



CUI BRIEFINGS

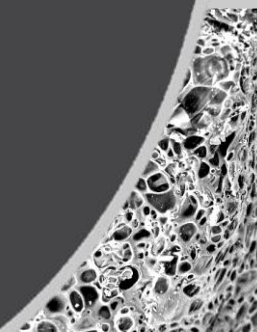
NC Waste to Energy Bench Scale Study

Prepared by ERDC-CERL, EL (Dr. Aaron Petri, Dr. Edith Martinez-Guerra, Kathryn Gunderson, Dr. Kathryn Guy, Stephen Cospers, Sulymar Arocho-Rodríguez)

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Distribution A: Approved for public release



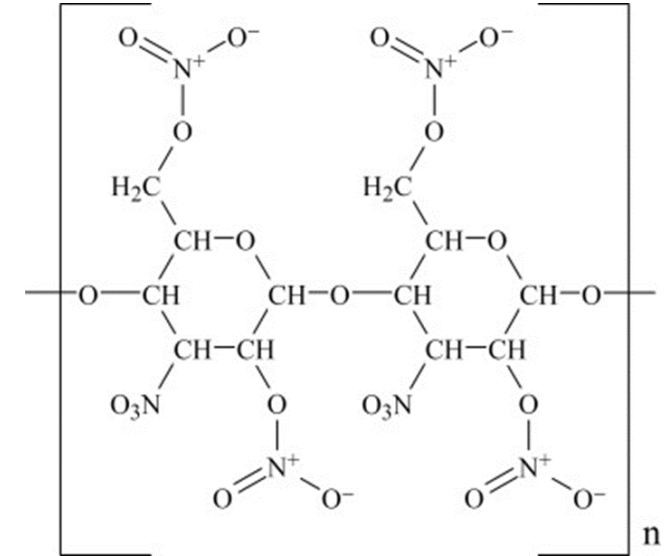
US Army Corps of Engineers



DISCOVER | DEVELOP | DELIVER

Energetic Waste Byproduct Challenge

- The production of munitions results in ~1600 tons/per year of waste energetic material
- Disposal of NC poses safety risks and can release toxins into the environment
- Hazardous waste disposal is costly and does not recover energy embedded in the material
- Goal: Safely dispose of NC fines and utilize as energy security and resiliency asset

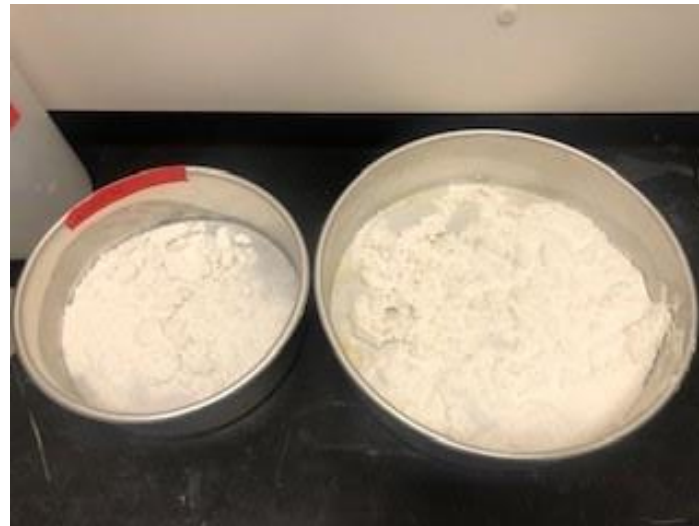


Nitrocellulose structure

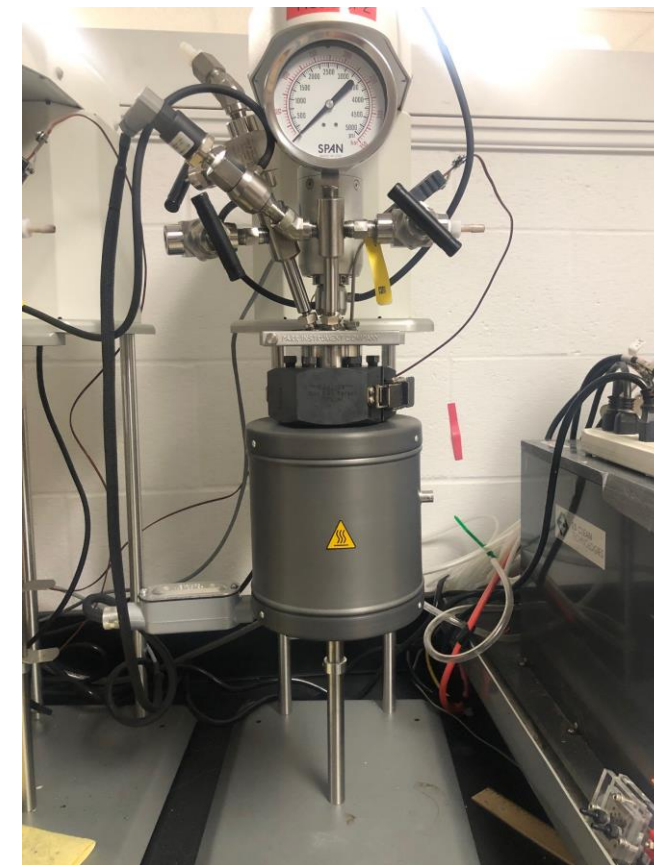
Current Project Status

Purpose: Preliminary investigation of Catalytic Hydrothermal Gasification (CHG) as WTE solution for processing and destroying nitrocellulose fines.

