Effect of operating parameters on the aqueous phase from batch hydrothermal liquefaction using a industrial lignosulphonate: An experimental design approach

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Background and motivation

2015 Paris Agreement “conference of the parties” (COP21) [20]

- 148 Parties signed
- Limit greenhouse gasses by 2020
- Limit global average temperature rising to below 2°C above pre-industrial levels

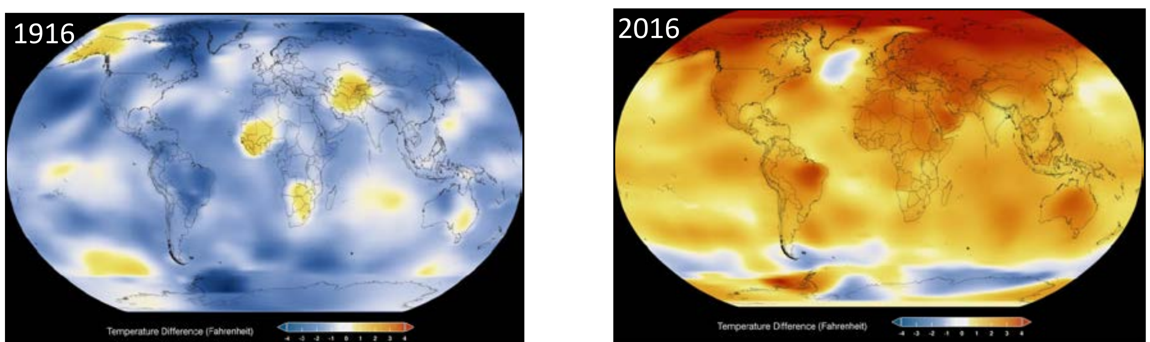


Figure1: Average global temperature from 1916 and 2016, where blue indicates areas cooler than average and red warmer than average [15].

Background and motivation

South Africa implementation of COP21 [6,19]

Integrated resource plan (IRP) for energy

- Northern Cape "Solar Corridor“
  - Solar PV
  - Concentrated solar power
  - 18GW
- Eastern, Western and parts of Northern Cape
  - Wind options
  - 37 GW

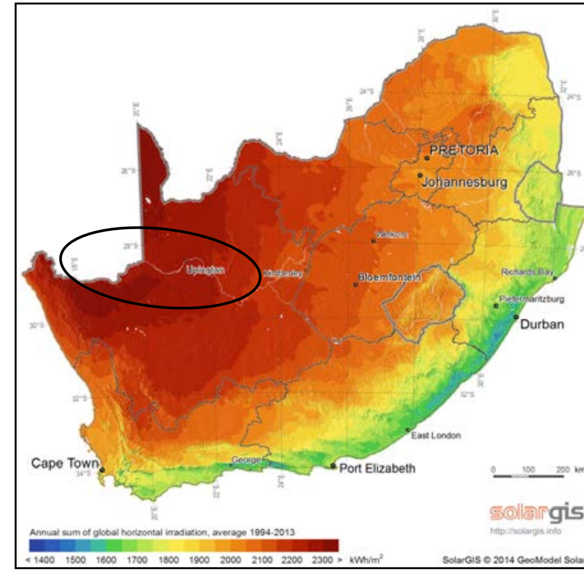


Figure 2: Average horizontal irradiance [4]

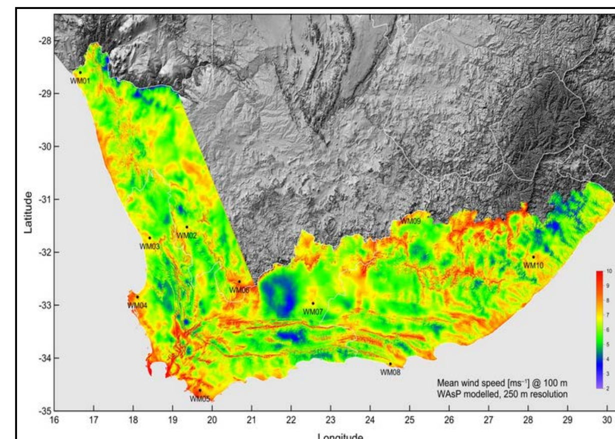


Figure 3: Average wind speed [5]

Background and motivation

Direct and indirect effects on land use change (LUC and iLUC) [14]

- Effect of using arable and grasslands
- Effect on displacing activities to other areas
- Contribute, rather than mitigate CO_2

A true carbon neutral process

- Wastes from current crops being produced for food [16]
  - Agricultural wastes (lignocellulose)

Background and motivation

Composition of Lignocellulosic material [3,17]

- Cellulose
- Hemicellulose
- Lignin

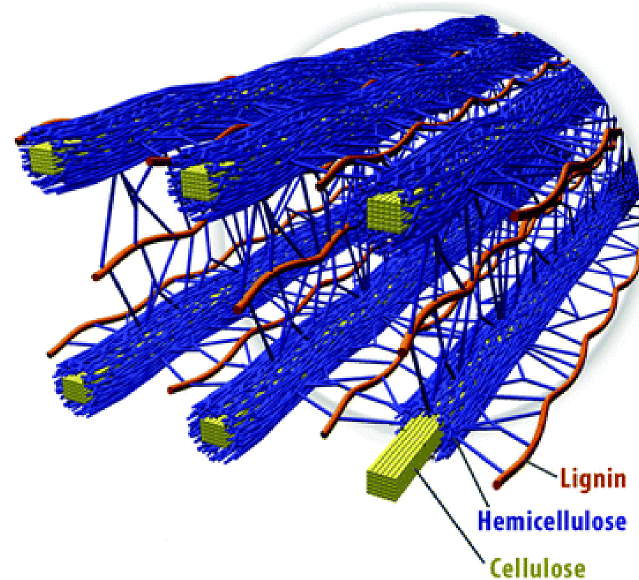


Figure 4: Typical lignocellulosic structure [2].

Lignin [1,7]

- 15-40 wt% biomass
- 40% of energy content
- Major product of the paper and pulping industries (Kraft process)
- 98% directly burnt as low value fuel
- Contributes to global warming
- Utilising lignin reduces carbon footprint through carbon capturing

Background and motivation

Previous use of lignin [1,7,13]

- Direct combustion
- Gasification
- Pyrolysis
  - —High temperature conversion
  - —Energy intensive
  - —Heat loss during lignin combustion

- Hydrothermal liquefaction (HTL) [13]
  - No pretreatment (drying of biomass)
  - Fast process
  - Moderate conditions
  - Narrow distribution of small molecule products

Background and motivation

Hydrothermal liquefaction (HTL) [1]

- Near critical water
- Temperature: 280-370°C
- Pressure: 10-25 MPa
- Produces biochar, bio-oil, aqueous phase and bio-gas

HTL of lignin

- Produced aromatic monomeric compounds without destruction of aromatic rings
- High economic value aromatic compounds [17,1,13,11]
  - Catechol
  - Guaiacol
  - Phenol
  - Syringol
  - Vanillin

Background and motivation

Phenolic compound used for:[8]

