

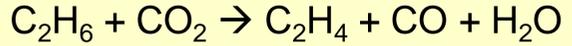
Field-Scale Testing of the Thermocatalytic Ethylene Production Process Using Ethane and Actual Coal-Fired Flue Gas CO₂

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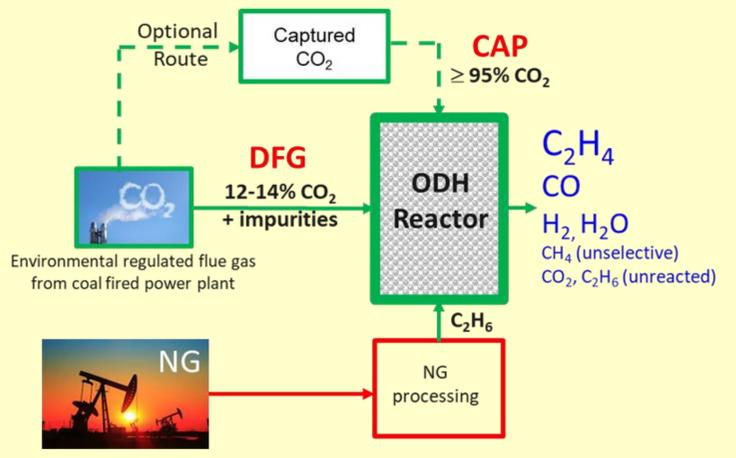
PROJECT BACKGROUND

INNOVATION: Novel oxidative dehydrogenation (ODH) catalyst for CO₂ (from coal-fired power plants) utilization to convert ethane to ethylene, and offset the cost of CO₂ capture



COLLABORATION WITH DOE-NETL-

	DE-FE0031713	DE-FE0029570
Status	Ongoing	Completed
Duration	02/2019-01/2021	03/2017-06/2019
Scale	Bench (80x of Lab scale)	Laboratory
Goals	Long term testing with actual CO ₂ streams	Catalyst development & Impurity effect study

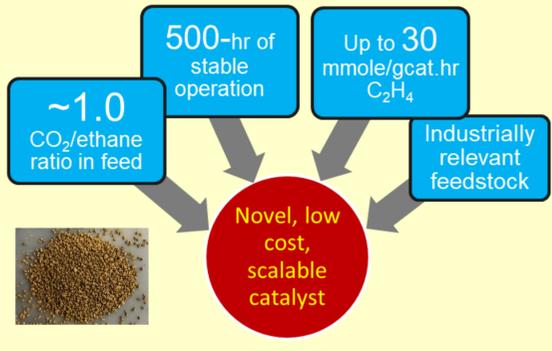


Two relevant coal fired flue gas CO₂ studied-
DFG – Direct flue gas and **CAP** – Captured CO₂

Benefits over commercial steam cracking (SC)-

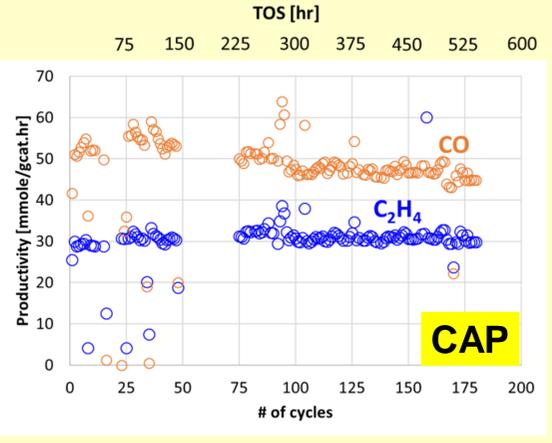
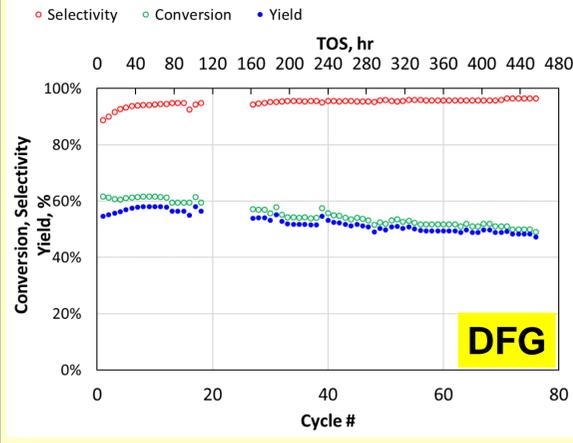
- At least **150°C** lower operating temperature
- Reduced water usage
- Process adaptable to CO₂ source/concentration
- ≥ 50%** or more overall GHG emission reduction
- Co-production of CO-rich syngas

