Prospect of Synthetic Liquified Gas

- DME and LPG -

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23rd World Gas Conference
Jun. 5-9, 2006
SYNTHESIS PROCESS FOR METHANOL AND DME

Indirect process

\[ \text{Syngas (C0+H}_2\text{)} \xrightarrow{1} \text{Methanol (CH}_3\text{OH)} \xrightarrow{2} \text{DME + H}_2\text{O (CH}_3\text{OCH}_3\text{+H}_2\text{O)} } 

Direct process

\[ \text{Syngas (C0+H}_2\text{)} \leftrightarrow \text{Methanol (CH}_3\text{OH)} \xrightarrow{} \text{DME + CO}_2 \text{ (CH}_3\text{OCH}_3\text{+CO}_2\text{)} } 

PHYSICAL PROPERTY OF DME

<table>
<thead>
<tr>
<th></th>
<th>DME</th>
<th>CH\text{\textsubscript{4}}</th>
<th>C\text{\textsubscript{3}}H\text{\textsubscript{8}}</th>
<th>CH\text{\textsubscript{3}}OH</th>
<th>Diesel (FT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point (\textdegree C)</td>
<td>-25.1</td>
<td>-161.5</td>
<td>-42.0</td>
<td>64.4</td>
<td>180-370</td>
</tr>
<tr>
<td>Density (g/cm\textsuperscript{3}, 20\textdegree C)</td>
<td>0.67</td>
<td>-</td>
<td>0.49</td>
<td>0.79</td>
<td>0.84 (0.78)</td>
</tr>
<tr>
<td>Vapor pressure (atm, 25 \textdegree C)</td>
<td>6.1</td>
<td>246</td>
<td>9.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cetane number</td>
<td>&lt;65</td>
<td>0</td>
<td>(5)</td>
<td>5</td>
<td>40-60 (70)</td>
</tr>
<tr>
<td>Heating value (kcal/kg)</td>
<td>6,900</td>
<td>12,000</td>
<td>11,100</td>
<td>5,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>
FUEL DME PRODUCTION

Direct process (JFE)
- 5t/d pilot plant at Kushiro (1999-2002) JAPAN
- 100t/d demonstration plant at Kushiro (2003-) JAPAN

Indirect (methanol) process
- Jiutai Chemical Corp., 100,000 ty (2005-) CHINA
- Mitsubishi Gas Chemical, 100,000 t/y (2007-) JAPAN
- Toyo Engineering Corp., 100,000 t/y (2005-) CHINA
- Toyo Engineering Corp., 210,000 t/y (2007-) CHINA
DME UTILIZATION

- Multi-resources
- Syngas (H2, CO)
- DME

Home fuel
- LPG substitute
- FC fuel

Transportation fuel
- Diesel fuel
- FC vehicle
- Hydrogen source

Power generation fuel
- Gas turbine
- Diesel co-generation

Chemical use
- Olefin production
- Methanol chemicals

LPG production
- Japan Gas Syn.
Three Roots for LPG Synthesis

- **Semi-direct method**
  - MeOH
  - DME
  - \( \text{+H}_2 \)

- **Direct method**
- **Indirect method**
  - MeOH
  - Olefin
  - \( \text{H}_2 \)
Schematic Diagram of LPG Synthesis Plant

- CO₂
- Natural Gas
- Gas Processing Unit
- Syngas Unit
- Synthesis Unit
- Fractionating Unit
- Newly Developing Section
- (CO, H₂)
- CO₂+CH₄
- C₂
- C₆⁺
- H₂O
- Propane/Butane
CONCEPT OF DME AS ENERGY

1. DME is a synthetic fuel
2. DME can be manufactured from many resources
3. DME is a clean fuel
4. DME can be used for multi way
5. DME is no toxic and gas-liquid
6. DME is an energy-media even superior to electricity
ENERGY CIF PRICE TRENDS (1996 January ~ 2003 February)