- Pharmaceutical
- Fragrance
- Industrial usage

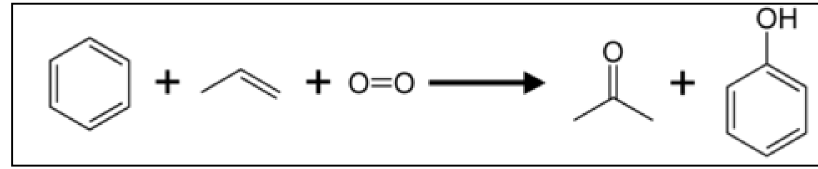


Figure 5: Hock process for producing phenol[21]

Current phenolic production

- Produced from petroleum-based phenolics[22,9,10,23,18]
- Hock process
- 95% of world's production
- Using benzene to produce phenol
- Lignin proven to produce similar phenolic compounds[8]
- Green and renewable source of phenolics

Research Aim & Objectives

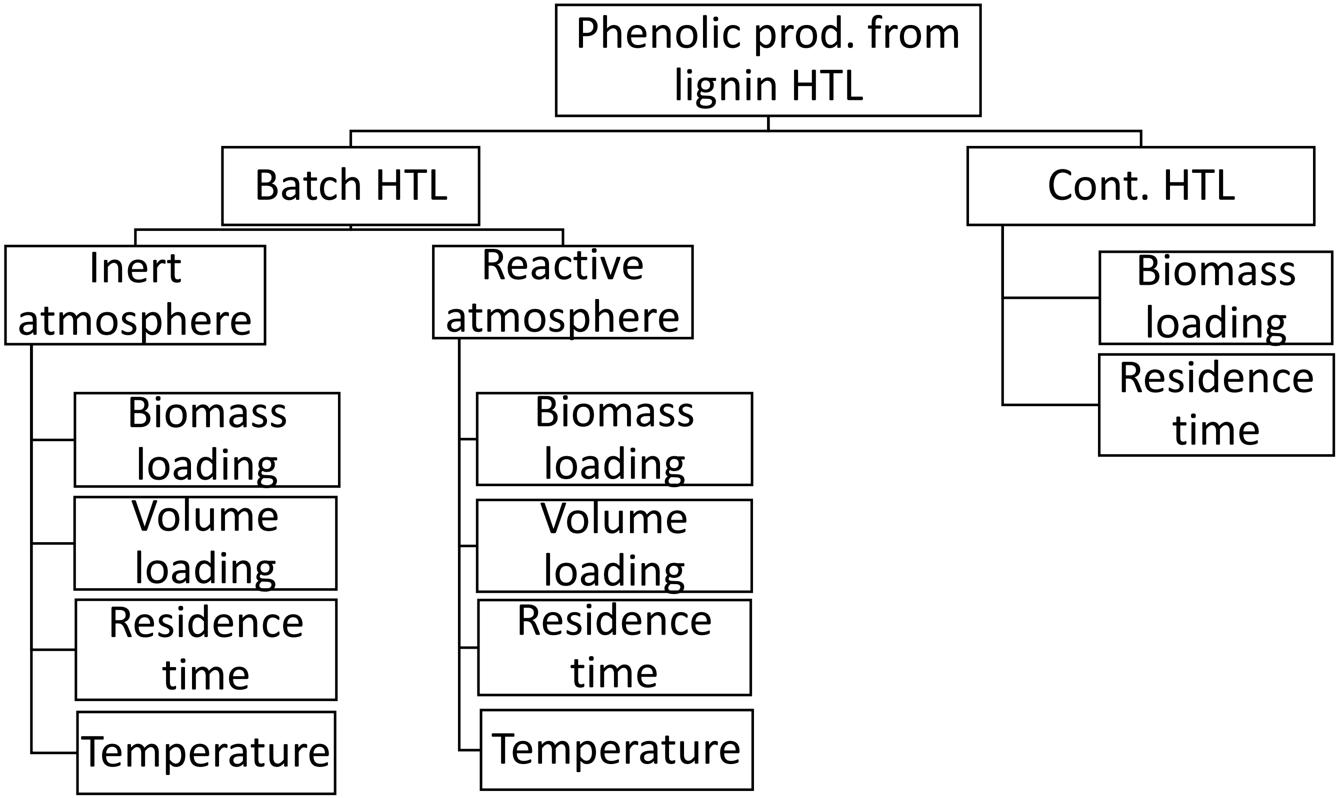
Aim:

The aim of this study was to determine the optimal conditions for the production of good quality and high yielding phenolics from hydrothermal liquefaction of industrial sodium lignosulphonate

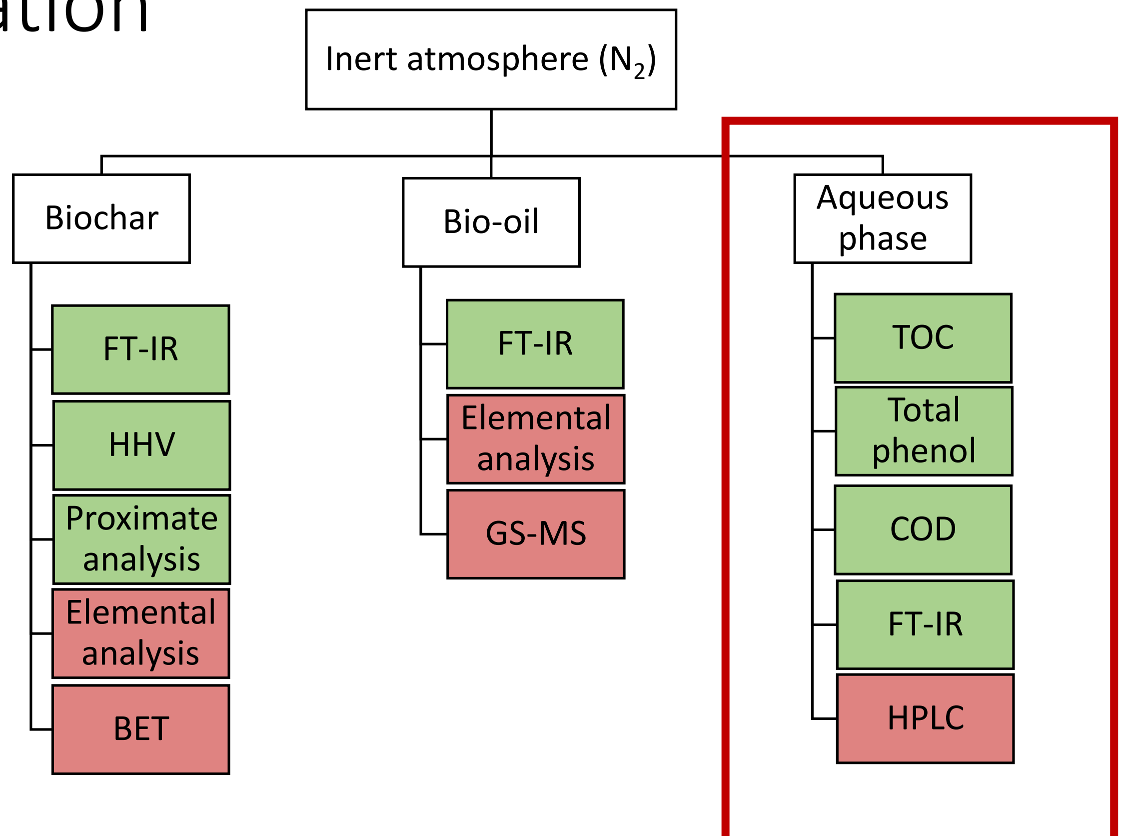
Objectives:

