Technology offer:

Waste treatment by sonochemical electrochemical and sonoelectrochemical technology
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Waste treatment by sonochemical, electrochemical and sonoelectrochemical technology

Reference: TO-SONO

Summary

The Department of Physical Chemistry, Group of Applied Electrochemistry and Electrocatalysis, at University of Alicante has expertise and know-how for the treatment of wastes (waste water in particular) by sonochemical and sonoelectrochemical technology. Waste water containing chlorinated compounds, volatile organic compounds (VOC’s), phenols, tensioactives, fats and hydrocarbons are able to be treated by this technology in order to decrease its polluting effect. Lab scale tests have been performed successfully. The Department also has a fully equipped pilot plant with the necessary infrastructure for the development of the pre-industrial phase and scaling-up of the different processes.

Technical description

SONOCHEMICAL AND SONOELECTROCHEMICAL TECHNOLOGY

Sonochemical technology is specially based on chemical effects produced by the ultrasound waves propagation in a reaction medium, thereby providing an enhancement in the activation or development of chemical reactions because of the acoustic energy. Electrochemical technology is based on the activation or development of chemical reactions because of the electric energy. The sonoelectrochemical technology uses both kinds of energy to develop chemical reactions using the benefits provided by the physical and chemical effects from the ultrasound propagation. Most of these effects are directly related to the cavitation phenomenun where the nucleation, growth and implosion of bubbles from the medium takes place. This high energy microenvironment provided in the reaction medium by the ultrasound, together with the electric field, implies the best conditions to carry out difficult or complex processes without extreme conditions of pressure and temperature.
SONO- AND SONOELECTROCHEMICAL DEGRADATION OF POLLUTANTS IN WASTE WATER

Nowadays, due to the increasing presence in extremely refractory molecules in the wastewater streams, the conventional biological methods cannot be used for complete treatment of the effluent and hence, the introduction of newer technologies has become imperative to degrade these refractory molecules into smaller molecules, which can be further oxidized by biological methods. In this way, the sono- and sonoelectrochemical technology may be the effective treatment of waste water, and other types of waste, in a wide concentration range of pollutant organic compounds (halocompounds, phenols, cyanides etc.).

In the past there was a prevailing feeling in industry that the ultrasonic power (and the electrical one) would be too expensive to be used for the wastewater treatment on an industrial scale. This was based on calculations involving the direct scale up of power consumption in small-scale laboratory experiments. Recently this attitude has changed somewhat as a result of the installation of a number of ultrasonic and electrochemical devices in operational waste or sewage treatment plants are being developed.

As far as the well-known advantages of the conventional treatments are concerned, the sono- and sonoelectrochemical degradation present several advantages compared with those in classical treatments:

1. These technologies are able to treat very toxic wastes at mild conditions.
2. They are environmentally friendly technologies using only electricity as a reactant.
3. The energy consumption depends on the chemical oxygen demand (COD).
4. The sono- and sonoelectrochemical treatment can be simply stopped by switching the power off.
5. Cost effective and safe
6. Fully-controlled by a computer.
7. Even effluents with low conductivity can be treated.

A suitable method for a specific effluent treatment can be developed using both technologies in:

- single mode, thus ultrasonic or electrochemical approach.
- alternative mode, thus working periodically on ultrasonic and electrochemical approaches.
- series mode, thus in cascade. During an established period one of the two techniques is applied; thereafter, the other one is used.
- Simultaneous mode, thus ultrasound and electric fields applied at the same time.

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The programme and mode of treatment will depend on the characteristics of the effluent. Nonetheless, the treatment can be considered as the last stage before disposal in order to fit regulations set by law.

At present, the sonochemical technology is used to treat aqueous solutions or suspensions of

- \( \text{CCl}_4 \)
- \( \text{CH}_3\text{I} \)
- \( \text{R}_2\text{CHCl} \)
- \( \text{Cl}_2\text{CCH(OH)}_2 \)
- \( \text{C}_6\text{H}_5\text{Br} \)
- \( \text{RCO}_2\text{H} \)
- \( \text{C}_5\text{H}_5\text{N} \)
- \( \text{RCH}_2\text{NH}_2 \)
- Cyanide and nitrite
- purification of waste water and in general as a method for the reduction of COD from any effluent
- Phenols
- tensioactive compounds and dyes.

DESIGN AND PILOT PLANT FACILITIES

The Department of Physical Chemistry also has a fully equipped pilot plant with the necessary infrastructure for the development of the pre-industrial phase and scaling-up of the processes. The pilot plant has set up several electrochemical reactors to produce chemicals at pre-industrial and industrial scale.

