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CARBON CAPTURE

Materials Science & Technology Division
U.S. Naval Research Laboratory, Washington DC

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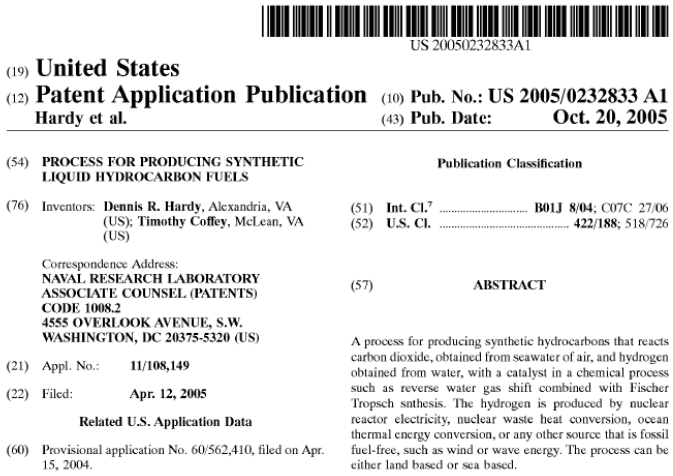
NRL Work in Carbon Capture



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(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0232833 A1**

Hardy et al. (43) **Pub. Date: Oct. 20, 2005**

(54) **PROCESS FOR PRODUCING SYNTHETIC LIQUID HYDROCARBON FUELS**

(76) Inventors: **Dennis R. Hardy**, Alexandria, VA (US); **Timothy Coffey**, McLean, VA (US)

Correspondence Address:
NAVAL RESEARCH LABORATORY
ASSOCIATE COUNSEL (PATENTS)
CODE 1008.2
4555 OVERLOOK AVENUE, S.W.
WASHINGTON, DC 20375-5320 (US)

(21) Appl. No.: **11/108,149**

(22) Filed: **Apr. 12, 2005**

Related U.S. Application Data

(60) Provisional application No. 60/562,410, filed on Apr. 15, 2004.

Publication Classification

(51) **Int. Cl.**[7] **B01J 8/04**; C07C 27/06

(52) **U.S. Cl.** **422/188**; 518/726

(57) **ABSTRACT**

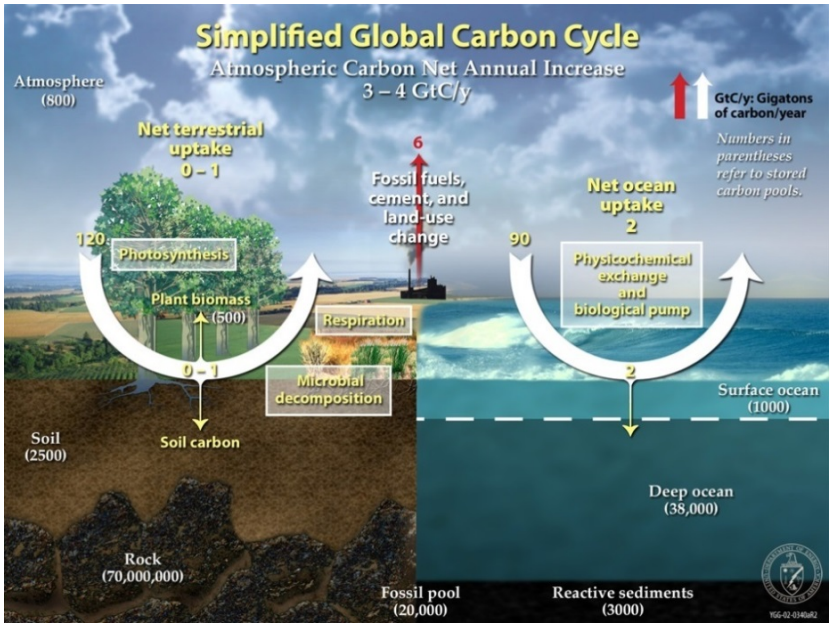
A process for producing synthetic hydrocarbons that reacts carbon dioxide, obtained from seawater of air, and hydrogen obtained from water, with a catalyst in a chemical process such as reverse water gas shift combined with Fischer Tropsch synthesis. The hydrogen is produced by nuclear reactor electricity, nuclear waste heat conversion, ocean thermal energy conversion, or any other source that is fossil fuel-free, such as wind or wave energy. The process can be either land based or sea based.

- NRL has been working in this space since 2000 with Dr. Dennis R. Hardy and Dr. Timothy Coffey as the lead scientist
- NRL's object is to make fuel on demand for the Navy
- I started work in this field in 2006

- Capturing large quantities of carbon dioxide and hydrogen quickly and efficiently.
- Achieving high catalytic conversion efficiencies and selectivities of carbon dioxide plus hydrogen to designer fuel.
- Keeping both the extraction module and the fuel production plant footprints to a reasonable size and weight.

