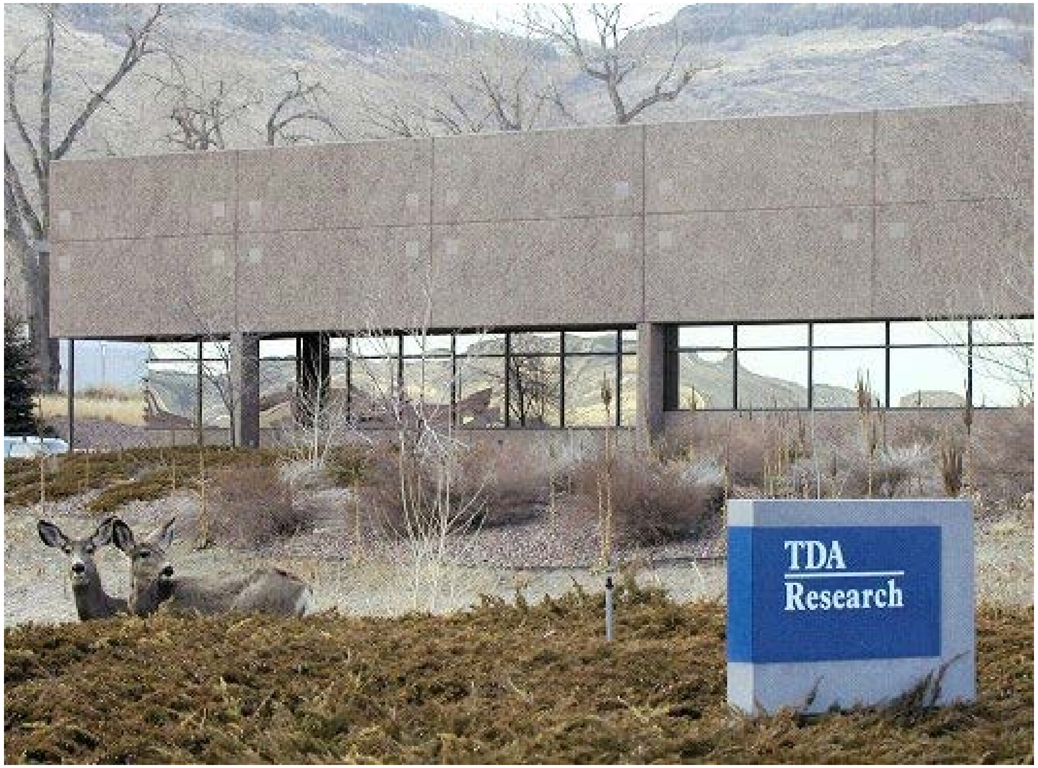
A Novel Process for Carbon Dioxide Conversion to Fuel (DE-FE0031714)



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TDA Research Inc. • Wheat Ridge, CO 80033 • www.tda.com

Project Objectives

- **The objective is to develop a new sorbent and the process around it for CO_2 utilization**
- **The sorbent converts CO_2 into CO in a redox process using CH_4 (natural gas) and a small fraction of H_2 generated by reforming/electrolysis**
  - CO and H_2 mixture (referred to as synthesis gas) is then used to synthesize a wide range of fuels, alcohols and oxygenates (methanol); methanol to gasoline or chemicals

- **Specific objectives**
  - **Sorbent synthesis and development**
  - **Bench-scale tests to assess technical feasibility**
  - **Long-term cycling to demonstrate sorbent life**
  - **Prototype design**
  - **Prototype fabrication and proof-of-concept tests**
  - **Process design and development**
    - Gasoline synthesis via methanol-to-gasoline process
    - Diesel fuel synthesis via Fischer-Tropsch

