Chasing the Dream of Half-Price Gasoline from Natural Gas

A startup called Siluria thinks itôs solved a mystery that has stymied huge oil companies for decades. By Kevin Bullis on January 15, 2014

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Why It Matters

The world depends almost exclusively on oil for chemicals and liquid fuels.

Quick screen: A technician at Siluria operates some of the companyôs equipment for quickly making and testing new catalysts.

At a pilot plant in Menlo Park, California, a technician pours white pellets into a steel tube and then taps it with a wrench to make sure they settle together. He closes the tube, and oxygen and methaneð the main ingredient of natural gasð flow in. Seconds later, water and ethylene, the worldôs largest commodity chemical, flow out. Another simple step converts the ethylene into gasoline.

The white pellets are a catalyst developed by the Silicon Valley startup Siluria, which has raised $63.5 million in venture capital. If the catalysts work as well in a large, commercial scale plant as they do in tests, Siluria says, the company could produce gasoline from natural gas at about half the cost of making it from crude oilð at least at todayôs cheap natural-gas prices.

If Siluria really can make cheap gasoline from natural gas it will have achieved something that has eluded the worldôs top chemists and oil and gas companies for decades. Indeed, finding an inexpensive and direct way to upgrade natural gas into more valuable and useful chemicals and fuels could finally mean a cheap replacement for petroleum.

Natural gas burns much more cleanly than oilð power plants that burn oil emit 50 percent more carbon dioxide than natural gas ones. It also is between two and six times more abundant than oil, and its price has fallen dramatically now that technologies like fracking and horizontal drilling have led to a surge of production from unconventional sources like the Marcellus Shale. While oil costs around $100 a barrel, natural gas sells in the U.S. for the equivalent of $20 a barrel.

But until now oil has maintained a crucial advantage: natural gas is much more difficult to convert into chemicals such as those used to make plastics. And it is relatively expensive to convert natural gas into liquid fuels such as gasoline. It cost Shell $19 billion to build a massive gas-to-liquids plant in Qatar, where natural gas is almost free. The South African energy and chemicals company Sasol is considering a gas-to-liquids plant in Louisiana that it says will cost between $11 billion and $14 billion. Altogether, such plants produce only about 400,000 barrels of liquid fuels and chemicals a day, which is less than half of 1 percent of the 90 million barrels of oil produced daily around the world.

The costs are so high largely because the process is complex and consumes a lot of energy. First high temperatures are required to break methane down into carbon monoxide and hydrogen, creating what is called syngas. The syngas is then subjected to catalytic reactions that turn it into a mixture of hydrocarbons that is costly to refine and separate into products.

Powerful pills: Two versions of catalysts developed by Siluria to convert natural gas into ethylene, which can be used to make gasoline and chemicals.

For years, chemists have been searching for catalysts that would simplify the process, skipping the syngas step and instead converting methane directly into a specific, desired chemical. Such a process wouldnôt require costly refining and separation steps, and it might consume less energy. But the chemistry is difficultð so much so that some of the worldôs top petroleum companies gave up on the idea in the 1980s.

Siluria thinks it can succeed where others have failed not because it understands the chemistry better, but because it has developed new tools for making and screening potential catalysts. Traditionally, chemists have developed catalysts by analyzing how they work and calculating what combination of elements might improve them. Siluriaôs basic philosophy is to try out a huge number of catalysts in the hope of getting lucky. The company built an automated systemð it looks like a mess of steel and plastic tubes, mass spectrometers, small stainless steel furnaces, and data cablesð that can quickly synthesize hundreds of different catalysts at a time and then test how well they convert methane into ethylene.

The system works by varying both what catalysts are made ofð the combinations and ratios of various elementsð and their microscopic structure. Siluria was founded based on the work of Angela Belcher, a professor of biological engineering at MIT who developed viruses that can assemble atoms of inorganic materials into precise shapes. Siluria uses this and other methods to form nanowires from the materials that make up its catalysts. Sometimes the shape of a nanowire changes the way the catalyst interacts with gases such as methaneð and this can transform a useless combination of elements into an effective one. ñHow you build up the structure of the catalyst matters as much as its composition,ò says Erik Scher, Siluriaôs vice president of research and development.

The process of making and testing catalysts isnôt completely randomð Siluria has the work of earlier chemists to guide it, and it has developed software that sorts out the most efficient way to screen a wide variety of possibilities. The result is that what used to take chemists a year Siluria can now do in a couple of days, Scher says. ñWeôve made and screened over 50,000 catalysts at last count,ò he says. ñAnd I havenôt been counting in a while.ò

Nonetheless, some seasoned chemists are skeptical that Siluria can succeed. Siluriaôs process is a version of one that chemists pursued in the 1970s and 1980s known as oxidative coupling, which involves reacting methane with oxygen. The problem with this approach is that itôs hard to get the reaction to stop at ethylene and not keep going to make carbon dioxide and water. ñThe reaction conditions you need to convert methane to ethylene do at least as good a job, if not better, of converting ethylene into carbon dioxide, which is useless,ò says Jay Labinger, a chemist at the Beckman Institute at Caltech.

In the late 1980s, Labinger wrote a paper that warned researchers not to waste their time working on the process. And history seems to have borne him out. The process ñhasnôt been, and doesnôt appear at all likely to beò an economically viable one, he says.

Yet in spite of the challenging chemistry, Siluria says the performance of its catalysts at its pilot plant have justified building two larger demonstration plantsð one across San Francisco Bay in Hayward, California, that will make gasoline, and one in Houston that will only make ethylene. The plants are designed to prove to investors that the technology can work at a commercial scale, and that the process can be plugged into existing refineries and chemical plants, keeping down capital costs. The company hopes to open its first commercial plants within four years.

Siluria canôt tell you exactly how itôs solved the problem that stymied chemists for decadesð if indeed it has. Because of the nature of its throw-everything-at-the-wall approach, it doesnôt know precisely how its new catalyst works. All it knows is that the process appears to work.

The hope for finding more valuable uses for natural gasð and making natural gas a large-scale alternative to oilð doesnôt rest on Siluria alone. The abundance of cheap natural gas has fueled a number of startups with other approaches. Given the challenges that such efforts have faced, thereôs good reason to be skeptical that they will succeed, says David Victor, director of the Laboratory on International Law and Regulation at the University of California at San Diego. But should some of them break through, he says, ñthat would be seismic.ò