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Innovative aspects of the technology

- The sonochemical, electrochemical and sonoelectrochemical treatments are able to cope with the destruction of a very toxic waste in a very wide concentration range in the effluent avoiding the use of high temperature and pressure.
- These technologies present the possibility of recovery some pollutants of high commercial value, for example, metals.
- They are suitable when traditional treatment methods are ineffective due to the presence of non-biodegradable materials, heavy metals, hazardous compounds which are incompletely degraded. They are specially attractive when coupling as a previous process with the traditional treatments.
- They can be designed to fit with the requirements of single pollutants.
- It is an environmentally friendly technology since it avoids the emission of gases, sulphur and metal particles and uses the electricity as reactant.
- It is a safe and effective technology

Current state of the technology

The electrochemical technology has been already tested at laboratory, pilot and industrial level and the research team has several years of experience in this field. The pilot plants are already working and some projects for Spanish and European clients has been carried out successfully. All the technicians and management staff have enough experience to guarantee the success of the projects.

Regarding sonochemical and sonoelectrochemical approaches, it is known that they are powerful technologies for the treatment of several wastes. At present, the group presents experience with the sonochemical, electrochemical, sonoelectrochemical degradation of chlorinated compounds. The sonoelectrochemical technology is developed at laboratory scale.

Intellectual property rights

- Concerning the use of the equipment, development and scaling of processes, process feasibility, etc, all the information is protected by know-how.

Market applications

These treatment methods could be of interest in:

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• **Industries with waste disposal in a wide range of pollutant** concentration and volume. Potential clients could be from the textile industry, metal manufacturing industry, chemical industry, etc.

• **Consultancy firms from the environmental sector** with activities in the effluent treatment, which look for incorporating new effective methods to their capability.

**Co-operation sought**

The Department of Physical Chemistry at University of Alicante has high experience and the know-how as well as the installations required to develop the new industrial treatments of high polluted effluents. The department could:

- develop sonochemical, electrochemical and sonoelectrochemical processes for the treatment of a wide range of wastes at laboratory, pre-industrial and industrial level.
- in collaboration with other high-quality partner, design and build sonochemical, electrochemical and/or sonoelectrochemical industrial pilot plants according to the specifications by the client

In this way, this research centre seeks transferring the technology and know-how on sonochemical, electrochemical and sonoelectrochemical field to companies by means of patent licence or know-how agreements.

**Department of Physical Chemistry**

The Group of Applied Electrochemistry and Electrocatalysis at the Department of Physical Chemistry at University of Alicante was created in 1983. The staff comprises of one Full Professor, two Senior Lecturers, two Associate Professors, two electrochemical pilot-plant technicians, one electronic engineer and several post and pre-doctoral research students.

The research carried out by the group is focused on both fundamental and applied electrochemistry in a wide range of research fields like the preparation and characterization of nanoparticles, organic and inorganic electrosynthesis, waste water electrochemical treatment, design and characterization of electrochemical reactors, and engineering of sonoelectrochemical processes.

One of the aim of this group is to develop electrochemical processes for industrial purposes in a wide range of subjects and the development of the new technologies. In this way, the department presents a long experience (at industrial scale) in:

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• Development of redox batteries and an 2 kW / 20 kWh accumulator based on Fe (III) / Fe (II) and Cr (III) / Cr (II) couples.
• Electro-organic synthesis of high value pharmaceutical products in an environmentally friendly way. Several patents are held for the synthesis of l-cysteine derivatives and citiolone (some of them PCT mode). To carry out electrochemical processes at industrial scale, we have designed and built an electrochemical pilot plant at the University in which, in co-operation with a Spanish industry, we have been able to synthesise 14Tm of carboxymethyl l-cysteine, a widely used pharmaceutical product.
• Recovery of lead from lead oxide secondaries such as used lead batteries (a BRITE-EURAM project). In this project we were in charge of the study and development of the cathodic process, lead deposition, at a pre-industrial scale, of the recovery of NaCl by electrodialysis and of the elimination of lead from the wastewater by electrochemical means.
• Development of a pre-industrial prototype for the electrochemical treatment of wastewater from a textile industry.

All these works developed up to pilot or industrial scale were carried out with a final purpose to demonstrate the feasibility of the process at an industrial scale.

To do all this work, we have not only acquired a deep knowledge about Electrochemistry (both Fundamental and Applied) but also the expertise for developing different types of electrodes - single crystal, DSA, gas diffusion electrodes etc., and different electrochemical reactors. All of this has contributed to our wide experience in the development of electrochemical processes at a pre-industrial scale.

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