An Integrated Hydrogen Production-CO_2 Capture Process from Fossil Fuel

Semiannual Progress Report

Reporting Period Start Date: March 16, 2004
Report Period End Date: August 31, 2004

Principal Authors: Z. Wang (PI) and K. B. Bota
Clark Atlanta University, Atlanta, GA 30314
Email: zwang@cau.edu Phone: 404-880-6934

D. Day
Scientific Carbons Inc, Blakely, GA

Date Report Was Issued: September 2004

DOE Award Number: DE-FG26-03NT41914

Submitted by: Clark Atlanta University, Atlanta, GA 30314
Eprida Scientific Carbons Inc., Atlanta, GA

DISCLAIMER

DISCLAIMER OF LIABILITY: This report was prepared as accounts of work sponsored by an agency of the U.S. Government. Neither the U.S. Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

DISCLAIMER OF ENDORSEMENT: Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government or any agency thereof. The views and opinions of document authors herein do not necessarily state or reflect those of the U.S. Government or any state government or any agency thereof.

.

ABSTRACT

The major project objective is to determine the feasibility of using the char from coal and/or biomass pyrolysis, ammonia and CO2 emissions at smokestacks to produce clean hydrogen and a sequestered carbon fertilizer. During this work period, literature review has been completed. The project plan, design and test schedules were made on the basis of discussion with partner in experimental issues. Installation of pilot scale units was finished and major units tests were fully performed. Modification of the pyrolyzer, reformer and gas absorption tank have been done. Integration testing is performing recently. Lab scale tests are in operation phase. The experimental installations are discussed in this paper.

TABLE OF CONTENTS

INTRODUCTION AND OBJECTIVES

The increasing anthropogenic CO_2 emissions and possible global warning have challenged the United States and other countries to find new and better ways to meet the world's increasing need for energy while, at the same time, reducing greenhouse gas emissions. The improved technology for integrated hydrogen production/CO2 capture that we plan to develop through this R&D effort could significantly support President Bush's Global Climate Change Initiative (GCCI) that commits America to an aggressive strategy to reduce greenhouse gas intensity by 18 percent over the next 10 years. Our new technology concept integrates two significant and complementary hydrogen production and CO_2-sequestration approaches that have now been developed at Oak Ridge National Laboratory (ORNL) and Clark Atlanta University.

The objective of the proposed study is to determine the feasibility of using the char from a coal and/or biomass pyrolysis-reforming process and CO_2 emissions at a smokestake to for solid NH_4HCO_3-char and/or $(NH_4)_2CO_3$-char products that may subsequently be used as a fertilizer. Part of the hydrogen from the pyrolysis-reforming process may be converted to ammonia that is used to solidify the CO_2 as NH_4HCO_3 and/or $(NH_4)_2CO_3$ in the char. The balance of the hydrogen may be purified and sold at market prices or used as a feedstock.

EXPERIMENTAL FACILITIES

This project plans to conduct bench scale experiments and pilot scale tests. The Combustion and Emission Lab at Clark Atlanta University has prepared to conduct the

bench scale experiments. The facility used for pilot scale tests has built in Athens, GA. The following photos show the major experimental equipment and facilities.

Figure 1 is the LINDBERG/BLUE 1.3kw tube furnace and its control consoles, which are used for the production of char material in bench scale tests. Figure 2 is an on-line Fourier Transform Infrared Spectroscopy/Gas Chromatography/Mass Spectrometry (FTIR/GS/MS) system, which are employed to characterize chemicals. Figure 3 shows part of the experimental desk of char analysis and NH_3-CO_2 solidification for the bench scale experiments.

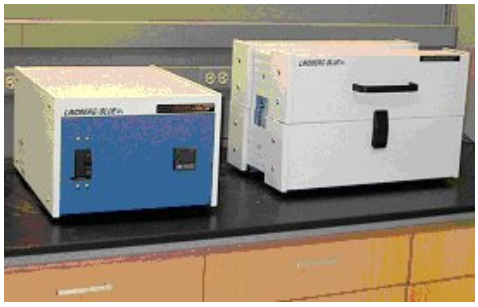


Figure 1 1.3 kW Tube Furnace/control consoles system

Figure 2 FTIR/GC/MS system

Figure 3 Fume hood and setup for bench scale tests

An overall view of the pilot scale experimental facility was shown in Figure 4. It is the pilot scale test facility. We have finished the installation and passed the tests parts by parts. The overall operation of whole system is running recently. Figure 5 and Figure 6 are the pyrolyzer and reformer, respectively. The pyrolyzer-reformer will be used for producing char and synthesis gas (containing mainly H_2, CO and CO_2)

Figure 4 the overall view of pilot pyrolyzer-reformer system

Figure 5 Pyrolizer with Biomass feedstack system

. Figure 6 Reformer and Vapor Heater

Figure 7 and Figure 8 are the gas analysis equipment. They are used for both bench scale and pilot scale experiments.