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Project Partners

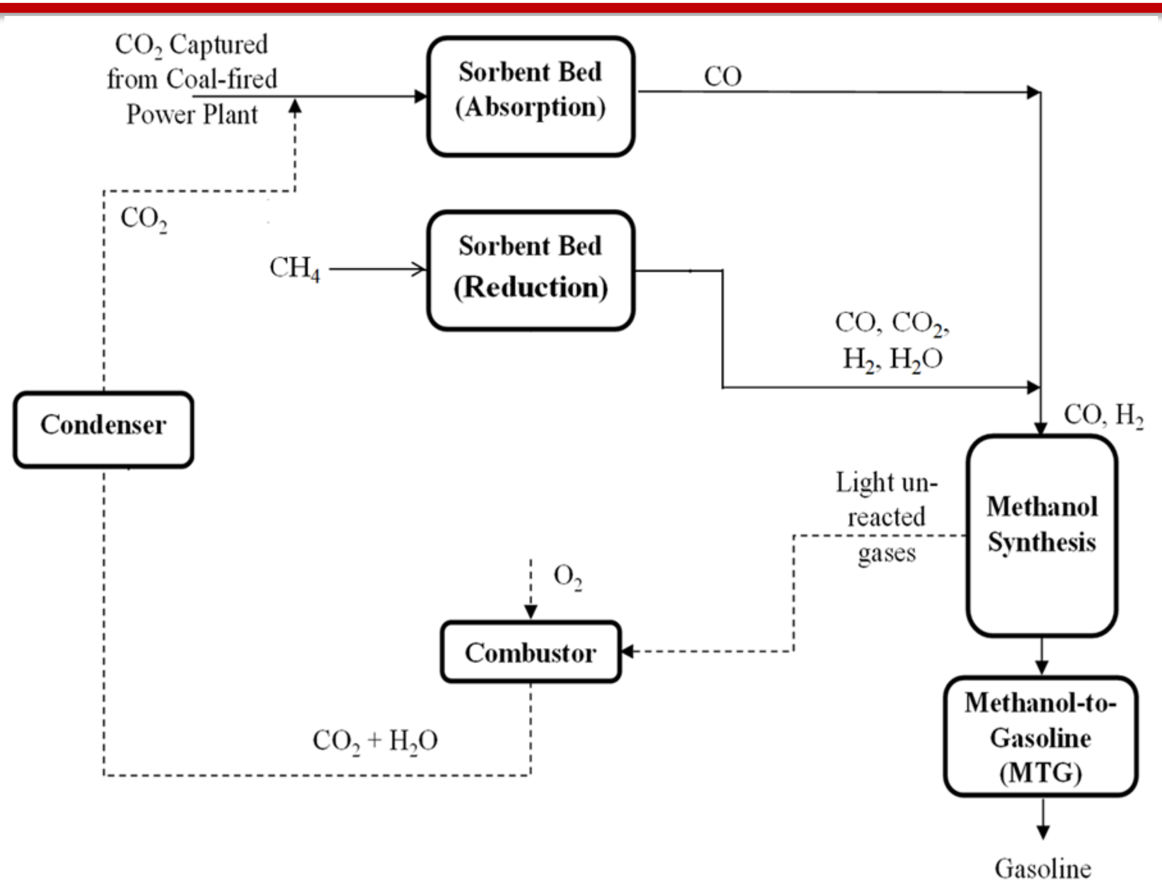
<u>Project Duration</u>

- **Start Date = January 10, 2019**
- **End Date = January 9, 2021**

<u>Budget</u>

- **Project Cost = $1,000,000**
- **DOE Share = $800,000**
- **TDA and its partners = $200,000**

