the electrochemical treatment into the overall system

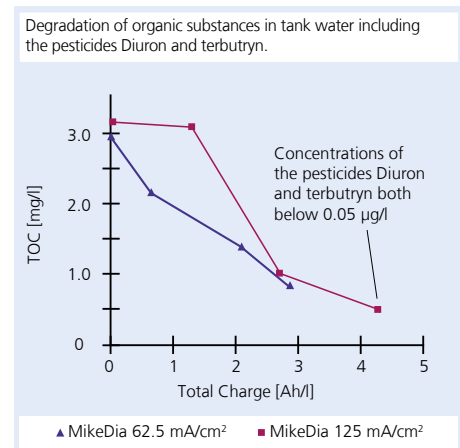
The corresponding advance research and development work necessary is carried out in the field with pilot systems. The results of these investigations make it possible to assess the economic and technical risks of industrial-scale implementation.

Advantages of the solution

Using diamond electrodes means that not readily degradable contaminants can be removed directly on site and without leaving any residues. No additional chemicals are required. Micropollutants, which even at low concentrations may represent a potential hazard, can be safely degraded. Current/voltage regulation means straightforward control of the systems while direct on-site deployment means that the introduction of even low concentrations of pollutants can be prevented.

The diamond electrodes and their application in the field of water treatment has to a significant extent been co-developed at the Fraunhofer IST and in 2001 was transferred to the spin-off company Condias GmbH which markets diamond electrodes under the trade name DiaChem®. In addition, Condias together with partners (amongst whom the Fraunhofer IST functions as a development partner) is developing electrochemical systems based on diamond electrodes.

This technology is part of the technology portfolio of the Fraunhofer Water Systems Alliance (SysWasser) of which the Fraunhofer IST is a member. As an R&D service provider, SysWasser researches, develops and designs sustainable system solutions for the water supply, wastewater treatment and water infrastructures.



2 Scanning electron microscope image of a conductive, polycrystalline diamond film on an electrode base body.