

More economical way to produce cleaner, hotter natural gas

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Hani M. El-Kaderi, assistant professor in the VCU Department of Chemistry, and Mohammad G. Rabbani, Ph.D., a research scientist in El-Kaderi's lab who led the research efforts, hold flasks containing a new material to make the transport, storage and use of natural gas more efficient. Credit: Timur Islamoglu/VCU

New technology is offering the prospect of more economical production of a concentrated form of natural gas with many of the advantages — in terms of reduced shipping and storage costs — of the familiar frozen fruit juice concentrates, liquid laundry detergents and other household products that have been drained of their water, scientists reported today.

They told the 243rd National Meeting & Exposition of the American Chemical Society (ACS) that this "super [natural gas](#)" would burn hotter

than the familiar workhorse fuel and occupy about 40 percent less space in pipelines, railroad tank cars and storage chambers. But its potential benefits range beyond that — to making natural gas a better source of hydrogen for use in fuel-cell-powered cars in the much-discussed "hydrogen economy" of the future, according to Mohammad G. Rabbani, Ph.D., who reported on the study and is a research scientist in the team of Hani El-Kaderi, Ph.D.

"Natural gas has a reputation among the public as a clean-burning fuel, and that is true," said El-Kaderi. "Compared to coal and oil, burning natural gas releases small amounts of pollutants and less [carbon dioxide](#), the main greenhouse gas. People may not realize, however, that natural gas straight from the well often is contaminated with carbon dioxide and other undesirable gases, such as sulfur dioxide and nitrogen oxides, that are highly corrosive, increase its volume and decrease its heating value. Our new porous polymers, which have exceptionally high thermal and chemical stabilities, remove that carbon dioxide and do it better than any other solid, porous material."

Scientists are searching for such new solid materials to purify natural gas, and the quest has grown more intense as reserves of high-quality gas, lower in contaminants and higher in heating value, grow scarcer, and concerns about global warming due to carbon dioxide continue. The traditional process for purifying natural gas, performed for decades, uses liquids to capture and separate the carbon dioxide and other gases. The process, however, is far from ideal, and scientists are seeking solids and other materials that can more efficiently capture the carbon dioxide, and then can be purged of the gas more economically, recycled and reused time and again. "Our theoretical studies on variable mixtures of CO_2/CH_4 have actually indicated that these polymers would have high selectivities for CO_2 ," said Thomas E. Reich, Ph.D., who performed these theoretical investigations as a part of his doctoral research in the El-Kaderi group.

El-Kaderi's group developed purely organic polymers termed benzimidazole-linked polymers (BILPs) that are riddled with nano-engineered, minute, empty chamber-like pores so small that thousands would fit on the period at the end of this sentence. When exposed to streams of natural gas, the pores absorb and trap its carbon dioxide. When all of the pores are full of carbon dioxide, the BILPs can be run through a low-pressure processing unit to remove the carbon dioxide and prepare them for reuse.

Rabbani, who is in El-Kaderi's team at Virginia Commonwealth University in Richmond, noted that the new material is as effective at capturing carbon dioxide as monoethanolamine, the most common nitrogen-based liquid used for carbon dioxide scrubbing. Amine liquids have a disadvantage, however, in that they must be purged of carbon dioxide by heating, which requires more energy than the BILPs, which are regenerated under low-pressure conditions.

El-Kaderi said the BILPs seem well-suited for removing the traces of carbon dioxide that remain in hydrogen produced with existing technology. "Carbon dioxide can account for 20 percent of the finished product, the hydrogen, and if we consider a true hydrogen economy of the future, we should be removing that carbon dioxide. Our technology appears to be an excellent candidate."

More information:

Abstract

There has been considerable interest in the development of new technologies and materials that allow CO₂ removal from natural gas which is typically contaminated with over 40% CO₂ and N₂. The removal of CO₂ would increase the energy density of natural gas making its storage and transportation more efficient, and enhances its conversion to hydrogen fuel. Given the relatively small and similar kinetic diameter of CH₄ and CO₂ molecules, their efficient separation remains a

nontrivial task. The preparation of a library of benzimidazole-linked polymers (BILPs) featuring high surface area and amine functionalized pore walls will be presented and their performance in CO₂ removal from natural gas will be discussed. Our studies show that the efficiency of BILPs in CO₂ removal from CH₄ depends upon the pore metrics and surface chemical functionalization. High CO₂/CH₄ selectivity in the range of 8.0~17 makes BILPs attractive for future use in natural gas purification applications.

Ref: Rabbani, M. G.; El-Kaderi, H. M., "Template-Free Synthesis of a Highly Porous Benzimidazole-Linked Polymer for CO₂ Capture and H₂ Storage," *Chem. Mater.* 2011, 23, 1650-1653. Rabbani, M. G.; Reich, T. E.; Kassab, R. M.; Jackson, K. T.; El-Kaderi, H. M. "High CO₂ Uptake and Selectivity by Triptycene-Derived Benzimidazole-Linked Polymers," *Chem. Commun.* 2012, 48, 1411-1413.

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