bio-oil produced from composted lignocellulosic biomass

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Climate change

The earth’s atmosphere is growing warmer due to GHG emissions generated by human activity.

-gradually stop using fossil resources for energy
- increase the use of renewable energy

186 industrialized countries committed to reduce GHG emissions
Alternative to fossil fuel

• First-generation biofuels
  - Esters (bio diesel) from seed oil
  - Bioethanol from cereals and sugar crops

Conflict with human food chain

• Second-generation biofuels

produced from agricultural waste, non food crops, forest residue
Biomass potential

Represents 236 million toe in EU

13 % of EU primary energy needs (1.8 billion toe in 2020)

80 % of the biomass is ligno-cellulosic biomass
difficult to convert due to high O content
Lignocellulosic biomass to biofuel

High quality bio-oil:

- High Heating Value (HHV) > 40 MJ.Kg⁻¹
- Oxygen content < 6% dry weight
- Hydrogen/Carbon > 1.5

$$HHV = 0.03383 \text{ wt } \%(C) + 1.422 \text{ wt } \%(H) - \text{ wt } \%(O)/8$$
Hydroliquefaction

Heated H₂ pressurised reactor

Gas (CO, CO₂)
water
Residue

- depolymerisation
- deoxygenation
- hydrogenation
Objective

Improve the conversion of ligno-cellulosic biomass into a low oxygen content bio-oil
Operating conditions for biological pretreatment

- 85L isothermal steel made reactor
- Forced aeration
- Moisture adjusted to 60%

Initial mixture

Green waste 45%
- Straw 17%
- Wood 38%

Thermocouple (temperature)
- Air input 250 L/h
- Air output

Biomass

Metal grid

Leachate


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Physico-chemical parameters

T (°C)

C/N

days

O/C

H/C

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Chemical fractionation

- Lipids: organo-soluble
- Biomass: $\text{CH}_2\text{Cl}_2/\text{MeOH}$
- Residue: $\text{HCl}$
- « humic Acids »: acido-soluble
- « Humin »: alcalino-soluble
- « fulvic Acids »: HCl

Complexification of Organic Matter

Humic acids/Fulvic acids
GCMS analysis of lipids

✓: branched fatty acids (i,a C15 et C17 ) of bacterial origin

Branched/linear fatty acids

stabilisation after 36 days
Operating conditions for hydroliquefaction

- Temperature: 300-400 °C
- Initial H₂ Pressure: 16 bar
- Catalyst: Raney Ni
- Hydrogen donor solvent: tetralin

Beauchet et al. Hydroliquefaction of green wastes to produce fuels. Bioresource Technology (2011) 102, 6200-6207
Influence of the catalyst

- **Poor effect on** conversion rate and oil yield

\[
\text{conversion rate} = 100 \times \frac{m_{\text{biomass ash free}} - m_{\text{residue ash free}}}{m_{\text{biomass ash free}}}
\]

\[
\text{oil yield} = 100 \times \frac{m_{\text{biooil}}}{m_{\text{biomass ash free}}}
\]

- **Increase the hydrogen transfer**: lower O% and best HHV for 400°C
Influence of the composting pretreatment

- **Low impact on** conversion rate ~ 90%; Oxygen content ~ 8%, HHV ~ 39 MJ/kg

- **High impact on** oil yield, hexane soluble fraction and hydrocarbons distribution
Bio oil from humic substances

Humin: up to 78% of composted biomass
Good conversion rate
Leads to highest oil and alkanes amount

emee et al. Evaluation of humic fractions potential to produce bio-oil through catalytic hydroliquefaction, Bioresource Technology (2013) 149, 465-469
Conclusion

1. The combination of biological pretreatment and hydroliquefaction of lignocellulosic biomass leads to good quality bio oil.

2. Best conditions for hydroliquefaction:
   - $380^\circ$ C
   - Raney Ni
   - 15 min.

3. Influence of biological pretreatment:
   - Oil yield increase with composting time
   - Maximum soluble fraction for 22 days
   - Distribution of alkanes similar to fossil fuel

4. Humin increases with biodegradation represents the Best compromise in term of reactivity, quantity and quality of bio oil.

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Thanks for your attention