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Quarterly Progress Report:
High Temperature Electrochemical Separation
of H₂S from Coal Gasification
Process Streams

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by

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Purpose and Goals of Research

An advanced process for the separation of hydrogen sulfide from coal gasification product streams through an electrochemical membrane is being developed using the funds from this grant. H_2S is removed from the syn-gas stream, split into hydrogen, which enriches the syn-gas, and sulfur, which can be condensed from an inert gas sweep stream. The process allows removal of H_2S without cooling the gas stream and with negligible pressure loss through the separator. The process is economically attractive by the lack of adsorbents and the lack of a Claus process for sulfur recovery.

Research conducted during the present quarter is here highlighted, with an emphasis on progress towards the goal of an economically viable H_2S removal technology for use in coal gasification facilities providing polished fuel for co-generation coal fired electrical power facilities and Molten Carbonate Fuel Cell electrical power facilities.

Introduction

The process under development is presented schematically in Figure 1. The process gas, cleaned of particulates, is passed by the cathode. Here, the most easily reduced species will be electronated; under these conditions, it is H_2S :

The sulfide ions are maintained, with alkali-metal cations, as a fused electrolyte in a ceramic membrane. The sulfide is transported across to the anode, where it is oxidized to elemental sulfur. An inert gas such as N_2 is used at the anode to carry away the vaporous sulfur, S_2 , to be condensed for recovery downstream.

Figure 1. Schematic of H_2S Removal Cell.

Theoretical Analysis

A theoretical analysis of the cell electronic performance for H₂S removal was performed during the previous quarter (January 1, 1992 - March 31, 1992) which modeled cross-cell potential in the removal cell as a function of applied current. Two amendments to the results reported in the report covering this period are needed. First, the calculation of Nernstian effects on the cross cell potential need to be revised. The results reported in the 1/1/92 to 3/31/92 report used gas phase concentrations in units of parts-per-million in the calculation of H₂S. A more precise estimate is afforded by using gas phase mole fractions in the natural log term of the Nernst equation:

$$E = E^{\circ} - \frac{RT}{nF} \ln \left(\frac{P_{H_2, cathode} P_{S_2, Anode}^{\frac{1}{2}} a_{S^{2-}, Anode}}{P_{H_2S, Cathode} a_{S^{2-}, Cathode}} \right) \quad (3)$$

Revised estimates of cross cell potentials for this model are listed in Table I and presented graphically in Figure 2.

The data presented in Table I and Figure 2 were generated using equal cathodic and anodic flow rates (200 cc/min), a system pressure of 1 atmosphere, a run temperature of 625°C, and polishing H₂S from 100 ppm down to 10 ppm. Other gas phase components consisted of 13.3% CO₂, 33.2% H₂S, 48.8% CO, and 4.8% H₂O.

Examination of the data presented in Table I and Figure 2 shows that at 90%

Table I. Predicted Cross Cell Potential vs H₂S Removal (Revised).

<u>Removal</u>	<u>Nernstian Potential</u>	<u>Ohmic Effect</u>	<u>Cathode Activation</u>	<u>Anode Activation</u>	<u>Concentration Polarization</u>	<u>Total (V)</u>
10%	-0.350	-2.60E-4	-3.42E-5	3.42E-5	-0.004	-0.359
20%	-0.368	-5.20E-4	-6.85E-5	6.85E-5	-0.009	-0.386
30%	-0.382	-7.80E-4	-1.03E-4	1.03E-4	-0.014	-0.410
40%	-0.393	-1.04E-3	-1.37E-4	1.37E-4	-0.020	-0.434
50%	-0.404	-1.30E-3	-1.71E-4	1.71E-4	-0.027	-0.460
60%	-0.417	-1.56E-3	-2.05E-4	2.05E-4	-0.036	-0.490
70%	-0.431	-1.82E-3	-2.40E-4	2.40E-4	-0.047	-0.527
80%	-0.450	-2.08E-3	-2.74E-4	2.74E-4	-0.062	-0.577
90%	-0.479	-2.34E-3	-3.08E-4	3.08E-4	-0.089	-0.660

Figure 2. Theoretical Cross Cell Potential vs % H₂S Removal (Revised).

removal (100 ppm H_2S going to 10 ppm H_2S), a total cross cell potential of only about -0.660 V (cathode to anode) is expected.