- The obtain the yield of phenolic compounds in the bio-product streams
- What process parameters can be manipulated to obtain specific phenolic compounds
- What process parameters can be manipulated to minimalise biochar yields and maximise phenolic compounds

Research Aim & Objectives – Overall picture



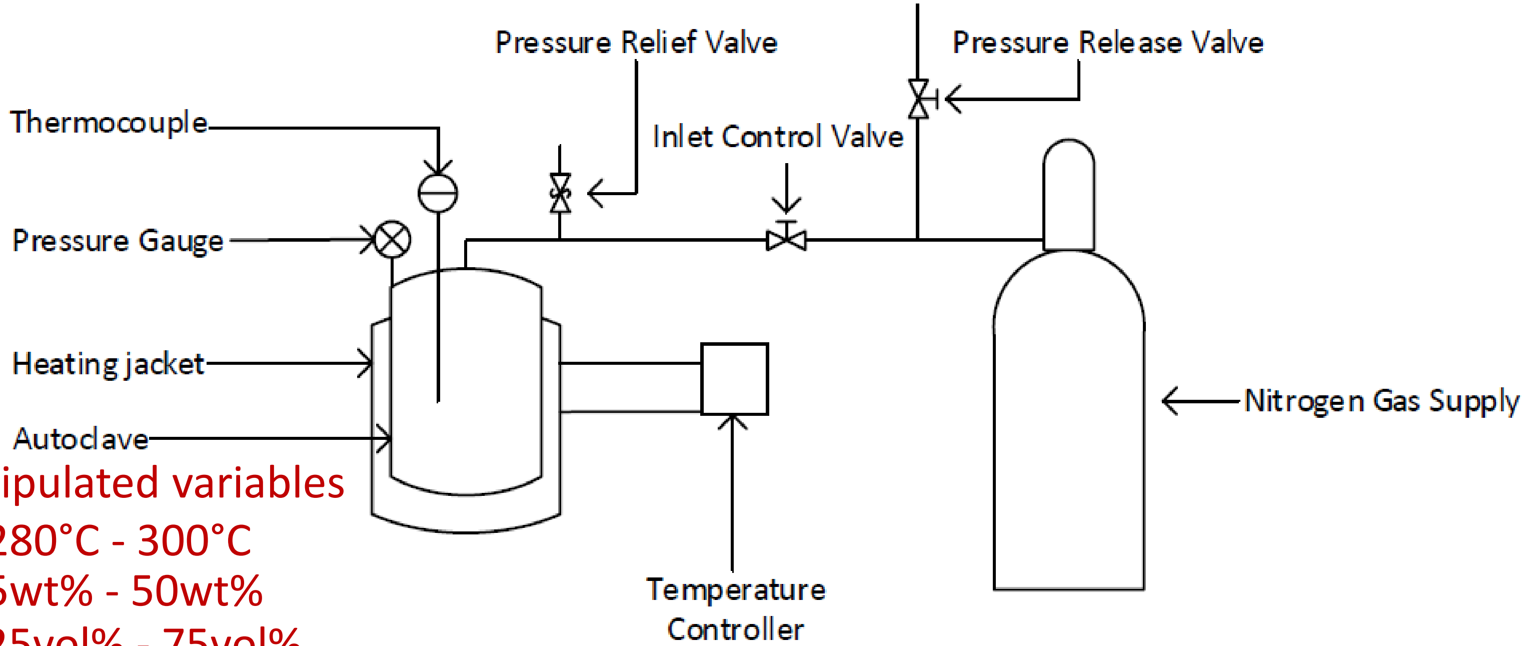
Research Aim & Objectives – This presentation



Research Methodology

Figure 6: Batch HTL reactor (left) and removable heating jacket (right)