BLUF: *We have demonstrated that CHG effectively destroys NC fines while generating an energy source*



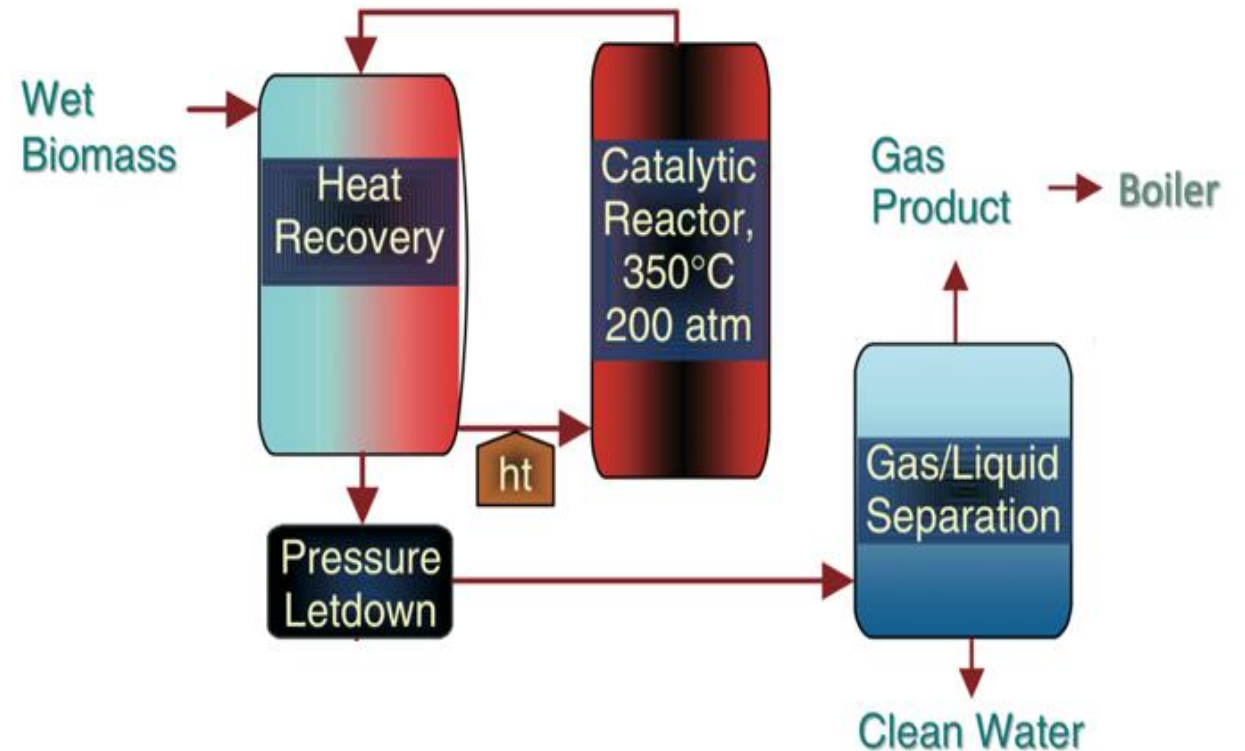
Dehydrated
NC fines



Bench scale Parr
reactor

Catalytic Hydrothermal Gasification

- Process for converting wet organics into useful fuels & chemicals
- Converts carbonaceous materials into Synthetic Natural Gas (SNG) that can be used for electricity generation
- Employs a catalyst to increase reaction rates and product yields



