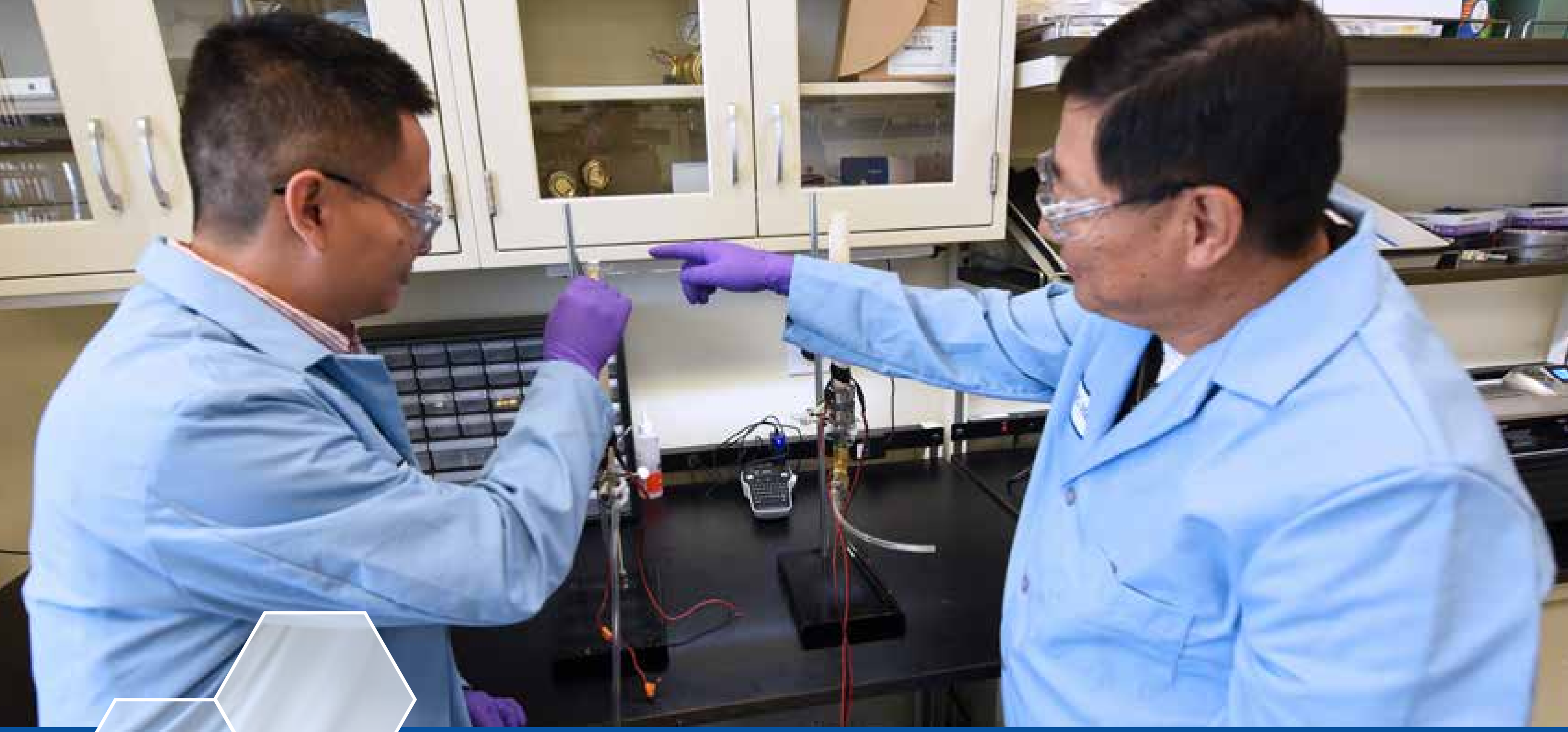


Electrochemical Activation of Small Alkanes

Manufacturing petrochemicals from domestic natural gas and natural gas liquids

Electrochemical processing of ethane, the major component of natural gas liquids, uses up to 65 percent less energy than the traditional process and captures hydrogen instead of burning it off.

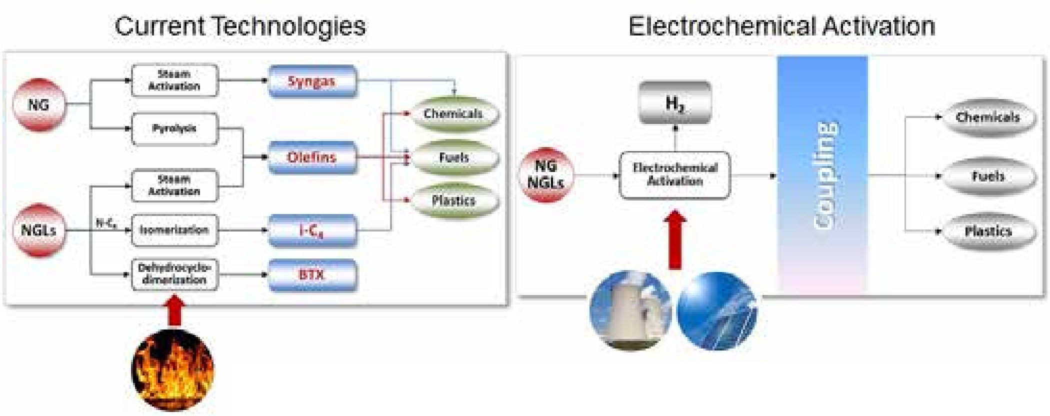
It's a long way from the bench to the refinery, but researchers at Idaho National Laboratory are investigating the possibility of manufacturing chemicals and fuels from plentiful shale gas using a process that, under the right circumstances, could produce more energy than it consumes.