Figure7 Micro-GC and the control computer

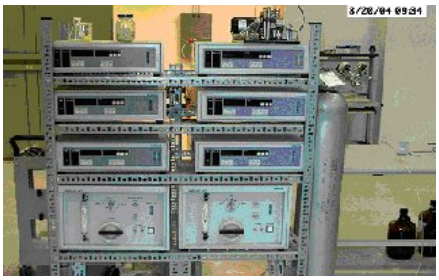
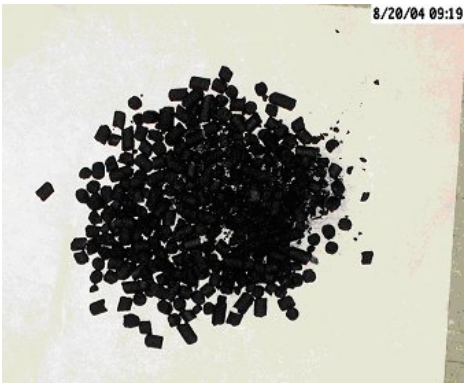


Figure 8 Gas (CO, CO_2, NO_x, SO_x, etc.) Analyzers

RESULTS AND DISCUSSION

Some primary experiments have been done. The pyrolyzer has produced some of char material, which planed to use as the sequestration material. Figure 9 is the photo of sample char material. Figure 10 is the result of primary structure of the formation of Ammonium Bicarbonate.



. Figure 9 Char material produced by the Pyrolyzer

Figure 10 Photo of formation of Ammonium Bicarbonate

FUTURE PLANS

In this report period, we have finished literature reviews, the project planning, installation of the pyrolyzer-reformer, the setup of bench scale experiments, and initiated the characteristic analysis of char products. The future works include the following tasks.

1. Operation of the pyrolyzer-reformer unit
2. Testing, Analysis an characterization of the char and gaseous products
3. Process optimization
4. NH_3-CO_2 solidification process
5. Tests to evaluate fertilizer usage

CONCLUSIONS

1. The bench scale equipment is prepared and ready for lab analysis.
2. The pilot scale facilities are installed and finished part of the tests
3. Primary investigation to char characteristics will continue to be conducted.

4. The future works include operation of pyrolyzer-reformer unit, NH_3-CO_2 solidification and tests to evaluate fertilizer usage.

REFERENCES

Lee, J.W.; Li, R. "A Novel Strategy for CO_2 Sequestration and Clean Air Protection", Proceedings of Fire National Conference on Carbon Sequenstration, Washington,DC, May 14-17, 2001. http://www.netl.doe.gov/publication/proceedings/01/carbon_seq/p12.pdf

Lee, J.W.; Li, R. "Method for Reducing CO_2, CO, NO_x, and SO_x Emissions", 1998 ORNL Invention Disclosure, ERID 0631; 2002 U.S. Patent No. US 6,447,437 BI.

Lee, J.W.; Li, R (2002). "Integration of Coal-Fire Energy Systems with CO_2 Sequestration through NH_4HCO_3 Production." Energy Convers. Manage, vol. 44, no.9, pg.1451-1464, June 2003.

Yelverton, F "The use of activated carbon to inactive agriculture chemical spills", Norh Carolina Cooperative Extension Service, March,1996. http://www.bae.ncsu.edu/bae/programs/extension/publicat/wqwm/ag442.html

Li, E. Hagaman, C. Tsouris, and J.W. Lee (2002). "Removal of carbon dioxide from flue gas by ammonia carbonation in the gas phase," Energy & Fuels, 2003, 17(1), 69-74.

Miller, D.W., and W.P. Miller, Land application of wastes. P. G217-G241. In M.E. jSummer (ed.) Handbook of Soil Science. CRC Press, Baca Raton, FL.

Miller, D.W., and W.P. Miller, S. Dudka, and M.E. Sumner. 2000, Characterization of Industrial By-Products. Soil Sci. Soc. Am., Madision WI.

Oren, R; Ellsworth, D.; Johnsen, K, et.al. (2001) "Soil fertility limits carbon sequenstration by forest ecosystems in a CO_2-enriched atmosphere" Nature 411, 469-472 (24 May, 2001), Letters to Nature.