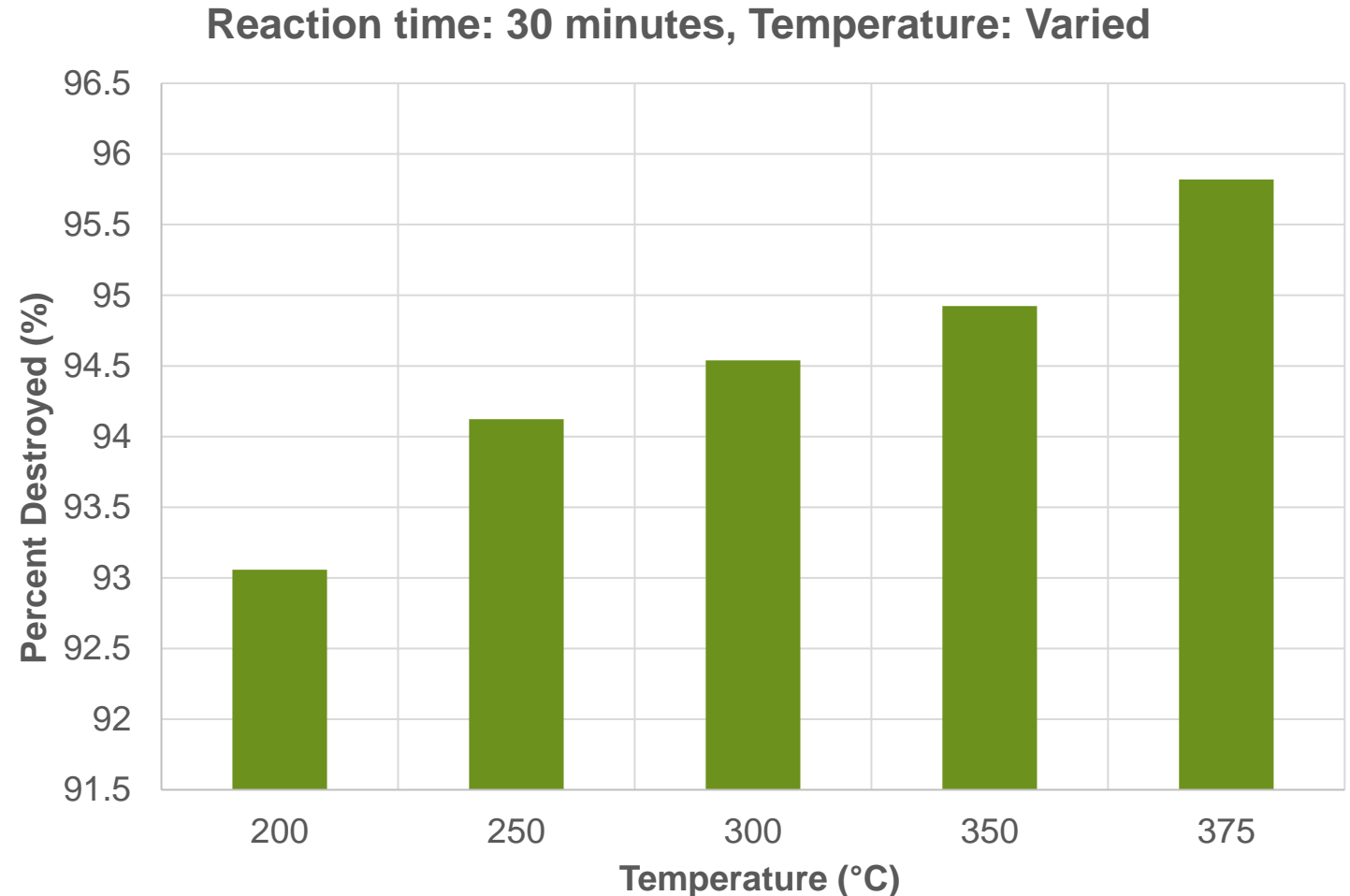
Experimental Design

- Sample Size: 10% solids feedstock (5 g in 50 mL)
- Reaction Conditions Tested:
 - Temperature: 200-375 °C (subcritical)
 - Reaction time: 30-120 mins
 - Catalysts:
 - Types: NaOH, 5% ruthenium on alumina powder, aluminum-nickel
 - Varied as a % weight of NC sample