上記数値は、為替変動の影響を避けるために、円ドルレート\$100/$で換算した。

CALCULATED DME PRICE (CIF JAPAN)

DME 1.4-1.9 \$/Mcal

-9-
Image of DME Distribution

Same infrastructure as LPG

Over seas plant

Ocean tanker

Import base

Second base

Home shop

Industry

出所：「DME検討会」報告書
DME Truck (8 ton)
High Power

CLEAN OFF GAS
# DME FUEL CELL SYSTEM

<table>
<thead>
<tr>
<th>Feul</th>
<th>DME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>5kW</td>
</tr>
<tr>
<td>Hydrogen occurrence ability</td>
<td>4Nm³/hr</td>
</tr>
<tr>
<td>Reforming Cata.</td>
<td>CuZn/Solid acid</td>
</tr>
<tr>
<td>Reforming Temp.</td>
<td>350°C</td>
</tr>
<tr>
<td>Constitution</td>
<td>Reformer, CO Remover, Water evaporation device, Combustion burner</td>
</tr>
</tbody>
</table>
REMODELING OF EXISTING APPARATUS

Development of DME retro-fit diesel engine for co-generation system
  Period : 2001-2003 (2 years)
  Partners : Yanmar Diesel, Iwatani, AIST
  Fund : JNOC’s fund (approx. 1.6m$)

Verification of DME fuelling to existing boilers on retrofit basis
  Period : 2001-2003 (2 years)
  Partners : MHI
  Fund : JNOC’s fund (approx. 1.6m$)
## DTO Process

<table>
<thead>
<tr>
<th>Product (C-wt%)</th>
<th>DME feed Ethylene max %</th>
<th>DME feed Propylene max %</th>
<th>Naphtha feed (Commercial)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene</td>
<td>48</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>Propylene</td>
<td>31</td>
<td>50</td>
<td>17</td>
</tr>
<tr>
<td>Butenes</td>
<td>9</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td>(\text{C}_2^=)/(\text{C}_3^=)</td>
<td>1.5</td>
<td>0.1</td>
<td>1.8</td>
</tr>
</tbody>
</table>

### WORLD PROPYLEN PRODUCTION

- Ethylene cracker: 30.6%
- FCC: 15%
- Others: 68.4%
Organization of JDF

Chairman (1)
Vice chairmen (3)
Board of Executive Directors (17) (Incl. Chairman & Vice chairmen)
Managing Committee (8)

Members
Planning Committee
- Administration Group (4)
- Codes/Standards Group

Technical Committee
- Manufacture Group (59)
- Utilization Group (58)

109 Members
Each member will join in the above one, two or three groups.
(The number of the member in each groups was updated on Dec.6, 2002)
JDF’S THREE STUDY GROUPS

1. Utilization Group
   Power generation /system including gas turbine
   Household/industry fuel, DME diesel related technologies
   Emission tests from diesel engine
   Marketing study, Road test of DME vehicle

2. Production Group (Manufacturing Group)
   Production technologies, 100t/d demo-plant construction
   Economic and LCA analysis of DME production by multiple processes
   Ocean transportation, etc

3. Codes & Standard Group (Legislative Group)
   Studies for standardization of DME fuel in Japan
JDF’S CONCEPT ON INTERNATIONAL TREND

1. In east Asian countries DME will be introduced quickly as home fuel.
2. Diesel DME will be introduced soon
3. Technologies and infrastructures are not sufficient.
4. JDF will co-operate with other countries.
SOCIAL SUBJECTS

1. Present regulation is not suitable for the introduction of DME
2. Social consensus is not sufficient.
3. Financial support should be made for its introduction.
4. Application of special Tax such as “Environmental Tax” is expected.
SUMMARY

1. A variety of new technologies has been developed which utilize DME as the new generation clean fuel and chemicals.

2. A large DME production plants are ready to be constructed for starting in 2006. Lower CIF price than gas oil can be expected.

3. Establishments of supply system is expected easy by utilizing existing system (LDG diesel)

4. DME will contribute to promote the energy security in many countries.