The evaluation of spent coffee grounds as feedstock for continuous hydrothermal liquefaction

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Background and motivation:

- Fossils fuels provides most of the worlds energy [1]
- Renewable fuels: Food vs. Fuels
- Spent coffee grounds (SCG) is a good alternative
  - SCG is not a food source
  - Global coffee consumption in 2017 was 9.51 million tons [2]
  - SCG is currently being sent to the landfill

Background and motivation:

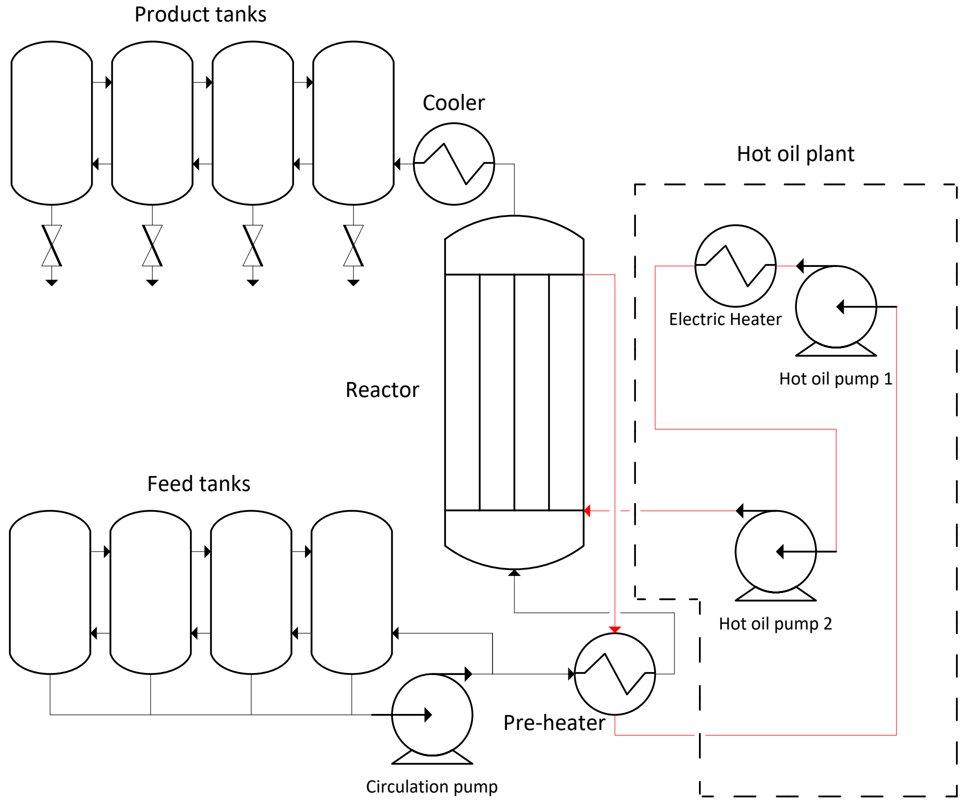
- Thermochemical reaction methods:
  - Pyrolysis vs. hydrothermal liquefaction (HTL)
    - Pyrolysis requires intensive drying [4]
    - SCG has a high moisture content of 60 wt.% [5]
    - SCG is ideally suited for HTL
    - HTL produces a higher quality biocrude [4]

Aims and objectives:

- Aim
  - To determine if SCG could be utilised as a feedstock in a continuous HTL reactor for the production of biocrude and biochar
- Objectives
  - Optimal biomass loading
  - Effect of retention time on product yield and quality

Reactor setup:

Reactor setup: PFD



Experimental procedure: Reactor conditions

Reactor condition	Range	Unit
Hot oil temperature	300 – 305	°C
Pressure	90 – 95	Bar
Flow rate	60 – 120	L/h
Residence time	10 - 20	min

