Dewatering and Deoiling Technology

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1 Wet & oily materials are mixed with liquefied DME at room temperature.
2 H₂O & oil are extracted by DME. Dried (dewatered & deoiled) materials are separated from H₂O-Oil-DME mixture.
3 Step by step, DME is evaporated. Supersaturated H₂O is phase-separated, and is pulled out from the bottom.
4 All DME is evaporated, from Oil-DME mixture, then oil is obtained.
5 DME gas is liquefied by compression or cooling, and is reused.
Outline of DME Dewatering & Deoiling Process

Theoretical dewatering energy for the compressor is 1109 kJ/kg-H$_2$O.

Deoiling energy is smaller than the above value.

H$_2$O saturated concentration in DME is 7-8 wt.%. Oil is mixed perfectly with DME.
DME circulation is energy efficient.

Waste heat utilization ➔ Energy-saving!

Heat exchanger

Cold Source 15°C

Earth thermal (<100m)

Liquefied DME

Extractor

Wet & oily materials

30°C, 0.7MPa

Dry materials

No compressor is needed.

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Design & production of the World's 1st prototype

Extractor 0.88MPa, 30°C
Condenser 0.62MPa, 23°C
Distilling equipment
Compressor 0.56MPa, 27°C
Storage tanks 0.65MPa, 30°C
Liquid DME sending pump

Compressor 100L/ hr
Condenser φ 15mm
Storage tanks 150L
Extractor φ 150mm L 550mm
Liquid DME sending pump <400L/ hr
Distilling equipment 100L

Heat exchanger

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Wet and/or oily materials

Lignite, Sub-bituminous coal
High-efficiency power generation

Biomass (especially, Biosolid / Microalgae)
Carbon-neutral & High-efficiency power generation

Oil / PCB / Dioxin polluted sediment
Environmental cleanup
Lignite, Sub-bituminous coal (2007)

- Bituminous coal
- Sub-bituminous coal
- Lignite

The World 8474 (hundred million ton)

- Russia 1570
- China 1145
- India 565
- Indonesia 43
- Australia 766
- Canada 66
- USA 2427

- Africa 16
- South Africa 480
- Europe 781
- South America 93
- Colombia 70
- Africa 89%
- Europe 30%
- Russia 1570
- China 1145
- India 565
- Indonesia 43
- Australia 766
- USA 2427
- Canada 66
- South America 93
- Colombia 70

Reference:
Japan coal energy center (2009)
Coal dewatering: Results

Indonesian sub-bituminous coal

- Water content: 40.6 wt.%
- Coal: 2.53 kg
- DME: 100L, 1hr
- Water content: 1.1 wt.%

Energy consumption of the prototype
- 2069 kJ/kg-H$_2$O

In general, the bigger the DME compressor, the smaller is the power consumed by it.

- DME compressor: 3 ton/hr
  - 1620 kJ/kg-H$_2$O

Theoretical energy (1109 kJ/kg-H$_2$O)

Adiabatic temperature increasing by air oxidation.

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Biosolids Disposal in Japan

Biosolids cannot be discharged from wastewater treatment plants. Japanese people particularly despise offensive odor.

Incineration is the favored method.

Available volume of sludge

High-pressure centrifugation for dewatering up to 78%
Deodorization and Dewatering of Biosolids

<table>
<thead>
<tr>
<th>Odorous components of biosolids</th>
<th>Original biosolids</th>
<th>Deodorized biosolids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor index</td>
<td>51</td>
<td>20</td>
</tr>
<tr>
<td>Hydrogen sulphide</td>
<td>0.26 &lt; 0.003</td>
<td></td>
</tr>
<tr>
<td>Methyl mercaptan</td>
<td>2.60 0.01</td>
<td></td>
</tr>
<tr>
<td>Methyl sulphide</td>
<td>0.280 0.010</td>
<td></td>
</tr>
<tr>
<td>Methyl disulphide</td>
<td>14.000 &lt; 0.003</td>
<td></td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>0.88 0.29</td>
<td></td>
</tr>
<tr>
<td>Methyl isobutyl ketone</td>
<td>5.9 &lt; 0.1</td>
<td></td>
</tr>
<tr>
<td>n-Butyric acid</td>
<td>0.0067 &lt; 0.005</td>
<td></td>
</tr>
</tbody>
</table>

Biosolids can be used as carbon-neutral fuel from the perspective of energy balance.
Microalgae – A new resource for biofuel

- The fossil fuel has caused environmental issues and will be exhausted by the near future.

