JPUR
JOURNAL OF PURDUE UNDERGRADUATE RESEARCH

ENGINEERING

Catalyst-Assisted Transformation of Shale Gas to Transportation Fuels: Performance of a Single-Site Cobalt Catalyst in Dehydrogenation and Oligomerization Processes

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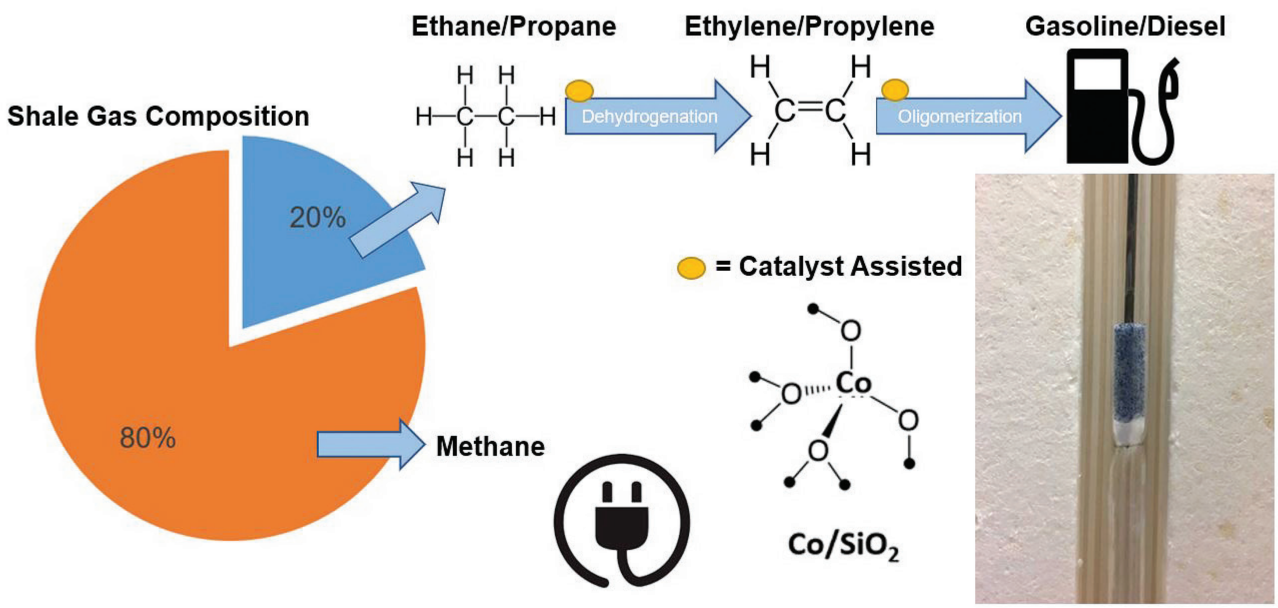
Shale gas is a form of natural gas that contains 20% ethane and propane and has become an increasingly vital source of energy as the methane component of shale gas is utilized for electricity generation. Currently, the United States' market is oversupplied with ethane and propane and, on average, exports over one million barrels of propane per day.

Alternatively, ethane and propane can be converted into more usable products, such as gasoline, through a two-step process. The first step, dehydrogenation, is a chemical process that removes hydrogen from an organic molecule such as ethane, subsequently creating ethylene. The second step, oligomerization, is the chemical process combining the products of dehydrogenation into longer chain products. These two processes are traditionally performed under different reaction temperatures and pressures with separate catalysts. In this research project, a single catalyst that can perform both reactions at comparable reaction conditions was developed.

A single-site cobalt catalyst (Co^{2+}/SiO_2) was synthesized using standard catalyst preparation methods and used in dehydrogenation and oligomerization. Propane dehydrogenation on Co^{2+}/SiO_2 showed the catalyst's ability to activate C-H bonds and had propylene selectivity above 98% at 6% conversion. Oligomerization was performed at temperatures above 400°C and at atmospheric pressure and resulted in conversions of 3%–6% with high selectivity to higher molecular weight hydrocarbons. High selectivity demonstrates success in that the products formed were desirable. High pressure (15–20 atm) should lead to higher conversions and the subsequent production of liquid fuels. The ultimate transformation of excess ethane and propane to liquid fuel products will allow shale gas to be compatible with the current United States transportation infrastructure, making it a viable alternative fuel.

Research advisor Jeff Miller writes: "With the ever-changing energy landscape, new technologies will be required to meet the increasing demand while also lowering the environmental impact. Ethan's research has led to exciting new opportunities for production of transportation fuels from U.S. shale resources, which could also reduce greenhouse gas emissions."

Edwards, E. (2019). Catalyst-assisted transformation of shale gas to transportation fuels: Performance of a single-site cobalt catalyst in dehydrogenation and oligomerization processes. *Journal of Purdue Undergraduate Research, 9,* 77. https://doi.org/10.5703/1288284316939



The process of transforming excess ethane and propane from shale gas is shown as a two-step process. Dehydrogenation processes ethane and propane into ethylene and propylene, which are further processed into transportation fuels in oligomerization. Both reactions are catalyzed by a Co^{2+}/SiO_2 catalyst.

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