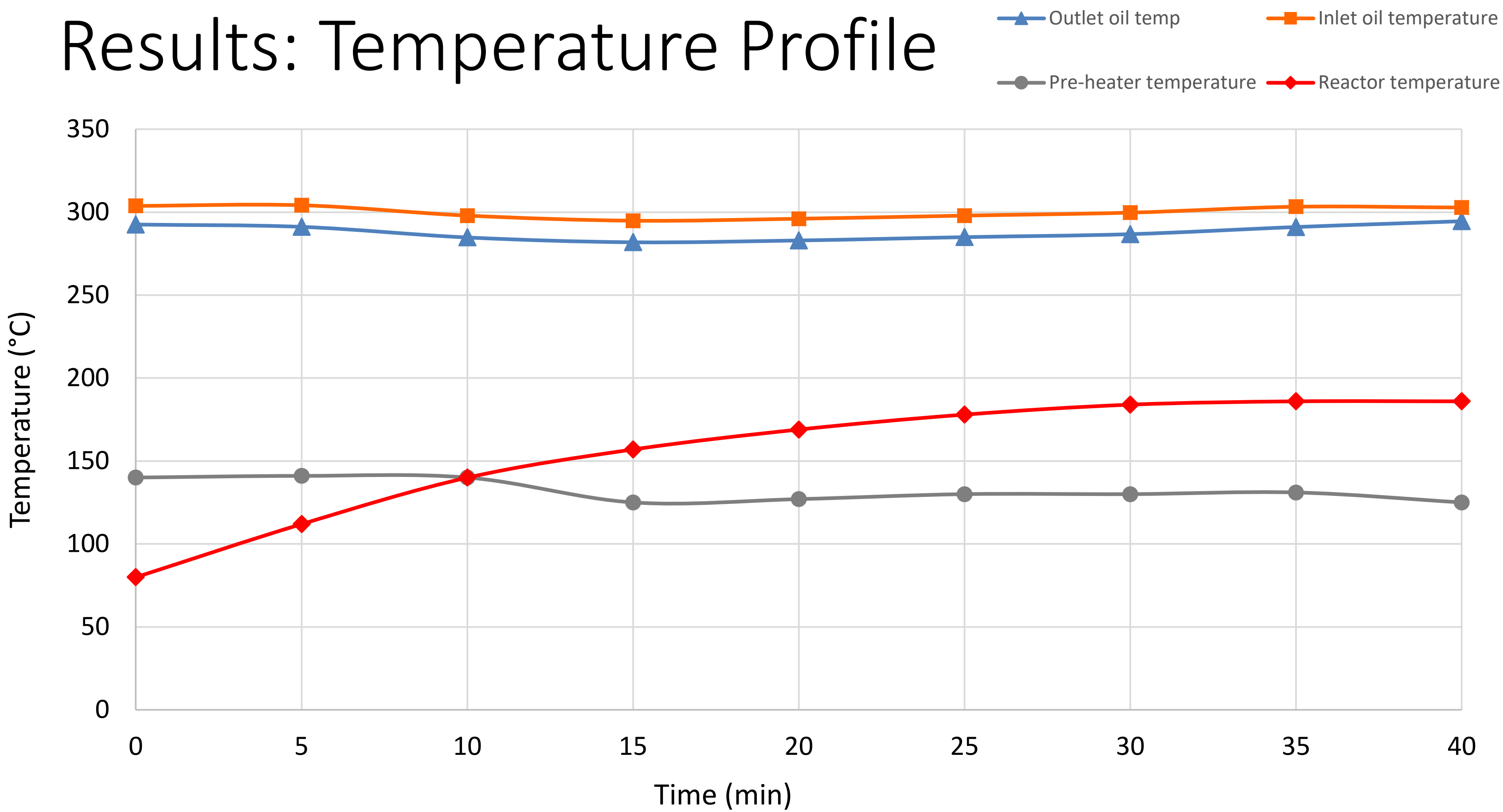
Results: Fibre Analysis

Component	wt.%
Ash	1.34
Protein	12.71
Fat (Ether extraction)	12.86
Carbohydrates	67.62
Hemicellulose	34.97
Cellulose	19.26
Lignin	10.54

Results: Biomass loading

- The biomass loading was varied:
  - 5 vol.% - 3 vol.%
  - SCG was not pre-treated
- Optimal biomass loading did not cause blockages
- A few blocked reactors later:
  - The optimal biomass loading was 3 vol.%

