

## ELECTROCHEMICAL OXIDATION OF AQUEOUS PHENOL WASTES USING ACTIVE AND NON-ACTIVE ELECTRODES

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The use of electrochemical oxidation for the destruction of the organics contained in industrial wastewaters has been tried on bench and pilot plant scale during the recent years, and nowadays there are some commercial processes in use. The main problem associated to the electrochemical treatment is its high operating cost. In the recent years, more work have been done to understand better the process and, hence, to obtain a less expensive application. Literature shows that anode material influences greatly in the process performance, controlling the final oxidation products and the current efficiency.

Each type of electrode shows a different behaviour depending on its superficial characteristics and properties. The most widely accepted theory for justify these behaviours classify electrodes into two limiting cases<sup>1</sup>: active and non-active electrodes.

To make the comparison between these types of electrodes, an AISI 304 stainless steel (active) and a diamond thin film (non active) ones were chosen for the oxidation of an aqueous acid phenolic waste. The characteristics of the oxidation tests are described in table 1. Results obtained are shown in figures 1, 2 and Table2.

As can be seen in figure 1, only the non active electrode achieves an almost complete mineralization of the waste, being the mineralization rate higher than those obtained with the active one.

Analysis of reaction intermediates (Table 2) shows that polymerisation is the main reaction pathway, using the active electrode. By GPC liquid chromatography it was found that the polymeric material developed in the process was a mixture of various polymers with low molecular weight (ranging from 200 to 500mg/mmol). Conversely, the oxidation of the phenol waste using a non active electrode deals to the sequential formation of aromatic compounds, carboxylic acids and carbon dioxide.

Figure 2 shows the evolution of current efficiencies in both processes. Non active electrodes maintained their current efficiency in a value close to 1 for low values of the current passed (Q) and then decrease to finally reach a value of 0. This behaviour is characteristic of non active electrodes<sup>2</sup> since in this kind of electrode only organic matter diffusion limitations makes the ICE decreases. Conversely the ICE obtained with the active electrode is very low, mainly due to the formation of stable polymers.

Results obtained in this work can be explained in terms of the oxidation of phenol to phenoxy radicals (first step of the process). The oxidation performed in non active electrode is stronger dealing to the quick formation of benzoquinone and to the split of the aromatic ring. On the contrary the softer oxidation performed in the active electrode allows the

combination of phenoxy radicals to form dimmers and higher molecular weigh compounds.

### Literature cited

- (1) Fóti, G.; Gandini, D.; Comninellis, C.; Perret, A.; Haenni, W. Oxidation of organics by intermediates of water discharge on IrO<sub>2</sub> and synthetic diamond anodes. *Electroch. and Solid-State Letters*, **1999**, 2, 228.
- (2) Rodrigo, M.A.; Michaud, P.A.; Duo, I.; Panizza, M.; Cerisola, G.; Comninellis Ch. Oxidation of 4-Chlorophenol at Boron-Doped Diamond electrodes for Wastewater Treatment. *J. Electrochem. Soc.*, **2001**, in press

Table 1. Experimental conditions

Cathode	Stainless Steel AISI 304
[Phenol] <sub>0</sub>	1000 ppm
[Na <sub>2</sub> SO <sub>4</sub> ]	5000 ppm
PH	2
Current density	30 mA / cm <sup>2</sup>

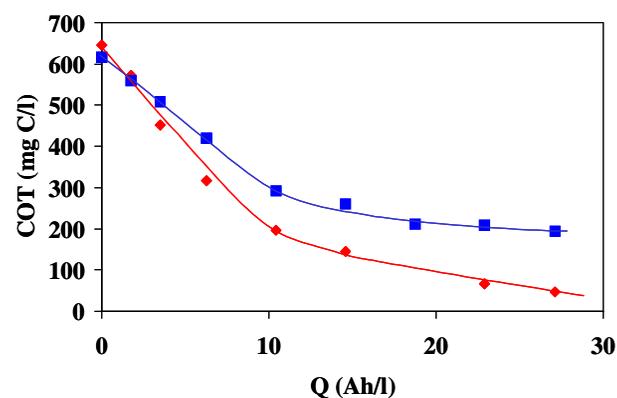


Figure 1. Total organic carbon (mg C/l). (♦ non active electrode; ■ active electrode)

Table 2. Maximum concentration of intermediates and final products (mg C/l)

parameter	Active electrode	Non active electrode
hydroquinone	10.0	3.0
benzoquinone	0.0	4.0
C <sub>4</sub> acids	16.1	10.4
C <sub>2</sub> acids	0.0	77.5
polymers	235.6	0.0
Carbon dioxide	185.0	584.3

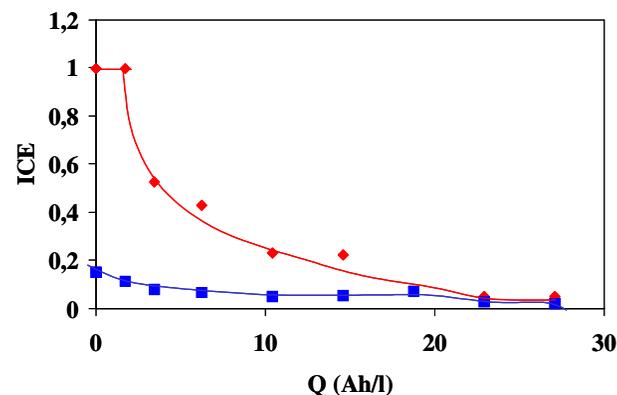


Figure 2. Instantaneous Current Efficiency (♦ non active electrode; ■ active electrode)