Process Schematic – NG Reduction

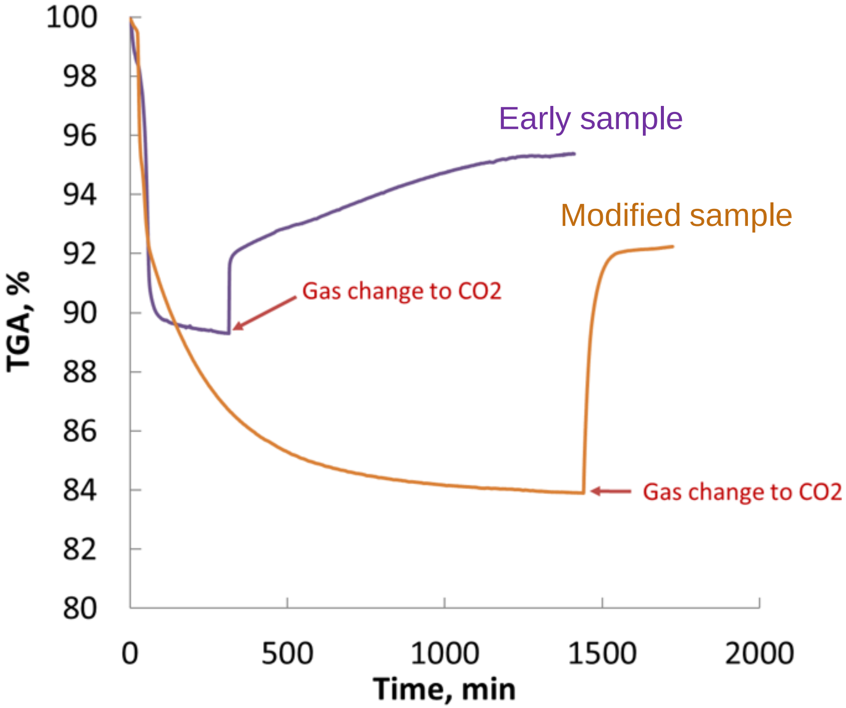


Reduction:	$CO_{2(g)} + M = CO_{(g)} + MO$
Partial Oxidation:	$CH_{4(g)} + MO = CO_{(g)} + 2H_{2(g)}$
Net Reaction:	$CH_{4(g)} + CO_{2(g)} = 2CO_{(g)} + 2H_{2(g)}$

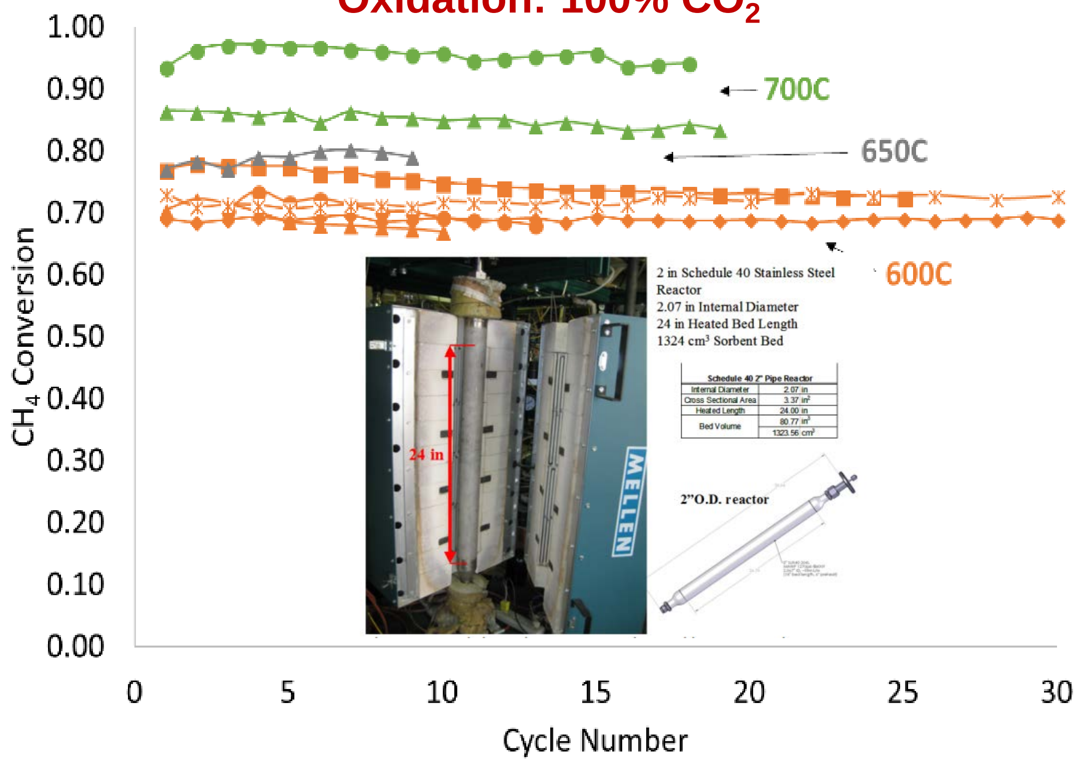
Dry reforming can be achieved with very high level of conversion

Initial Results

Reduction in 2% CH_4/N_2, 600˚C
Oxidation: 100% CO_2



Reduction: 2% CH_4/Balance N_2
Oxidation: 100% CO_2



- **Modified sorbent has 9.5% wt. oxygen uptake at 600ºC in TGA tests**
- **CH_4 conversion (at 5,000 h^{-1} GHSV) is strongly dependent on temperature**
  - **Nearly 100% CH_4 conversion at 700ºC**
  - **Performance at 700ºC (green) is higher than 600ºC (orange)**

