Estimation of the Electro-combustion Activity of the Anode
With the Use of the Normalized Current Efficiency

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In the field of the electro-combustion of the bio-refractory organic species usually the applied current density is higher of the limiting one especially at the end of the process when the organic species concentration reach low values. At these conditions the obtained low value of the instantaneous current efficiency *ICE*, is not due only to the low electrocatalytic activity of the anode but also to the mass transfer limitation.

The normalized current efficiency ϕ, has been introduced in the field of the electro-combustion of the organic species [1], to separate the two effect and this new efficiency is related to the electrocatalytic quality of the anode even when the anode operates under mass transfer limitation.

The normalized current efficiency is related with the instantaneous current efficiency, as well as, with the limiting current density i_{lim}, that represent in a suitable way the maximum mass transfer of the organic species forward the anode. The expression of the normalized current efficiency is given by:

$$\phi = \frac{i_{appl}}{i_{\lim}} ICE$$

where i_{appl}, *is* the applied current density (A m^{-2}). The normalized current efficiency measure the electrocatalytic activity of the anode during the electro-combustion of the organic species and it assumes its maximum value (ϕ=1), when highly electrocatalytic anodic material is used.

This parameter has been obtained in the case of the elettro-combustion of 4-chlorophenol (4-CP), to point out the electrocatalytic activity of the two used anodes, diamond doped boron (BDD) on silica and $Ti/SnO_2/PbO_2$ anode. The experimental systems, shows in Fig. 1., was used and the same electrolyte solutions of 4-CP with 1 mole dm^{-3} H_2SO_4 were used in both cases. Some experimental results of COD vs. specific charge, for the case of $Ti/SnO_2/PbO_2$ anode, have been reported. Fig. 2.

The evolution of the normalized current efficiency ϕ, vs. chemical oxygen demand conversion X, has been reported in Fig. 3. The value of ϕ assumes its maximum value in any condition when the BDD anode is used and this result confirms, quantitatively, the well known electro-combustion activity of this anodic material. The same figure indicates that in the case of the lead dioxide anode the normalized current efficiency decrease with the conversion. This result probably indicates that, this anodic material, eliminates more efficiently the initial 4-CP than the successively formed organic species.

In conclusion the reported results show that the normalized current efficiency is a suitable tool to estimate the electro-combustion activity of the tested anodic material, in the case of the mass transfer limitation.

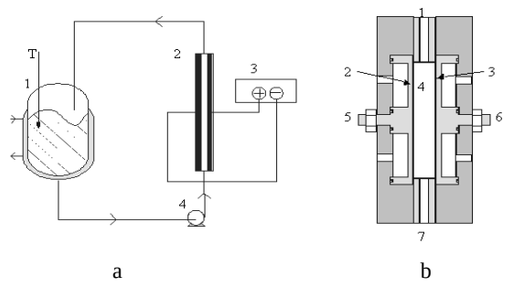

Fig. 1. Scheme of the system (a) Set-up used: 1: thermoregulated reservoir, 2: electrochemical cell, 3: power supply, 4: pump. (b) Electrochemical cell, 1: electrolyte outlet 2: anode, 3: cathode, 4: electrolysis compartment 5: and 6: electrical contacts, 7: electrolyte inlet;

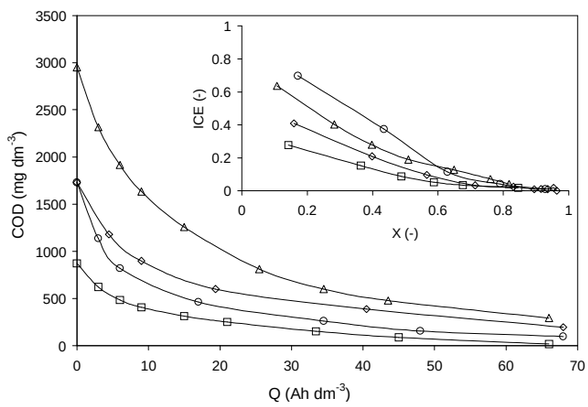

Fig. 2. Trends of COD during the electrolyses of 4-CP on lead dioxide anode. Conditions: (Δ) [4-CP]=2000 ppm, i=30 mA cm^{-2}, (◊)[4-CP]=1000 ppm, i=30 mA cm^{-2}, (□)[4-CP]=500 ppm, i=30 mA cm^{-2}, (○)[4-CP]=1000 ppm, i=15 mA cm^{-2}. Inset: Instantaneous current efficiency (ICI) as a function of chemical oxygen demand conversion (X).

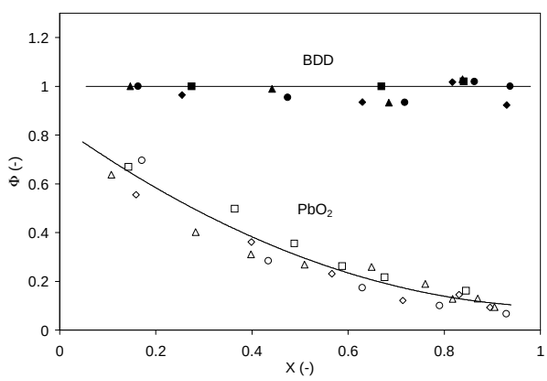

Fig. 3**.** Normalized current efficiency ϕ vs. chemical oxygen demand conversion X. Conditions: (Δ) [4-CP]=2000 ppm, i=30 mA cm^{-2}, (◊) [4-CP]=1000 ppm, i=30 mA cm^{-2}, (□) [4-CP]=500 ppm, i=30 mA cm^{-2}, (○) [4-CP]=1000 ppm, i=15 mA cm^{-2}. Empty symbols: lead dioxide (PbO_2), full symbols: boron-doped diamond (BDD).

References

[1] L. Gerardini et al., Electrochemical Oxidation of 4-Chlorophenol for wastewater treatment. Definition of Normalized Current Efficiency ϕ, In Press