Research Methodology



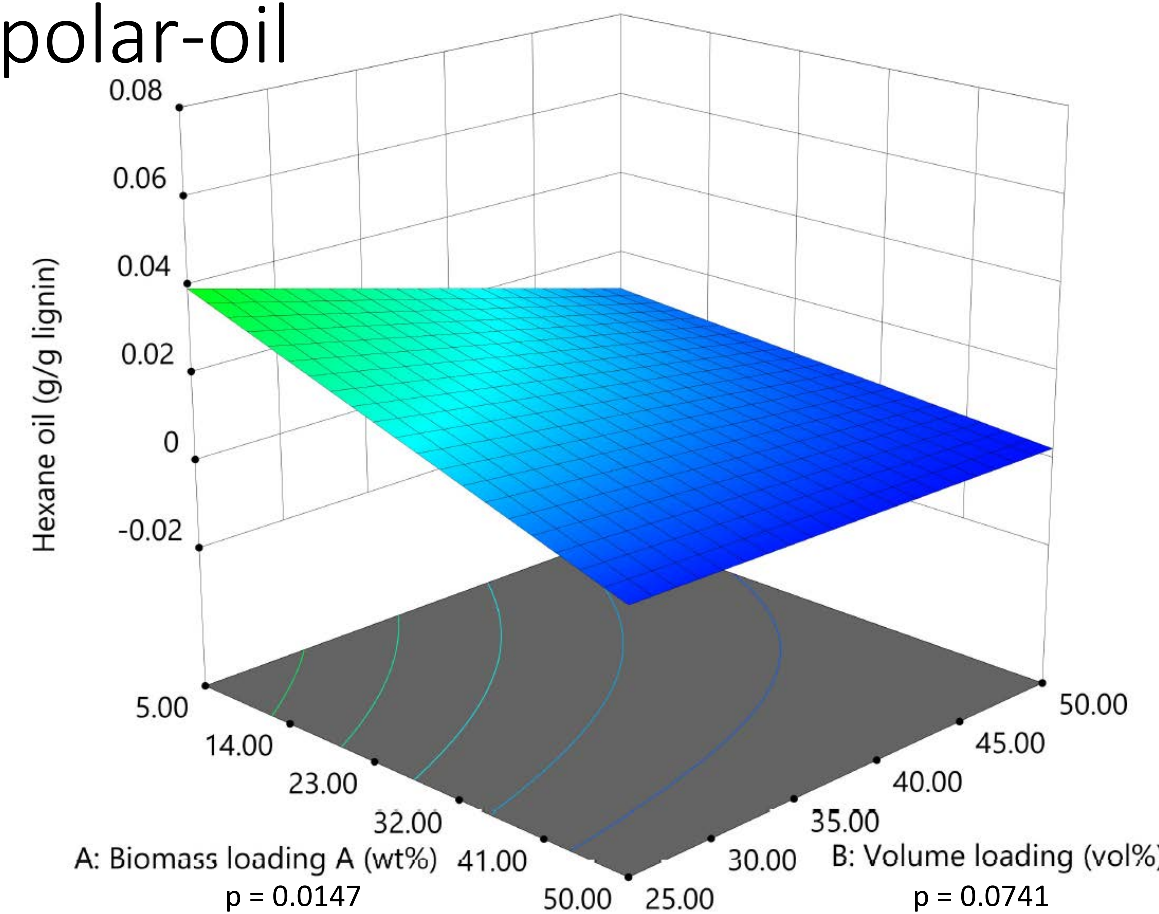
Manipulated variables

- 280°C - 300°C
- 5wt% - 50wt%
- 25vol% - 75vol%
- 15min - 45min

NWU®

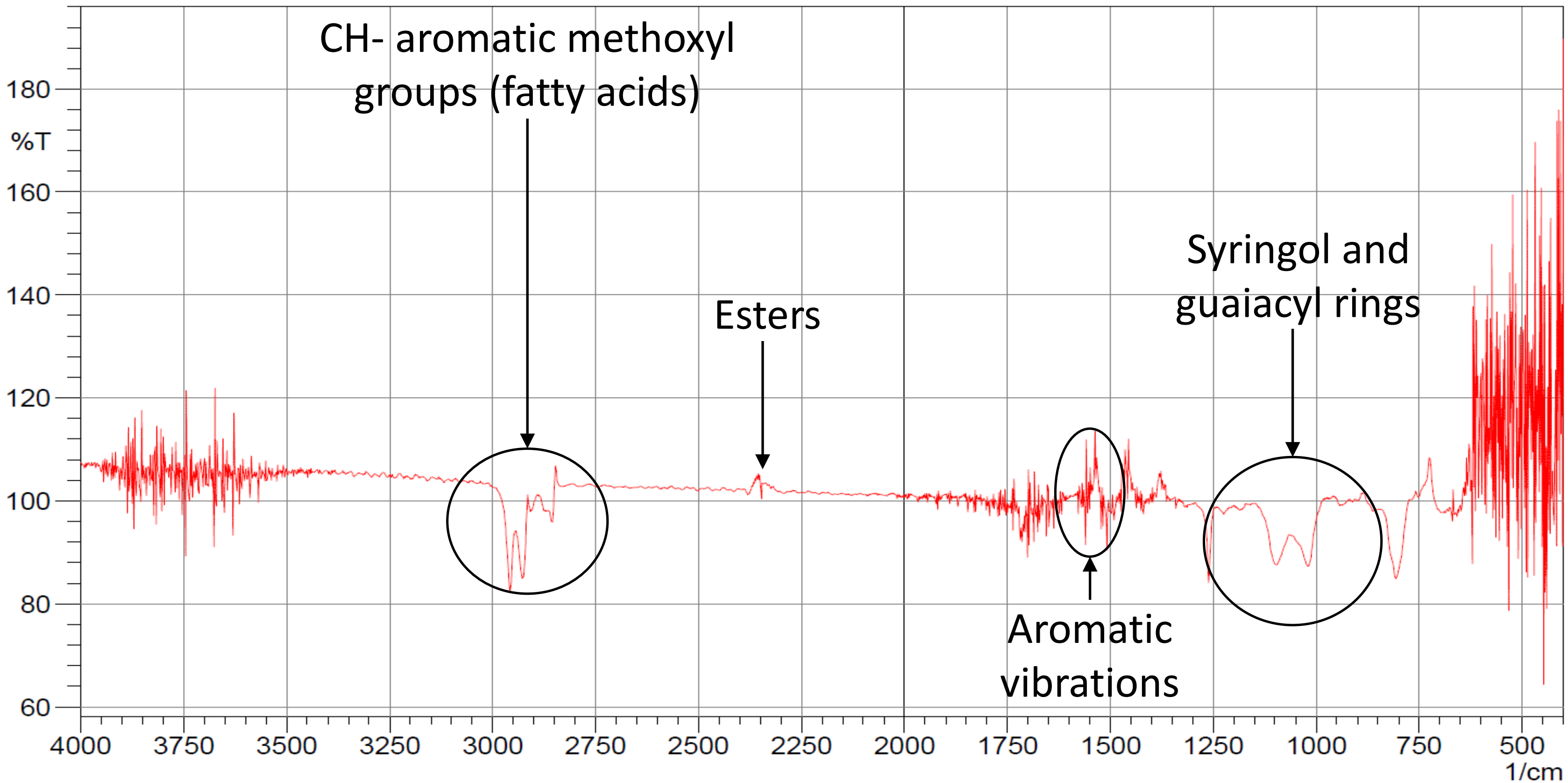
Results: Non-polar-oil

Highest non-polar oil yield: 0.080 g/g lignin