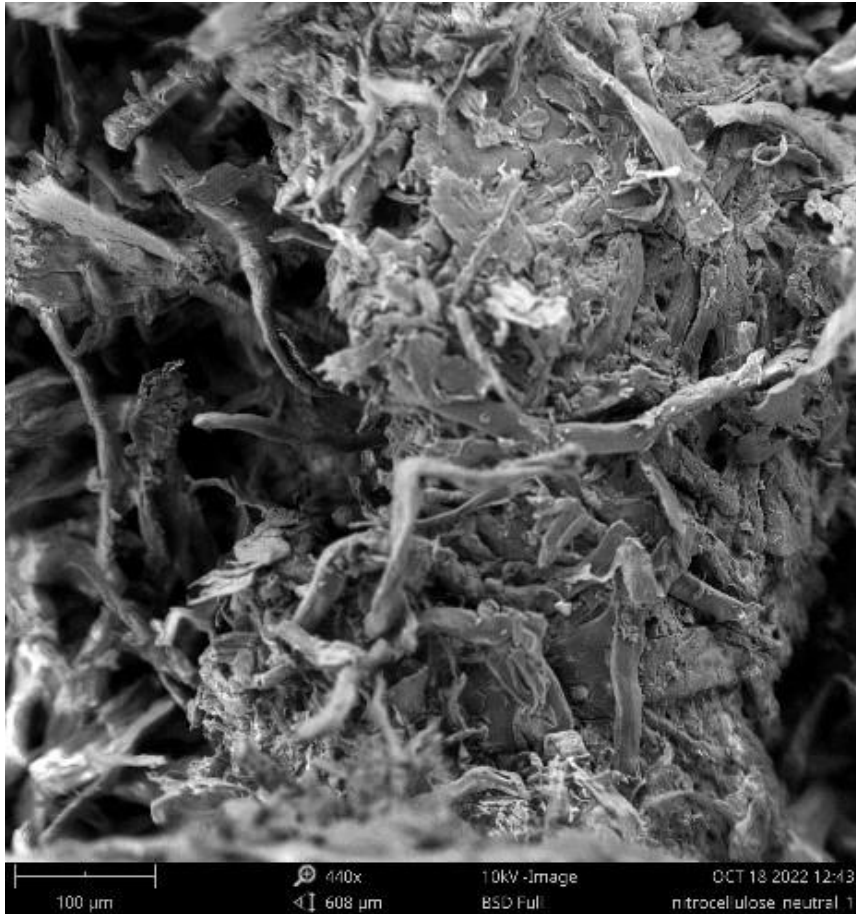


Solid Product Findings

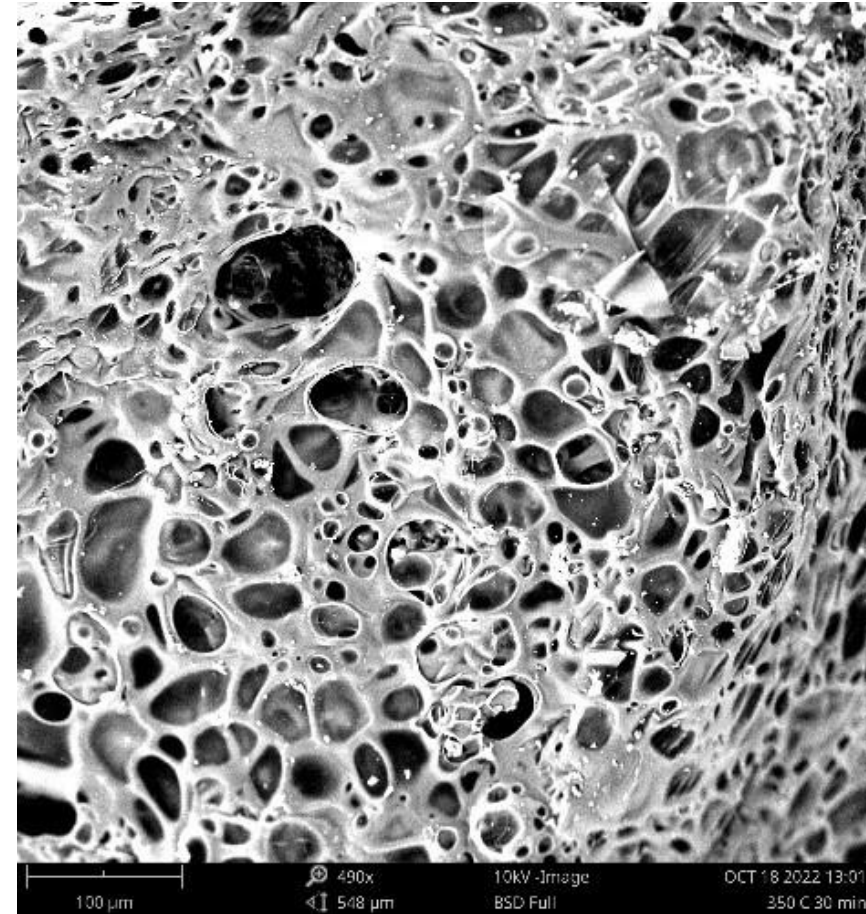
- Gasification effectively destroys the solid nitrocellulose up to 96%
- % destruction increases as the reaction temperature increases



