



## INDUSTRIAL TECHNOLOGIES PROGRAM

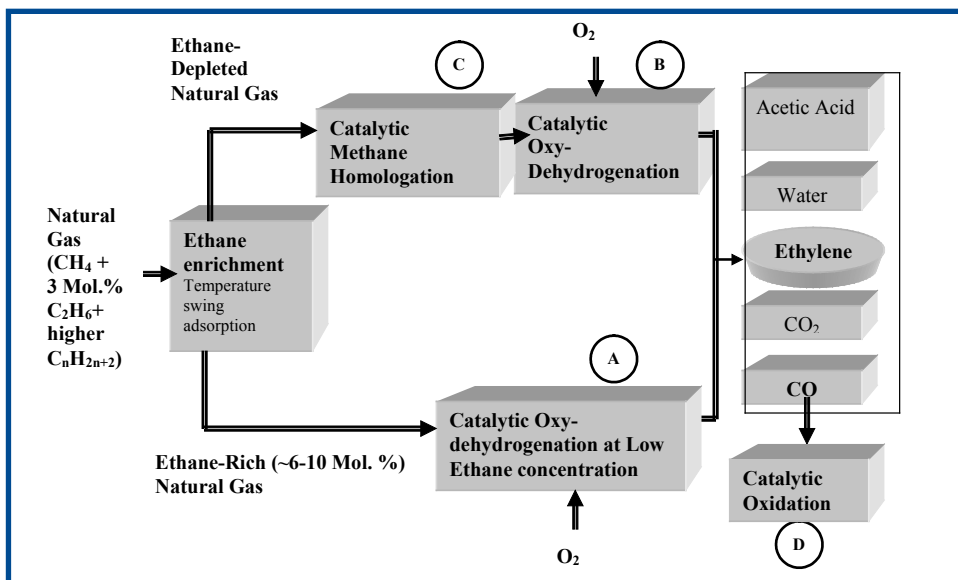
# From Natural Gas to Ethylene via Methane Homologation and Ethane Oxidative Dehydrogenation

## New catalysts promise higher selectivity, throughput, and economic competitiveness

Ethylene is an important building block in the production of many common and commercially important materials, such as plastics and chemicals. Currently, ethylene is produced in a highly energy-intensive two-step process. Ethane is first recovered from natural gas and refinery streams through catalytic cracking and hydrocracking processes, and then it is thermally cracked in the presence of steam to produce ethylene. A more efficient but not yet commercialized alternative to this method is catalytic oxydehydrogenation, which directly produces ethylene from crude ethane found in natural gas in a single step.

This technique has not yet been implemented because of high capital investment in existing equipment and techniques.

This project seeks to develop catalysts that will enable direct production of ethylene by the oxydehydrogenation of crude ethane found in natural gas. This exothermic process will offer high selectivity and throughput of ethylene from ethane-concentrated gas streams in addition to saving energy and reducing emissions. It will also lower capital costs through the use of crude ethane, which is cheaper than ethane purified through other processes.



Schematic of the catalytic oxydehydrogenation processes for ethylene production from natural gas. The research challenge is to discover catalysts A, B, C, and D that would possess desired characteristics to make the overall process economically competitive with existing processes.



## Benefits for Our Industry and Our Nation

As an alternative to thermal cracking, oxydehydrogenation will save more than 640 trillion British thermal units (Btu) per year while reducing emissions of many pollutants. New ethylene plants will save 50 percent in capital costs over plants installing cracking furnaces.

## Applications in Our Nation's Industry

Catalytic oxydehydrogenation will find immediate application in the petrochemicals industry, which uses ethylene as a primary feedstock for manufacturing plastics and chemicals. Downstream benefits will also be reflected in industries utilizing these products.

## Project Description

The overall objective of this project is to develop, synthesize, and test catalyst(s) that will enable higher selectivity and throughput of the direct production of ethylene from crude ethane.

## Barriers

- Verifying successful results of the molecular modeling design of the catalysts
- Ensuring that the catalysts meet selectivity and throughput requirements
- Validating the catalysts' stability over an extended period of time in commercial use

## Pathways

The objectives of this project will be achieved through (1) designing catalysts using knowledge of existing structures and with an integrated systems-level approach that considers how chemical process demands will affect catalyst performance; (2) synthesizing new potential catalysts using a state-of-the-art technique permitting micro-engineering of many sites on/beneath the surface; (3) identifying structural changes when the catalysts are exposed to chemical reaction with advanced in-situ characterization techniques; (4) evaluating overall performance of the catalysts with a rapid, automated screening technique; (5) making a final selection of appropriate catalyst(s).

## Progress and Milestones

- Year 1 – Synthesis and evaluation of baseline catalysts.
- Year 2 – Identification of new potential catalytic structures using molecular modeling methods.
- Year 3 – Synthesis of new catalysts based on molecular modeling results; picking the catalysts with the highest selectivity and throughput for optimizing design for scale-up.
- Year 4 – Testing of the scaled-up catalysts for long-term stability.

## For additional information, please contact:

Dickson Ozokwelu  
Industrial Technologies Program  
U.S. Department of Energy  
1000 Independence Ave., SW  
Washington, D.C. 20585  
Phone: (202) 586-8501  
Fax: (202) 586-9234  
dickson.ozokwelu@ee.doe.gov

## Project Partners

Oak Ridge National Laboratory  
Oak Ridge, TN  
(Vinod K. Sikka: sikkavk@ornl.gov)

C3 International  
Alpharetta, GA

Chemical Alliance Zone  
Charleston, WV

Dow Chemical Company  
Charleston, WV

Energy Industries of Ohio  
Cleveland, OH

Engelhard Corp.  
Cleveland, OH

Equistar  
Wilmington, MA

Kellogg Brown & Root, Inc.  
Houston, TX

MATRIC  
Charleston, WV

Rampant Technology Partners, LLC  
Charleston, WV

Texas A&M  
College Station, TX

## A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.



**U.S. Department of Energy**  
**Energy Efficiency**  
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Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

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