Results: Temperature Profile



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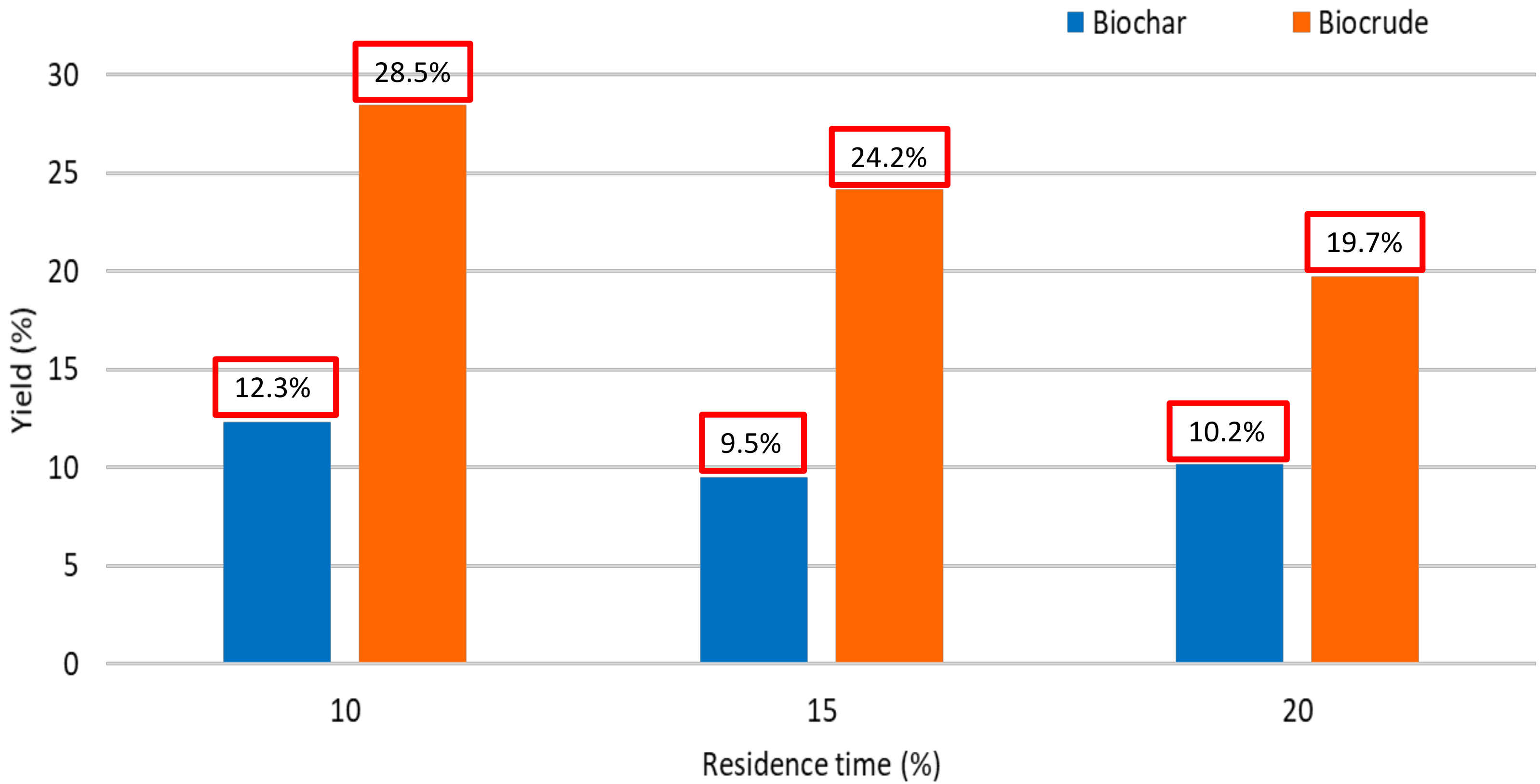
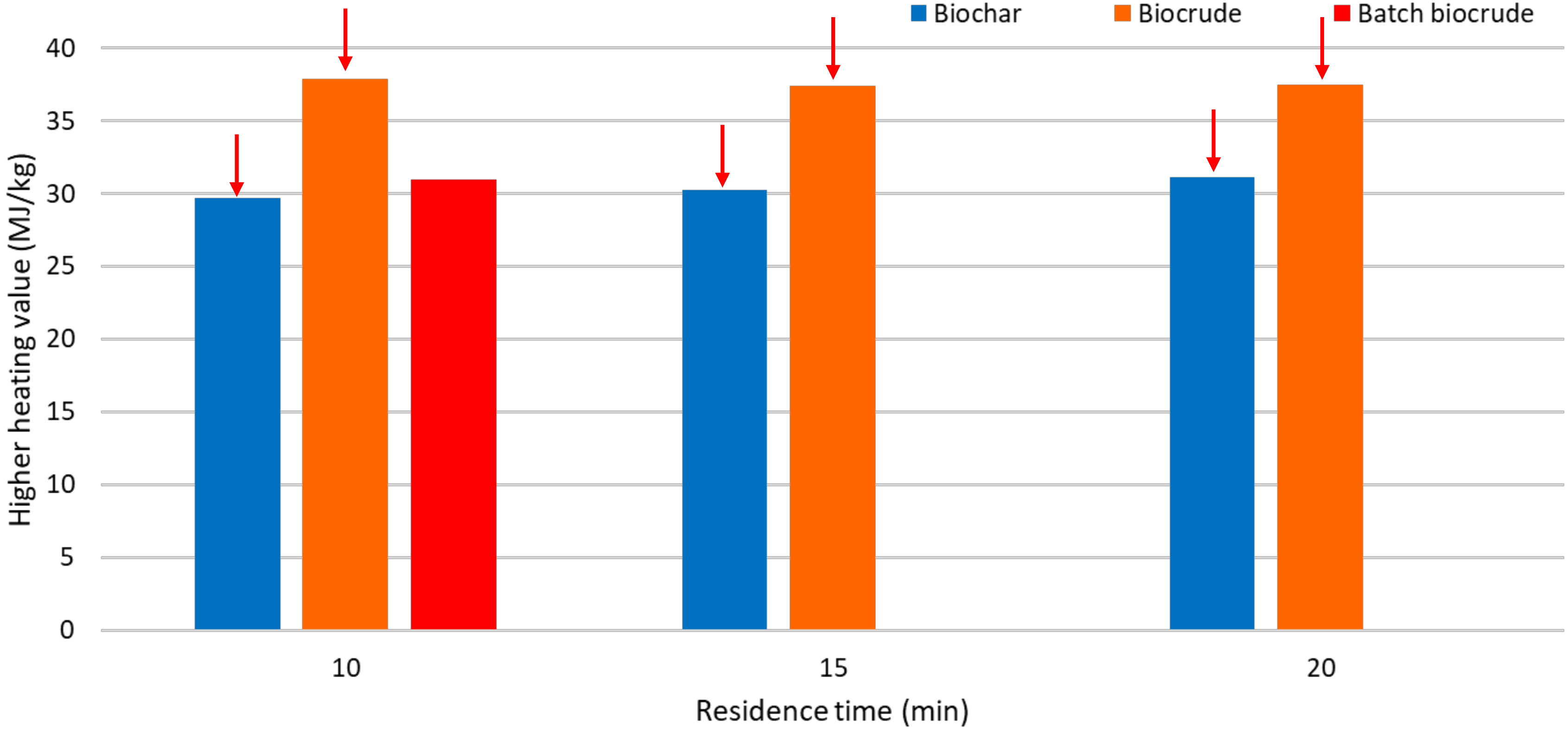
Results: Yields