SEM Results



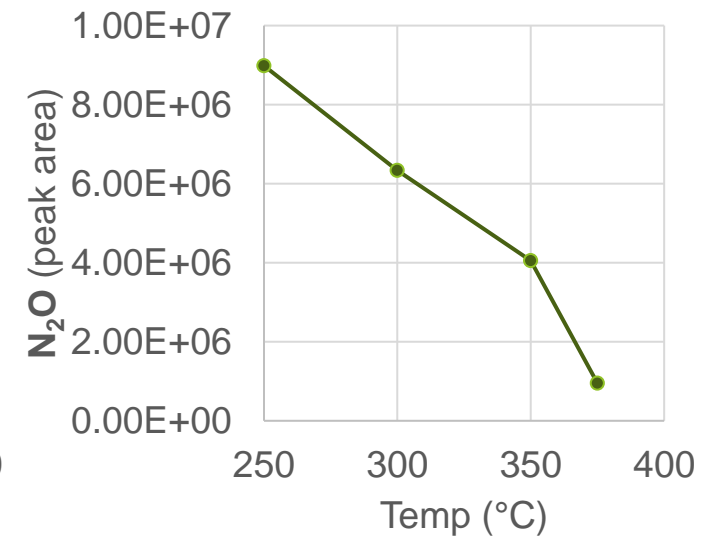
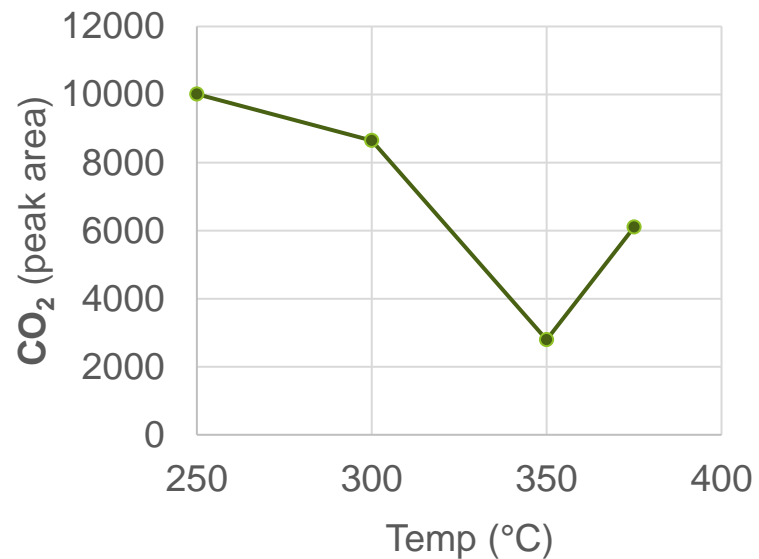
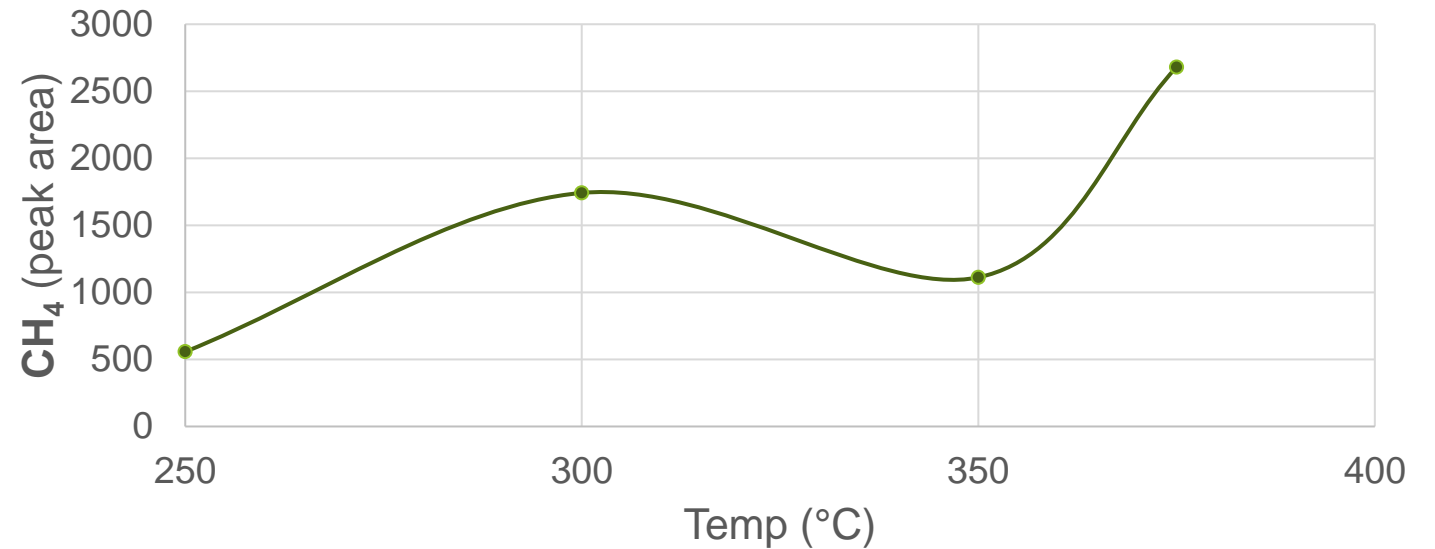
NC before HTL



