



A Green Approach to Convert Energetics to Biofuels

Global Demilitarization Symposium and Exhibition
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Presented by: Ms. Karen Shaw , Leidos

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ALGENOL
Cleaner - Greener - Cheaper™

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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 CO₂
 - CO₂ 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.

Obama Orders Cuts in Federal Greenhouse Gas Emissions

By JULIE HIRSCHFELD DAVIS MARCH 19, 2015



President Obama signing an executive order on Thursday to cut the federal government's greenhouse gas emissions.

A screenshot of the Council on Environmental Quality (CEQ) website. The page features a blue header with navigation links: BRIEFING ROOM, ISSUES, THE ADMINISTRATION, PARTICIPATE, and 1600 PENN. Below the header, the main content area is titled "Federal Leadership on Climate Change and Environmental Sustainability - EXECUTIVE ORDER 13693". It includes a sub-section for "INITIATIVES" with links to Climate Change Resilience, Federal Sustainability, Sustainable Plans, OMB Scorecards, GHG Accounting and Inventories, and Sustainable Laboratories. A large text block describes the executive order's goal to cut federal GHG emissions 40 percent over the next decade from 2005 levels.

Executive Order 13693, Planning for Federal Sustainability in the Next Decade

Executive Order (EO) 13693 was signed March 19, 2015. EO 13693 introduces new requirements and expands upon requirements established by EO 13514, EO 13423, the Energy Policy Act of 2005 (EPAct 2005), and the Energy Independence and Security Act (EISA) of 2007.

The White House

October 05, 2009

Executive Order 13514 -- Focused on Federal Leadership in Environmental, Energy, and Economic Performance

THE WHITE HOUSE
Office of the Press Secretary

For Immediate Release
President Obama signs an Executive Order
Focused on Federal Leadership in Environmental,
Energy, and Economic Performance

October 5, 2009

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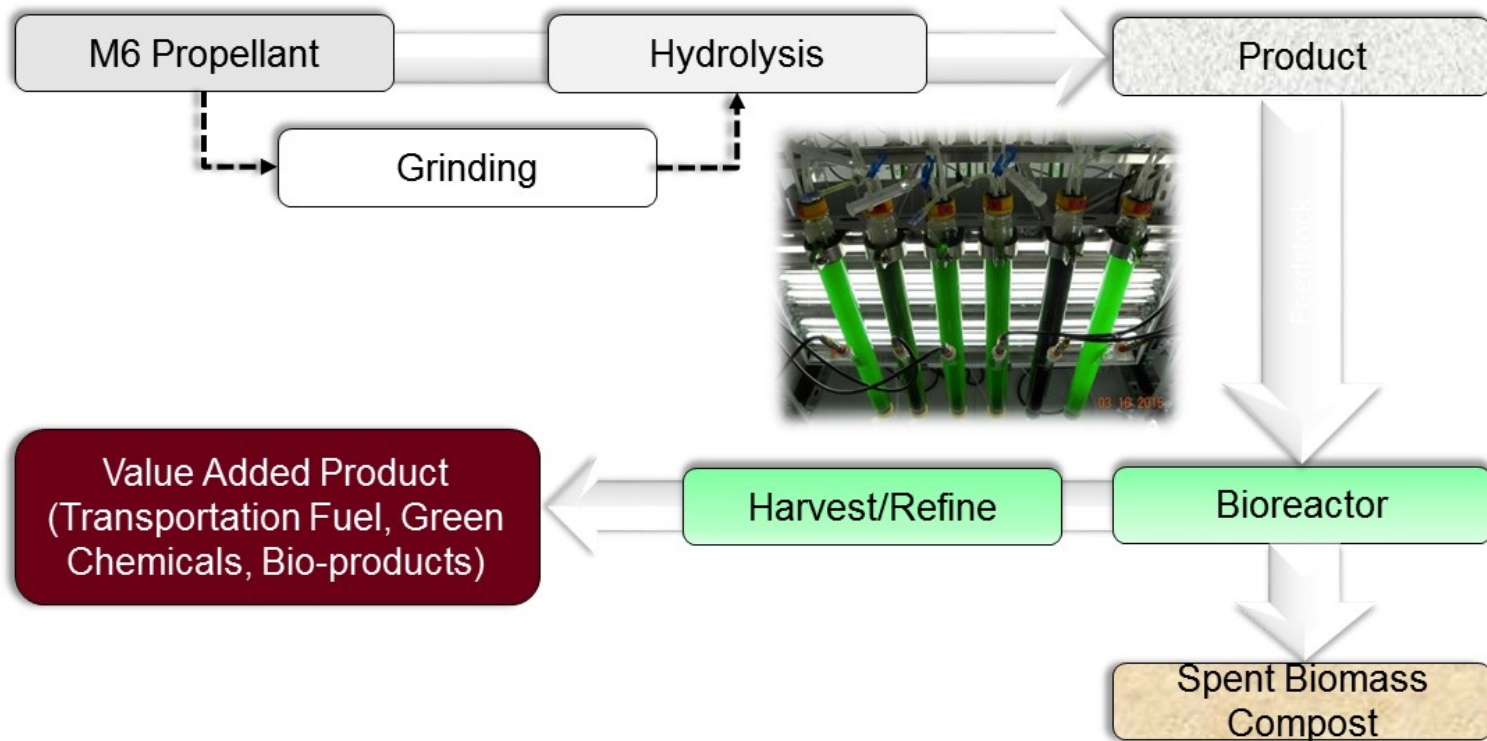
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Approach



