Researchers find new, lower-cost way to separate valuable ethylene from ethane gas

September 23 2019

From soda bottles to polyester clothing, ethylene is part of many products we use every day. In part to meet demand, the Shell Oil Company is building an ethane cracker plant in Beaver County, Pa., specifically to produce ethylene molecules from the abundant ethane found in natural gas. However, the chemical reaction used to convert ethane into valuable ethylene is incomplete, so such plants produce an impure mixture of ethylene and ethane. Separating pure ethylene from ethane is a difficult and costly process, but one that new research from the University of Pittsburgh's Swanson School of Engineering is poised to streamline.

The technique investigated in two new papers, published in the *Journal of the American Chemical Association* and *Organometallics*, would avoid liquefaction and distillation by designing a material that only binds ethylene molecules, thus separating them from ethane.

Ethylene is an olefin—a molecule with an unsaturated bond (like unsaturated fats). Current methods of separating ethylene from ethane involve cooling the mixture to very low temperatures, liquefying it, and feeding it into a large distillation column, which is an energy-intensive and costly process. Developed by a team led by Professors Karl Johnson, Ph.D., and Götz Veser, Ph.D., from Chemical and Petroleum Engineering, and Professor Nathaniel Rosi, Ph.D., from the Department of Chemistry, this new process would potentially save a great deal of energy, reducing carbon emissions and costs at the same time.

The heart of this new separation method is isolated copper atoms that olefins like ethylene can bond to strongly. Since copper atoms naturally want to clump together, which destroys their ability to bond with olefins, the Pittsburgh researchers used metal-organic frameworks (MOFs) to effectively isolate single atoms of copper in the right location to produce high-grade ethylene at least 99.999 percent pure.

"The uniqueness of this material is that the isolated copper atoms are in the right oxidation state and the right geometry within the metal organic framework to provide very high selectivity—higher than other adsorption methods—and it can easily be scaled up," says Johnson, the W.K. Whiteford Professor in the Department of Chemical and Petroleum Engineering and Associate Director of the Center for Research Computing. "MOFs are a practical alternative to an inefficient and costly process."

"Designing Open Metal Sites in Metal-Organic Frameworks for Paraffin/Olefin Separations," was published in the Journal of theAmerican Chemical Society and was co-authored by Mona H. Mohamed, PhD, Austin Gamble Jarvi, Sunil Saxena, PhD, and Nathaniel Rosi, PhD, from Pitt's Chemistry Department; and Yahui Yang, Lin Li, PhD, Sen Zhang, Johnathan Ruffley, Götz Veser, PhD, Karl Johnson, PhD, from the Department of Chemical and Petroleum Engineering. Rosi holds a secondary appointment in the Chemical and Petroleum Engineering.

"Fundamental Insights into the Reactivity and Utilization of Open Metal Sites in Cu(I)-MFU-4/," was published in Organometallics and was co-authored by Lin Li, PhD, Yahui Yang, Mona H. Mohamed, PhD, Sen Zhang, Götz Veser, PhD, Nathaniel Rosi, PhD, and Karl Johnson, PhD.

More information: Mona H. Mohamed et al, Designing Open Metal Sites in Metal–Organic Frameworks for Paraffin/Olefin Separations,

Journal of the American Chemical Society (2019). DOI: 10.1021/jacs.9b06582

Lin Li et al. Fundamental Insights into the Reactivity and Utilization of Open Metal Sites in Cu(I)-MFU-4l, *Organometallics* (2019). DOI: 10.1021/acs.organomet.9b00351

Provided by University of Pittsburgh