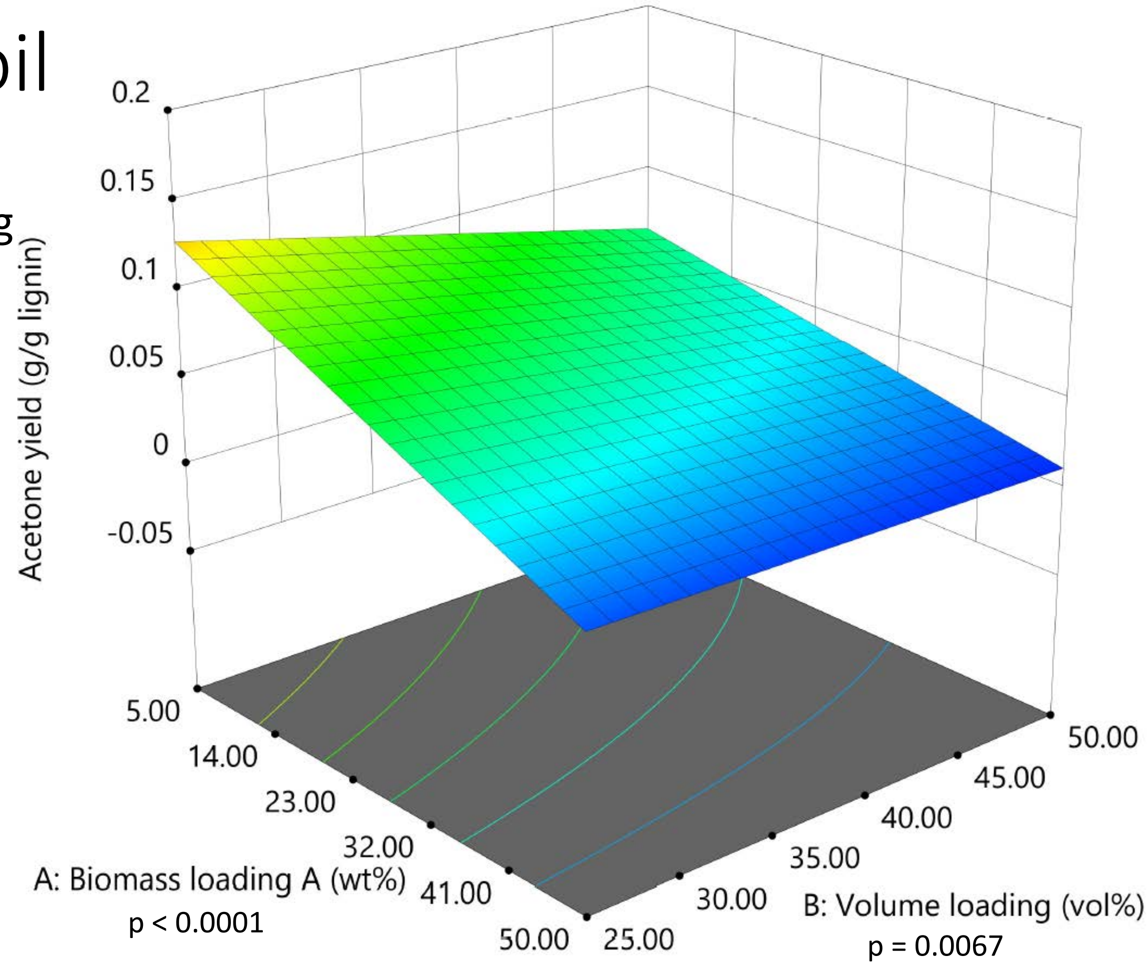
NWU

Results: Non-polar oil

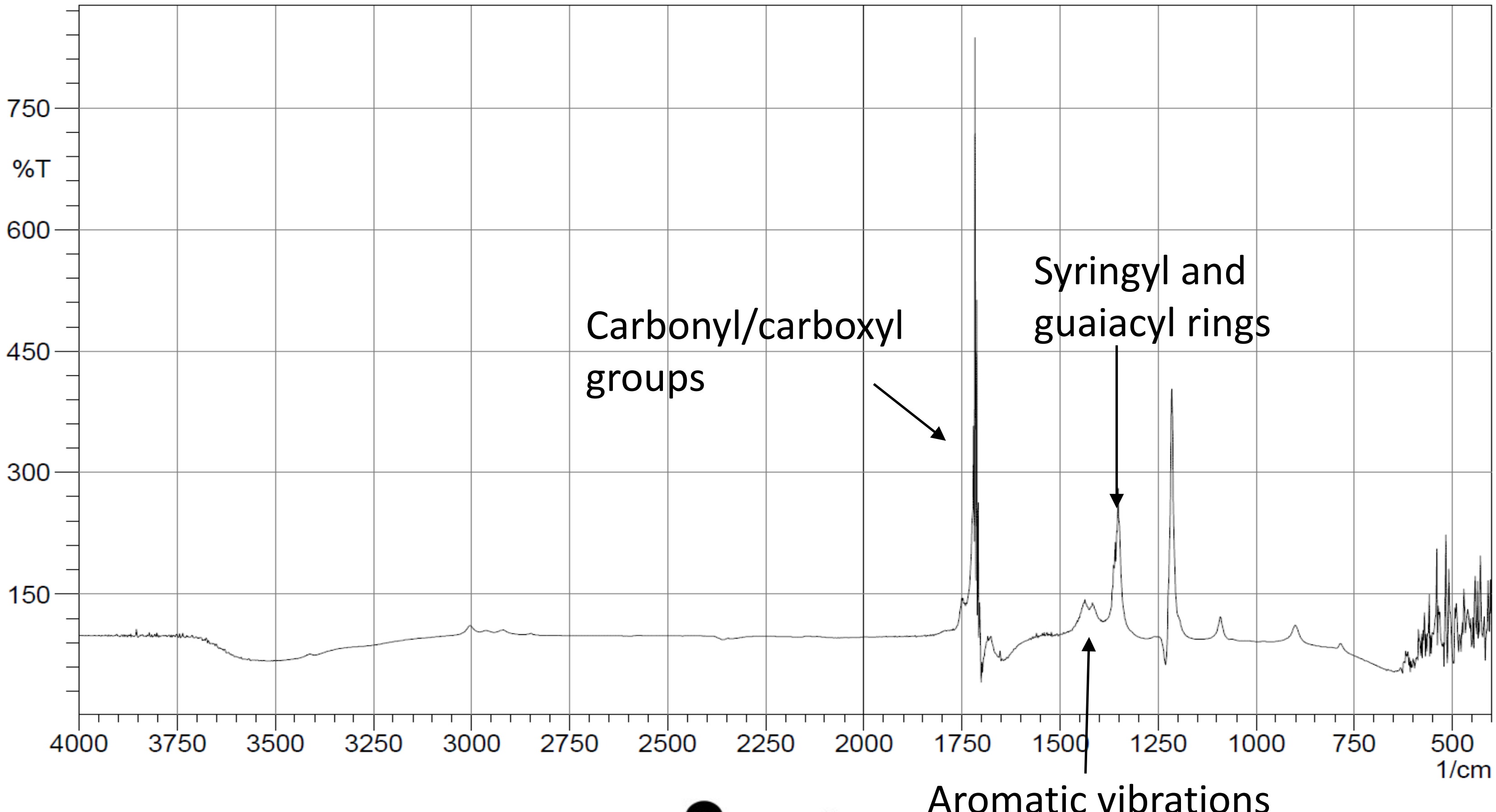


Results: Polar oil

Highest polar oil yield: 0.16 g/g lignin



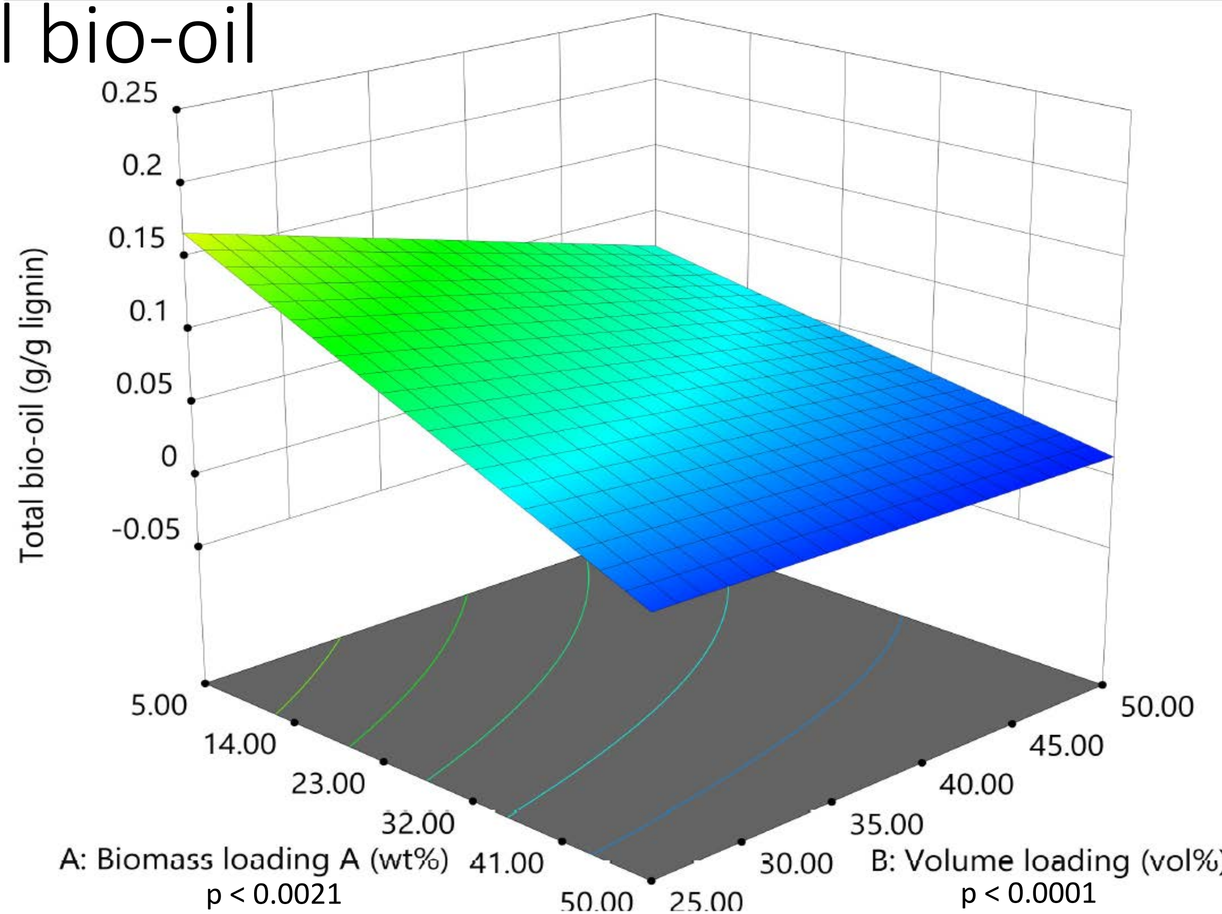
Results: Polar-oil



NWU®

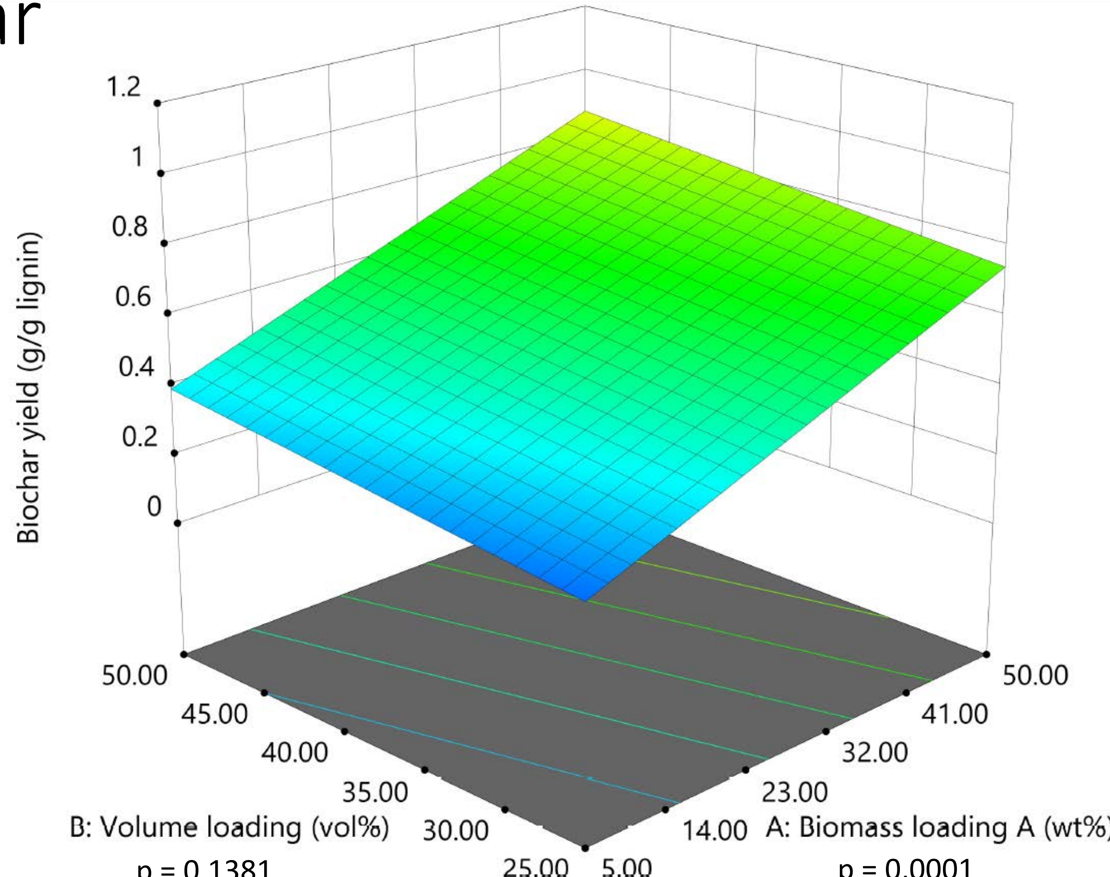
