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# ADVANCED OXIDATION PROCESSES WITHOUT ADDITIVES


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Fraunhofer IGB has within its portfolio numerous technologies for treating an extremely wide range of chemically and biologically polluted process wastewaters from branches of industry such as the chemical and pharmaceutical industries or metal processing, process wastewater with a high organic load from paper and cellulose processing, and also from the food and beverages industries.

## Photo induced Advanced Oxidation of pollutants using 172 nm excimer lamps

Traces of pharmaceuticals, personal care compounds, hormones, etc. are increasingly detected in lakes and rivers. The presence of these micropollutants is an emerging threat to human and environmental health. Domestic wastewater is the main entrance point of such micropollutants into the environment. Only few wastewater treatment plants have the technology installed to remove these compounds. Fraunhofer IGB has been researching the abatement of those components under Advanced Oxidation Processes during the last years; due to the development of excimer lamps, this process has been validated and demonstrated to be an alternative for the removal of these hardly degradable pollutants.

It is known that water molecules are efficiently photolyzed under irradiation at wavelength $\lambda < 190$ nm and the main photolysis product is the highly reactive hydroxyl radical OH. The use of OH radicals for oxidation leads to faster reaction rates when compared with other oxidation processes. Oxidation reactions initiated by OH radicals are essentially non-selective, this has the advantage of high reaction rates with most target compounds. Oxidation via water photolysis offers the advantage


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of no use of additional auxiliary oxidants to produce sufficient amounts of OH radicals. This is because in almost all the cases, water itself is the prominent absorber of radiation at 172 nm, due to its high molar concentration [$H_2O$] = 55,39 mol $L^{-1}$ ($\rho$ = 0,9982 kg $L^{-1}$ at T = 20°C) and of its molar absorption coefficient $\varepsilon\lambda$.

Fraunhofer IGB has developed a series of UV reactors for different purposes and able to deliver specific wavelenghts depending of the application.

## Laboratory setup

In a laboratory scale set-up of four parallel 172 nm UV reactors wastewater samples provided by customers can be screened and characterized. In the reactor Xe-filled lamps are lit by a high frequency electric field inducing them to glow and irradiate UV at 172 nm. This setup is used to investigate under laboratory conditions the oxidation of different hardly degradable components between them sulfaquinoxaline, bisphenol A, carbamazepine, paracetamol, methylene blue and caffeine as well as its mixtures and real process water. The concentration of the components is measured using HPLC, and the mineralization is followed by TOC measurements.

## Industrial scale setup

In industrial scaled units a number of 172 nm UV reactors arranged serial or in parallel can treat the wastewater in batches or continuously. The process is followed and controlled via continues TOC measurement. The industrial scale setup is therefore robust, ready to use and easily transportable.

## Advantages of UV treatment at 172 nm

- Chemical free process
- No handling of oxidizers is required
- Fast abatement of hardly degradable pollutants
- Sequential decomposition of larger NOM molecules
- Complete mineralization of pollutants possible
- Safe and affordable solution for the removal of micro pollutants
- EE/O less than 1 kWh/$m^3$ for trace elements
- Compact reactor design
- High energy irradiators
- High formation of hydroxyl radicals
- Disinfection of the treated water as a side-effect
- No increase in salinity, which enables recirculation
- VUV system can be used as a pre-treatment to enhance biodegradability
- Adjustable treatment capacity
- Scalable process
- Instant on/off – for optimal management of energy adjustable to energy supply
- Integrated treatment control and quality documentation
- Robust process
- Available rapidly – standby operation possible
- Suitable for varying quantities and qualities of wastewater

## Other applications

- New possibilities for special applications
  - Ultrapure water
  - Decentralized system
- Food & Beverages: main oxidizing process and polishing
- Pulp & Paper: polishing
- Chemical: main oxidation process and polishing
- Pharmaceuticals: main oxidation process and polishing
- Metals: polishing
- Textile main oxidation process and polishing
- Treatment of concentrated micro pollutants containing waters

## Services offered by Fraunhofer IGB

- Development of chemical-free processes for specific contaminations or water qualities
- Quantification of treatment results and quality assurance by water relevant analytics (COD, TOC, GC-MS, HPLC)
- Process optimization
- System integration
- Benchmarking with different AOP processes identifying the best suitable process or combination of processes
- Market research
- Technology validation
- Technology transfer