



BETO FY16 Industrial Seedlings Lab Call

Cooperative Research and Development Final Report

CRADA Number: CRD-17-655

NREL Technical Contact: Calvin Mukarakate

**NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC**

This report is available at no cost from the National Renewable Energy
Laboratory (NREL) at www.nrel.gov/publications.

CRADA Report
NREL/TP-5100-70776
January 2018

Contract No. DE-AC36-08GO28308

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States 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. 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 United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Available electronically at SciTech Connect <http://www.osti.gov/scitech>

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
OSTI <http://www.osti.gov>
Phone: 865.576.8401
Fax: 865.576.5728
Email: reports@osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
NTIS <http://www.ntis.gov>
Phone: 800.553.6847 or 703.605.6000
Fax: 703.605.6900
Email: orders@ntis.gov

Cover Photos by Dennis Schroeder: (left to right) NREL 26173, NREL 18302, NREL 19758, NREL 29642, NREL 19795.

NREL prints on paper that contains recycled content.

Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article X: REPORTS AND PUBLICATIONS A. (2), of the CRADA agreement, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the DOE Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: Annex IO, LLC

CRADA number: CRD-17-655

CRADA Title: BETO FY16 Industrial Seedlings Lab Call

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind
Year 1	\$ 65,000.00
TOTALS	\$ 65,000.00

Abstract of CRADA Work:

The CRADA will focus on the production and characterization of biomass briquettes produced from post-industrial textile waste.

Summary of Research Results:

NREL researched the chemical characterization of gaseous and solid products of pyrolysis and combustion from briquettes made from textile industry solid waste. This was done on selected samples that were identified as having desirable physical properties (density, heating value, etc.) using an existing semi-batch micro-reactor system. NREL also treated two samples consisting of whole-cloth variants of cotton textile residues to investigate the feasibility of producing nanocellulose materials. The yields of nanocellulose, liberated glucose, and unconverted solids were quantified. The nanocellulose product was characterized by atomic force microscopy (AFM), transmission electron microscopy (TEM), and dynamic light scattering (DLS) to assess the size and shape of the resultant nanoparticles. The waste stream from this process was identified to be potentially useful as a binding agent for the production of textile briquettes.

Briquettes produced by Annex IO were pyrolyzed in nitrogen at 500C and combusted in 20% flowing oxygen at temperatures up to 900C in a semi-batch micro-reactor system. Evolved gases were characterized by the Molecular Beam Mass Spectrometer and characteristic pyrolysis and combustion products identified semi-quantitatively by pattern recognition based on NREL's extensive expertise in this area. An example of the results is shown in Figure 1. These data allowed NREL to advise Annex on the suitability of waste textiles as a fuel to replace charcoal in home use. Samples of briquettes produced by Annex were sent to an outside lab (Huffman Labs, Golden, CO) for proximate analysis (moisture, fixed carbon, volatile matter, ash). These data

were used to calculate the energy density of the briquettes following well recognized procedures. Solid samples (ash) were recovered post-combustion and sent to Huffman Labs for compositional analysis and speciation of metals present in the ash.

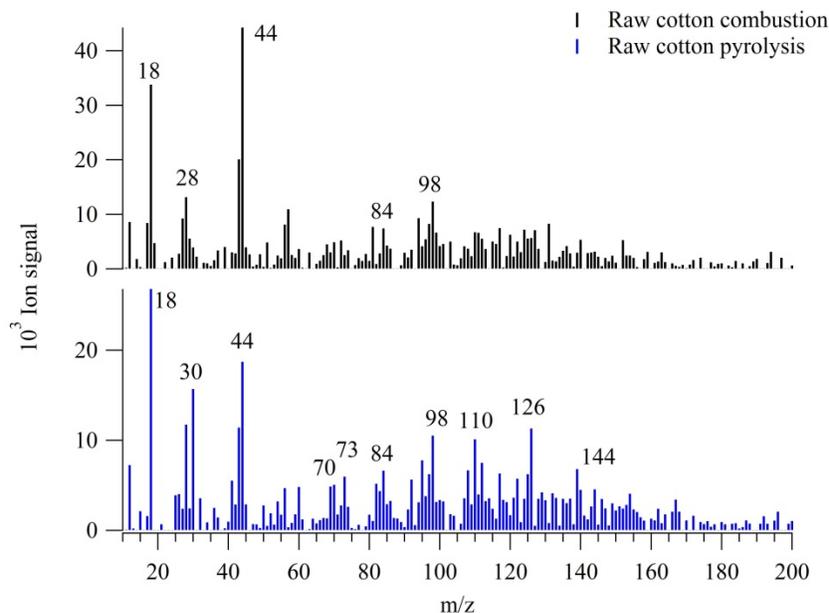


Figure 1. MBMS characterization of combustion (top trace) and pyrolysis (bottom trace) products from textile briquettes

Subject Inventions Listing:

N/A

ROI #:

N/A

Report Date:

12/01/2017

Responsible Technical Contact at Alliance/NREL:

Calvin Mukarakate

Name and Email Address of POC at Company:

Sacha Nelson, sacha@annex.io

DOE Program Office:

Bioenergy Technologies Office (BETO) FY16 Industrial Seedlings Lab Call

This document contains NO confidential, protectable, or proprietary information.