Carbonate can also be electrochemically transported across the cell. At the cathode we have:

and at the anode we have:

The sum of these two half cell reactions and the standard cross-cell potential at 900 K is:

The Nernst equation predicting the potential of this reaction as a function of product and reagent concentration is:

$$E = E^\circ - \frac{RT}{nF} \ln \left(\frac{P_{CO_2, \text{anode}} P_{O_2, \text{anode}}^{\frac{1}{2}} P_{H_2, \text{cathode}} a_{CO_3^{2-}, \text{cathode}}}{P_{CO_2, \text{cathode}} P_{H_2O, \text{cathode}} a_{CO_3^{2-}, \text{anode}}} \right) \quad (7)$$

If reactions (1) and (2) are summed the total cell reaction and standard cross cell potential are:

Since the carbonate transport reaction (6) is parallel to the sulfide transport reaction (8), some current to the cell will also act to transport CO_2 across the cell. This means that there is a finite maximum current efficiency with respect to H_2S removal for any given H_2S removal, depending on gas composition and the cross-cell potential required for the desired separation of H_2S . By solving the Nernst equation for carbonate transport (7) at a given cross cell potential for the CO_2 , H_2O and H_2 levels in the cathode gas and CO_2 and O_2 levels in the anode gas, the extent of this parallel reaction can be determined. This assumes that the electrode kinetics for sulfide and carbonate transport are equivalent (both contributing negligible activation overpotential) and that concentration overpotential for CO_2 removal is also negligible (a reasonable assumption since in this case study the concentration in some two to three orders-of-magnitude higher for CO_2 and H_2O than for H_2S). The extent of the anode CO_2 production with % H_2S removal is presented in Table II and Figure 3. Examination of this data shows that current efficiency drops to 34.9% at 90% H_2S removal. This means that applied current to the cell must be increased by a factor of 2.86 over stoichiometric current to achieve this removal level. The excess current goes to production of anodic CO_2 . Thus, a total of 0.845 milliWatts/cm² of electrical

Table II. Predicted Anodic CO₂ Production and Maximum Current Efficiency vs H₂S Removal

<u>Removal</u>	<u>Total Cell Potential (V)</u>	<u>Anode CO₂ (ppm)</u>	<u>Maximum Efficiency</u>
10%	-0.359	0.95	93.0%
20%	-0.386	1.52	92.9%
30%	-0.410	2.29	92.9%
40%	-0.434	3.46	92.0%
50%	-0.460	5.40	90.2%
60%	-0.490	9.05	86.9%
70%	-0.527	17.1	80.4%
80%	-0.577	40.3	66.5%
90%	-0.660	168	34.9%

Figure 3. Predicted Anodic CO_2 Production and Maximum Current Efficiency vs H_2S Removal

power are actually required with 0.296 milliWatts/cm² going to H₂S removal. Even with a current efficiency of only 34.9%, power costs to perform this removal are negligible.

Research Summary

Work has continued on application of this technology to polishing H₂S from simulated coal gasification process streams. Both stainless steel and MACOR housings were successfully used, with 98% (100 ppmv H₂S to 2 ppmv H₂S) removal observed at a flow rate of 230 cc/min and a process temperature of 700°C with stainless steel housings (Run 57) and greater than 80% (11 ppmv H₂S to less than 2 ppmv H₂S) at a flow rate of 100 cc/min and a temperature of 650°C with MACOR housings (Run 65). Work has continued with attempts to increase removal efficiency by increasing the density of the membrane and slowing down H₂ diffusion from the cathode side to the anode side of the cell.

Experimental Run Results

Successful Runs

Run 56

This experiment used lithiated Ni as both the cathode and the anode of the cell. The membrane was two tapes of MgO suspended within an acrylic binder layered with two mats of zirconia cloth. This was layered with a pressed electrolyte

disk which used hydroxyethyl cellulose (HEC) as a binder material. These electrodes and membrane were loaded into a set of new 316 stainless steel housings which were painted with aluminum paint.

The cell was then heated to the binder burnout temperature of 350°C under pure O₂ at a rate of 200°C per hour. Once at the burnout temperature, N₂ was started to the cell and the cell was heated to 420°C. At this temperature, fuel gas (14.5% CO₂, 46.5% CO, 34.3% H₂, 6.1% H₂O, and 106 ppm H₂S after shift reaction at run temperature of 700°C) was started to the cell and the furnace was heated to 700°C. Under these conditions, the equilibrium sulfide level in the membrane should have been 0.6 mole%. The gas phase limiting current density was calculated as 1.22 mA/cm² and the membrane limiting current density was estimated as 1.87 mA/cm².