NC after reacting for 30 min.
at 350 °C

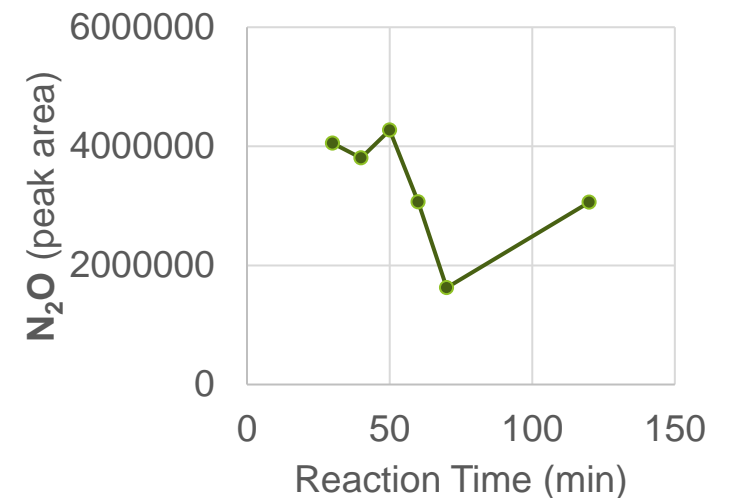
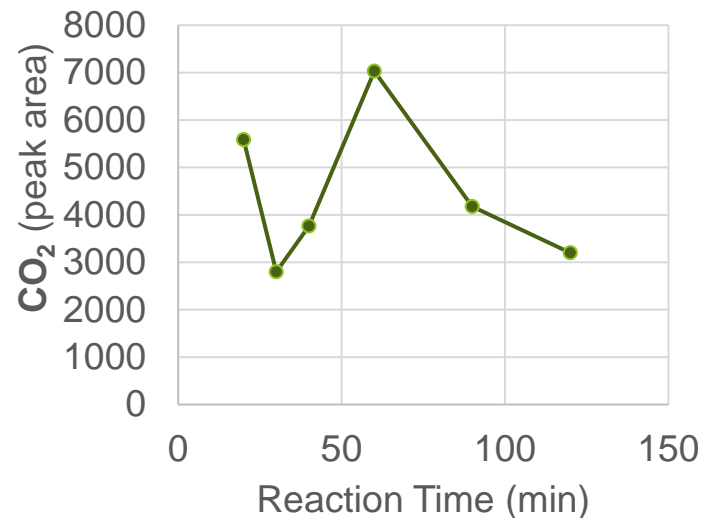
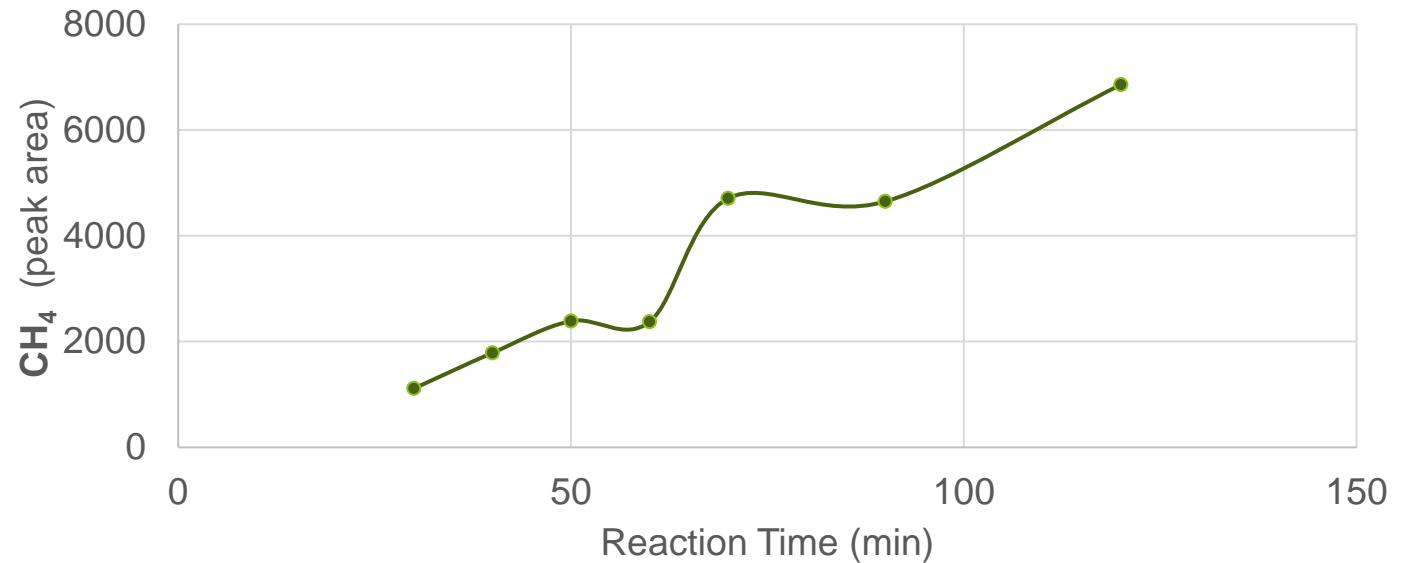
Temperature Experiment Findings