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



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.

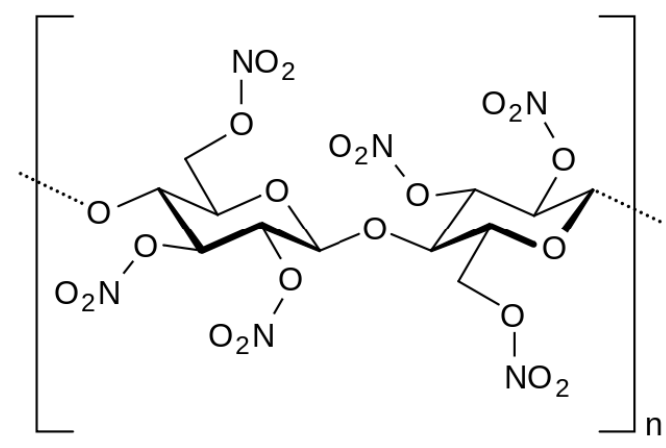
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Hydrolysis process for recovery of nitrogen from M6 pellets

- ▶ 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

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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

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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

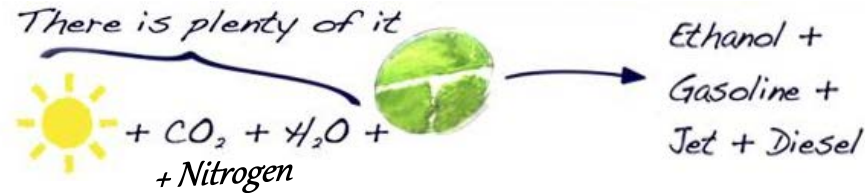
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Basic Principle



Recovered Nitrate
and Nitrite from M6
hydrolysis



Bench Scale Reactors

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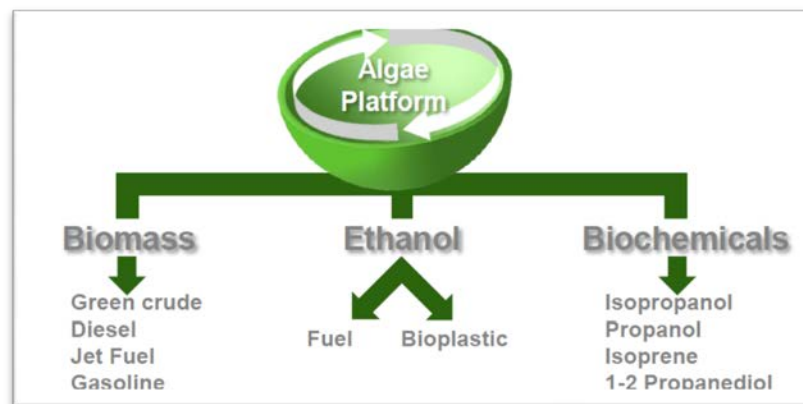
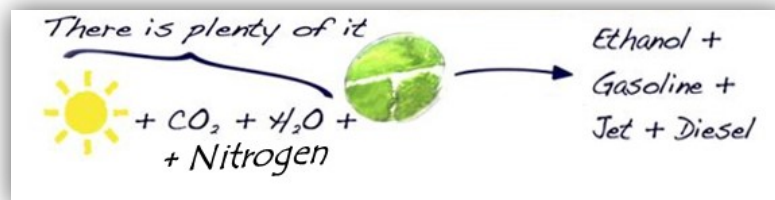
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Algenol



- ▶ 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



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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

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Energetics to Biofuels

M6



Consumed
greenhouse gas



~20-30%
of CO₂

Algae Biomass



Ethanol



~70-80%
of CO₂

1 tonne CO₂ 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 CO₂ 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

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