H₂S removal data (presented in Figure 4 and Table III) and cross-cell potential data (presented in Table III) were recorded. While some H₂S removal was recorded, current efficiencies were unacceptably low (with stoichiometric current at this concentration an flow rate being only 3 mA applied current). Current efficiency was low due to H₂ cross-over and the presence of a possible alternative current path.

After cell shut-down, carbon build-up between the electrodes in the membrane was observed. This may have been caused by pyrolyzed HEC since this was not observed in runs which did not use HEC as an electrolyte binder.

Run 57

Both electrodes in this experiment were lithiated Ni. The membrane was two

Figure 4

Table III. Run 56 Data.

<u>Run 56</u>	
Cathode = lithiated Ni	Anode = lithiated Ni
Membrane = two tape casts of MgO layered with two mats of ZYW-30A (zirconia cloth)	
Electrolyte = 0.8 mole% sulfide in eutectic Li/K carbonate pressed with HEC binder	
Housings = type 316 SS with Al paint coating	
Inlet Gas Composition =	
96 ppm H ₂ S	
18% CC ₂ , 45% CO, Balance H ₂ (dry comp., before shift reaction)	
Hydrated to 3.1% H ₂ O (before shift reaction)	
Anode Flow = 50 cc/min	
Cathode Flow = 235 cc/min	
Run Temp = 700°C	
<u>I_{app} (mA)</u>	<u>E_{C-A} (Volts)</u>
0	-0.047
5	-0.039
200	-0.390
500	-0.739
500	-0.808
800	-1.598
1200	-2.020
	<u>Cath Exit H₂S (ppm)</u>
	81.0
	86.0
	83.0
	77.0
	69.0
	52.0
	46.0

tapes of MgO with two mats of zirconia cloth. One of the zirconia mats was cut with a wick extending out of the cell and resting in an electrolyte reservoir. This was to provide a continuous supply of electrolyte to the membrane in the event of electrolyte evaporation/reaction with the cell materials. The electrolyte loaded into the cell was 0.8 mole% sulfide in a carbonate supporting electrolyte. Eutectic carbonate electrolyte was loaded into the reservoir. The cell housings were 316 stainless steel painted with aluminum.

After binder burn-out and the cell had reached run temperature, fuel gas of final composition 14.4%CO₂, 45.1% CO, 6.2% H₂O, 34.2% H₂, and 113 ppmv H₂S was fed to the cell. This gives an equilibrium sulfide level in the electrolyte of 0.63 mole% sulfide. The gas phase limiting current density under these conditions was estimated to be 1.28 mA/cm² and the membrane limiting current density was estimated at 1.97 mA/cm².

H₂S removal data (presented in Figure 5 and Table IV). Removal of H₂S below 2 ppmv (GC detector limit) was recorded with only 5 mA (0.63 mA/cm²) applied to the cell and a cross cell potential of only -275 mV (cathode to anode). Upon shutting off applied current, exit H₂S levels only returned to 24 ppm (113 ppm entering the cell). The electrolyte reservoir was removed since it was a potential carbonate sink for reaction with H₂S in the gas. Cell cross flow started soon after this and the cell was shut down. Apparently, electrolyte was wicked out of the membrane onto the surface of the steel housings thereby depleting the membrane of electrolyte and allowing gas cross-over.

Exit H2S Level vs Applied Current Run 57

Inlet H2S = 110 ppmv
Cathode Flow = 230 cc/min
Temp = 700 C

Figure 5

Table IV. Run 57 Data.

<u>Run 57</u>	
Cathode = lithiated Ni	Anode = lithiated Ni
Membrane =	two tapes of MgO layered with two mats of ZYW-30A (zirconia cloth)
	(wick from ZYW-30A into carbonate reservoir)
Electrolyte =	0.8 mole% sulfide in eutectic Li/K carbonate
Housings =	type 316 SS with Al paint coating
Inlet Gas Composition =	
	110 ppm H ₂ S
	18% CO ₂ , 45% CO, Balance N ₂ (dry comp., before shift reaction)
	Hydrated to 3.1% H ₂ O (before shift reaction)
Cathode Flow = 230 cc/min	Anode Flow = 80 cc/min
Run Temp = 700°C	
<u>I_{app} (mA)</u>	<u>E_{C-A} (Volts)</u>
0	-0.545
5	-0.275
5	-0.250
	<u>Cath. Exit H₂S (ppm)</u>
	49.0
	0.0
	2.1

