PETROCHEMICALS

Polyester made from coal? China is betting on it

New ways of producing the polymer's ethylene glycol feedstock are taking off in the coal-rich country

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Credit: Jiutai Group

Jiutai Group is building a huge coal-based ethylene glycol plant in Inner Mongolia.

Clothing and drinking bottles made from coal? In China, that's more and more the case. Widely viewed in much of the world as dirty, planet warming, and on its way to obsolescence, coal is on the ascent in China's chemical industry, where it is increasingly a raw material for making polyester fiber and resin.

China's chemical industry is at a chronic cost disadvantage compared with other countries' because of a lack of domestic crude oil and natural gas. But China has a lot of coal. The only country to do so on such a scale, China produces millions of metric tons of polyvinyl chloride, polyolefins, and liquid fuels every year using coal as a raw material.

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Until recently, polyester wasn't on the list of materials made from coal, but this is changing rapidly. Relatively new processes that use coal to obtain ethylene glycol—a raw material for making polyester fiber and packaging resin—have gained traction in China.

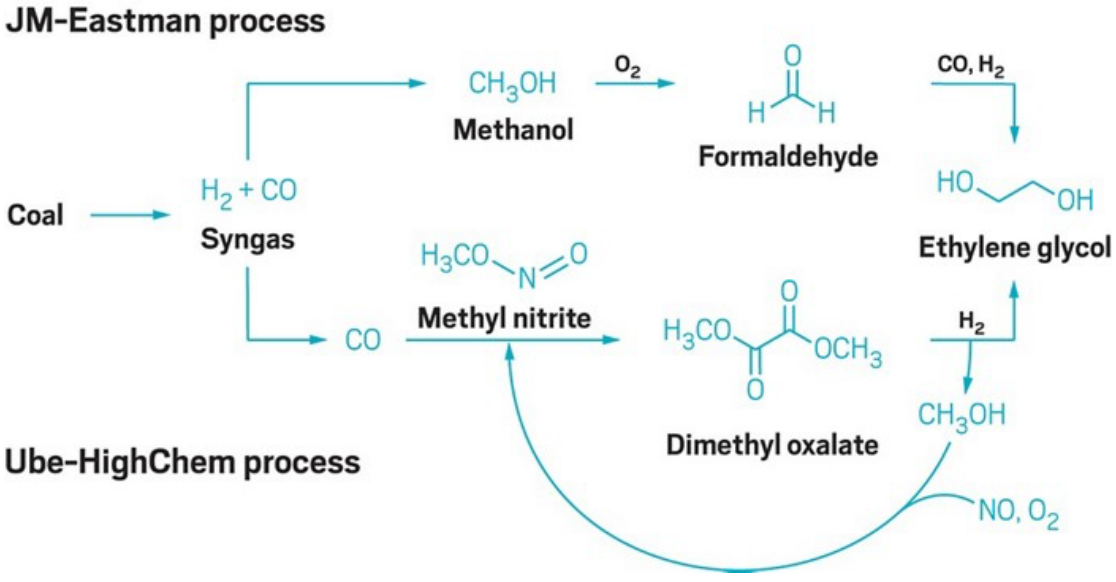
And the pace of adoption of coal for making ethylene glycol may accelerate if a new technology takes hold. In Inner Mongolia, a Chinese company is building a huge facility using a new process that, its backers say, makes ethylene glycol at a lower cost and with improved plant safety.

Every year, China imports about one-quarter of the world's ethylene glycol output of 31 million metric tons (t), says Atul Shah, licensing development director at Johnson Matthey (JM), which codeveloped the new process with Eastman Chemical. "China imports a lot of ethylene glycol, and the government wants to reduce this."

Most of the world's ethylene glycol is produced from ethylene, a basic chemical that is typically made by cracking oil or natural gas in a petrochemical plant.

But the pace at which coal-based production is being implemented in China is spectacular. From nothing in 2011, China now has 3.5 million t of coal-based ethylene glycol capacity, says Cao Mengting, a polyester consultant at CCFGroup, which is focused on the Chinese fiber industry. By 2022, this capacity will have doubled, she expects. Today, coal-based facilities represent about 40% of China's ethylene glycol production capacity and 14% of actual output, according to Michael Zhao, another CCFGroup consultant. In five years, he expects coal-based facilities will account for 20% of the country's output, while production capacity will be half of the country's total.

The basic technology for producing ethylene glycol from coal has been around for decades. In the 1970s, Japan's Ube Industries developed a process that harnesses synthesis gas (syngas), often made from coal, to produce ethylene glycol through a multiple-step reaction involving the consumption and regeneration of methyl nitrite.



The process didn't catch on at the time, but about 10 years ago it resurfaced in China. HighChem, a Japanese chemical producer and process licensor focused on matching Japanese capabilities with Chinese needs, worked with East China Engineering Science and Technology, an engineering firm, to update the Ube process. The effort came to fruition in 2012 when China's Xinjiang Tianye opened a 50,000 t plant using the Ube process.

