SCALE-UP OF A MEMBRANE ELECTROCHEMICAL REACTOR FOR ZINC RECOVERY FROM SPENT PICKLING BATHS

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INTRODUCTION

The aim of the galvanizing process is to protect steel pieces from corrosion by means of a zinc coating. As a result, some waste effluents are generated from which the spent pickling baths (SPBs) appear as the most hazardous waste. These SPBs present a high content in Zn and Fe, 0-1.87 M and 0.5-2.8 M respectively, in HCl media (0.3-4 M).

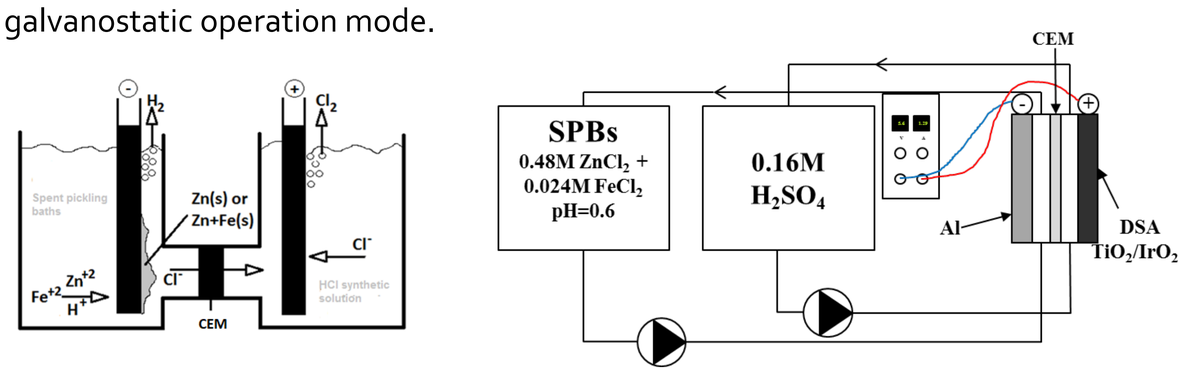
The feasibility of using an electrochemical reactor to recover the Zn coming from SPBs with a high current efficiency has been demonstrated. Furthermore, pure Zn can be obtained up to a 70 % of Zn conversion beyond which Fe begins to co-deposit. On the other hand, the use of a separator between the anode and the cathode is needed, as the free Cl_2 released at the anode may cause the redissolution of the Zn deposited on the cathode.

GOAL

This work presents the scale-up of a laboratory batch reactor of 250 mL to a first-stage pilot plant reactor of 10 L with feed recirculation.
The effect of the applied current will be studied to optimize the process.

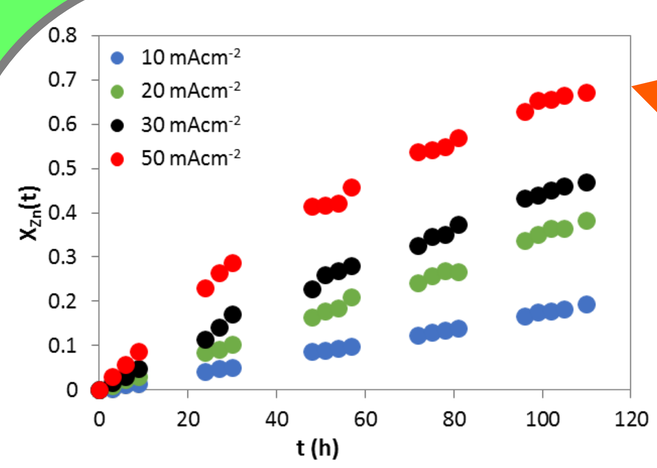
METHODOLOGY

An electrochemical membrane reactor with a Nafion-117 membrane as separator between anode and cathode was employed (Fig.1). Both cathode and anode have an effective surface of 72.25 cm^2. Both solution tanks have a volume of 10L. The current, cell potential, pH and temperature were recorded during the electrolysis. Zn and Fe content of the solutions were measured by AAS. The experiments were carried out in galvanostatic operation mode.



▲ ***Figure 1.*** Schematic representation of the laboratory reactor and its main reactions (left) and pilot plant reactor(right).