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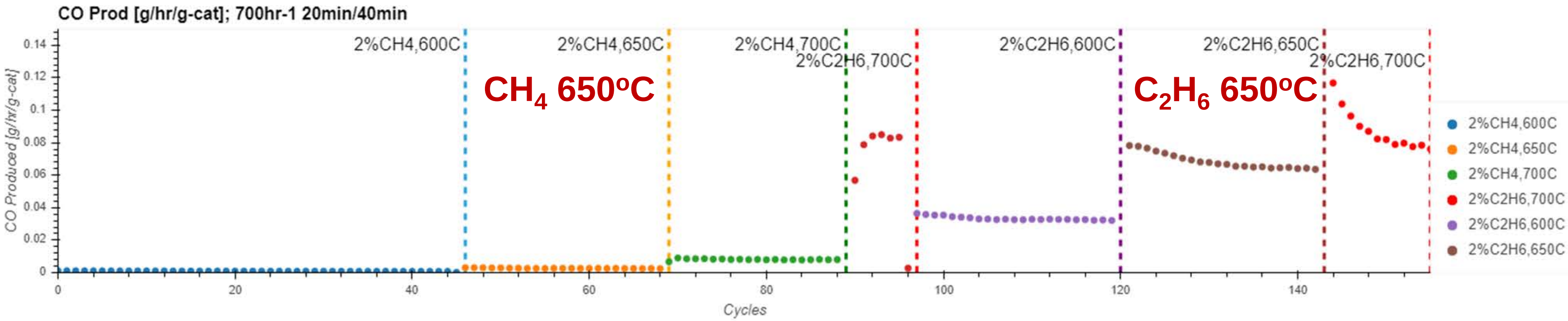
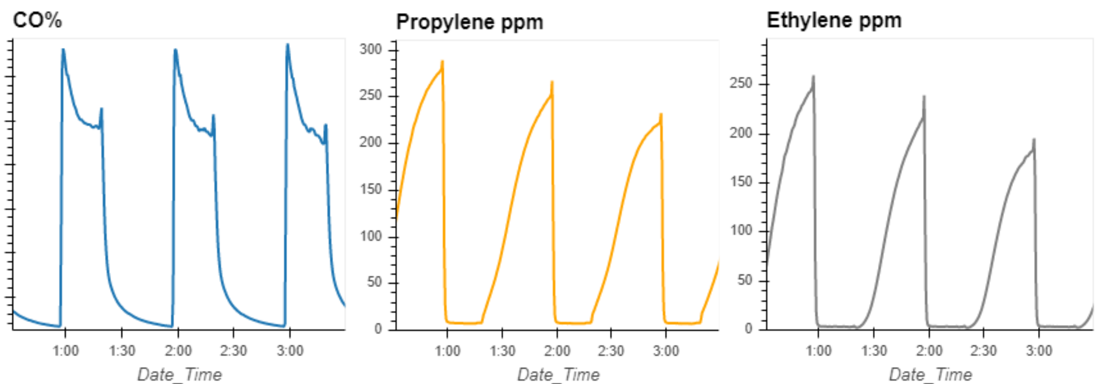
$CH_4/C_2H_6/C_3H_8$ and CO_2 Cycling

Reduction: 2% CH_4 or 2%C_2H_6 or 2%C_3H_8 Balance N_2; 40 minutes
Oxidation: 100% CO_2; 20 minutes



Product Distribution with 2%C_3H_8/N_2 reduction, T= 600°C



- **C_2H_6 and C_3H_8 have much higher activity than CH_4 that will enable lower light-off temperatures**
- **Formation of CO and olefins were evident during the sorbent reduction step**

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Preliminary Simulation Results

	CASE		
	Case 1 H2-MeOH	Case 2 H2-FT	Case 2 NG-FT
CO2 Entering Plant, tonne/h	56	56	32
Steam Turbine Power, kWe	10,395	11,793	10,625
Net Electricity Imported, kWe	427,905	375,798	133,505
Product(s), tonne/h	37.54	13.97	13.97
Cost of Product(s), $/tonne	567	1,362	784
Cost of Product(s), $/gal	1.71	3.81	2.19

- **Under a separate DOE project (DE-FE0029866), TDA and UCI developed an Aspen Model for the CO_2 conversion to fuels**
- **The use of H_2 and natural gas was evaluated as reductants**
  - **FT Liquids are produced at $3.81/gal or $2.19/gal based on the reductant source (H_2 or CH_4, respectively)**
- **An Life Cycle Analysis (LCA) will be carried out to fully assess the carbon capture and utilization**