Concurrently, the Shanghai-based company Pujing Chemical Industry tweaked the methyl nitrite process and began to license a competing version of it. According to CCFGroup's Cao, the processes sold by HighChem and Pujing differ mainly in the catalysts they use. "The catalyst is key," she says.

The two variants have proved attractive to Chinese coal producers, Cao says. "Coal chemistry is very profitable." The coal-made ethylene glycol is also attractive to cost-conscious polyester producers, she adds, because it usually sells at a discount to traditionally made ethylene glycol owing to lower purity and inconsistent availability.

The process has some shortcomings, Cao says. The technology is complex, and plants are plagued by unscheduled shutdowns. One reason for outages, she says, is that some producers source their syngas from external suppliers, an often insecure arrangement.

But a key challenge in the Ube process, according to JM's Shah, is its reliance on the intermediate material methyl nitrite, a hazardous gas. According to IHS Markit, an industry consultant, methyl nitrite is reacted with carbon monoxide over a catalyst to yield a mixture of dimethyl oxalate and nitric oxide. The dimethyl oxalate is in turn converted into ethylene glycol, and the methyl nitrite is regenerated.

To reduce the risks associated with methyl nitrite, producers using the Ube process tend to build relatively small plants, Shah says—sometimes several in one location. In contrast, the huge Inner Mongolia facility, being built by China's Jiutai Group, will consist of only two production lines.

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> — ***Atul Shah,*** *licensing development director, Johnson Matthey*

Although it starts with coal and ends with ethylene glycol, the process to be used on those lines takes a completely different route. It processes syngas into methanol and then into formaldehyde using a commercially proven JM technology. Then, using the process developed by JM and Eastman, formaldehyde is reacted with carbon monoxide, hydrogenated, and refined to yield ethylene glycol and the coproduct diethylene glycol.

Eastman and JM worked for about a decade on the formaldehyde-to-glycol process and tested it at a mini plant in the UK, Shah says. Jiutai's plant will mark its first commercial implementation. Jiutai is deploying it on a massive scale, building an ethylene glycol plant with a capacity of 1 million t that will be fed by a 1.5 million t formaldehyde plant.

Wang Zongzhen, chairman of Inner Mongolia Jiutai New Material, the Jiutai subsidiary that is building the plant, insists his firm did its homework before selecting the commercially unproven Eastman-JM process. Negotiations with JM went on for over four years, and several Jiutai employees, including Wang, went to the UK, some more than once.

He and his colleagues grew confident about the technology after reviewing test results, inspecting the demonstration plant, and testing the ethylene glycol it produced. "No one is better than Johnson Matthey at catalysts," he adds.

Economically, Wang says, the project is a solid one. Its output can easily be sold to polyester plants in eastern China, he says. Demand in eastern China is very strong, and the ethylene glycol will be of higher quality than the product made by the Ube method, he says. Moreover, in recent years, he says, producers of diethylene glycol have enjoyed good margins in China. Currently under construction, the plant is scheduled to open in late 2021.

Wang expects that the plant will produce ethylene glycol more cheaply than both the Ube and traditional petrochemical routes. And by relying on Air Products and Chemicals for syngas, Jiutai is reducing its outlay for the huge facility. The US firm is spending $650 million to build a syngas plant at the Jiutai site that will use low-grade coal.

When it comes to discussing chemicals from coal, the elephant in the room is the large amount of CO_2 emitted in the production process. China is by a wide margin the world's largest source of CO_2, with annual emissions nearly twice as high as those from the US, the world's second-largest source.

Asked about the problem, Jiutai's Wang is unperturbed. Soon, he expects, China will launch a national scheme to control the country's carbon emissions. "The more you emit, the more you will be taxed," he predicts.

In a November 2018 update of its climate change policy, China's Ministry of Ecology and Environment noted that in recent years the country has tested emission-trading schemes in several cities. The ministry stated that the Chinese government is currently drafting a national climate change law that will address CO_2 emissions at the national level.

JM's Shah similarly says that CO_2 emissions associated with the new process aren't a major issue. "Oil-based ethylene glycol also has CO_2 emissions," he says. "I suspect the difference is not that big taking into consideration the CO_2 emissions associated with shipping oil into China."

In fact, Shah expects that other countries will likely start producing ethylene glycol from coal in the future. Some of the prime candidates, he says, are India and Indonesia. "If you don't want to build a cracker but want ethylene glycol, you can consider our technology," he says.

By Shah's reckoning, the Eastman-JM process is competitive against the petrochemical route whenever the price of oil is above $50 per barrel. With oil at about $55 per barrel these days, the process is very competitive, he says.

Environmentalists perhaps won't be heartened, but it looks like the polyester in shirts and dresses sewn in China will increasingly be made from coal.

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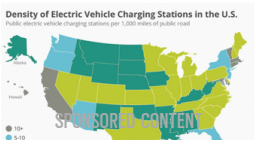

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