LABORATORY SCALE VALIDATION SUMMARY

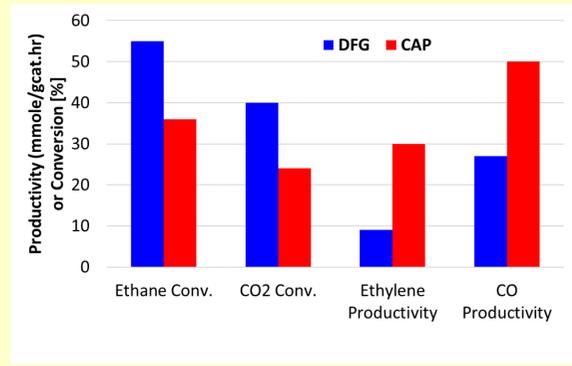


Operating Parameters		
	DFG	CAP
Cycle	5hr run, 1hr regen	2.5hr run, 1hr regen
CO ₂ spec.	12.5% CO ₂ , 80ppm SO ₂ , 80ppm NO, Trace O ₂ , balance N ₂	95% CO ₂ , balance N ₂
T	600 – 700°C	

LONG TERM CATALYST STABILITY



PERFORMANCE SUMMARY



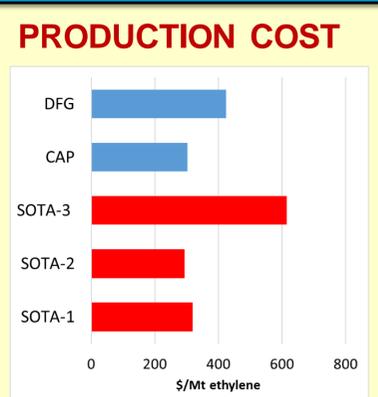
DFG – High conversion, Low productivity (9 mmole/gcat.hr C₂H₄)
CAP – Low conversion (36% C₂H₆ per pass), High productivity

Representative raw ODH product vol%

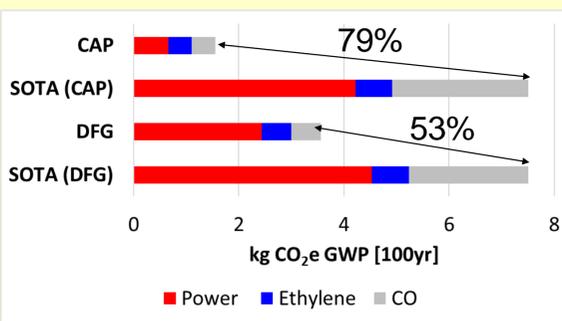
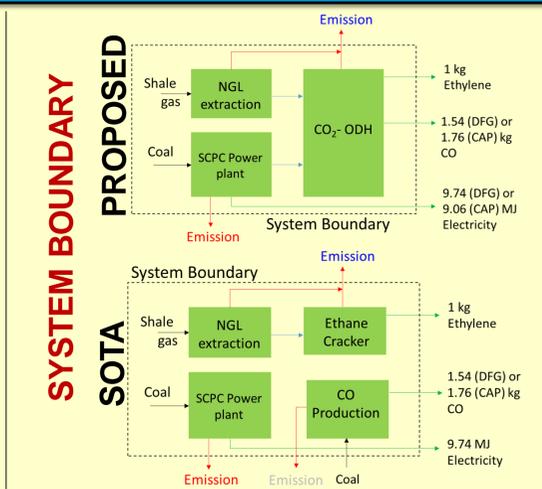
	DFG	CAP
C ₂ H ₆	10.2%	21.3%
CO ₂	12.0%	38.3%
C ₂ H ₄	5.1%	8.7%
CO	7.6%	14.8%
CH ₄	0.9%	2.6%
H ₂	2.7%	4.9%
H ₂ O	6.2%	8.5%
N ₂	Balance	Balance

TECHNO-ECONOMIC & LIFE CYCLE ANALYSIS (TEALCA)

TEA BASIS		
	DFG	CAP
Production capacity (Mt/year):		
Ethylene	499,991	500,000
CO	772,377	879,142
Product Purity		
Ethylene	99.8%	
CO	98%	
MW power	160	150



CAP production cost same as the lowest SOTA case
SOTA ref: Yang et al. 2017. I&ECR. 56(14), 4038-4051



Significant reduction in GWP [100yr] compared to SOTA cases

FUTURE WORK

- Host Site:** National Carbon Capture Center (NCCC), Wilsonville, AL
- ~100g catalyst scale up and testing
- Two (FG & CAP)** actual CO₂ streams (2000hrs of total testing)
- Update TEA/LCA and Gap analysis
- TEST THROUGHPUTS**

Test Case	Max. flow rate (L/min)				Ethane vol% in feed	Testing duration (hrs)
	Cap. CO ₂	Flue gas	C ₂ H ₆	Total Max.		
CAP	10	N/A	5	12	≥ 20%	1000
FG	N/A	12	1	12	≤ 10%	1000

Composition	
FG	14% CO ₂ , 4.5% O ₂ , N ₂ +Ar 68.5%, H ₂ O 13%, SO ₂ 2.5ppm, NO < 10ppm
CAP	> 99.5% CO ₂ , balance N ₂



- 52" x 76" skid enclosure (Class I, Division 2 and industrial code standards)
- Skid successfully transported to NCCC on February 25, 2020
- Continuous operation at field scale pending