Fuels and Chemicals from Biomass and Waste

Esben Taarning, Haldor Topsøe A/S
Haldor Topsøe A/S

Headquarter (Lyngby)

Turnover 2008: ~5 mia kr
Catalyst volume: 40,000 tons

2000 employees
- 1700 in Denmark
  - 300 in R&D
- 300 abroad

Catalyst prod. in Fr.sund
Catalyst prod. in Houston, Tx
Technology to Fuel, Feed and Clean the Planet

- **Hydrotreating**
  \[
  C_{12}H_8S + 2H_2 \rightarrow C_{12}H_{10} + H_2S
  \]

- **Ammonia**
  \[
  N_2 + 3H_2 \rightarrow 2NH_3
  \]

- **Sulphuric acid**
  \[
  S + 1\frac{1}{2}O_2 + H_2O \rightarrow H_2SO_4
  \]

- **Hydrogen plants**
  \[
  CH_4 + H_2O \rightarrow CO + 3H_2
  \]

- **Emission control**
  - Power sector
  - Diesel truck producers
  \[
  4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O
  \]
Conversion Options for Biomass

- Bio-oil
- Thermochemical treatment
- Catalytic conversion
- Fermentation
- Chemicals
- Syn-fuels
- Gasification
- Fertilizers
- Syn-fuels
- Ethanol
- Chemicals
Gasification

- Biomass
- 30-70 bar

Combustion

- Syn-gas
- CO
- CO₂
- H₂

Products:
- Methanol
- Dimethyl ether
- Gasoline
- Diesel
- SNG

Temperature: 1500°C

Pressures: ~1 atm > 25 atm
Dimethyl ether from Black Liquor

Black liquor → Gasification → Gas Cleaning

O₂, H₂O → DME

DME: CH₃-O-CH₃

- Power generation
- Diesel vehicles
- Fuel cell
- Domestic gas
- Chemical feedstock

DME Volvo’s preferred alternative
Waste Processing and Biorefinery Integration

- Waste / Biomass
- Metals / Glass / Plastic

Gasification

O₂

Coal

Gas Cleaning

Gas Turbine

Steam Turbine

Max.

Min.

Off-gas

Steam

Gasoline Synthesis

Light Ends

Gasoline

Water

Power

Heat
Energy Input for the Production of Chemicals

- Fossil feedstocks
- Renewable feedstocks
- Ethanol platform
  - Ethyl acetate
  - Ethylene
  - Acetic acid

Ethanol platform

Energy input

Acetic acid

Syn-gas

Diesel

Gasoline

Fossil feedstocks

Renewable feedstocks
Energy Efficiency: Ethylene and Acetic acid

Energy input

Steam cracking

2.9 Gcal/ton

Cheap natural gas conversion

4.75 Gcal/ton

Energy input

Oxidation

1.5 Gcal/ton

Dehydration

1.5 Gcal/ton

Ethanol

Fossil
Economic Evaluation: Ethylene and Acetic acid

Ethanol to ethylene

- Ethanol: 1000 kg, 278 $
- Ethylene: 610 kg, 356 $

Ethanol to acetic acid

- Ethanol: 1000 kg, 278 $
- Acetic acid: 1300 kg, 585 $

HALDOR TOPSOE
Oxidation of Ethanol to Acetic Acid

- CO₂ + H₂O

Tunable parameters
- Temperature
- Pressure
- Catalyst
- Feed composition
- Oxygen amount
Conclusion

- The production of chemicals is in some cases the best use of our limited bio-resources.

- Conversion of waste to energy will become an important aspect of future resource management.

- New business opportunities will emerge as the renewable chemical industry becomes established.
Thank you for your attention!

Everything is possible