- The biofuel produced from terrestrial crops caused increasing in world food price and food crisis.

- Microalgae have high CO₂ absorption capacity, high oil content, and high growth rate.

- Mass microalgae cultivation can be performed on unexploited land, therefore, avoiding competition for agricultural lands.
Research on microalgae biofuel

Overall process:

- Species selection
- Microalgae cultivation
- Recovery of green crude oil (energy intensive)
- Biofuel refining

Recovery of green crude oil:

- Physical method
- Chemical method (thermochemical pyrolysis)

We propose a new recovery method.
Problems of conventional solvent extraction

- **Hot drying** of microalgae by sun light etc.
- **Cell disruption**
- **Extraction using** toxic organic solvent Chloroform-methanol.
- **Reuse**
- **Cooling**
- **Evaporation by heating**

**Water content > 90%** by centrifugation

For example: Bligh-Dyer’s method by using chloroform-methanol
Liquefied DME extraction (without drying, cell disruption, and solvent heating)

No drying of microalgae
Energy-saving!

No cell disruption
Energy-saving!

Extraction using liquefied DME
Eco-friendly!

Water content > 90% by centrifugation

Evaporation of DME at room temperature
Energy-saving!

Reuse!

Reuse!

Reuse!

Liquefied DME

Green crude oil

Evaporation of DME

DME vapor

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Microcystis slurry. Water content is higher than 90%. 

Extraction column
Colorless glass beads (Diameter is 1mm)

DME extraction apparatus

Liquefied DME 100cm³

Filter 0.65μm

Flow speed valve 10cm³min⁻¹

Extraction column 10cm³

DME & Water & Green crude Mixture

N₂

DME & Water & Green crude Mixture

Microcystis slurry. Water content is higher than 90%.
DME extraction apparatus

DME & Water & Green crude Mixture

Liquefied DME 100 cm³

DME

Flow speed valve 10 cm³ min⁻¹

Filter 0.65 μm

Extraction column 10 cm³

Extraction column

N₂

Liquefied DME (colorless) running from bottom to top

Glass beads

Green

Microcystis

DME

Colorless

Liquefied DME 100 cm³

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DME extraction apparatus

DME was evaporated at room temperature.

Extraction column

Liquefied DME (colorless) running from bottom to top

Green crude

Water

DME gas

Flow speed valve 10 cm³ min⁻¹

Extraction column

Filter 0.65 μm

N₂

Liquefied DME 100 cm³

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Results

DME extraction

Green crude oil!

Main genus: *Microcystis*
Sampling: Hirosawa mere, Kyoto

Energy-saving and simpler method

From high-moisture microalgae
Without drying, cell disruption, solvent heating

HHV: 45.8 MJ/kg (Gasoline ≈ 43.5 MJ/kg)

GC–MS analysis

C₁₆H₃₂O₂
C₂₄H₃₈O₄

Lipid
DME Dewatering & Deoiling Technology

- Deodorization of biosolid
- Cleanup of heavy oil-polluted ground
- Cleanup of PCB-polluted sediment
- Microalgae fuel production
Publication List


Kazuyuki Oshita, Masaki Takaoka, Yusuke Nakajima, Shinsuke Morisawa, Hideki Kanda, Hisao Makino, and Nobuo Takeda, “Characteristics of Biosolids in Dimethyl Ether Dewatering Method”, Water Environment Research, in press (Manuscript Accepted for Publication 2011/Aug/11)