Results: Higher heating value (HHV)



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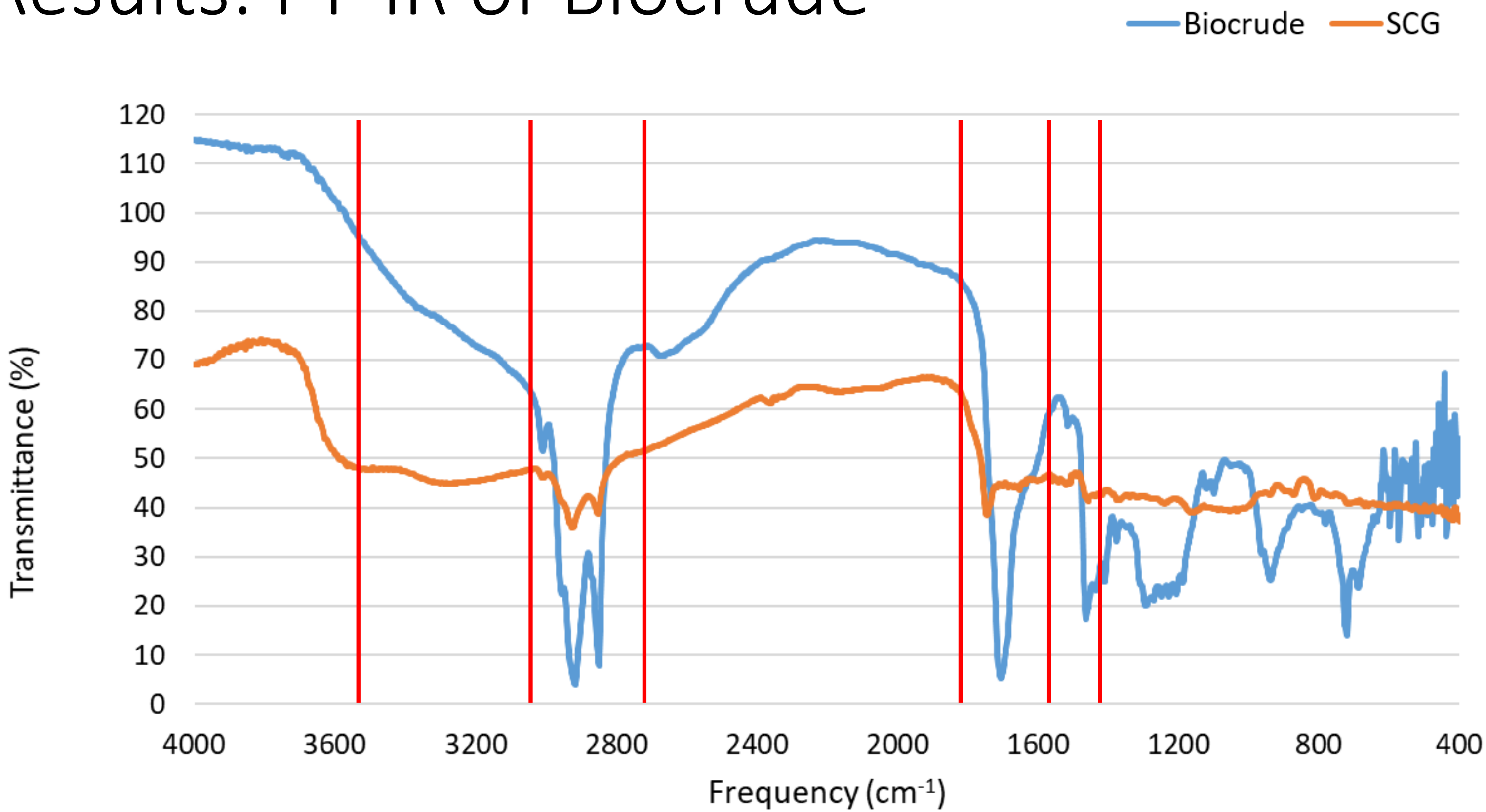
Results: GC-MS

Component	Retention time (min)	Area (%)
Palmitic acid	32.769	34.46
Linoleic cid	35.643	29.92
Oleic acid	35.75	13.92
Stearic acid	36.161	9.67
Linoleic acid methyl ester	33.901	2.84
Methyl 9,12-Heptadecanoic acid	36.364	2.28

