MAGNETIC FIELD EFFECTS ON A LABORATORY SIZE CHLOR-ALKALI CELL

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Introduction

Magnetic fields can affect electron transfer rates through spin polarization [1-3]. This can in turn alter the reactions' pathways and product distributions of electron transfer reactions with one or more free radical reactant, product, and intermediate. Although there are no paramagnetic reactants or products in the chlor-alkali cell, there are paramagnetic intermediates and adsorbates. These paramagnetic intermediates and adsorbates have the potential to be susceptible to magnetic field effects. In this system, another important effect that alters the overall reaction kinetics is at work. This effect is referred to as magneto-adsorption/desorption. When a molecule adsorbs to a catalyst surface, there is a partial electron transfer that occurs as they share electron density. This partial electron transfer is dependent on the magnetic field, if the adsorption/desorption process causes a delocalization of the charge density from the spin density. This effect is very common and has been seen for a wide variety of adsorbates and catalysts [4-7]. This investigation studied magnetic field effects on the voltage performance of a lab-size membrane cell operated at typical commercial conditions.

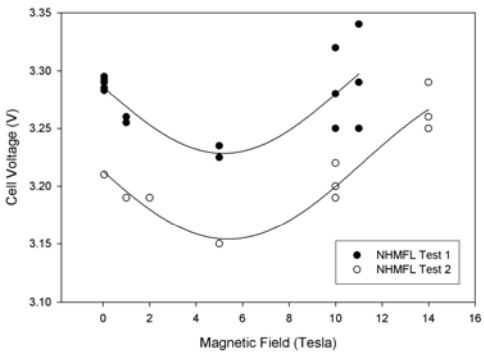

Figure 1: Effects of varying magnetic field strength on the operating cell voltage.

Experimental

A 56 cm^2 planar electrode-based portable lab cell was constructed in Freeport, Texas with commercial electrocatalytic coatings on expanded mesh. The electrodes were spaced 3 mm apart and separated by Nafion 982. This lab cell was placed in the center of the 20 tesla, 195 mm bore resistive magnet. The cell was operated at 88-91°C and 4.0 kA/m^2 = 22.5 amperes, while feeding purified condensate and brine and making hydrogen and chlorine gas, along with 32% caustic soda. After reaching steady state operating conditions, the applied magnetic field was varied from 0.05 teslas to 14 teslas while monitoring cell voltage. During the testing, the magnetic field strength was intermittently returned to 0.05 teslas in order to observe the deviation from the baseline. The testing was conducted for several hours on two different days with the same cell.

Results and Discussion

The two tests on separate days are shown by the cell voltage curves in Figure 1. The decreasing cell voltage to about 50 mV lower than baseline at 5 teslas corresponded to measured reductions in the over-potentials at the two electrodes. The increases in cell voltage as the field strength was increased above 5-6 teslas were not expected, however. In fact, the over-potential at the cathode continued to decrease and the over-potential measurement at the anode showed increased fluctuation as the magnetic field strength was increased beyond 5-6 teslas. One explanation of this voltage increase is the movement of the membrane toward the cathode.

Conclusions

Magnetic field effects were observed in a portable cell operated at conditions typical of commercial chlor-alkali cells. Essentially all of the observed cell voltage decrease with increasing magnetic field strength was confirmed to be improved kinetics at the electrodes. The reduction of about 50 mV at 5 teslas and 4.0 kA/m^2 was 1.5 % of the total cell voltage.

References

[1] N.J. Turro and B. Kraeutler, Acc. Chem. Res., **13**, 369 (1980).
[2] S. Ronco and G. Ferraudi, J. Chem. Soc., **3**, 887 (1990).
[3] S.D Minteer, in "Ph.D. Thesis," (University of Iowa, Iowa City, 2000) p. 1-161.
[4] S. Ozeki, *et al*., J. Phys. Chem., **100**, 4205 (1996).
[5] I.I. Mikhalenko and V.D. Yagodovskii, Russion Journal of Physical Chemistry, **74**, S411 (2000).
[6] P. Lin, *et al*., J. Phys. Chem., **97**, 1471 (1993).
[7] L.L. Makarshin, *et al*., Physica C, 282-287, 1609 (1997).