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NATIONAL RENEWABLE ENERGY LABORATORY

Renewable Energy Institute International (REII)

Cooperative Research and Development Final Report

CRADA Number: CRD-10-387

NREL Technical Contact: Daniel Carpenter

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CRADA Report
NREL/TP-5100-63268
November 2014

Contract No. DE-AC36-08GO28308

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In accordance with Requirements set forth in Article XI.A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

CRADA Number: CRD-10-387

CRADA Title: MBMS Monitoring of Toledo IBR Plant Trials

Parties to the Agreement: Renewable Energy Institute International (REII)

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1	$ 28,029.00
Year 2	$ 205,976.00
Year 3	$ 139,265.00
Mod 1	$ 384,516.00
TOTALS	$ 757,786.00

Abstract of CRADA Work:

NREL provided REII with real-time monitoring of syngas using the NREL transportable Molecular Beam Mass Spectrometer (MBMS) from a thermochemical conversion (TCC) process at an integrated biorefinery (IBR) plant located in Toledo, OH. This information was used successfully to support the optimization of the TCC operating conditions for the production of high-purity syngas with H_2/CO ratios in the ideal range of 1.85 to 2.25 for the direct catalytic production of "drop-in" fuels.

Summary of Research Results:

The Renewable Energy Institute International, in collaboration with Red Lion Bio-Energy and Pacific Renewable Fuels, was awarded American Recovery and Reinvestment Act (ARRA) funding in December of 2009 to demonstrate the operation of a 25 ton per day, integrated biorefinery (IBR) plant for the direct production of synthetic fuels (premium synthetic diesel and reformulated gasoline blendstock fuels) from agriculture and forest waste (wood chips and rice hulls). In support of this project, a portion of the ARRA award was directed to NREL to provide real-time, hot product gas analysis (specifically tars) using the NREL MBMS. In September of 2013, NREL staff relocated, installed, and interfaced the MBMS system with the IBR plant at the Toledo, OH demonstration site, and provided process analytical support for the one-week independent engineer (IE) test. Hot syngas samples were drawn directly from the process at a point after the cyclones and before the syngas scrubbing/purification system. Syngas samples (at ambient temperature) were monitored after the purification system to provide information regarding the effectiveness of the scrubber for removing syngas contaminants. Tar species observed in the hot, raw syngas were typical of those generated during biomass gasification, primarily benzene, small amounts of polycyclic aromatic hydrocarbons (naphthalene, phenanthrene, pyrene), and trace amounts of fused-ring

and alkyl derivatives (toluene, indene, acenaphthene). The tar concentration in the raw syngas during the IE tests, excluding benzene and toluene, averaged <1.9 g/Nm^3 (<300 ppm by volume). Real-time analysis of the purified syngas demonstrated that these tars were effectively removed from the gas stream (>99% for naphthalene and ~100% for heavier tars).

Including the IE test runs, the IBR plant was operated under integrated conditions for 992 hours using wood chips and rice hulls as feedstock. The carbon conversion (Csyngas/Cbiomass) averaged 85%, and the fuel production averaged approximately 57 gallons/dry ash-free ton for the wood and rice hull feedstocks. The fuel consisted of two drop-in fuel products, a premium, synthetic diesel fuel (syndiesel) and reformulated gasoline blendstock. The yields of the premium, synthetic diesel fuel and reformulated gasoline blendstock averaged 72 volume % and 24 volume % of the total fuel produced, respectively. The remaining 4 volume % was benzene (a high-value commodity chemical). The information generated from this IBR project is being used to design and deploy the first biomass to "drop-in" fuel production plant in Northern California.

Subject Inventions Listing: None

Report Date: 10/27/14

Responsible Technical Contact at Alliance/NREL: Daniel Carpenter

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