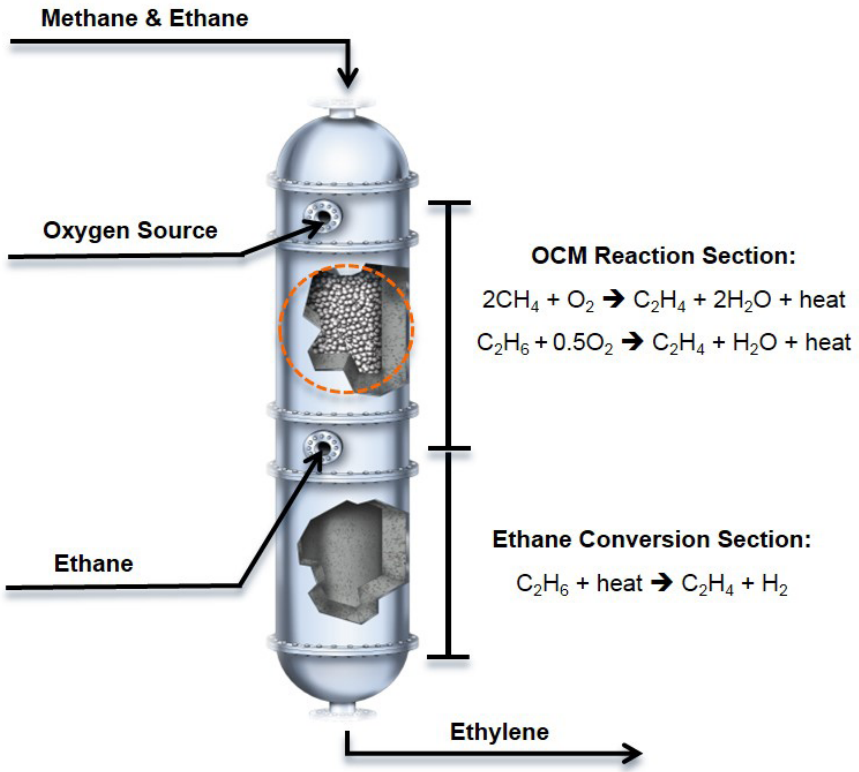
Low-Energy, Low-Cost Ethylene Production by Low-Temperature Oxidative Coupling of Methane

Enabling small scale high-value ethylene production at more favorable conditions using natural gas as feedstock.

Ethylene, one of the highest volume production chemicals in the U.S. and globally, is an essential chemical building block that is used to manufacture countless products, from packaging to antifreeze to tires. Most ethylene is produced via a process called steam cracking, where the feedstock (mostly ethane, sometimes naphtha or propane) is heated to high temperatures over a catalyst. The naphtha feedstock typically comes from petroleum refineries, while ethane is becoming increasingly used as a feedstock in the U.S. due to the rise in domestic natural gas production from shale resources. However, steam cracking is energy intensive and occurs in large-scale facilities.

Low-temperature oxidative coupling of methane (LT-OCM) is an alternative ethylene production method that converts methane (natural gas) and optionally ethane to ethylene in a single-step, energy-producing conversion system using an innovative process including a novel reactor and inorganic catalyst. While OCM has been studied for over 30 years due to its potential to reduce ethylene production cost, past efforts did not result in a viable catalyst with performance needed for commercialization. These catalysts, while at times achieving promising yield and selectivity, were hampered by very high operating temperatures, low activities, and short lifetimes on the order of hours to days.



Schematic illustrating Siluria's new low-temperature oxidative coupling of methane (LT-OCM) catalyst and reactor for distributed production of ethylene. This project aims to overcome poor scalability at smaller scale and enable economically attractive small scale ethylene production. *Image courtesy of Siluria Technologies Inc.*

Recognizing this, Siluria applied a combination of new innovations in catalyst development and a thorough definition and understanding of the problem to develop unique catalysts that will enable commercialization of OCM. The OCM catalysts operate at significantly lower temperature (several hundreds of degrees lower) and practical operating pressures (5-10 atmospheres), have high activities and standard lifetimes of years under said conditions. In addition, the simple reactor design provides excellent scalability and flexibility to the process, especially when compared to today's mega-scale steam crackers, thus enabling small-volume "distributed scale" reactors for on-demand ethylene production for applications such as on-site conversion of ethylene to high-value polymer derivatives.

Benefits for Our Industry and Our Nation

This technology will reduce cost, energy consumption, and emissions across the U.S. chemical industry. This innovative technology has many potential benefits, including:

- Improved ethylene manufacturing energy efficiency.
- Reduced lifecycle emissions of carbon dioxide and other pollutant emissions compared to traditional ethylene production methods.
- Tapping ubiquitous natural gas reserves as feedstock for production of high value petrochemicals, lowering the dependence on crude oil.

- Enabling economically competitive, distributed, small-scale production of ethylene for on-site generation of high-value derivatives such as polymers.

Applications in Our Nation's Industry

Ethylene is an important chemical that is produced upstream by a small number of large-scale facilities, consumed downstream by many producers, and converted into various products. This project will offer distributed, small-scale ethylene production solution for the downstream consumers, due to its unique combination of utilizing cheap feedstock (natural gas) and simple overall process design.

Project Description

The project objective is to develop a new catalytic process for distributed small-scale production of ethylene by oxidative coupling of methane at low temperatures using the advanced OCM catalyst developed by Siluria Technologies. The current design shows excellent scalability for regional-world scale ethylene capacities. However, the specific operating and capital costs increase sharply for lower capacities. The project aims to overcome the hurdles for small-scale implementation of ethylene production through oxidative coupling of methane.

Barriers to small-scale production

- Utilizing cryogenic separation systems that scale poorly at lower capacities.
- Certain unit operations in the current design require minimum capital expenditure and are cost efficient only at large scale.
- Changes to the process scheme to address the above issues necessitate a complete re-evaluation and optimization of the current large–scale OCM process scheme.

Pathways

The project will be completed over the course of three phases: detailed process analysis for scalability of the current OCM design to identify roadblocks for small-scale implementation; process design and development using alternative process concepts that overcome the bottlenecks identified in the first phase; and refined conceptual design and techno-economic analysis for the final optimized process model. The project team will use four well-defined tasks in order to accomplish the phases and reach the project objective; some of these tasks will be completed in parallel.

Milestones

This 18-month project began in October 2015.

- Develop target list of unit operations and/or process steps that constitute roadblocks to small-scale implementation (Completed)
- Identify alternative process concepts/ technologies that demonstrate potential to meet performance and cost targets at small-scale (Completed)
- Preliminary alternative process concepts/technologies, with preliminary experimental laboratory data for application in small-scale OCM process. (Completed)
- Refined alternative process concepts/ technologies, validated with refined experimental laboratory data suitable for application in small-scale OCM process (2016).
- One or more LT-OCM process concepts for small-scale ethylene production, validated with simulations and experimental laboratory data (2017).
- Techno-economic analysis of one or more process concepts for small-scale ethylene production with total feed and energy consumption lower than 20 MMBTU per ton ethylene and cost advantaged to merchant ethylene produced by cracking (2017).

Commercialization

Siluria has partnered with RTI International in their efforts to develop the new process concept/s for small-scale OCM implementation. The project is expected to provide all the data and analysis needed to justify design for the small-scale, distributed ethylene production via LT-OCM.

Project Partners

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DOE/EE-1417 • August 2016