Results: FT-IR of Biocrude



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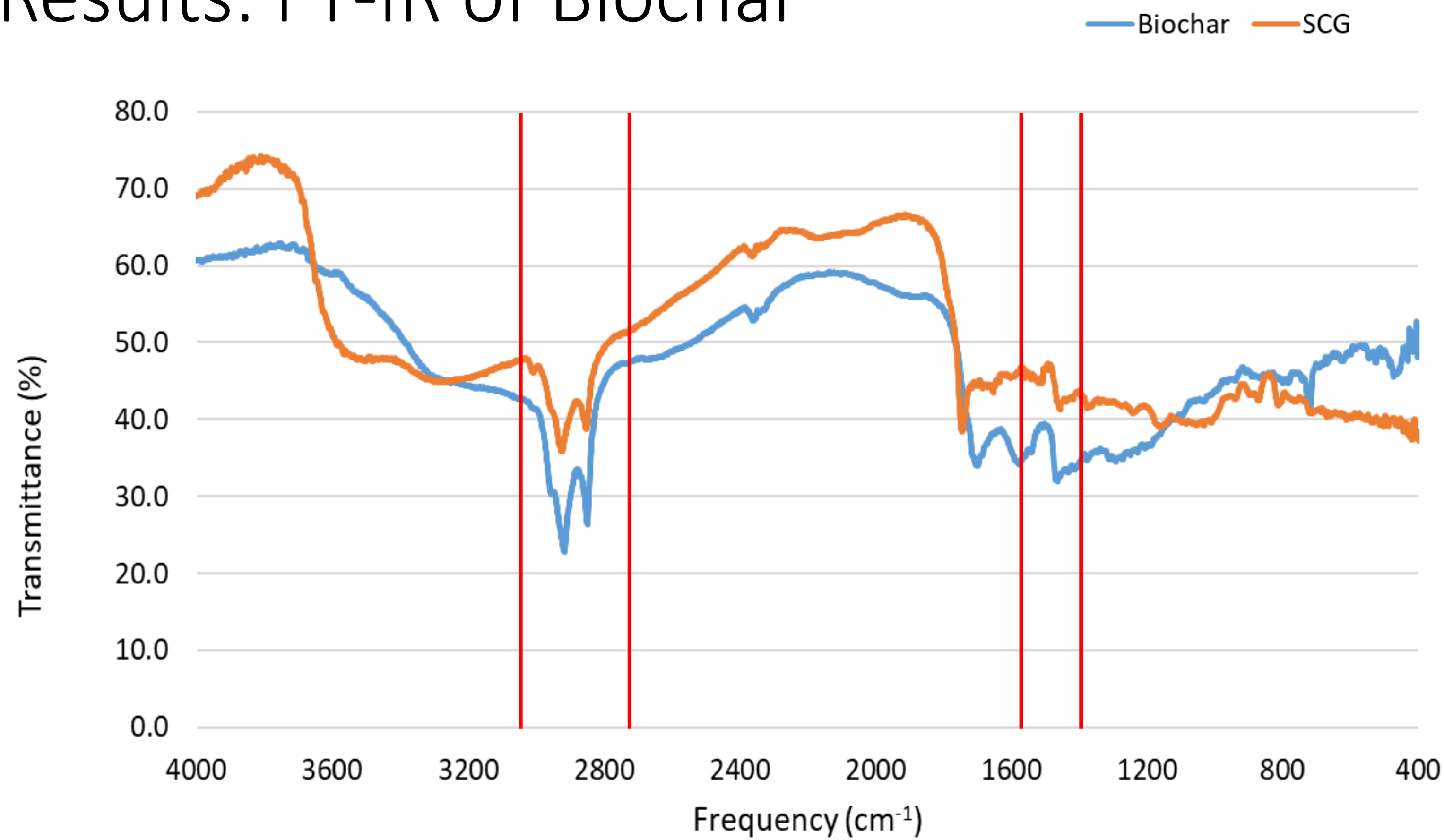
Results: FT-IR of Biochar



