Fuel of the Future: Stimulating the Production of Dimethyl Ethers Through Catalysts

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Introduction:

- Diesel is a commonly used fuel source and a large contributor towards global warming largely due to its substantial emissions of carbon dioxide.
- In its place, dimethyl ethers (DME) have been proven to be a promising alternative to the fuel as it comes with many eco-friendly benefits:

Produces less emissions of carbon dioxide

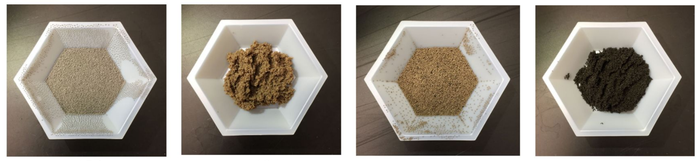
Synthesized from a renewable resource (Methanol)

Energy efficiency comparable to diesel

- Our experiments aim to discover a catalyst which can most effectively aid in the creation of DME, with the eventual goal of using it in a reactive distillation column in order to produce it on a larger scale.

Methods:

- 4 different catalysts were used in this experiment:
  - Amberlyst 15 Dry (A15D)
  - Amberlyst 35 Wet (A35W)
  - Amberlyst 16 Wet (A16W)
  - Amberlyst 36 Wet (A36W)



A15D	A16W	A35W	A36W
Surface Area: 53 m^2/g	Surface Area: 30 m^2/g	Surface Area: 50 m^2/g	Surface Area: 33 m^2/g
Avg. Pore Diameter: 300 Å	Avg. Pore Diameter: 250 Å	Avg. Pore Diameter: 300 Å	Avg. Pore Diameter: 240 Å
Acid Site Conc.: 4.7 eq/kg	Acid Site Conc.: 4.8 eq/kg	Acid Site Conc.: 5.2 eq/kg	Acid Site Conc.: 5.4 eq/kg
Max Op. Temp.: 120 °C	Max Op. Temp.: 130 °C	Max Op. Temp.: 150 °C	Max Op. Temp.: 150 °C

Figure 1. Catalyst properties

- ~0.500g of each catalyst were placed in an oven (excluding A15D) for a minimum of 24 hours at 65°C in order to evaporate any traces of water from their pores.

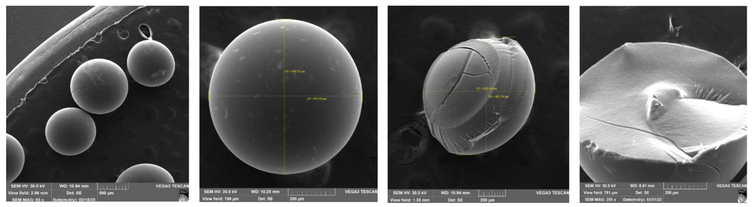


Figure 2a. MIcroscopic image of Amberlyst Catalyst BEFORE drying

Figure 2b. MIcroscopic image of Amberlyst Catalyst AFTER drying

- Each catalyst was reacted with pure methanol using a Methanol Mini Reactor Loop to dehydrate the methanol and produce dimethyl ether gas. The Opentrons Robot was then used to inject the product into 20mL vials at 50min intervals.
- Within the reactor, all catalysts were subjected to specific conditions:

Temperature: 130°C

Pressure: 135psi

- The vials were placed into a gas chromatograph (GC).
  - The quantity of DME that was produced during the reaction was able to be analyzed through the use of this machine.

Results:

Figure 3. The average production of DME produced during 50 minute intervals represented by the integration area number given by the gas chromatograph. This graph averages 4 different runs through the methanol reactor using each catalyst. Pure methanol ran through the reactor at 0.22 mL/min and filled 7 vials over the course of 6 hours.

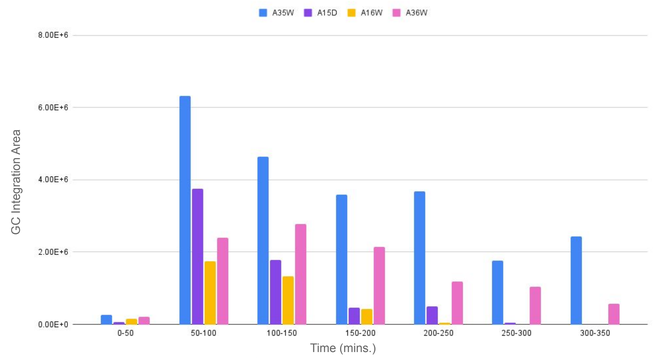


Figure 4. The average production of methylal produced during 50 minute intervals represented by the integration area number given by the gas chromatograph. This graph averages 4 different runs through the methanol reactor using each catalyst. Pure methanol ran through the reactor at 0.22 mL/min and filled 7 vials over the course of 6 hours.

Conclusions:

- Results have shown (*Figure 5.*) that Amberlyst 35 Wet (A35W) consistently produces the most amount of DME when compared to A15D, A36W, and A16W.

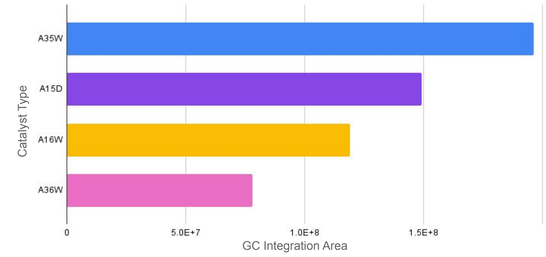


Figure 5. Overall average of DME produced by catalyst type. GC integration area was averaged across 4 runs, each spanning 350mins.

- This is due to the fact that A35W has a bigger pore size. It can be observed that pore diameter of a catalyst plays an important role in the production of DME.

Larger pore diameter = Greater amounts of DME

- Results in *Figure 4.* indicate the presence of another substance.
  - Methylal was unintentionally produced at lower levels than DME but remains a recurring byproduct during every run.

Moving Forward:

- A35W and other catalysts that exhibit similar physical properties (average pore diameter, acid strength, etc.) may be used to aid in the larger production of DME.
- The detection of methylal during this reaction may open a gateway into further research:

Discovering WHY methylal is being produced

Producing methylal to be used in the creation of another climate-friendly fuel (OME2)

Further understanding the chemical process by which DME is made

Acknowledgements & References:

- A huge thank you to Danish Dar, Selam Demoz, WISEST, and the entire Clean Technologies team for their guidance and support!
- Thank you to the Alberta Government and Syncrude for making this project possible.

Dar, D. & Nokes, E., Northern Alberta Institute of Technology [NAIT], 2022