Electrochemical Elimination of Chloranilic Acid by using Pb/PbO_2, Ti/IrO_2 and Si/Diamond Electrodes

C. A. Martínez-Huitle[1], M. A. Quiroz[1] and Ch. Comninellis[2].

[1]Universidad de las Américas-Puebla. Escuela de Ciencias. Departamento de Química y Biología.Sta. Catarina Martir, Cholula 72820 Puebla, México.
[2]Institute of Chemical Engineering, Swiss Federal Institute of Technology, CH-1015 Lausanne, Switzerland.

There are several methods of treating industrial wastewater containing organic pollutants including incineration, adsorption, biological treatment, and chemical and electrochemical oxidation processes. However, the kind of treatment depends on differents factors as well as reability, control, economics and treatment efficiency [1].

The electrochemical oxidation method has been proposed for the destruction of hazardous waste and the conversion of mixed waste to low-level toxicity, when the wastewater contains refractory organic pollutants or toxic substances. For these cases, the better electrocatalysts found are metallic oxides such as IrO_2, PbO_2, and SnO_2 [2] and, more recently, Ti/Diamond or Si/Diamond as new technology [3]. These electrocatalysts have shown high performance levels to the conversion and/or combustion by electrochemical oxidation of non-chlorinated compounds. For the elimination of chlorinated compounds the electrochemical reduction [4] as well as the electrooxidation [5,6] have been matter of great attention. From these studies, it has generally been observed that chlorinated compounds were effectively removed from the solution but their reaction intermediates were still toxic. Therefore, the aim of this work is shows the experimental results an their conclusions on the electrochemical oxidation of dilute aqueous solutions of chloranilic acid (CAA) by using different electrodes materials (Pb/PbO_2, Ti/IrO_2 and Si/Diamond) and as a function of the reaction temperature and the applied current density.

The electrooxidation experiments were made in an one compartment parallel plate cell. The electrode dimensions were 90 mm of diameter with 635 cm^2 of exposed area to the aqueous solution. The cathode was a zirconium disc. For the electrochemical cell, inlet and outlet were provided for electrolyte circulation through the parallel disc cell using a peristaltic pump. The solution composition was 400 ppm CAA in 0.5 M H_2SO_4 as supporting electrolyte. Constant current density of electrolysis was kept at the desired level (6.3, 12.5, 25 and 50 mA cm^{-2}), and the temperature effect (25, 60 and 80ºC) analyzed at 25 mA cm^{-2} of current density. The electrolyte flow rate was kept at 165 Lh^{-1}. The solution composition during the electrolysis experiments was analyzed by using several analysis methods such as liquid chromatography (HPLC), total organic carbon (TOC), chemical oxygen demand (COD), and spectrophotometric measurements (UV-vis). The COD method [7] was used in order to determine the general current efficiency (GCE) for the anodic oxidation of CAA.

The influence of anodic material (Pb/PbO_2, Ti/IrO_2 and Si/Diamond) on the GCE values was similar for Pb/PbO_2 and Si/Diamond electrodes, Fig. 1. This figure shows that the elimination rate of CAA is not dependent on the current density but is depends on the specific electrical charge passaded (Q). For Pb/PbO_2 electrode, the better efficiencies were observed at current density values of 6.3 and 12.5 mA cm^{-2}. At current density values higher than 50 mA cm^{-2} the elimination of CAA was minimum. It was also observed that the changes in temperature have not influence in the CAA elimination, but the Pb/PbO_2 electrodes showed GCE values higher than those for the Si/Diamond electrodes, Fig. 2. For the Ti/IrO_2 electrodes the values of applied current density (12.5, 25 and 50 mA cm^{-2}) shown to be very high. In this case, it is important to take into account that these electrodes are considered as "active electrodes" and, consequently, must be used at small values of current density [2].

In conclusion, the GCE for the electrochemical elimination of CAA from aqueous solutions follow the sequence: Si/Diamond ≥ Pb/PbO_2 > Ti/IrO_2 which depends on the variations of temperature, current density and lifetime service of the electrode.

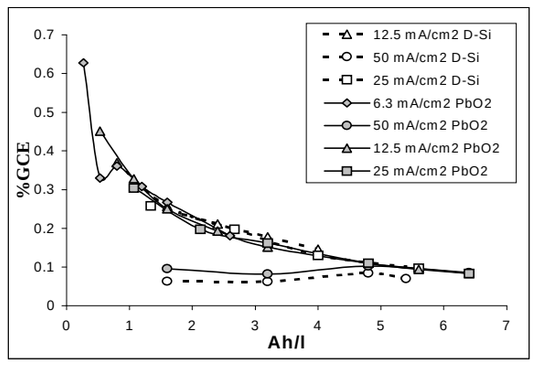

Fig. 1 Effect of the applied current density on the CAA elimination for Pb/PbO_2 and Si/Diamond electrodes.

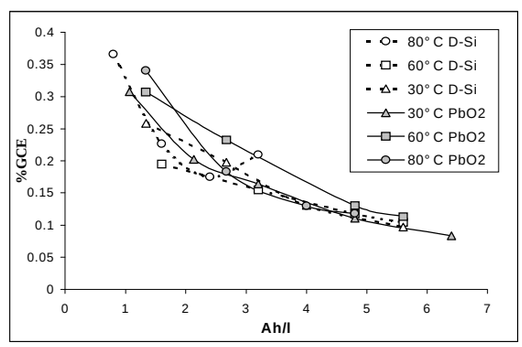

Fig. 2 Effect of the reaction temperature on the GCE values.

Acknowledgement-The authors are indebted to the CONACYT and INIP for financial support of this work.

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