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Catalytic Co-hydroprocessing of Pyrolysis Bio-oils for Enhanced Yields of Upgraded Biofuels

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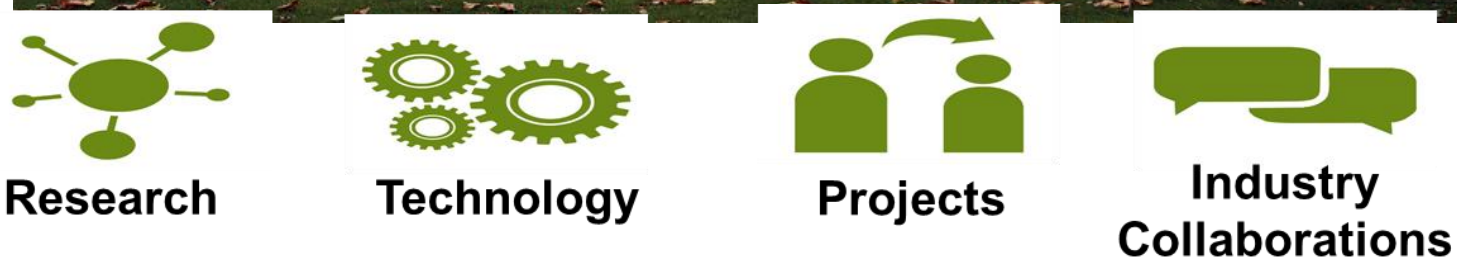
EBRI
Energy & Bioproducts Research Institute

EBRI Team

- 21 Academics as members or associates
- 15 Research Fellows
- 14 Admin, technical and business staff
- 30 PhD students



https://www.aston.ac.uk/research/eps/ebri

Strategies for Catalytic Upgrading of Biomass/Bio-oils

GOAL

Production of fuel-range liquid hydrocarbons

Remove Oxygen
Increase energy density

Control MW
Formation of C-C bonds

First Step/Conversion

- **Convert** the solid biomass into **Gas or Liquid** streams
- **Partial removal of Oxygen**

Second Step/Upgrading

Catalytic conversion to final biofuel
- Removal of remaining Oxygen
- Controlled C-C coupling reactions

Extraction
Lipids

Hydrolysis
Sugar monomers
Upgradable intermediates

Thermochemical
Deconstruction of
Whole Biomass

Final hydrocarbon biofuel

PROCESS SEVERITY & COMPLEXITY

Need for Bio-oil Upgrading

- Comparatively low heating value (18 MJ/kg *ca.* gasoline: 43 MJ/kg)
- Poor thermal stability - charification
- Tends to polymerise during long periods of storage
- Low volatility
- High viscosity > 100 cP (Water = 1cP, diesel = 3.5 cP)
- Highly corrosive due to the presence of carboxylic acids
- Immiscible with fossil fuels (diesel)
- Comprises various compounds with different functional groups/chemistries

➔ needs upgrading

Upgrading: process of altering the chemical compositions of bio-oil to improve fuel properties, making it more suitable for the end-use equipment – usually an engine

Solvent preparation - Results

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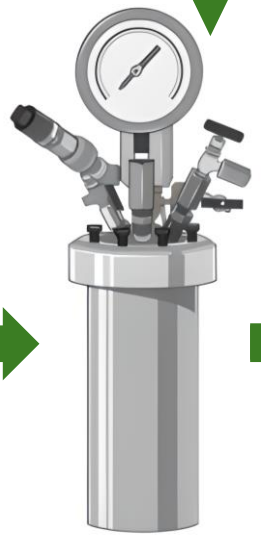
Waste Cooking Oil (WCO)
86.07 cP ± 0.83
39.1 MJ/kg

$C_{17}H_{34}O_2$ (13.31%)
$C_{19}H_{36}O_2$ (49.69%)
$C_{19}H_{34}O_2$ (31.39%)

Catalyst



One pot
400 °C,
3 h,
10 bar N_2

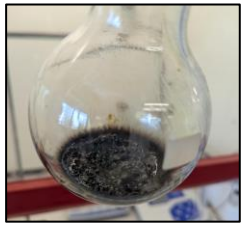
CO_2, CO

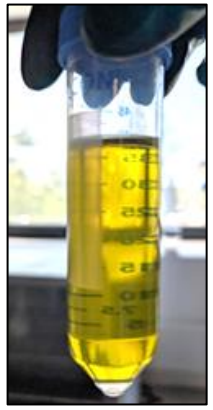
Upgraded WCO
30.12 cP ± 0.04
39.0 MJ/kg

C5 to C20 range HCs

Distillation

- 88.7±1.02 wt% of distillate recovered
- 5.8±0.24 wt% of solid residue
- Mass balance = 94.5±1.23 wt%
- Difference = volatile losses





