ADVERTISEMENT FEATURE

A final link in the global hydrogen supply chain

After almost 20 years in the making, CHIYODA CORPORATION'S LOW-COST HYDROGEN TRANSPORT TECHNOLOGY is now a reality, with the successful demonstration of shipment from Brunei to Japan — a big step towards realizing a hydrogen-energy society

A dehydrogenation plant in Kawasaki city, Japan.

An image of a chemical tanker conveying methylcyclohexane (MCH).

A hydrogenation plant in Brunei that produces methylcyclohexane (MCH).

"The societal rewards were too great for us not to invest in our promising methylcyclohexane (MCH) technology, although daily setbacks in the beginning really tested our resolve," says Yoshimi Okada, principal researcher of hydrogen technologies at Chiyoda Corporation. The investment paid off with the result that Chiyoda's MCH catalyst is now a commercially viable means of safely storing and transporting hydrogen.

"SPERA OVERCOMES MANY OF THE INTRINSIC DRAWBACKS OF LIQUEFYING HYDROGEN"

Hydrogen is abundant, renewable, packs a high energy density, and produces only water vapour when burnt. On paper, it is the ideal fuel source, but in practice there have been significant technical challenges to overcome, from its primary production to its storage, transport, delivery and use.

Some of these challenges have already been addressed — we now have efficient hydrogen fuel cells capable of powering vehicles, the first large-scale hydrogen power plants are starting to appear, and hydrogen production from solar and wind power is well advanced.

But the entire concept of hydrogen as a fuel hinges on its economics: it has to be producible and transportable as part of a global supply chain at prices comparable to those of petroleum. This is the grand challenge of hydrogen, and one that the Japanese engineering company Chiyoda Corporation has tackled head on.

THE HEADACHE POSED BY HYDROGEN TRANSPORT

"Back in the 1990s, the hydrogen development sector was really at a standstill on transport," explains Okada. "The three transport candidates, liquefied hydrogen, liquefied ammonia and a promising chemical method based on MCH, were not viable at that time — ammonia is highly toxic, while it wasn't known whether the catalyst needed for the MCH method could ever be developed."

Ten years later, in 2002, the Japanese government recognized that fuel-cell development was going well, but that large-scale hydrogen-transportation technology needed more time for development.

"MCH really stood out to us a way to solve the hydrogen-transport problem, and that's when Chiyoda pivoted towards developing an MCH catalyst," says Okada.

FROM PARTNER TO TECHNOLOGY LEADER

Chiyoda has been an engineering and construction partner to the oil and gas industry for more than 70 years, yet in the early 2000s it began looking for opportunities to diversify by developing its own technology.

Researchers at Chiyoda experimented with finer and finer platinum particles. "At around 1 nanometre — approaching just a few MCH molecules in size — we achieved a jump in catalytic activity performance," says Okada. "That changed everything and opened a new era in catalyst chemistry."

In 2011, Chiyoda started mass producing their nanoscale MCH dehydrogenation catalyst and demonstrated the technology in a pilot plant in 2014. Named SPERA after the Latin for 'hope', Chiyoda's MCH technology was inching closer to commercial reality. All that remained was to demonstrate an end-to-end international supply chain.

LIKE PETROLEUM, BUT HYDROGEN

SPERA overcomes many of the intrinsic drawbacks of liquefying hydrogen, which involves compressing or chilling hydrogen gas to cryogenic temperatures — an expensive, energy-intensive process. Instead, the SPERA process involves fixing hydrogen gas to the common petroleum product toluene at ambient temperature. It produces MCH as a stable liquid, which can be transported in large volumes using conventional petroleum tankers. At the destination, the MCH can be stored in standard tanks for long periods, and when needed, the hydrogen is efficiently separated from the toluene using Chiyoda's dehydrogenation catalyst. The toluene is recovered for reuse and shipped back to the hydrogenation plant, and the hydrogen is delivered for use at the destination.

"Liquefied hydrogen needs new technologies that will reduce energy loss due to the physical liquefaction process and transport, whereas the energy loss for SPERA is much less at just 35%," says Okada. "This has given us a great start on the way to achieving the US$3 per kilogram price target by 2030, set by the Japanese government. And, unlike with liquefied hydrogen, we see many ways we can further reduce cost and energy in our chemical process over time on the way to a US$2 price target by 2050."

ON THE PATH TO COMMERCIALIZATION

"In April 2020, Chiyoda, in collaboration with Mitsubishi Corporation, Mitsui & Co., Ltd. and NYK Line, demonstrated the world's first end-to-end global hydrogen supply chain, successfully transporting MCH produced in Brunei Darussalam to a refinery in Kawasaki, Japan," says Osamu Ikeda, head of hydrogen supply chain development at Chiyoda. "These collaborators are part of our Advanced Hydrogen Energy chain Association for technology Development (AHEAD) covering the entire supply chain, including production, maritime transport and logistics, storage and dehydrogenation."

Supported by Japan's New Energy and Industrial Technology Development Organization (NEDO), Chiyoda is now rapidly expanding the local market and conducting feasibility studies on new business models and markets using the SPERA technology.

"It's time to start building the global framework to support international hydrogen trading and safety, and we're looking for partners and collaborators to develop the global supply chain and be part of the hydrogen-energy future," Ikeda says. "The low energy losses and the ability to make use of existing infrastructure make SPERA a highly promising route to achieve this goal." ■

CHIYODA CORPORATION

SPERA HYDROGEN

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