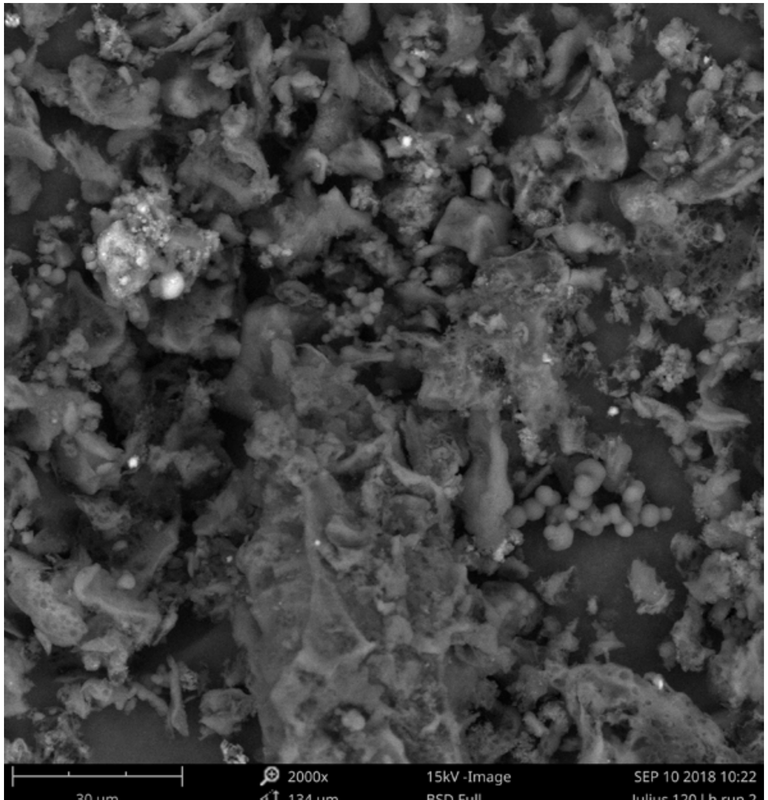
Results: Proximate analysis of the biochar

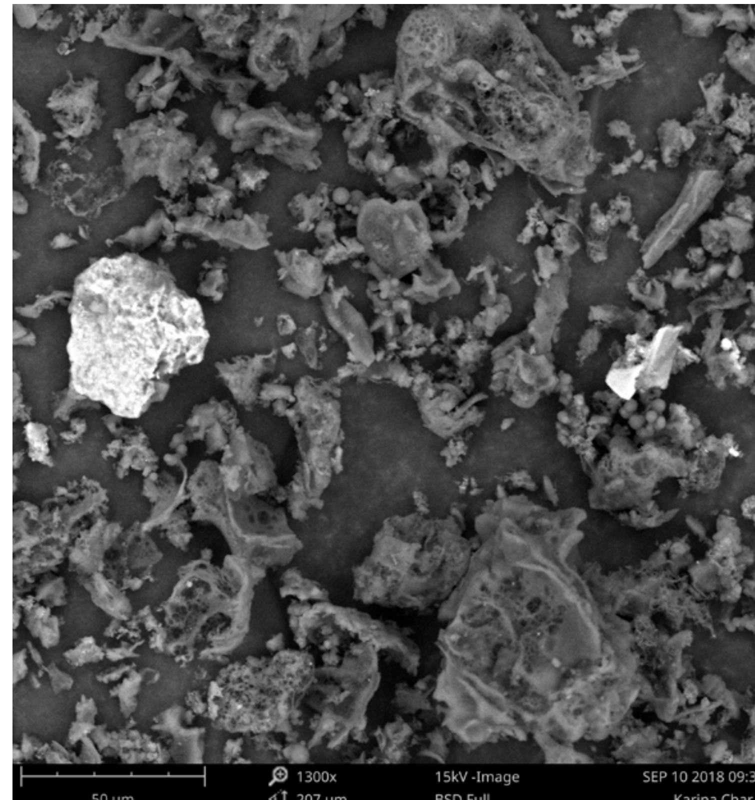
	Composition (%)			
Residence time(min)	Moisture	Volatiles	Fixed Carbon	Ash
10	1.7	44.6	50.3	3.7