Upgraded WCO
after distillation
2.64 cP±0.02
41.6 MJ/kg

Solvent assisted
bio-oil upgrading

Engine ready fuel

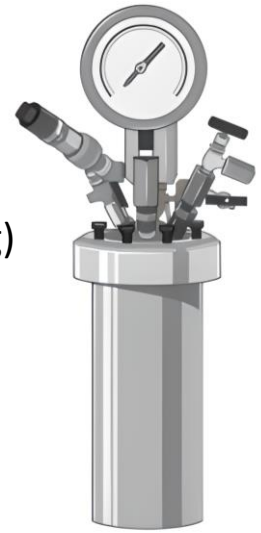
SA-HDO- Results

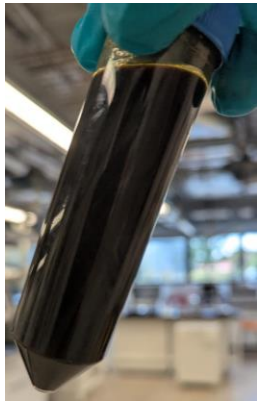
Bio-oil organic phase
3500±5 cP
27.6 MJ/kg
68.29±3.71 mg KOH/g
>90% oxygenates

+

Catalyst
(8-17 wt.% loading)

U-WCO:Bio-oil = 2:1





Distillation

Upgraded WCO
30.12±0.04 cP
39.0 MJ/kg
23.27±3.66 mg KOH/g
C5 to C20 range HCs

1st stage = 160 °C, 3 h,
10 bar H_2

2nd stage = 300 °C, 3 h,
10 bar H_2

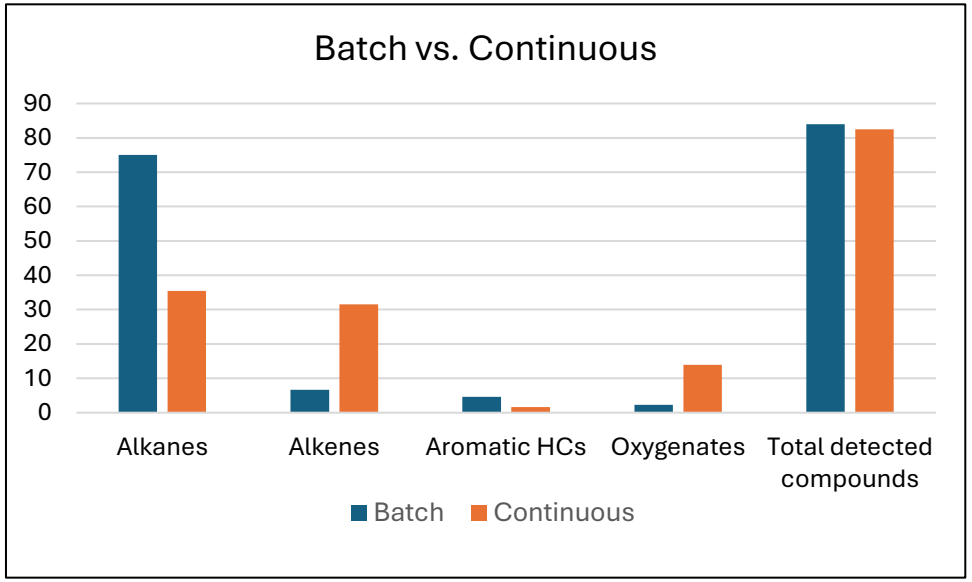
Upgraded bio-oil
8.33±0.01 cP
40.84±0.77 MJ/kg
TAN = 17.66 mg KOH/g
C5 to C20 range HCs

Distilled U-bio-oil
4.47 ± 0.02 cP
42.43±0.09 MJ/kg
TAN = 11.39 mg KOH/g
C5 to C20 range HCs

Scale-up using continuous rig

Operating conditions: up to 500 °C, 50 bar, 30 mL/min, H_2/N_2

U-WCO
after distillation



Acknowledgments

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