**Electrochemical recovery of $Cl_2$ from Anhydrous HCl using a PEM reactor**

PremKumar Sivasubramanian & John W. Weidner
Center for Electrochemical Engineering
Department of Chemical Engineering
The University of South Carolina
Columbia SC 29208

## Introduction

The chemical process industries annually generate 36 million tones[1] of HCl as byproduct which then has to be either sold, neutralized & disposed or used in further processes. The constantly fluctuating market for HCl renders that undependable and neutralizing is not a cost effective process. The remaining possibility is to reprocess the byproduct HCl to obtain the chlorine. DuPont discovered and patented a gas phase electrolysis process involving a polymer electrolyte membrane (PEM) reactor[1]. Processes like Bayer AG's electrolysis[2] process run using HCl fed as hydrochloric acid and generally use low current densities (up to 4 kA/m$^2$) but the PEM reactor uses anhydrous HCl gas and can operate at higher current densities and thus lead to a lower foot print for the reactor and lower capital cost.

The gas phase electrolysis has the further advantage that little or no down stream processing is necessary for the chlorine obtained during electrolysis is almost dry and pure. The reactions are shown here:

Anode: $2HCl(g) \rightarrow Cl_2 + 2\,H^+(aq) + 2e^-$ (1)

Cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (2)

Overall: $2HCl \rightarrow H_2 + Cl_2$ (Electrolysis) (3)

## Experimental

The PEM cell has an active area of 40 cm$^2$. The active catalyst is ruthenium oxide coated on carbon cloth. The membrane used was Nafion 105. The flow fields were high flow carbon paper obtained from Spectracorp. The cathode flow field was machined to accommodate two phase flow. The experiments were conducted at a pressure of 30 psig. The anode gas consists of pure HCl (technical grade). The catholyte was pure (DI) water. The water entered the cell at 75$^0$C. The cell was maintained at a constant temperature of 80$^0$C. The anode outlet when current was passed through the cell was HCl, $Cl_2$ and water with dissolved HCl and $Cl_2$. The cathode outlet had water and hydrogen in a two phase flow coming out of the cell. The experiment is conducted galavanostatically. A separate experiment was carried of to observe the influence of flow field orientation in the cathode side the result is presented in fig 2.

## Results and Observation

The VI curves for different conversion are plotted here in figure 1. As can be seen the potential drop as the conversion increases is not large but at higher conversions there is very little difference caused by increasing the conversion. From the second graph we can see that reverse orienting the flow field in such a way that the channels in the flow field face away from the Nafion membrane, gives a better performance due to better contact between the membrane and the GDL on the cathode side.

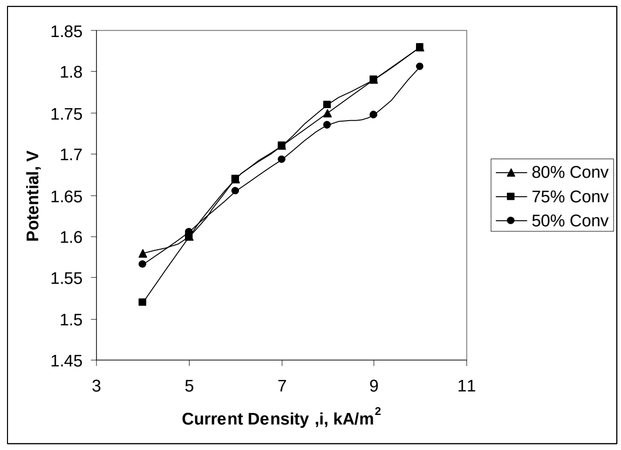


Figure 1: Voltage current curves generated with a PEM reactor at 80$^0$C and 30 psig.

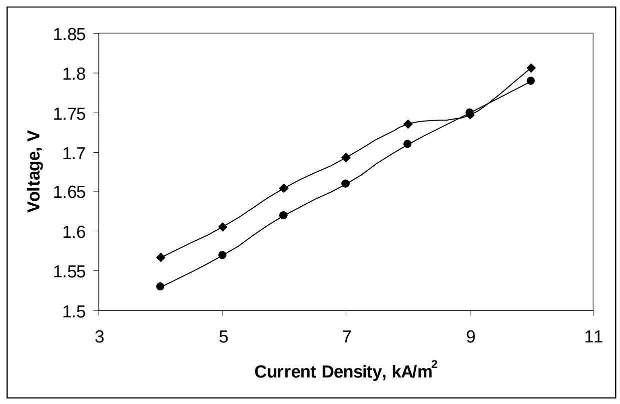


Figure 2: The data represented by ♦ is from the run with the channels in the flow field facing the Nafion membrane in the reactor. The data represented by ● are from the run in which the channels were facing away from the Nafion membrane. The reactor was operated at a pressure of 30 psig at a temperature of 80$^0$C.

## Acknowledgement

We wish to thank DuPont and the USC research foundation for the support provided.

## References

1. S. Motupally, D.T. Mah, F. J. Freire and J. W. Weidner "Recycling Chlorine from Hydrogen Chloride" *Interface* 7(3), 32-36 (1998).
2. Process Technology section, Chemical Engineering Progress, Circle No. 134 April 2004.