Results: Total bio-oil

Consisted of 59-94 wt% of polar oils
Highest oil yield: 0.22 g/g lignin

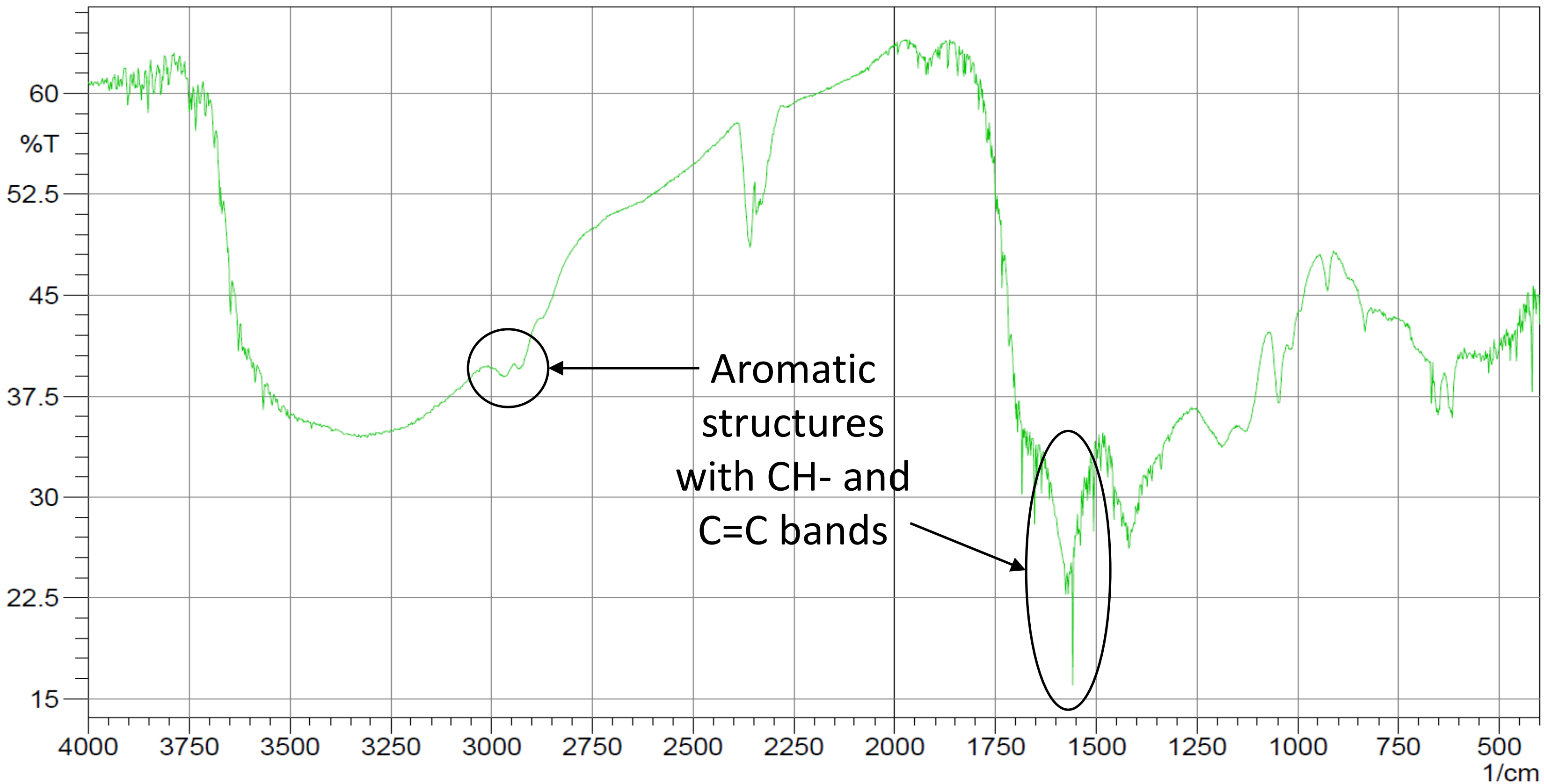


Results: Biochar

Highest char yield: 0.9 g/g lignin
HHV of 27 MJ/kg

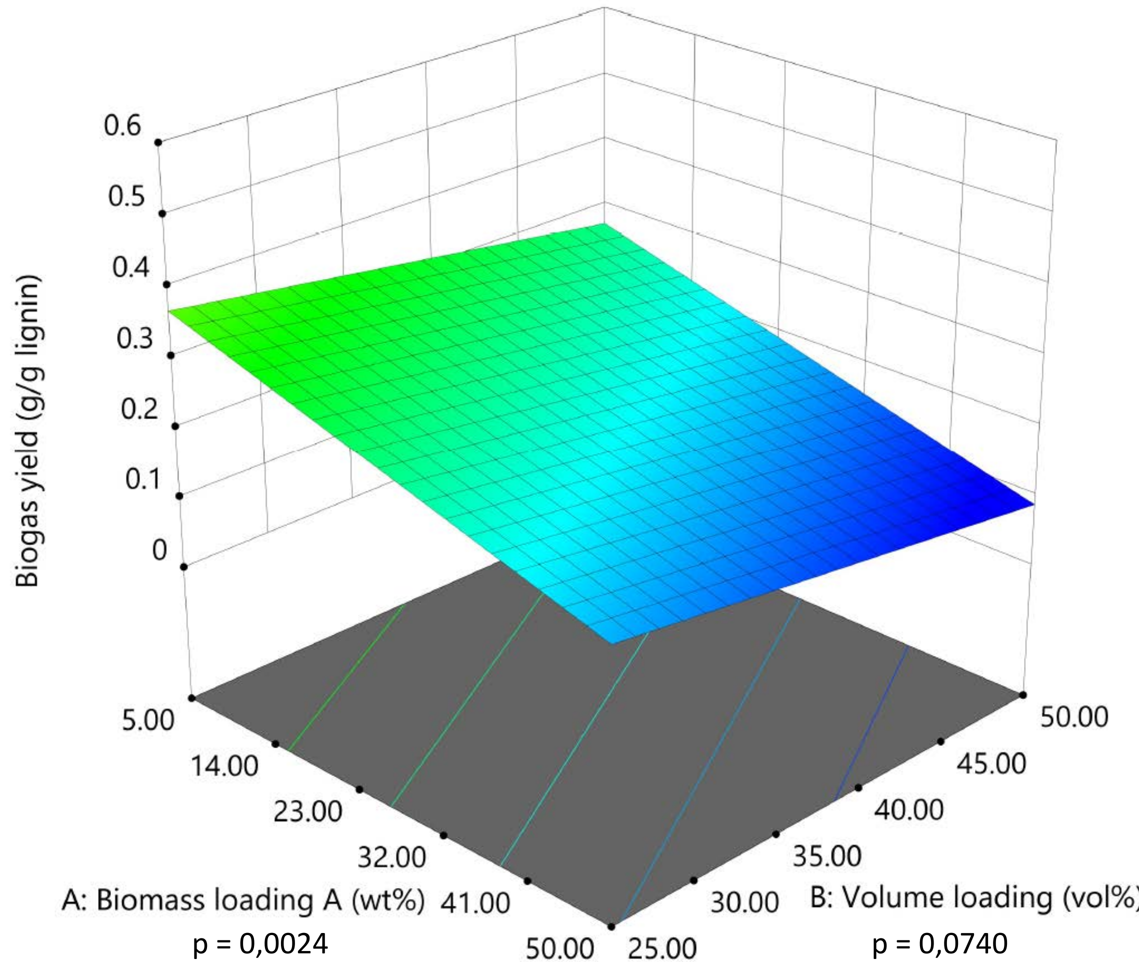


Results: Biochar



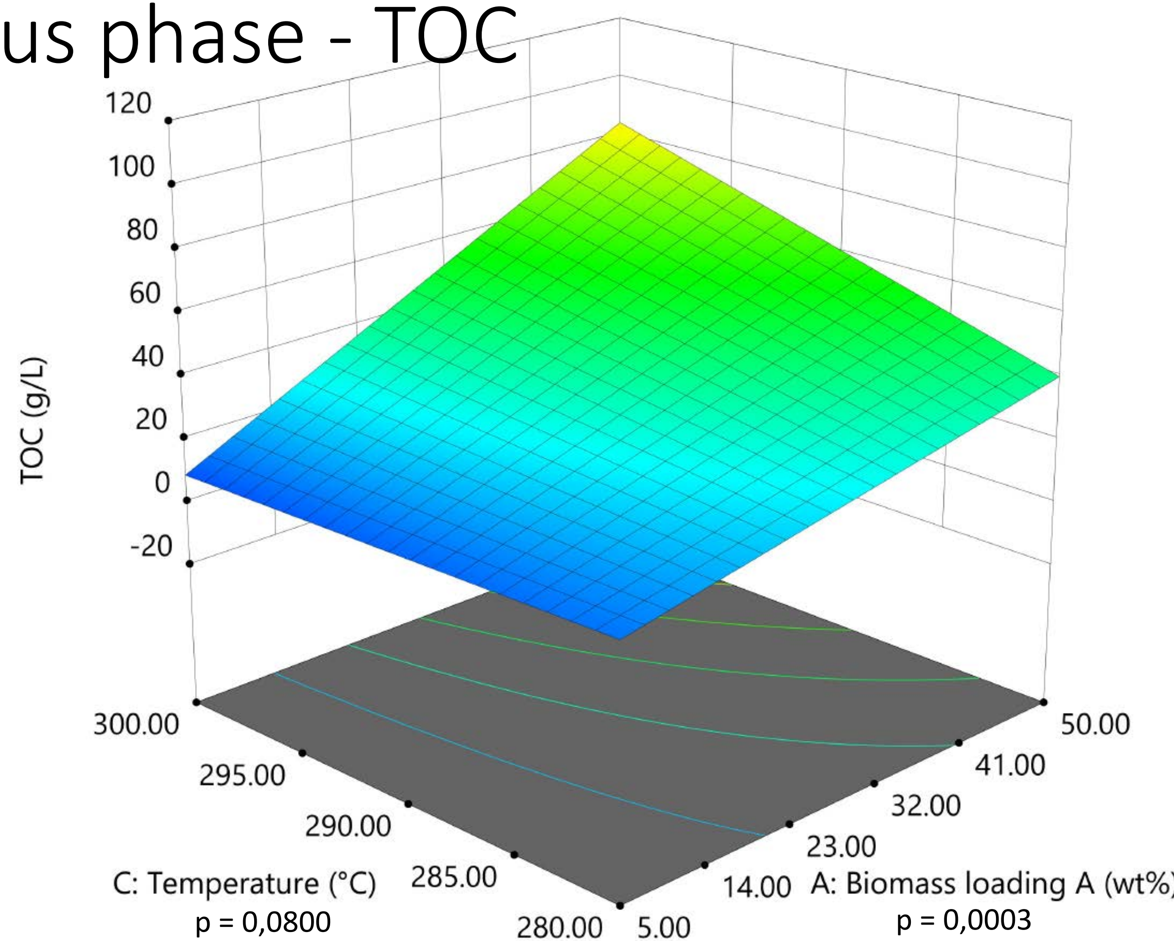
