NRL Work in Carbon Capture

- 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.
**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)

**CO₂ and H₂ Capture Process** 2009 to 2019

- Laboratory scale production of hydrocarbons (TRL 3)

- Flight using fuel from CO₂ and H₂

- Commercial scale testing of NRL catalyst systems (TRL 6)

- NRL Fuel Synthesis Skid (TRL 7)

https://www.youtube.com/watch?v=lavz7AnKj8I

**Fuel Synthesis Process** 2011 to 2019
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
6.1 Conversion of CO₂ Waste to Energetic Molecules ($2.5 M)

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

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

CRADA – CO₂ Extraction from Seawater and Fuel Synthesis ($50K)

ONR Test Evaluation Alternative Fuel ($100K)

CRADA – Fuel Ship Concept ($35K)

NRL Carbon Capture Module (TRL 3)

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

NRL Fuel Producing Skid Evaluation (TRL 7)

CRADA – Fuel Ship Concept ($35K)

NRL Carbon Capture Prototype Skid Design (TRL 7)

NRL Commercial Scale Catalyst Testing (TRL 6)

Demonstrate and Integrate NRL Technologies (TRL 7)

NRL Carbon Capture Prototype Skid Evaluation (TRL 7)

6.1 Synthesis of Naval Mobility Fuel ($1.1 M)

6.1 FY20-FY22 ($1.4 M)
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.