Gasoline Blendstock/Ethylene from Methane - The Synfuels Process Today

Presented by

Edward Peterson, PhD, P.E.,
Chief Engineer, Synfuels International
Gas-To-Liquids (GTL)
A New Source of Fuel

- Over 75% of the world’s known gas reserves are remote and/or stranded
- Could yield 1.5 billion barrels of fuel per year
- Over 4 million barrels per day
Incentives to pursue an economical GTL process

- Rising energy prices
- New source of fuel
- Government restrictions on flaring and emissions
- Environmental concerns
- Laws for cleaner fuels
- A country’s desire to monetize its resources
Fischer-Tropsch based GTL Limitations

“In fact, most, if not all, GTL plants to date would not have been built if it were not for governmental subsidies or political restrictions or influences.”

- Mega-scale plants planned and under construction
  - Need huge plants to create the necessary economy of scale
  - Enormous capital cost is primary concern

- Over 15,000 gas fields outside North America
  - Less than 200 can support mega-scale plants

“Smaller fields need smaller plants that require much less capital.”
Innovative new approach – Not an F-T modification

Achieves better returns than mega-plants at a fraction of their capacity and capital requirements

Thousands of gas fields capable of utilizing a Synfuels GTL plant
FT Risks

Major Projects

- Pearl - 120M B/D (2010)
- Escravos - 120M B/D (2009)

- In many cases, costs have more than *tripled* for planned projects.
FT Risks

• Many Players/Many patents
  ➢ Since 1976 the following companies collectively have been granted 151 patents granted related to Fischer-Tropsch Technology. The chance of one of these being accused of infringing upon another’s protected art is substantial.

<table>
<thead>
<tr>
<th>Company</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>Chevron</td>
<td>36</td>
</tr>
<tr>
<td>Shell</td>
<td>29</td>
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<tr>
<td>Exxon</td>
<td>17</td>
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<tr>
<td>ExxonMobil</td>
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<td>Sasol</td>
<td>13</td>
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<td>ConocoPhillips</td>
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<tr>
<td>Mobil</td>
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<td>Rentech</td>
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<td>Syntroleum</td>
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<td>ChevronPhillips</td>
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<td>Conoco</td>
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SYNFUELS INTERNATIONAL GTL TECHNOLOGY

Conversion

Absorption

Hydrogenation

Oligomerization

Natural Gas

Oxygen

Solvent

H₂

CO

CO₂

H₂

CO

CO₂

H₂

C₂H₂

CO

C₂H₂

C₂H₄

Conversion Absorption Hydrogenation Oligomerization
SYNFUELS INTERNATIONAL GTL TECHNOLOGY

Conversion | Absorption | Hydrogenation | Oligomerization

Natural Gas | Oxygen

Solvent

H2, C2H2, CO, CO2

H2, CO, CO2

H2, CO, CO2

Syngas

Gasoline
Gas-Phase Hydrogenation Problems

- Must limit acetylene concentration for reaction and temperature control
- Requires processing large volumes of gas
- High temperature can lead to a “run-away” reaction
- Tends toward over-conversion to ethane
Synfuels Process using
Liquid-Phase Hydrogenation of Acetylene

- Selectively absorbs acetylene
- Rejects unwanted gases
- Greatly reduces reaction volume
- Operates at moderate conditions
- No thermal “run-away” reaction
- Much higher acetylene concentrations can be used
SYNFUELS INTERNATIONAL GTL TECHNOLOGY

Conversion  Absorption  Hydrogenation  Oligomerization

Natural Gas  Oxygen  Solvent  Syngas

Conversion:
- H2
- C2H2
- CO
- CO2

Absorption:
- Solvent
- H2
- CO
- CO2

Hydrogenation:
- Syngas
- H2
- CO
- CO2

Oligomerization:
- Gasoline
- C2H4

Conversion to Syngas to Gasoline through Hydrogenation and Oligomerization processes.
• Synfuels Product Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>0.7599 (Water=1)</td>
</tr>
<tr>
<td>API Gravity</td>
<td>54.71 @ 60 F</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>100.422</td>
</tr>
<tr>
<td>Weight</td>
<td>6.33 Lbs/Gal</td>
</tr>
<tr>
<td>Gross Heating Value</td>
<td>124190 BTU/CF</td>
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</table>

• Synfuels Product Composition

<table>
<thead>
<tr>
<th>Component</th>
<th>vol%</th>
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<tbody>
<tr>
<td>Paraffins</td>
<td>12</td>
</tr>
<tr>
<td>Iso-paraffins</td>
<td>35.9</td>
</tr>
<tr>
<td>Olefins</td>
<td>1</td>
</tr>
<tr>
<td>Naphthenes</td>
<td>9.8</td>
</tr>
<tr>
<td>Aromatics</td>
<td>38.5</td>
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</tbody>
</table>
World Market Vehicle Trends

### Intellectual Property

Synfuels Technology is covered by 8 US Patents and dozens of patents pending:

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,130,260</td>
<td>Method for converting natural gas to liquid hydrocarbons</td>
</tr>
<tr>
<td>6,323,247</td>
<td>Method for converting natural gas to liquid hydrocarbons</td>
</tr>
<tr>
<td>6,602,920</td>
<td>Method for converting natural gas to liquid hydrocarbons</td>
</tr>
<tr>
<td>7,045,670</td>
<td>Process For Liquid Phase Hydrogenation</td>
</tr>
<tr>
<td>7,119,240</td>
<td>Method for converting natural gas to olefins</td>
</tr>
<tr>
<td>7183451</td>
<td>Process For The Conversion Of Natural Gas To Hydrocarbon Liquids</td>
</tr>
<tr>
<td>7208647</td>
<td>Process For The Conversion Of Natural Gas To Reactive Gaseous Products Comprising Ethylene</td>
</tr>
<tr>
<td>7,250,449</td>
<td>High temperature hydrocarbon cracking</td>
</tr>
</tbody>
</table>
Typical Hydrogenation Conversion and Selectivity Lab Data

- Conversion
- Ethylene (mol%)
- Ethylene selectivity

Time on Stream (Hours)
Extended Duration Conversion and Selectivity – Lab Data

![Graph showing time on stream (HR) vs. conversion and selectivity percentages for different gases.](image-url)

- Methane: 0.18
- Ethane: 0.42
- Ethylene: 97.42
- Acetylene: 0.52
- Butene: 1.35
- Heavy: 0.11
Demonstration Unit
Pilot Plant Data

Hydrogenation

SELECTIVITY TO ETHYLENE

Date
Percent

Summary

- New Synfuels GTL Process dramatically reduces capital cost
- Now majority of stranded gas fields can be utilized
- Unique new technology that blends established industrial practices with patent protected innovation
- Key to the Synfuels process are the innovative steps that isolate and convert intermediates, reducing recycle, compression, and system volumes
- Synfuels liquid-phase hydrogenation is the technology’s cornerstone
- Liquid-phase hydrogenation may be applicable to other hydrogenation processes outside GTL
The Synfuels Team

- **Synfuels International, Inc.**
  - Ben Weber, CEO
  - Tom Rolfe, President
  - Charles Matar, Managing Director
  - Ed Peterson, Chief Engineer

- **Bryan Research and Engineering**
  - Jerry Bullin, President
  - Joel Cantrell, Operations Manager

- **Texas A&M University**
  - Kenneth Hall