Run 58

This experimental run also used lithiated Ni electrodes. In this experiment, the membrane was a hot pressed Molten Carbonate Fuel Cell (MCFC) membrane provided by Gas Research Institute (GRI). This structure is a 50/50 weight mixture of LiAlO_2 and eutectic Li/K carbonate. The housings were MACOR (with a stainless steel coil in the feed gas line to act as a shift reactor) and aluminum foil gaskets were used. Excess Li_2CO_3 (for reaction with the Al gaskets in conversion to LiAlO_2) was sprinkled on the membrane surface with enough Li_2S to bring the electrolyte to 0.8 mole% sulfide.

After the electrolyte was molten, fuel gas with composition 17.3% CO_2 , 42.2% CO, 3.3% H_2O , 37.1% H_2 , (after shift reaction) and 117 ppmv H_2S was fed to the cell. This gives an equilibrium sulfide level of 0.65 mole%. The calculated gas phase limiting current density at this temperature was found to be 1.31 mA/cm^2 and the membrane limiting current density was estimated to be 1.53 mA/cm^2 .

H_2S removal data (see Figure 6 and Table V), anodic CO_2 production data (see Table V), and cross-cell potential data (see Table V) was taken. Examination of Figure 6 shows the most dramatic H_2S reduction takes place at currents less than 10 mA (1.23 mA/cm^2). Beyond this, diffusion of H_2 across the cell decreases H_2S current efficiencies in favor of CO_2 production with applied current. Cross-cell potentials were very high at large applied currents ($> 500 \text{ mA}$). This was due to concentration effects as the cathode gas was depleted of H_2O by the carbonate transport reaction. H_2S levels were driven as low as 6 ppmv even with H_2 cross-over.

Exit H₂S Level vs Applied Current Run 58

Inlet H₂S = 117 ppmv
Cathode Flow = 200 cc/min
Temp = 700 C

Figure 6

Table V. Run 58 Data.

Run 58

Cathode = lithiated Ni Anode = lithiated Ni
 Membrane = GRI MCFC membrane spiked with Li₂S to 0.8 mole%
 (LiAlO₂ matrix)
 Electrolyte = 0.8 mole% sulfide in eutectic Li/K carbonate
 Housings = MACOR with SS shift reactor
 Gaskets = Al foil

Inlet Gas Composition = 104 ppm H₂S
 18% CO₂, 45% CO, Balance H₂
 (dry comp., before shift reaction)
 Hydrated to 3.1% H₂O (before shift reaction)
 Cathode Flow = 200 cc/min Anode Flow = 175 cc/min
 Run Temp = 700°C

<u>I_{app}</u> (mA)	<u>E_{C-A}</u> (Volts)	<u>Cathode</u> <u>Exit H₂S</u> (ppm)	<u>Anode</u> <u>Exit CO₂</u> (mole%)
0		129.3	
10		132.5	
10	+0.030	106.5	
100	-0.790	95.8	
100	-0.941	89.7	1.00
100	-0.962	97.0	
10	-0.160	90.2	0.20
50	-0.405	89.4	0.45
100	-0.816	83.7	0.95
150	-1.571	77.6	1.50
250	-2.090	71.1	2.40
350	-2.450	59.7	
500	-2.640	51.9	
750		41.4	7.10
1000	-3.750	33.3	9.00
1500	-5.510	22.6	13.5
2000	-6.160	12.8	
3000	-12.08	6.0	

Run 59

This experimental run used two mats of zirconia cloth that were densified from 83% voids to 72% voids by soaking in an ethyl alcohol slurry of LiAlO_2 (slurry 20 wt% LiAlO_2). Particles of LiAlO_2 were suspended within the ZrO_2 mesh after the water was evaporated away. No tapes of MgO were used in this experiment. The electrodes were both lithiated nickel. The electrolyte was pressed and loaded as a disk into the cell prior to heat-up. The electrolyte composition was 0.8 mole% sulfide and the balance was eutectic carbonate. The housings were MACOR and aluminum foil gaskets were used.

