Future Directions for AD

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International Workshop: Renewable Energy Biogas Technologies,
Hydrolysis

Carbohydrates → Sugars
Proteins → Amino acids
Lipids → Long-chain fatty acids

Acidogenic fermentation
Volatile fatty acids others than acetic acid
Acetogenic oxidation

Acetic acid → Homoacetogenesis
Hydrogen → Methane

Beta oxidation
Hydrogenotrophic methanogenesis
To promote AD

1) More biogas is needed on the market

2) New AD products are needed
To promote AD

1) More biogas is needed on the market

- Novel feedstocks
- Increased biodegradability
  - Pre-treatments
- Improved process optimisation
Typical AD feedstocks - Waste First
Biogas and Bio – SNG

• Wood based Bio – SNG multiplies methane potential

• For biogas production
  – High yield crops
  – Macroalgae
  – Microalgae
Microalgal biomass for biodiesel and biogas
AD for algae from wastewater treatment
Pretreatments

Targets

- Increased biodegradability and rate
- Improved process performance

Autoclaving darkens the color and changes the odor of the Food Waste
Pretreatment – e.g. Autoclaving

- An effective tool for hygienisation of food waste
- Formation of refractory Maillard compounds from sugars and amino acids
  - CH$_4$ yield decreases by 5-10 %
  - Decreased concentration of NH$_4$-N
    - Lower inhibition risk
    - Lower fertilising values
- Lower H$_2$S content in the biogas
  - Easier to upgrade and safer to handle
To promote AD
2) new AD products are needed

• Nutrient products
• Different energy carriers
• Chemical products (VFAs, biopolymers from VFA, CH₄)
• Demand-driven biogas supply for power grid
Nutrient products – Struvite from digestates

Phosphorous solubility

- H2O: 0%
- NH4Cl pH=7: 16%
- CH3COONa pH=5: 1%
- NH2OH•HCl pH=2: 1%
- HNO3 + H2O2: 82%
- HNO3 + HCl + HF: 0%
Biogas and nutrients

- Capacity 120,000 t pig manure + industrial by-products (50:50)
- Pre-hygienisation (1 h at 70 °C)
- 6700 m³ CSTR (+38…+40 °C)
- 4 MW CHP

Feed tank, hygienisation

Biogas and post methanisation

CHP

Nitrogen recovery

- Post-processing of the digestate
  - Mechanical separation
  - NH₃ stripping
  - Evaporation

- Fertiliser products:
  - Digestate
  - Liquid and solid fractions of digestate
  - Ammonium-water
  - N:P-concentrate

Fertiliser production
AD – potential for different energy carriers

• Methane (CH$_4$) through anaerobic digestion
• Ethanol / butanol fermentation
• Hydrogen (H$_2$) fermentation
• Electricity (e$^-$) production in microbial fuel cells (MFCs)
AD various energy carriers

Hydrolysis

Fermentation

Methanogenesis

Cellulose → Glucose → Volatile fatty acids, Ethanol, Butanol → \( \text{H}_2 + \text{CO}_2 \) and Acetate → \( \text{CH}_4 + \text{CO}_2 \)

Hydrogen gas (\( \text{H}_2 \)) and carbon dioxide (\( \text{CO}_2 \)) are produced during the fermentation process, facilitating the production of ethanol and butanol. The acetate produced can then be methylated to form methane (\( \text{CH}_4 \)) and carbon dioxide (\( \text{CO}_2 \)).
Production of various energy carriers
Summary

• AD combines energy production and waste management

• Increased methane potential
  • Novel feedstocks
  • Pre-treatments
  • Process optimisation

• Novel products
  • Nutrients, chemicals, energy flexibility