- Experimental Goal: Determine how temperature impacts the gas products by holding **reaction time constant at 30 minutes**
- Trend: As **temperature increased from 250-375 °C**, methane content increased and both nitrous oxide and carbon dioxide content decreased



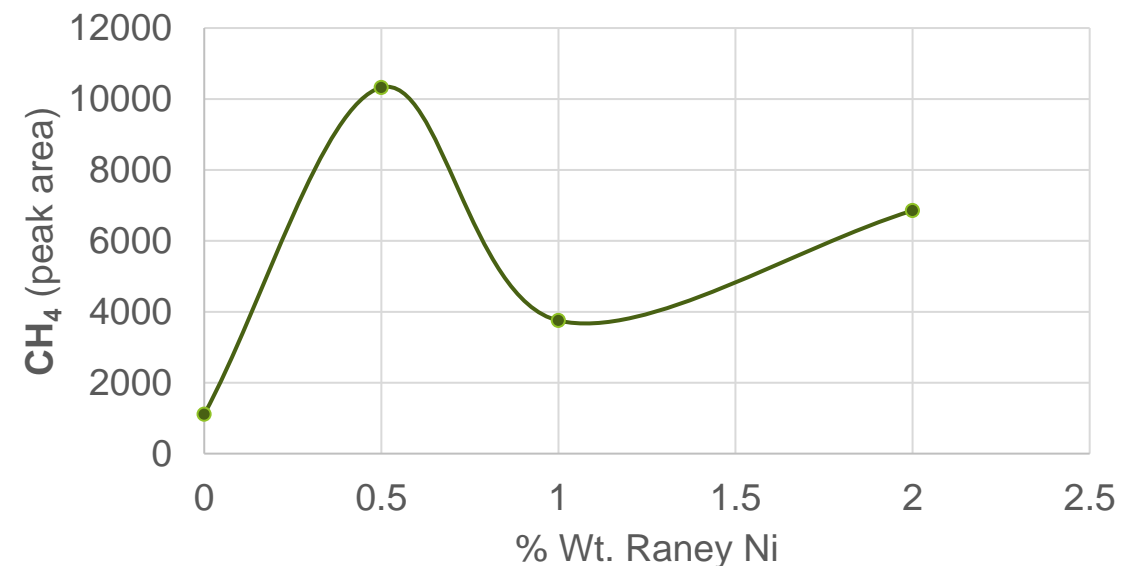
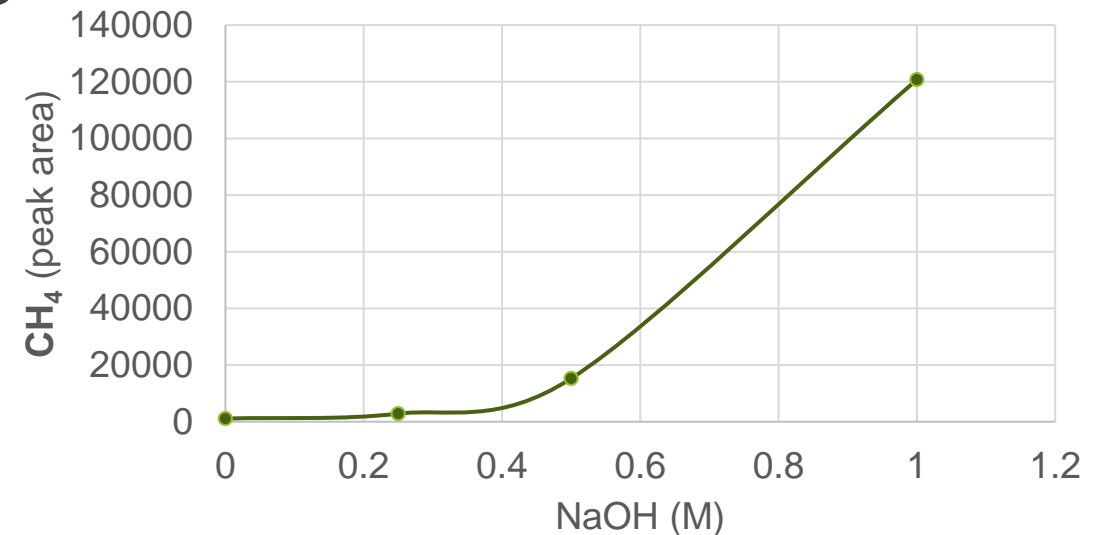
Reaction Time Experiment Findings

- Experimental Goal: Determine how reaction time impacts the gas products by holding **temperature constant at 350 °C**
- Trend: As **reaction time increased from 30-120 minutes**, the methane content increased, and both the carbon dioxide and nitrous oxide content decreased