After melting the electrolyte into the matrix, fuel gas of composition 14.4% CO_2 , 45.1% CO , 6.2% H_2O , and 34.2% H_2 (after shift reaction) with 85.7 ppm H_2S was started to the cell. This gives an equilibrium sulfide level of 0.48 mole %. The gas phase limiting current density was estimated to be 1.06 mA/cm^2 and the membrane limiting current density was estimated to be 1.5 mA/cm^2 .

H_2S removal data (see Figure 7 and Table VI) and cross-cell potential data (see Table VI) were taken. The inlet H_2S level was 85.7 ppm, but with zero current applied to the cell, the exit H_2S level was seen to be 165 ppm. This was due to excess sulfide initially present in the electrolyte. With application of current, H_2S levels were driven as low as 73 ppm with 400 mA applied to the cell (50.5 mA/cm^2). Hydrogen cross over hampered H_2S removal efficiency causing higher current levels to be needed to achieve removal. With higher currents came higher cross-cell potentials until the carbonate transport region was reached. Here, H_2S removal

Exit H2S Level vs Applied Current Run 59

Inlet H2S Level = 85.7 ppmv
Cathode Flow = 237 cc/min
Temp = 700 C

Figure 7

Table VI. Run 59 Data.Run 59

Cathode = lithiated Ni Anode = lithiated Ni
 Membrane = two mats of ZyW-30A (zirconia cloth) densified with LiAlO_2
 Electrolyte = 0.8 mole% sulfide in eutectic Li/K carbonate
 Housings = MACOR with SS shift reactor
 Gaskets = None

Inlet Gas Composition = 85.7 ppm H_2S
 18% CO_2 , 45% CO , Balance H_2
 (dry comp., before shift reaction)
 Hydrated to 3.1% H_2O (before shift reaction)
 Cathode Flow = 237 cc/min Anode Flow = 100 cc/min
 Run Temp = 700°C

<u>I_{app} (mA)</u>	<u>$E_{\text{C-A}}$ (Volts)</u>	<u>Cathode</u> <u>Exit H_2S (ppm)</u>	<u>Anode</u> <u>Exit CO_2 (mole%)</u>
0	-0.014	164.6	0.40
10	-0.064	158.7	0.30
20	-0.131	143.4	0.30
40	-0.350	110.6	0.10
80	-0.549	91.4	0.20
160	-0.908	84.1	0.30
320	-1.362	89.7	0.40
320	-1.392	80.1	0.4
0	+0.002	174.0	
100	-0.713	69.0	
200	-1.261	64.4	
400	-2.230	73.2	

stopped due to the concentration preference for carbonate transport.

Run 62

This experimental run was also identical in set-up to run 60. The zirconia mats were densified to 64 void %. Only enough electrolyte was added to wet the membrane, extra electrolyte was slowly added after the cell had reached run temperature to react with the Al gaskets. Once the electrolyte had melted, fuel gas of composition 14.4% CO₂, 45.1% CO, 6.2% H₂O, 34.2% H₂ (after the shift reaction at 700°C) with 120.4 ppmv H₂S. H₂S removal data was taken at 216 cc/min and a temperature of 700°C. At this temperature and gas composition, the equilibrium sulfide level in the electrolyte is calculated to be 0.68%. The gas phase limiting current density is 1.33 mA/cm² and the membrane limiting current density is 2.10 mA/cm². A second set of H₂S removal data was taken at a flow of 100 cc/min and a temperature of 750°C (gas composition 13.6% CO₂, 45.8% CO, 6.9% H₂O, 33.4% H₂ with 93.6 ppmv H₂S) (see Figure 8, Figure 9, and Table VII). At this temperature and gas composition, the membrane equilibrium sulfide level was estimated to be 0.91 mole% sulfide. The gas phase limiting current density was estimated to be 1.15 mA/cm² and the membrane limiting current density 2.82 mA/cm². Anodic CO₂ production was also monitored (see Table VII) and cross-cell potentials were recorded for 100 cc/min and run temperature of 750°C (see Table VII). Comparison of Figure 8 and Figure 9 shows that H₂S removal efficiency is improved by lower flow rates (higher residence time) and higher temperatures (higher limiting current densities).