Electrochemical processing of ethane, the major component of natural gas liquids, uses up to 65 percent less energy than the decades-old steam ethane cracker process and captures hydrogen instead of burning it off. Considering that the resulting product, ethylene, is a building-block chemical for everything from diapers to diesel fuel, this represents a potential opportunity for petrochemical companies to save massive amounts of money while cutting carbon emissions and producing valuable hydrogen that can be used, for instance, in fuel cell vehicles.

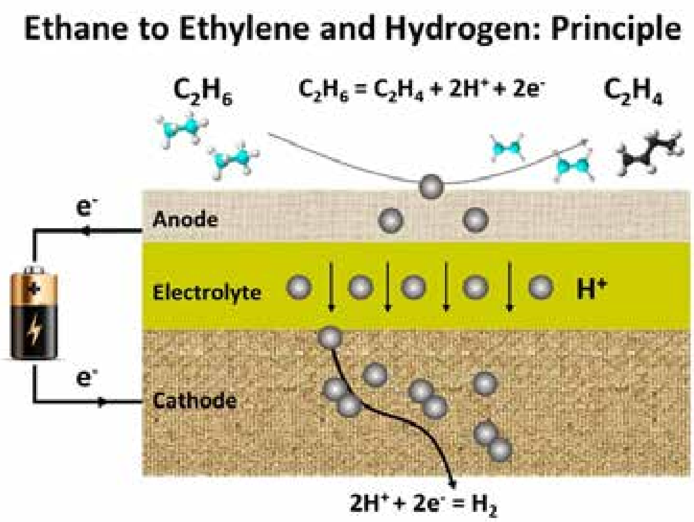
Since the early 20th century, the standard process for making everything from gasoline to chemicals to plastics has involved cracking complex hydrocarbon molecules found in oil and coal, using tremendous amounts of heat and energy. With the shale gas boom in the United States, however, plentiful quantities of affordable natural gas and natural gas liquids have opened new possibilities to the nation's petrochemical manufacturing. Ethane, a major component of natural gas liquids, offers a simpler hydrocarbon to refine and use as the basis for advanced manufacturing.

Compared to the energy required for an industrial steam cracker, the electrochemical technology developed at INL reduces process energy by as much as 65 percent, without taking into account the energy of the produced hydrogen. The electrochemical process also offers the advantage of a low carbon footprint, with CO2 emissions at only one-fourth of the industrial steam cracker process if fossil-based electricity is used and one-tenth if renewable electricity is used.

Idaho National Laboratory



Clean energy manufacturing aims to replace thermal processes with approaches that reduce both process energy input and carbon emissions.



CHEMISTRY OVERVIEW

Briefly, an alkane such as ethane is fed to the anode of an electrochemical membrane reactor where it is electrochemically deprotonated into an alkene and protons. The protons migrate through a fully dense proton-conducting electrolyte to the cathode, where they combine with electrons, forming hydrogen gas. The alkene produced on the anode can be further coupled into higher hydrocarbons, including gasoline, diesel, lubricants and wax, depending on what coupling catalyst is applied and at what point the chain growth reaction is terminated (Anderson-Schulz-Flory distribution).

The first demonstration of this electrochemical technology used ethane as the feedstock alkane molecule. At 400 C and ambient pressure, ethane could be deprotonated at very low overpotential (~130 mV) with an ethylene selectivity of close to 100 percent. The INL research team's next step was to incorporate an ethylene coupling (oligomerization) catalyst into the anode to produce liquid fuels.

NEXT STOP, METHANE

INL researchers propose to expand electrochemical processing technology to methane feedstock, a more abundant and clean hydrocarbon source, but a harder one to deprotonate than ethane. On the cathode side of the reactor system, the same hydrogen evolution catalyst can be used. Likewise, the proton-conducting membrane will remain unchanged. The challenge will be on the anode side, where a deprotonation catalyst must be found. Success could expand the value of natural gas beyond power generation, hydrogen production, and residential, commercial and industrial heating.

FOR MORE INFORMATION

Technical contact
Dong Ding
208-526-4226
dong.ding@inl.gov

General contact
Abby Todd
Communications Liaison
208-526-6166
abby.toddbloxham@inl.gov

www.inl.gov

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