Yara – Global Player with Sales to >150 Countries
Yara – Business Unit Nitrates

• Established Applications
  • Nutriox: Waste water / sewage treatment system for odour and corrosion control
  • NitCal: Additive for cement / concrete
  • DipCal: Coagulant for latex
  • …

• New Developments
  • Conventional energy sector
  • Renewables:
    o Biogas: Improvement of the fermentation process, higher methane yield, …
    o Concentrated Solar Power
  • …
Yara BPO Concept
Optimization of the Anaerobic Digestion Process

Application of Nitrate-solution to enhance biogas yield and to reduce H$_2$S
Yara BPO Concept Mechanism

- Redox-Potential shifted
  - Small-scale
  - More energy-efficient conversion of organic compounds by bacteria

- Nutrient availability (theory)
  If feasible energy sources are available, various bacteria are able to metabolize certain nutrients more completely or at all.
  Genetic analyses and enzyme tests in prep.

FISH / Epi-fluorescence-technology:
Genetic method to verify different metabolic pathways by bacteria

Source: FORSTER, D., ETTL, M., FRANKE, W. & STOECK, T. (in prep.)
Yara BPO Concept
R&D Activities and Outlook

• Continued lab tests
  • Fraunhofer UMSICHT (DE, Oberhausen)
    - Batch test corn / cattle manure: +2.6 - 6.3% CH₄
    - Batch test food waste: +10.2% CH₄, -31.3% H₂S
    - Continuous tests: no negative impact
  • Fraunhofer UMSICHT (DE, Sulzbach)
    - Positive effect on thermal pressure hydrolysis
  • Kaiserslautern University (DE): Genetic verification of changed bacterial metabolism
    - 30% growth of methanogenic bacterium *Methanoculleus* sp.
    - Shift of total bacteria community towards methanogenic species
    - Verification via enzyme activity tests in prep.

• Additional applications
  • Digestate: Odour control application
  • Landfill sites: Field test
  • Digester (WWTP):
    - Successful pilot test (FiW Aachen, DE)
    - Field tests started (DE, PT); positive interim results
Yara BPO Concept
Results

Biogas plants running with agricultural substrate
• 2.5 - 5.0% more biogas
• 1.5 - 2.0% higher methane-concentration
• around 20% lower H₂S-concentration
• 6.5 - 10% less substrate demand (in cases of limited CHP capacity)
• enhanced buffer of plant operation - especially when changing the substrate
  ⇒ stabilization of the fermenter reactions

Calculation example (I): 700 kW_{el}
2.8% more biogas

<table>
<thead>
<tr>
<th>Additional income</th>
<th>40.500 € / a</th>
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</thead>
<tbody>
<tr>
<td>Product costs</td>
<td>13.800 € / a</td>
</tr>
<tr>
<td>Profit</td>
<td>26.700 € / a</td>
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</tbody>
</table>

Calculation example (II): 500 kW_{el}
8% less substrate and digestate

<table>
<thead>
<tr>
<th>Saving on substrate</th>
<th>25.000 € / a</th>
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</thead>
<tbody>
<tr>
<td>Saving on digestate</td>
<td>2.000 € / a</td>
</tr>
<tr>
<td>Product costs</td>
<td>8.000 € / a</td>
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<tr>
<td>Profit</td>
<td>19.000 € / a</td>
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</table>
Thermal Pressure Hydrolysis (TPH®)
Basics

1. Step
Splitting of Macro molecules

- Carbohydrates
- Fats
- Proteins

2. Step
Fermentation of decomposition products

- Saccharide
- Fatty acids
- Amino acids
- Bases

- Carboxylic acids
- Gases
- Alcohols

3. Step
Generation of Methanogenic substrates

- Acetic acid
- Hydrogen
- Carbon dioxide

4. Step
Generation of biogas

- Methane
- Carbon dioxide

Hydrolysis = process limitation step for anaerobic fermentation
Thermal Pressure Hydrolysis (TPH®)
Advantages

Conventional fermentation
- All process steps in digester
- AD residence time 25 - 40 days

TPH & fermentation
- TPH = Thermal pressure hydrolysis
- $T = 200^\circ C$, $p = 20$ bar, $RT > 30$ min
- AD residence time about 15 days
- Smaller reactors possible
- Sterilization guaranteed
- Higher grades of anaerobic degradation
- Safe prion inactivation
Thermal Pressure Hydrolysis (TPH®)
Impact of TDH® Pre-Treatment (examples)

Wheat Bran: without TPH®

with TPH®

Digestate: without TPH®

with TPH®
Thermal Pressure Hydrolysis (TPH®) Pre-Treatment of Biogenic Residues

Brewers Grain (without TPH) 500
Brewers Grain (with TPH) 715
Wheat Bran (without TPH) 490
Wheat Bran (with TPH) 691
Rye Bran (without TPH) 500
Rye Bran (with TPH) 596
Digestate (without TPH) 225
Digestate (with TPH) 499

NI / kg oDM

Günter Doppelbauer / Sara Ekström 10.09.2015
Thermal Pressure Hydrolysis (TPH®) in Combination with Yara BPO (smale scale test)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Biogas Yield (NI/kg oDM)</th>
<th>Methane Yield (NI/kg oDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biowaste</td>
<td>477</td>
<td>323</td>
</tr>
<tr>
<td>Biowaste + BPO</td>
<td>534</td>
<td>378</td>
</tr>
<tr>
<td>Biowaste + TPH</td>
<td>546</td>
<td>378</td>
</tr>
<tr>
<td>Biowaste + BPO &amp; TPH</td>
<td>564</td>
<td>393</td>
</tr>
<tr>
<td>Biowaste + BPO &amp; TPH + BPO</td>
<td>650</td>
<td>443</td>
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</tbody>
</table>
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