A Green Approach to Convert Energetics to Biofuels

Global Demilitarization Symposium and Exhibition

December 7 - 9, 2015

Presented by: Ms. Karen Shaw , Leidos

Authors

leidos

ALGENOL
Cleaner - Greener - Cheaper℠

- Dr. Pamela Sheehan, RDECOM-ARDEC
- Dr. William Porubusky, Algenol LLC
- Dr. Eugene Rozumov, RDECOM-ARDEC
- Ms. Peggy Sanchez, RDECOM-ARDEC
- Ms. Karen Shaw, Leidos
- Dr. Shauna Dorsey, UTRS
- Dr. Soledad Fuentes, Algenol, LLC

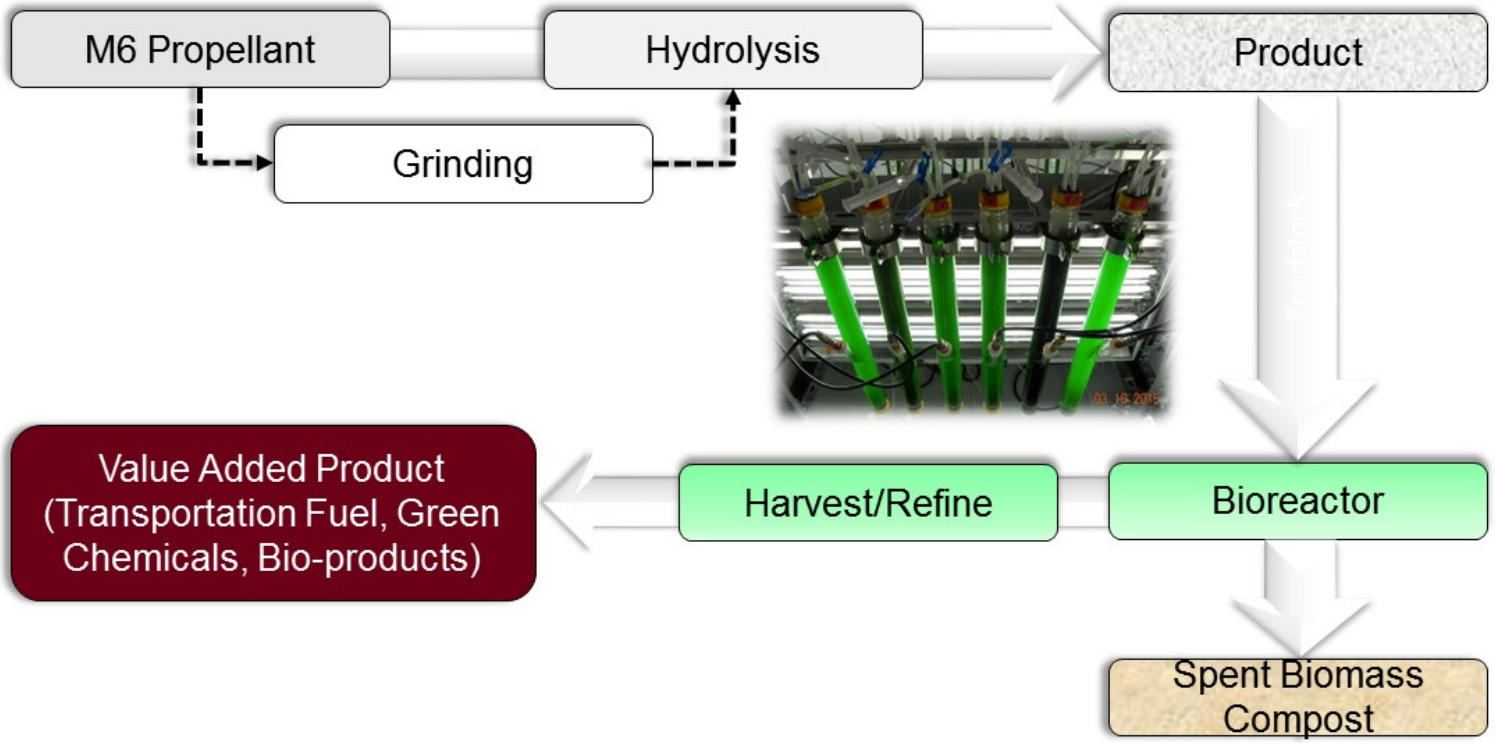
leidos

Introduction

- Many explosives and energetics are demilitarized through OB/OD
- This is a relatively slow but inexpensive process however,
- OB/OD produces large amounts of CO_2
  - CO_2 contributes to climate change
- The research objective is to develop a cost competitive, technical alternative to OB/OD that can be used to demilitarize a wide variety of energetics and explosives without the production of greenhouse gases.

