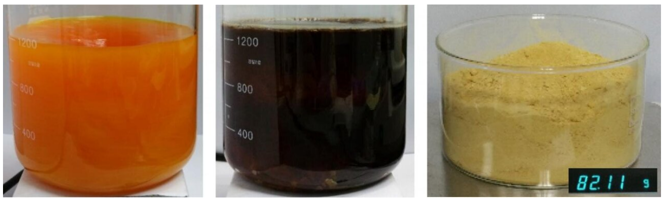
Natural gas storage research could combat global warming

7 August 2019, by Deana Totzke



Synthesis at small scale (82.11 grams of product). Note that the reaction is carried out in a beaker open to air. Credit: Vepa Rozyyev/Texas A&M University

To help combat global warming, a team led by Dr. Mert Atilhan from Texas A&M University and Dr. Cafer Yavuz at the Korea Advanced Institute of Science and Technology (KAIST), is working on a new porous polymer that can store natural gas more effectively than anything currently being used. Their research focuses on adsorbed natural gas (ANG), a process to store natural gas that is a safer and cheaper alternative to compressed natural gas and liquefied natural gas.

Natural gas burns more cleanly as a fuel, making it a useful alternative in vehicles, and applications such as cooking, heating or running generators. It contains mostly methane and ethane, and has almost zero sulfur dioxide emissions and far fewer nitrogen oxide and particulate emissions. Natural gas also releases almost 30 percent less carbon dioxide (the leading cause of greenhouse gases) than oil and 43 percent less than coal.

"Currently we are facing serious issues that are related to global warming due to the excessive use of coal and petroleum," said Atilhan. "Natural gas is a much cleaner source and there is an abundant amount of gas being explored in the United States, the Mediterranean Sea and elsewhere all around the world. If natural gas can be stored effectively, it can be utilized easily, even in remote areas. We have high aspirations to utilize these materials in vehicular applications as well, which is one of the main causes of global warming."

Adsorbed gases collect condensed gas from a surface. These light gases have very high vapor pressure at ambient temperatures, and their storage requires either high-pressure compression, adsorbent (solid substance that adsorbs another substance) systems or an extreme reduction of temperature. In the ANG process, natural gas adsorbs to a porous adsorbent at relatively low pressure (100 to 900 psi) and ambient temperature, solving both the high-pressure and low-temperature problems.

Atilhan and Yavuz have been collaborating since 2008 on the development of new materials for gas capture and separation. In the last few years they have been specifically looking more into storing natural gas in novel porous based materials. The team focused on swelling mechanisms of network polymers. The idea would be to pressurize natural gas on the sorbent so that it would expand and take a lot. During consumption (desorption), the swollen polymer would release the gas until it completely deflates.

"With this work, we are introducing a new plastic-based material that can store natural gas very effectively," said Atilhan. "We broke the world record for natural gas storage and passed well above the target for materials in order to be considered feasible, which is determined by U.S. Department of Energy (DOE). Yet it has a very cheap production cost, which makes it even more attractive to use it in widespread applications."

"We looked into designing an ANG adsorbent from a different perspective, most research is focused on raising the upper limit, the total capacity by introducing more pore volume," said Yavuz, adding that the more pore volume also meant more leftover gas since it remains comfortably stored even if the pressure went below the minimum tank pressure needed by a vehicle. "We said, 'Let's make sure the porous material squeezes all out when desorbed to the minimum pressure.'"

This expansion/contraction mechanism also solves certain ANG issues. As it turns out, all the adsorbents warm up when in contact with gas and that causes all kinds of problems, not to mention new safety risks.

Atilhan said by having the adsorbent release energy by expanding itself, they are solving many issues at once. By keeping the adsorbent unheated, they get the maximum performance. And since thermal management is an absolutely critical design feature in engineering fuel systems, they eliminate any unsafe pressure spikes that might come up because the temperature swings and contamination is minimized since the adsorbent remains contracted when no gas is stored.

To fast forward the feasibility checks on their technology, the team began working on real gas cylinders.

"Lab results were great but you always have this what-if question when it comes to pushing your technology out in real life," said Vepa Rozyyev, the first author of an article published in *Nature Energy* on the research, who has since moved from KAIST to the University of Chicago for a Ph.D. He said to test it they went to a gas station and stuck the pressurized nozzle onto a cylinder full of their adsorbent. Their material beat the top industrial and literature examples by at least 20 percent. It also marked the first time any study ever did this type of field testing.

The team is excited about the prospects and possibilities that this work will introduce. "This is just the beginning," said Yavuz. "We envision a whole host of new designs and mechanisms based on our concept. Since natural gas is much cleaner fuel than coal, new developments in this realm will help in switching to less polluting fuels."

Atilhan agrees the most important impact of their research is on the environment. He said lowering toxic gaseous emissions by using natural gas more than coal or oil will significantly reduce the greenhouse gas emissions that are emitted from various sources.

"It will also help to reduce the operating cost that is spent on acid/sour gas capture operations since we propose to store much cleaner fuel source and replace current state-of-the-art with these materials for fuel storage," he said. "We believe one day we might see vehicles equipped with our materials that are run by a cleaner fuel source—natural gas."

More information: Vepa Rozyyev et al. High-capacity methane storage in flexible alkane-linked porous aromatic network polymers, *Nature Energy* (2019). DOI: 10.1038/s41560-019-0427-x

Provided by Texas A&M University