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Electricity Kills Pollutants

Challenges and Opportunities in Modern Wastewater Treatment

Cost-effective – Incineration is one of the most expensive disposal methods for contaminated industrial wastewater, but in some cases seemingly the only possibility. But clever combinations of Electrochemical Advanced Oxidation Processes (EAOPs) offer a cost-effective alternative by destroying dangerous substances by applying only electricity and air.

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Until today in many cases no economic alternative to wastewater incineration has been available, therefore thousands of tons of contaminated wastewater are being transported from the place of origin to central incinerators. Besides the enormous cost of such treatment, issues of safety and logistical burden force operating companies to look for alternatives.

So called Advanced Oxidation Processes (AOPs) are well known in industrial wastewater treatment. Using these processes persistent or toxic organic pollutants are partly or totally oxidized to water, CO_2 and harmless salts as they undergo mineralization. Since there is no shift of the problem to solid or gaseous wastes like in case of activated carbon or filtration, the pollution problem is sustainably resolved. The effect is achieved by oxidizing agents such as ozone, hydrogen peroxide or oxygen, and it can be further enhanced through the use of UV radiation, ultrasound or special catalysts.

Complex Logistics

For a specific wastewater stream a sufficient amount of oxidizing agents such as hydrogen peroxide (H_2O_2) has to be provided. This can lead to extra cost for the oxidizing agent when large quantities of hydrogen peroxide are required, since

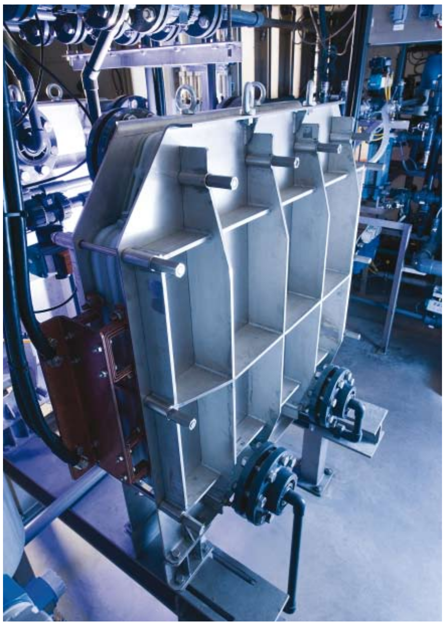

Fig 1: Electrolysis cell treating wastewater and producing hydrogen peroxide *in situ*

efficiency losses resulting from transport and storage can only be avoided by complex logistics and the addition of stabilizers. Through on-site production this can be avoided.

In recent years, there have been major efforts to find commercial technologies to produce hydrogen peroxide on-site. Previously, low yields and high energy needs resulted in the inefficiency of on-site production. The development of so-called gas-diffusion electrodes (GDE) has been a major step in the right direction. The industrial application of these systems, however, was not successful due to the poor scalability and short life times. Through the use of novel electrode materials and the direct gas supply to the electrodes, the disadvantages of the gas-diffusion electrodes have been overcome.

Just in Time

Through consequent development hydrogen peroxide can now be economically produced in sufficient quantities directly in the wastewater stream. So providing additional hydrogen peroxide may be omitted entirely. The injected atmospheric oxygen or pure oxygen is reduced in the electrolytic cell to hydrogen peroxide; the wastewater is used as electrolyte. Stimulated by UV radiation, ultrasound, or catalysts, the hydrogen peroxide can immediately achieve its desired effect – the decomposition of the pollutants. Using this method, there is an additional effect in the water treatment, as pollutants are partially oxidized at the anode first (fig. 1).

Clever Combinations

The control of the interactions of many complex effects and processes requires extensive know-how. Through a combination of electrochemical, photochemical and catalytic processes the best solution for a given wastewater problem can be designed; because no wastewater is like another. Main fields of application are the chemical and pharmaceutical industry, oil and gas, petrochemical, pulp and paper, textile and food industries. Non-industrial applications are the treatment of hospital wastewater, landfill leachate and sewage with undesirable coloring or odor problems.

The processes described work at room temperature and atmospheric pressure, which also simplifies the regulatory approval process. Besides electricity and compressed air (or oxygen) no additional utilities and resources are necessary. The simple On/Off mode avoids time-consuming start-up and shut-down procedures.

Fig 2: mobile EAOP pilot plant (capacity: 2,000 liters per hour)

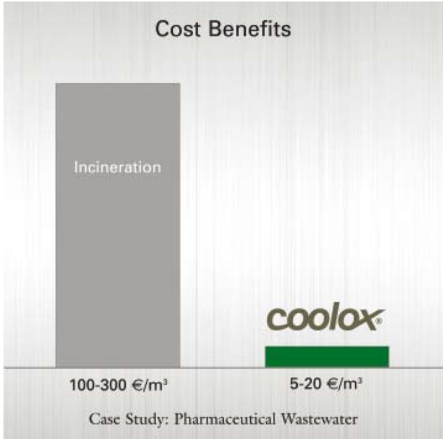

Fig 3: Cost benefits compared to wastewater incineration

Customized Solutions

VTU has undertaken comprehensive research and generated a pollutant database which covers the technical and economic feasibility for well known pollutants. The applicability of these oxidation processes for new substances are examined through the use of standardized process screenings in special AOP laboratories with up to date analytical equipment. The best combination is then tested on site using a mobile pilot plant (fig. 2).

The modules of the pilot plant (electrolysis cells, photo reactors) already reflect full-scale units. Further up-scaling is done by simple numbering-up. The risk in the scale-up is thus largely eliminated for customers and suppliers.

Cost Benefits

For wastewater streams with moderate COD values the treatment costs including depreciation are in the range between €5 to 20 per cubic meter. The pure operating costs for electricity and compressed air or oxygen are even under €1/m³. Comparing this with disposal costs incurred by incineration (€100 to 300/m³), the cost advantage is clear and impressive.

EAOP processes are ready for widespread industrial use. By using this innovative oxidation processes, complex pollution problems of wastewater can be sustainably resolved – a contribution to the protection of our scarce and valuable water resources.

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