Why capture CO_2 from Seawater?

- Renewable supply of CO_2 and H_2 feedstocks in Navy marine and littoral environments ~72% of the globe.
- CO_2 is 140 times more concentrated in seawater than air on a (w/v) basis (100 mg/L seawater vs 0.77 mg/L air).
- CO_2 from seawater is 1/3 (100 mg/L) the concentration of CO_2 found in stack gas from coal fire power plants (296 mg/L).
- Additional electrolysis equipment for production of H_2 is required if CO_2 is capture from air.



Genomics: GTL Roadmap, U.S. Department of Energy Office of Science, August 2005

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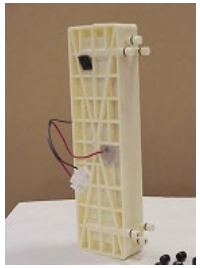
NRL R&D

NRL Technologies Developed In Parallel

Electrolytic cation exchange module (E-CEM), 110 mL seawater (TRL 3)



Scaling and integrating E-CEM to process 0.5 gpm seawater

E-CEM 4, 0.5 gpm seawater

Scaling E-CEM, 25 gpm (TRL 7)

CO_2 and H_2 Capture Process **2009 to 2019**

Laboratory scale production of hydrocarbons (TRL 3)

Flight using fuel from CO_2 and H_2

https://www.youtube.com/watch?v=Iavz7AnKI8I

Commercial scale testing of NRL catalyst systems (TRL 6)

NRL Fuel Synthesis Skid (TRL 7)

Fuel Synthesis Process **2011 to 2019**

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Specific Challenges in DOC

- Basic Research
  - Environmental effects on the ocean and marine life
  - Can it serve to help with ocean acidification

- Cost and Power
  - JP5 $2.40/gallon and F76 $2.39/gallon
  - Fully Burden cost $5.66 and $5.65
  - Size and cost of power source

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S&T Investment Operational Fuel From Seawater

TRANSITION

CRADA – Fuel Synthesis from Ocean Water FY08-FY10 ($227K)

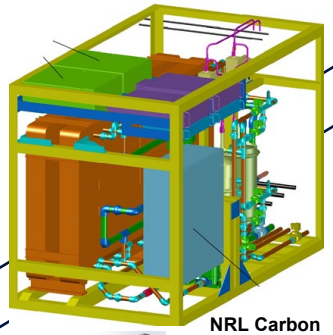
CRADA – CO_2 Extraction from Seawater and Fuel Synthesis ($50K)

Naval Sea Systems Command Operational Fuel From Seawater ($2.0M)

Demonstrate and Integrate NRL Technologies (TRL 7)

ONR Feasibility, Synthesis and Synthesis of Alternative Fuels ($1.8 M)

CRADA – Fuel Ship Concept ($35K)



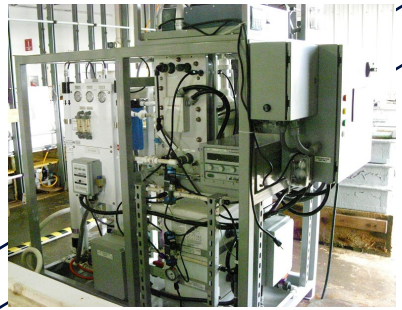
NRL Carbon Capture Prototype Skid Design (TRL 7)

NRL Carbon Capture Prototype Skid Evaluation (TRL 7)

NRL Fuel Producing Skid Evaluation (TRL 7)

ONR Test Evaluation Alternative Fuel ($100K)

NRL Carbon Capture Module Skid (5ft x 3ft x 5 ft), (TRL 6)



Key:

Base Programs (open box)

External programs (filled box)

NRL Carbon Capture Module (TRL 3)

NRL Commercial Scale Catalyst Testing (TRL 6)

Today

6.1 Synthesis of Naval Mobility Fuel ($1.1 M)

6.1 Conversion of CO_2 Waste to Energetic Molecules ($ 2.5 M)

6.1 FY20-FY22 ($ 1.4 M)

FY10 FY11 FY12 FY13 FY14 FY15 FY16 FY17 FY18 FY19 FY20

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ONR/DOE Collaboration

- Objective is to enhance DON & DoD fuel and energy security.
- Combining Blue Carbon and Direct Air Capture technologies with fuel producing technologies will offer DON & DoD fuel production options.
- Leverage DOE expertise in DAC to identify and support technologies to enhance fuel and energy security.