Introduction of Liquid Organic Hydrogen Carrier and the Global Hydrogen Supply Chain Project

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Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD)
I. Chiyoda’s Hydrogen Technology & Projects

II. The Global H2 Supply Chain Project
I. Chiyoda’s Hydrogen Technology & Projects
Hydrogen Storage & Transportation Technology

• Chiyoda has established an efficient and large scale hydrogen storage and transportation system.
• Methylcyclohexane (MCH), Liquid Organic Hydrogen Carrier (LOHC), stays in liquid state under ambient temperature and pressure anywhere.

Key Technology is New Catalyst of Dehydrogenation.
## LOHC Technology

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
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<tr>
<td>Long term storage &amp; long distance transport</td>
<td>Chemically stable&lt;br&gt;Very minor loss by long term storage &amp; long distance transport</td>
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<td>Easy to handle</td>
<td>Liquid under ambient temperature &amp; pressure</td>
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<td>Use of existing oil infrastructure</td>
<td>Conventional Oil &amp; Chemicals Infrastructure can be&lt;br&gt;Used for storage &amp; transportation.</td>
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<td>Reduced risk of H2 storage &amp; transport</td>
<td>Hydrogen gas is converted to chemical liquid.</td>
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<td>Combination of Proven technologies</td>
<td>Combination of conventional equipment except for new catalyst for dehydrogenation.</td>
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LOHC Technology - lab test

- Catalyst developed by Chiyoda
- Life longer than 1 year was confirmed by lab test – longer life possible

Feed: Methylcyclohexane (purity: 99.85%)

Catalyst: S-Pt/Al₂O₃
Temp.: 345→351°C
Press.: 0.3MPa
LHSV: 2.0h⁻¹

Catalyst performance
MCH Conversion: >95%
Toluene Selectivity: >99.9%
H₂ Yield: >95%
H₂ generation rate: >1,000 Nm³-H₂/h/m³-cat. (1,000 Ncc-H₂/h/cc-cat.)
Catalyst life: >8,000 (1year)
LOHC Technology - demo plant

- After lab tests, another 10,000hr of demo plant operation was successfully completed.
- Expected performance was confirmed.

\[ H_2 \]

50Nm³/h

Dehydrogenation

Hydrogenation

TOL

MCH

Process Plant

Storage Tank

TOL

MCH

TOL

TOL

MCH

TOL

Tank
Chiyoda and its partners established the Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD), and started the world’s first global hydrogen supply chain demonstration project toward 2020.

1. Global Hydrogen Supply Chain Demonstration
2. Power to X Technology

Demonstration project to produce hydrogen by variable renewable energy, funded by the New Energy and Industrial Technology Development Organization (NEDO)

- Variable output of wind power (simulated)
- Rectifier
- Electro-lyser
- Purification
- HGN*: hydrogenation
- DeHGN**: Dehydrogenation
- MCH***: Methylcyclohexane
- TOL****: Toluene

New demo plant

New laboratory test

Electro-lyser

Location: Chiyoda Koyasu Office & Research Park (Yokohama - city)
3. Hydrogen Fueling Station Technology

Develop compact-type dehydrogenation facility (downsizing and automatic operation) in order to fit for FCV fuel stations, funded by NEDO.

Dehydrogenation facility downsized

Location: Chiyoda Koyasu Office and Research Park (Yokohama - city)
II. Global H2 Supply Chain Project
PROJECT OVERVIEW

**Brunei**

- LNG Plant (BLNG)
  - Processed Gas
  - LUMUT

- Hydrogenation Plant
  - SPARK Industrial Park

- ISO Container Land Transport
  - Container Yard

- MCH
  - TOL

- Container Yard
  - MUARA

**Japan**

- Power Generation (Kawasaki)
  - Hydrogen Gas
  - KAWASAKI

- De-Hydrogenation Plant
  - ISO Container Land Transport
  - Container Yard

- TOL
  - MCH

- Container Yard
  - KAWASAKI

MCH: Methyl cyclohexane, TOL: Toluene

[Plant Scale] 300 Nm³/h – H₂ (Plant Capacity)
[Transport] ISO Tank Container (5 Containers / week)
1. Brunei

1) GEOGRAPHICAL LOCATION

- Hydrogen production / hydrogenation plant will be located at SPARK, and hydrogen will be transported on land using ISO tank containers (in form of MCH) to Muara Port for shipping.
1. Brunei

2) HYDROGENATION PLANT (IMAGE)

Hydrogenation plant will consist of Hydrogenation unit, H2 production unit, utility & offsite facilities, administration/control building and ISO tanks area.
1. Brunei

3) GROUND BREAKING CEREMONY

- Ground breaking ceremony was held on April 21, 2018, and the guest of honor was Deputy Minister of Ministry of Energy and Industry, together with 150 other guests.
1. Brunei

4) CONSTRUCTION WORK (as of July 2018)

- Construction started in April 2018, and foundation/building work is ongoing.
2. Kawasaki

1) GEOGRAPHICAL LOCATION

The site of dehydrogenation will be located at Keihin Industrial Zone in Kawasaki, and ISO tank containers from Brunei Darussalam will arrive at Kawasaki Port.
Dehydrogenation Plant will be located inside TOA OIL's Keihin Refinery, and extracted hydrogen gas will be transported to existing power generation by pipeline.

[ Cooperation with TOA OIL ]
- Land in TOA OIL’s refinery
- Utility supply to Dehydrogenation plant
- Operation of Dehydrogenation plant

TOA OIL (Zone - F)
- Dehydrogenation plant
- MCH / TOL storage tank
- Loading/unloading facility

EXISTING POWER PLANT
- Output 79,300 kW
- Fuel Refinery gas
- Type Gas Turbine
2. Kawasaki

3) DEHYDROGENATION PLANT (IMAGE)

• Dehydrogenation plant will consist of Process unit, MCH/TOL storage tanks, administration/control building and loading/unloading facility.
Construction will begin from October 2018, and Hydrogen Supply Chain will operate between Brunei and Japan in 2020.

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<tr>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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<tr>
<td></td>
<td></td>
<td>Engineering &amp; Procurement</td>
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<td>Site Prep</td>
<td>Construction</td>
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<td>Opening Ceremony (Dec)</td>
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<td>Tokyo Olympic (Jul-Aug)</td>
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- **AHEAD Establishment (Jul)**
- **Construction Comm.**
- **Grand Breaking in Kawasaki city (Oct)**
Thank you!