

Contract No. R002-006
“Renewable Electrolytic Nitrogen Fertilizer Production”

Submitted by Energy & Environmental Research Center
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PARTICIPANTS

Sponsor	Cost Share
Energy & Environmental Research Center Utilizing National Alternative Fuels Laboratory Program funding	\$104,255
North Dakota Corn Utilization Council & Minnesota Corn Research & Promotion Council	\$100,000
North Dakota Industrial Commission	<u>\$200,000</u>
Total Project Cost	\$404,255

Project Schedule – 12 months

Contract Date – October 21, 2008

Start Date – September 1, 2008

Completion Date – December 31, 2009

Project Deliverables:

Status Report: December 1, 2008 ✓

Status Report: March 1, 2009 ✓

Status Report – June 1, 2009 ✓

Final Report– December 31, 2009

OBJECTIVE/STATEMENT OF WORK:

This project will optimize processes for producing nitrogen fertilizers using biomass gasification-derived synthesis gas (biosyngas), nitrogen extracted from air and electricity. Because the processes have been demonstrated to operate with low-cost biosyngas rather than high-cost hydrogen derived from natural gas, they offer the potential for lower-cost and smaller-scale fertilizer production than achievable via the traditional natural gas-based route. Commercialization of the processes would enable regionally produced fertilizer to compete economically with imports and simultaneously develop a new fertilizer production industry.

The Energy & Environmental Research Center has been granted confidentiality for their application and reports with the understanding that a non-confidential version of each report and final report will be made available to the public.

STATUS

December 1, 2008 status report received – During the time period of October 30 – November 30, 2008 the 2-W cell was designed and fabricated, and electrocatalyst evaluation activities were initiated. This is part of Task 1 which is the process optimization activities to be

conducted using an EERC-designed and fabricated 2-W planar electrolyzer with two gas chambers (an anode chamber and a cathode chamber) separated by a membrane electrode assembly (MEA). No Task 2 activities were conducted during this reporting period.

March 1, 2009 status report received – During the time period of December 1, 2008 – February 28, 2009 about 65 different catalyst formulation-catalyst support combinations were evaluated at reaction temperatures ranging from 150°C to 550°C, reaction pressures ranging from ambient to 100 psi, and hydrogen-to-nitrogen ratios ranging from 0.05 to 20. Variations in catalyst design included the use of five different supports, combinations of four metal promoters in different ratios, and combinations of up to five different active metals. The goal was to find the most active catalyst at the lowest possible temperature, pressure, and hydrogen-to-nitrogen ratio. The criterion utilized as the basis for evaluation was catalyst activity expressed as millimoles ammonia produced per hour per gram catalyst (mmol/hr/g). In optimizing the cathode catalyst, EERC researchers developed a catalyst formulation-support combination that provided an activity of 15 mmol/hr/g at 350°C and atmospheric pressure. Based on our status at project initiation (a catalyst with an activity of .31 mmol/hr/g at 350°C), catalyst activity has been improved by a factor of about 50. The best cathode catalysts that emerged from the thermal microreactor screening tests were subsequently evaluated in the 2-W electrolysis cell for confirmation of the screening results. Under Task 2 the design of the 200-W electrolysis system was completed, and fabrication of the system was initiated.

June 1, 2009 status report received – During the time period of March 1 – May 31, 2009 catalyst previously reported has been significantly improved. The compositional ratio of the key metallic components of the catalyst and the temperature, pressure, and other parameters utilized in the catalyst fabrication process were optimized. As result, cathode catalyst activity was improved to 60 millimoles of ammonia produced per hour per gram of catalyst ($\text{mmol hr}^{-1} \text{g}^{-1}$) at 350°C and atmospheric pressure, compared to the 15- $\text{mmol hr}^{-1} \text{g}^{-1}$ activity reported in the previous quarter. To the best of our knowledge this activity level is a record not previously seen in the literature; however, we believe further improvement is achievable. Research is now focused on maintaining high activity at lower temperature—ideally, a temperature of 200° - 250°C—since this temperature range enables use of a wider choice of commercial membrane materials, which would help reduce the capital cost of the electrochemical cell. A catalyst has been developed with a measured activity of 10 $\text{mmol hr}^{-1} \text{g}^{-1}$ at 250°C. This catalyst has undergone endurance testing for over 1 month and shown no sign of a decrease in activity. In regards to Task 2 fabrication of the 200-W electrolysis system is ongoing. It is anticipated that system fabrication will be completed during the next quarter.

No cost extension to December 31, 2009 has been granted.

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