Results: Biogas

Highest biogas yield: 0.56 g/g lignin



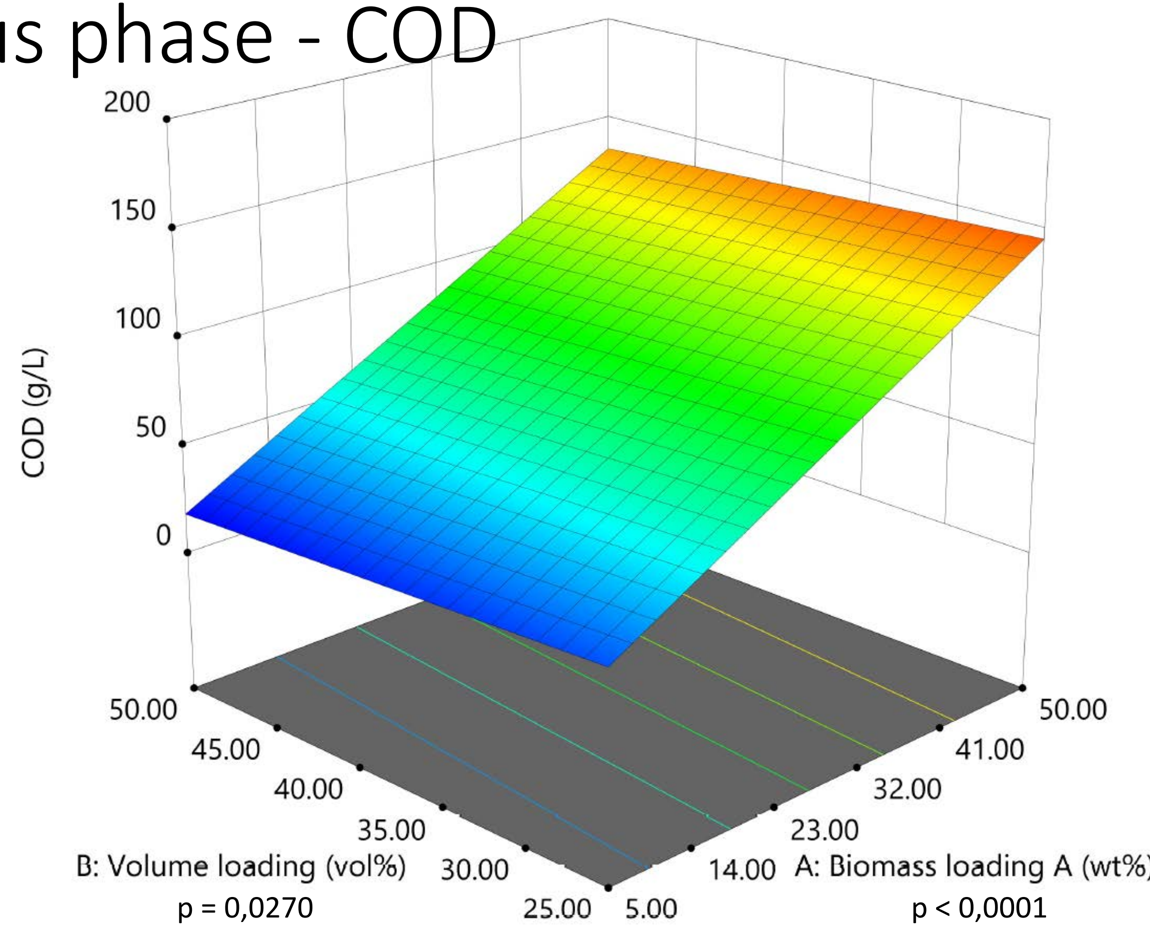
Results: Aqueous phase - TOC

Highest TOC: 110 g/L



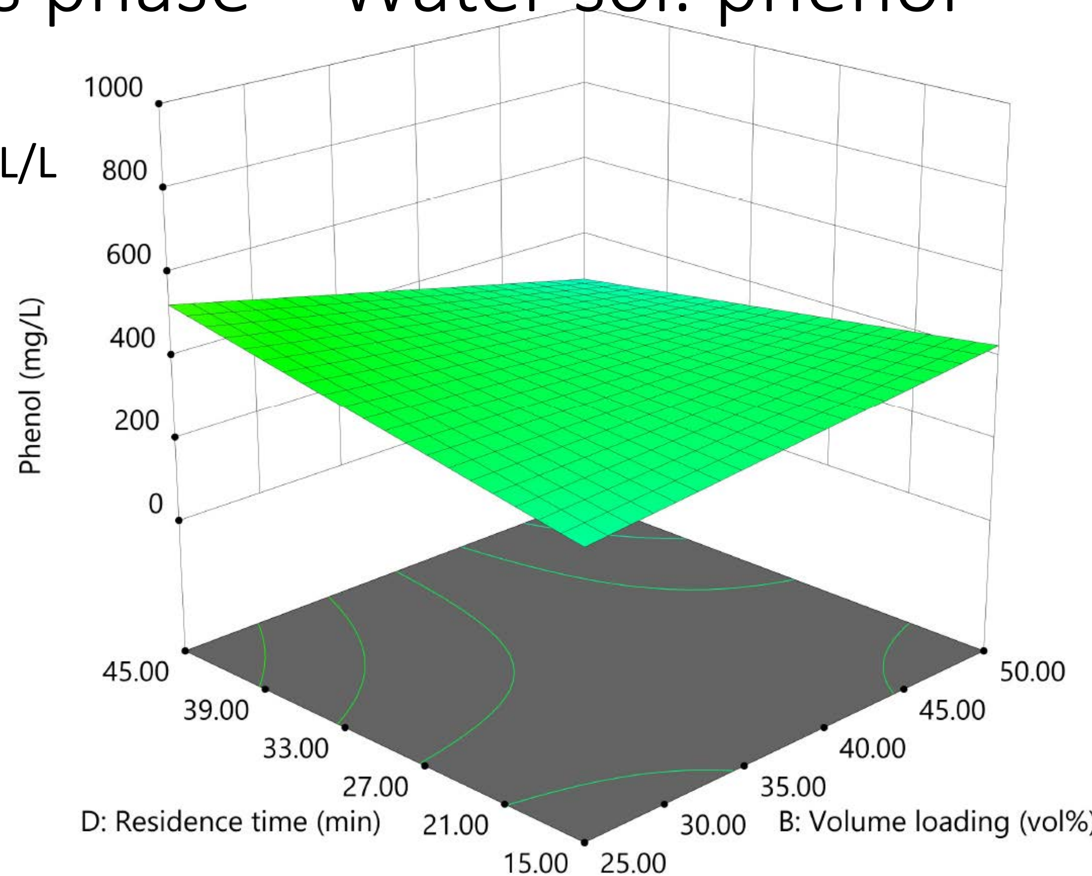
Results: Aqueous phase - COD

Highest COD: 158 g/L COD



Results: Aqueous phase – Water sol. phenol

Highest phenol content: 940 mL/L



Conclusion

	Biomass loading	Volume loading	Temperature	Non-significant
Bio-oil				
Biochar				
Biogas				
Aqueous phase:				
TOC				
COD				
Total phenol				

Thank you

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