Approach

- ✓ Resource recovery,
- ✓ Resource reuse in carbon neutral process
- ✓ Produce value added product
- ✓ Develop business case analysis

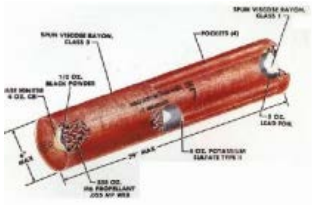


Test Material

DODIC D533

M119A2 155-mm Propelling Charge, red bag propelling charge used in the M185 and M199 155-mm howitzers.

- One of the top 10 most abundant items in the Demil Stockpile
- 87% nitrocellulose
- Current disposal method is by OB/OD



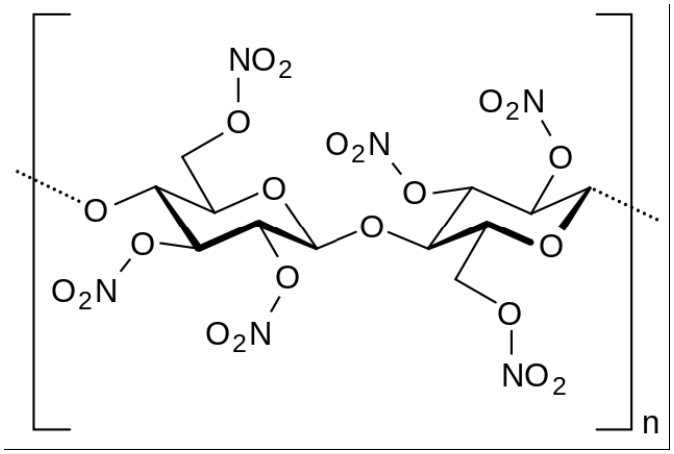
Sustainable Demilitarization

Net weight of M6 in stockpile = 4,350 s-tons (8,700,000 lbs)

Metrics: lower unit cost, improved throughput, reduced green house gas emission.

Hydrolysis process for recovery of nitrogen from M6 pellets

- Not a new concept
  - data exists for hydrolysis of M6 fines
- New process for M6 pellet
- Goal is to recover optimal concentrations of nitrite and nitrate from nitrocellulose



Mechanism is assumed to be
The direct substitution of nitro groups by hydroxide

Hydrolysis screening study results

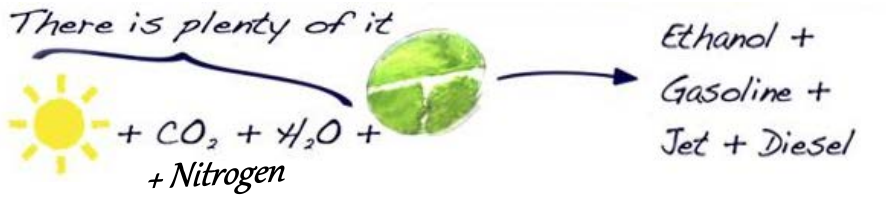
- ✓ NaOH dissolves pellet and liberates nitrite and nitrate NO GRINDING NECESSARY
- ✓ Ratio of M6:NaOH (wt %) is key
- ✓ Recovered ratio of nitrite to nitrate is less than observed for NC fines
- ✓ Demonstrated high nitrogen yield
- ✓ Tests run at high temperatures
- ✓ Reaction time < 28 hrs

Hydrolysis DOE Study Plan

- Short-Term Goal – Statistical model based on JMP to maximize nitrogen recovery
  - Response- nitrogen yield
  - Factors-
    - M6 concentration (wt % reactor volume)
    - NaOH concentration (wt % reactor volume)
    - Temperature

