Tri-reforming of Methane and CO_2: A Novel concept for Catalytic Production of Solid Waste Syngas with Desired H_2/CO Ratios for Liquid Biofuels

4-7-11

John T. Wolan

University of South Florida
Department of Chemical & Biomedical Engineering

And

John Kuhn

University of South Florida
Department of Chemical & Biomedical Engineering

State University System of Florida
Hinkley Center for Solid and Hazardous Waste Management
University of Florida
4635 NW 53rd Avenue, Suite 205
Gainesville, FL 32653
www.hinkleycenter.org

COMPLETION DATE: 9-30-2011

PHONE NUMBER: 813.974.3997

Email address: wolan@eng.usf.edu

Research Description

This research focuses on converting Municipal Solid Waste (MSW) to liquid fuels using Fischer-Tropsch synthesis (FTS). The process includes novel gasification of MSW via a tri-reforming process which involves a synergetic combination of CO_2 reforming, steam reforming, and partial oxidation of methane. Typical biomass or MSW derived syngas H_2:CO is 1:1. This innovation allows for cost-effective one-step production of syngas in the required H_2:CO of 2:1 for use in the FTS. The USF group has already developed a process that converts this syngas into diesel and jet fuel. This project will focus on the development of an appropriate gasification catalyst to convert MSW to the required syngas composition for production of liquid fuels.

Work Completed To-Date

During this report period a test matrix was developed to identify important variables that would maximize the amount of info we can learn from while minimizing the total number of catalysts needed to be synthesized. This matrix can be seen at the end of this report in Table 1. The variables to be observed are the amount of nickel nitrate, nano-nickel, amount of magnesium, amount of gold, technique for loading metal, and composition of cerium and zirconium oxide. Four of these catalysts from the matrix were synthesized and tested. It was found that the Ce:Zn mixed oxide support ratio of 6:4 (based on mass) performed the best and that a loading of nickel and magnesium in a 1:1 ratio extended catalyst lifetime. Characterization techniques to be used were identified and extended X-ray absorption fine structure (EXAFS) was used to characterize catalysts in this report period.

Figure 1. Shown here are some of the catalysts that have been synthesized. The gray color seen in the first four vials is attributed to the metal loaded onto the catalysts. The two vials to the right show prepared catalyst support before loading with metals.

Future Tasks

Future work will be focused upon identifying the overall best performing catalyst in our matrix. This decision will be based upon experimental and characterization results. We will consider total conversion of methane, product ratios of hydrogen to carbon monoxide, and rate of catalyst deactivation as factors to judge catalyst performance. In evaluating catalyst synthesized we first test catalyst using a component gas mixture as a

control then move to biomass derived syngas to evaluate effects of trace components often found in syngas. We will also be using multiple characterization techniques including EXAFS, BET, XRD, SEM, and TEM. These characterization techniques will provide such data as oxidation state, distortion of lattice, metal content, surface area, crystal structure, metal mapping, and dispersion of metal. By the end of this summer we will hope to have identified a thermally stable catalyst with a high resistance to coking while maintaining high conversions of methane to hydrogen and carbon monoxide in the desired ratio of 2:1 respectively.

Figure 2. Here is a closer look at the heated region of the micro-reactor. The heater is raised into place to control the temperature of the quartz u-tube while a gas mix is flowed through reactor.

TAG Meetings Held

10/31/10

TAG Meetings Scheduled

TBD (~early May)

TAG Members

T.J. Couch	Vice President	University Commerical Center
Dan McGinnis	Corporate Spokesperson	Waste Management
Kyle Mowitz	President	Imperium Energy
Tonja Brickhouse	Director of Solid Waste	City of Tampa
Tom Snelling	Green Officer	City of Tampa
John Ramil	CEO	TECO
Tim Cesarek	Organic to Gas Director	Waste Management
Mark Talbott	Operations	Republic Services
Rose Ferlita	County Commissioner	Hillsborough County
Mark Sharpe	County Commissioner	Hillsborough County
Barry Boldissar	Director of Solid Waste	Hillsborough County
Paul Vanderploog	Executive Enterprise	Hillsborough County
Matt Yung	Researcher	National Renewable Energy Lab

Project Website Address (URL): http://wolan.blog.usf.edu/tri-reforming/

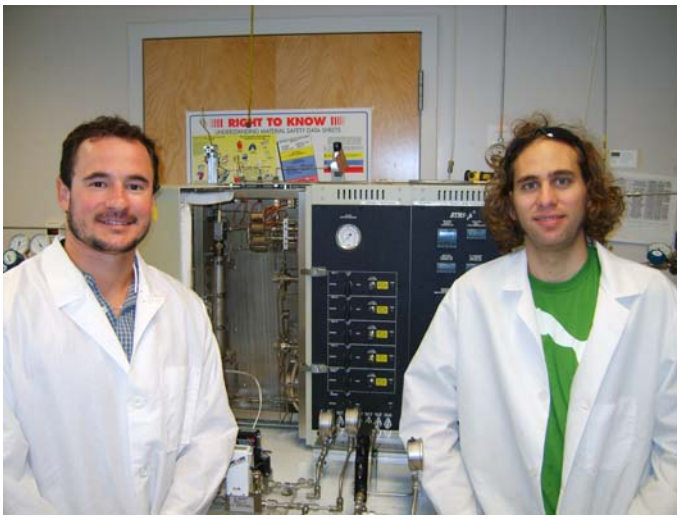
Papers Presented

Identifying future energy conferences to network and market our research will play an important role in our success. Potential conferences to present our research are being

looked into and we are currently preparing a paper to present at the national AICHE meeting coming up this October.

Student Researchers

Student researchers for this project include Louis Rufo, Philip Saraneeyavongse, and Devin Walker. Under this project Louis received his masters in chemical engineering last fall and is now currently working for the US Patent Office in Washington DC. Philip and Devin are both pursuing masters degrees in engineering and hope to incorporate this research into their thesis work.



Devin Walker (left) and Louis Rufo (right) are part of the team developing the tri-reforming catalyst. Here they are standing in front of the fischer tropsch reactor currently being used to make synthetic jet fuel and diesel at the University of South Florida.

Table 1. Tri-reforming catalysts matrix.

Nickel wt%	Ni:Mg	Ce:Zr	Metal Loading Method
8	1:0	0.16 : 0.84	wet impregnation
8	1:1	0.16 : 0.84	wet impregnation
8	1:0	0.6 : 0.4	wet impregnation
8	2:1	0.6 : 0.4	wet impregnation
4	1:1	0.16 : 0.84	wet impregnation
4	1:1	0.6 : 0.4	wet impregnation
4	2:1	*	wet impregnation
4 or 8*	*	0.9 : 0.1	wet impreganation
4 or 8*	*	0:1	wet impregnation
4 or 8*	*	1:0	wet impregnation
4 or 8*	*	*	deposition precipitation
4 or 8* (nano nickel)	*	*	*
4 or 8*	1:1 (< 1 wt. % gold)	*	*

* Denotes variables are dependent upon results from previous runs and best performer will be chosen.