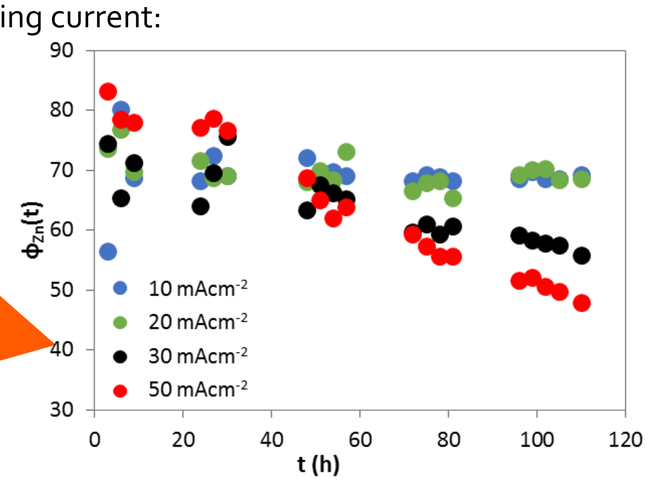
RESULTS AND DISCUSSION



▲ ***Figure 2.*** Zn fractional conversion of the SPBs for all the applied current values.

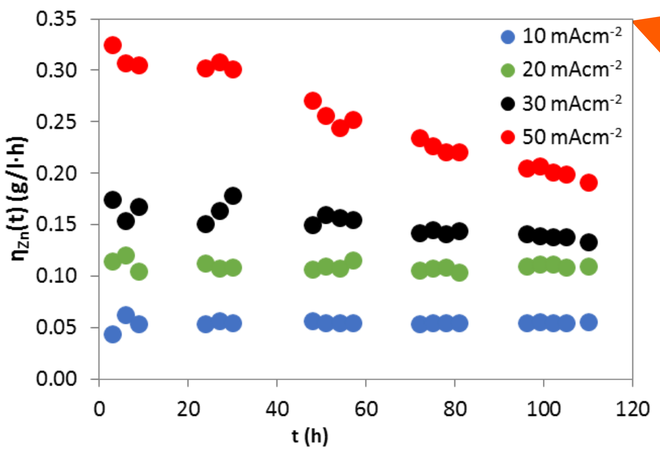
Lowest applied currents shows linear X_{Zn} growth, corresponding with a process under charge control.
30 $mAcm^{-2}$ is under charge control up to 48h when the growth become exponential, due to the surpassing of the limiting current.
Highest applied current is under mass control from the beginning of the experiment.
For a given time, X_{Zn} increases with the applied current, as expected. No Fe co-deposition phenomenon is observed in any of the experiments performed.
These results are in agreement with the theoretical limiting current:

$$J_{lim} = n \cdot F \cdot k_m \cdot [Zn]_0 \longrightarrow \textbf{37.16 mAcm}^{-2}$$



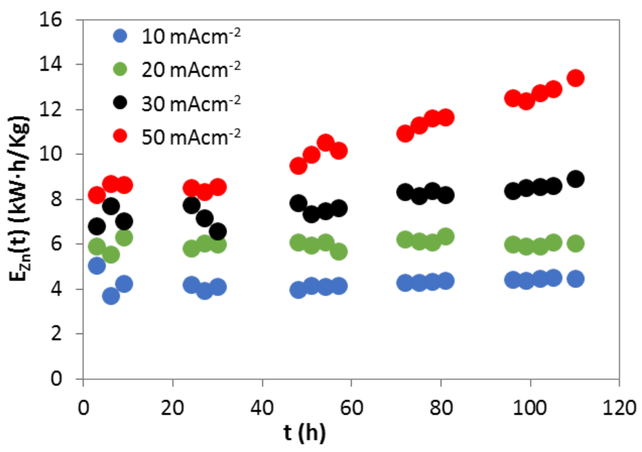
▲ ***Figure 3.*** Zn current efficiency of the SPBs for all the applied current values.

While $J<J_{lim}$, Φ_{Zn} and η_{Zn} remain practically constant as X_{Zn} increases linearly with time. Otherwise, when $J>J_{lim}$, both Φ_{Zn} and η_{Zn} initially present higher values as the turbulence is promoted by the hydrogen generation. However, they rapidly decrease with time as more current is wasted in this secondary reaction.



▲ ***Figure 4 .*** Zn space-time yield of the SPBs for all the applied current values.

In this case, the evolution of the E_{Zn} is opposite to that showed for Φ_{Zn} and η_{Zn}, that is, E_{Zn} increases with time when $J>J_{lim}$ but, for lower currents, E_{Zn} stays practically constant for the whole electrolysis.



▲ ***Figure 5.*** Zn specific energy consumption of the SPBs for all the applied current values.

CONCLUSIONS

The best operating conditions are those obtained at the closest value to the limiting value, 30 $mAcm^{-2}$, as the process is maintained under charge control for 2 days.

ACKNOWLEDGEMENTS

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