Catalyst Experiment Findings

- Experimental Goal: Determine how gas products are affected by addition of catalysts at different concentrations at **350 °C for 30 minutes**
- Trends:
 - Addition of catalyst significantly increases methane content at 350 °C for 30 minutes
 - NaOH is a more effective catalyst than Raney nickel for methane production

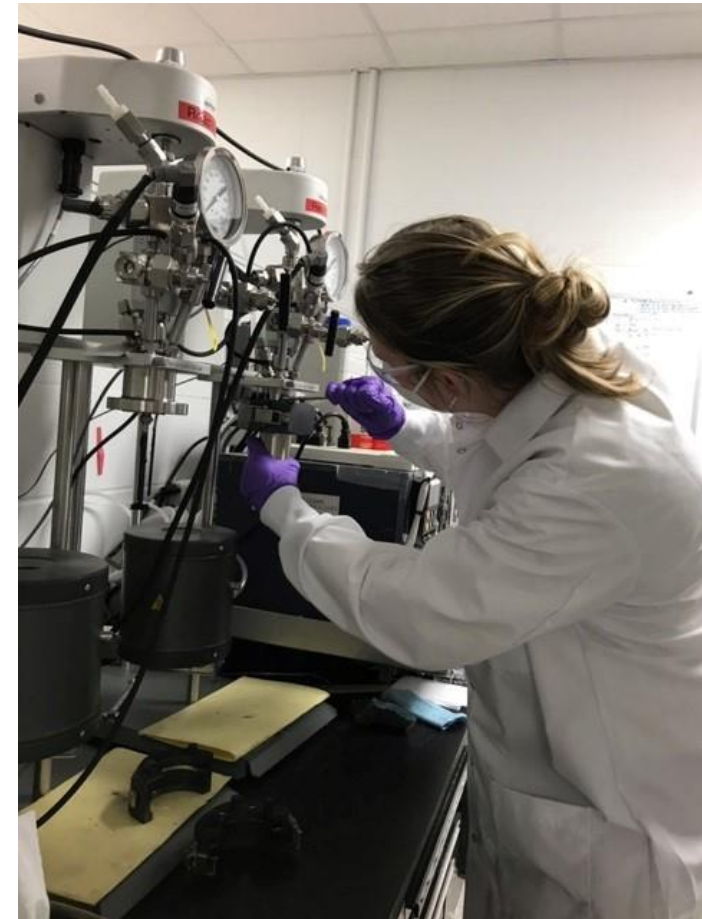


Summary of Findings

1. Gasification at temperatures greater than 200 °C for 30 minutes destroy NC solids at least 93%
2. Increasing the temperature and reaction time increased the methane content and decreased both the carbon dioxide and nitrous oxide content
3. Sodium hydroxide (NaOH) at a concentration of 0.5 M causes the methane content to increase by ~10x

Currently in Progress

- Further understanding of gas product by refining calibration curve and analytical method to analyze for more compounds and determine concentrations
- More in depth analysis of catalyst addition as well as testing more catalysts (5% ruthenium on alumina powder)
- Analysis of liquid product for nitrogen content and identification of carbon species and creation of mass balance



Long-term Goals

Goal 1: Increase amount of NC we can process

- Use higher quantities and volumes in bench scale studies
- Start developing an outline for pilot scale

Goal 2: Create a usable gas stream

- Explore additional ways of harvesting energy from waste NC
- Analyze purity of methane and assess integration with existing steam plant

POC/Team Information

Organization	Name	Contact	Function
ERDC-CERL	Dr. Aaron C. Petri	217-373-3377, aaron.c.petri@usace.army.mil	Energy & Environmental Planner, Project Manager
ERDC-EL	Dr. Edith Martinez Guerra	870-200-0423, edith.l.martinez-guerra@usace.army.mil	Environmental Engineer
ERDC-CERL	Mr. Stephen D. Cospers	217-398-5569, stephen.d.cospers@erdc.dren.mil	Environmental Engineer
ERDC-CERL	Dr. Kathryn Guy	217-373-3378, kathryn.a.guy@usace.army.mil	Chemist
ERDC-CERL	Ms. Kathryn Gunderson	217-840-1445, kathryn.g.gunderson@usace.army.mil	Environmental Engineer

Backup Slides

Catalytic Hydrothermal Gasification

- **Thermochemically converts wet biomass into a gaseous product using elevated temperatures and pressures**
 - Temperatures: >250 C
 - Pressures: >500 psi
- **Gasification is the partial combustion of biomass therefore typical gaseous products are:**
 - Methane (CH₄)
 - Carbon Dioxide (CO₂)
 - Hydrogen (H₂)
 - Carbon Monoxide (CO)
- **Catalysts are often used to increase efficiency of the reaction**

Principal reactions with pure carbon:



CHG Process Flow