- Long-Term Goal – Testing Template for other propellants and explosives

Basic Principle



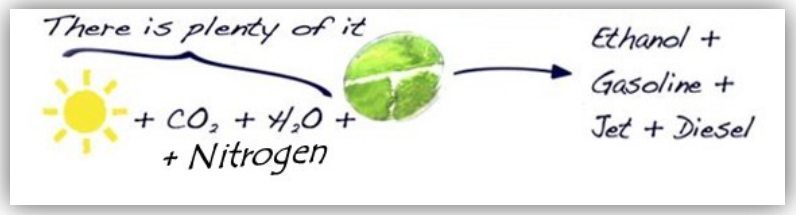
$$16\ NO_3^- + 124\ CO_2 + 140\ H_2O + HPO_4 \longrightarrow C_{106}H_{263}O_{110}N_{16}P + 138O_2 + 18CO_3^-$$

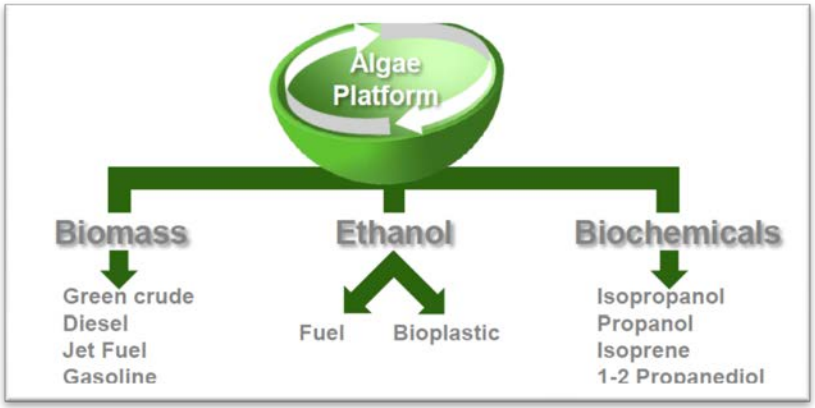
Recovered Nitrate and Nitrite from M6 hydrolysis

Bench Scale Reactors

Algenol

- Neutralized M6 Hydrolysate is fed to Algenol cyanobacteria being grown in Algenol photobioreactors
- Carbon Dioxide is consumed during this process
- Algenol cyanobacteria consume the nitrogen from the neutralized M6 Hydrolysate to produce Biomass and support the production of Ethanol
- When produced at a greater quantity, the Ethanol is removed and concentrated
- The Biomass is dewatered and processed through a hydrothermal liquefaction (HTL) unit to produce green crude oil





Algenol screening study results

- ✓ Proprietary cyanobacteria strains screened for growth on combined nitrite and nitrate from M6 hydrolysis
  - ✓ No toxic effects observed
  - ✓ Strain growth equal to or greater than growth on nitrate alone
  - ✓ Ethanol production about 20% lower than by strains growing on nitrate alone

Energetics to Biofuels

M6

$16\ NO_3^- + 124\ CO_2 + 140\ H_2O + HPO_4$

Consumed greenhouse gas

$2\ CO_2 + 3\ H_2O$

→ ~20-30% of CO_2

→ ~70-80% of CO_2

Algae Biomass

$C_{106}H_{263}O_{110}N_{16}P + 138O_2 + 18CO_3^-$

Ethanol

$C_2H_6O + 3O_2$

1 tonne CO_2 consumed produces 144 gal of fuel

~90% direct to ethanol, 10% green crude oil from biomass

37.4 lb N is needed per s-ton CO_2 consumed

0.26 lb N is needed to produce 1 gal of fuel

Path Forward

- M6 Propellant Hydrolysis/Neutralization process will continue to be refined, optimized and scaled-up to support the Algenol process scale-up
- Optimize induction of ethanol pathway in selected strain for improved ethanol production
- Substitution of M6 derived nitrogen in the Algenol process will be scaled-up from Lab Scale reactors to Field Scale reactors - outdoor cultivation in commercial photobioreactors (150 to 300L scale) and production of primary product – Ethanol
- When sufficient cyanobacterial biomass is produced, process the biomass into green crude oil and confirm quality

Contact Information

Dr. Paritosh Dave
Leidos
paritosh.r.dave@leidos.com

Ms. Karen Shaw
Leidos
karen.o.shaw@leidos.com

Dr. Pamela Sheehan
RDECOM-ARDEC
Picatinny Arsenal
pamela.l.sheehan.civ@mail.mil