Exit H2S Level vs Applied Current Run 62

Inlet H2S Level = 120.4 ppmv
Cathode Flow = 216 cc/min
Anode Flow = 42 cc/min

Figure 8

Exit H2S Level vs Applied Current Run 62

Inlet H2S Level = 93.6 ppmv
Cathode Flow = 100 cc/min
Temp = 750 C

Figure 9

Run 65

This experimental run used 1 mat of 30 mil zirconia cloth which was rigidized to 60.8% and two tapes of MgO/ZrO₂ in vinyl binder. The electrolyte was eutectic carbonate and was added to the cell as a pressed disk. The electrodes were lithiated Ni. The housings were MACOR and Al foil gaskets were used. The run temperature was 650°C. After binder burnout and electrolyte melting, fuel gas of composition 15.2% CO₂, 44.2% CO, 5.4% H₂O, 35.0% H₂ with 18.8 ppmv H₂S was put through the cell. This gas composition and temperature gives an equilibrium membrane sulfide level of 0.06 mole% sulfide. The gas phase limiting current density is estimated to be 0.18 mA/cm² and the membrane limiting current density is 0.34 mA/cm².

H₂S removal data was taken at cathodic flow rates of 200 cc/min and 100 cc/min (see Figure 10, Figure 11, and Table VIII). Cell polarization data was also take at these flow rates (see Table VIII). Anodic CO₂ production data was also taken at cathodic flow of 100 cc/min (see Table VIII).

Figure 10

Figure 11

Unsuccessful Runs

Run 60

This experimental run used two zirconia mats that were densified with sub-micron particles of ZrO_2 in aqueous solution purchased from Zircar, Inc. This rigidizer is composed of 44 wt% ZrO_2 , 8 wt% Acetic acid, 3 wt% Y_2O_3 , in an aqueous slurry. Mats were densified by soaking in rigidizing solution under a vacuum to pull air out of the woven cloth and facilitate complete wetting. These were then dried and soaked again. This process was repeated for three consecutive soakings. These mats were densified to 66 void%. The electrolyte was 0.8% sulfide and was pressed into a disk and loaded into the cell to be melted in-situ. The electrodes were lithiated nickel and the housings were MACOR with aluminum foil gaskets.

Poor electrical contacts between the electrodes and the membrane lead to high cell resistance and high cross-cell potentials. The cell was shut down before any useful data was taken.

Run 61

This experimental run was identical in set up to run 60. Excess electrolyte was also added to accommodate reaction of Li_2CO_3 with the Al foil to form LiAlO_2 . The rate of this reaction is evidently slow, however, since the excess electrolyte flooded the anode channels and froze in the exit anode tube. This caused a pressure spike on the anode side of the cell which ruptured the membrane. The cell was shut

down before any useful data was taken.

Run 63

This experimental run used Si_3N_4 tapes with vinyl binder as the membrane support material. Eutectic carbonate electrolyte was also added to the membrane by mixing in a 50/50 weight mixture with the same binder material and laminating the structure together under pressure. The electrodes in this experiment were both lithiated Ni and the housing was MACOR. No aluminum foil gaskets were used.

The cell was heated under O_2 to 520°C . Cross-flow between the cathode and the anode side of the cell indicated that the membrane had lost integrity. No amount of electrolyte added corrected the situation. The cell was shut down before any useful data could be taken.

Run 64

This experimental used lithiated Ni as both the cathode and the anode. The membrane was a single mat of 15 mil thick zirconia cloth which was rigidized to 66 void%. This was layered with two tapes of MgO within the vinyl binder. The housings were MACOR and no gaskets were used. The electrolyte was soaked into the electrodes previous to run start-up. Since the electrodes could not hold all of the required electrolyte, the remainder was sprinkled onto the membrane before assembly.

The cell was heated under O_2 to 300°C over a 3 hour period and then switched to N_2 for the final heating to 600°C . No seals were formed on either side of the cell.

Cross-flow between the cathode and the anode could not be controlled. When the cell was shut down, it was seen that carbon build-ups had formed the cell housings apart and damaged the membrane. This was from pyrolyzed binder material from incomplete burn-out. No useful data was taken.

Summary

Polishing application (100 ppmv H_2S to less than 5 ppmv H_2S) of this technology to coal gasification synthesis gas has been repeated with both MACOR and 316 Stainless Steel housings. Polishing application has further been demonstrated at removing H_2S to below 5 ppmv with only 16 ppm entering the cell.

Planned Work for Next Quarter

Work will continue with the stainless steel housings. Priority will be placed on improving H_2S removal efficiency by developing even more H_2 impermeable membranes.

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