Results: BET & BJH

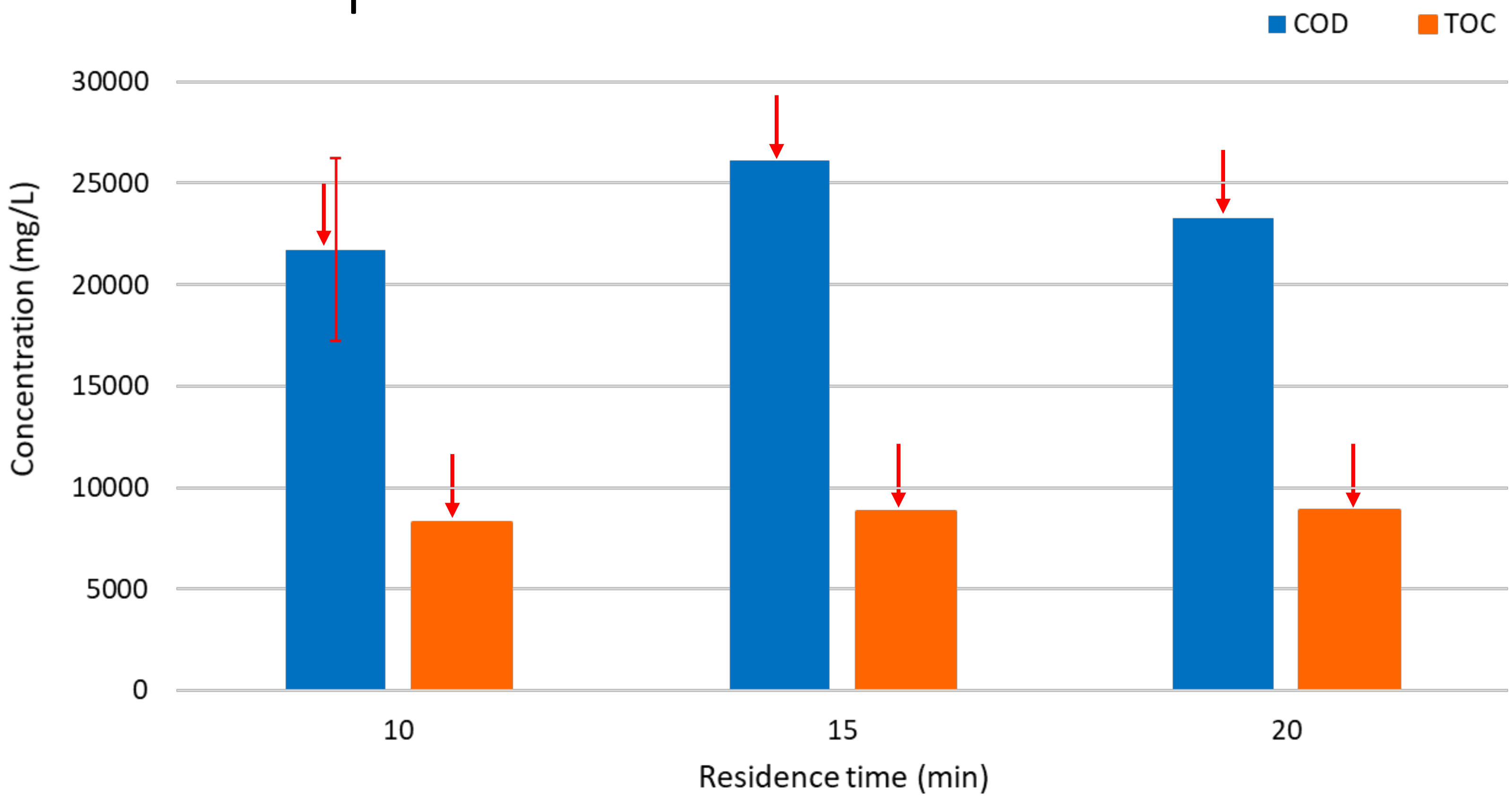
Analysis	Result	
BET surface area	7.651	m^2/g
Langmuir surface area	24.096	m^2/g
BJH Adsorption cumulative surface area of pores	16.746	m^2/g
BJH Desorption cumulative surface area of pores	19.751	m^2/g
BJH Adsorption cumulative volume of pores	0.154	cm^3/g
BJH Desorption cumulative volume of pores	0.155	cm^3/g
Median pore width	13.280	nm

Results: SEM of biochar





Results: Aqueous Phase



Conclusion:

- SCG produced high quality biochar and biocrude
- Residence time had a significant impact on the yields
- Residence time had no significant effect on the quality of the products

Thank you

References

[1]Dell, R.M., and Rand, D.A.J.: ‘Energy storage—a key technology for global energy sustainability’, Journal of Power Sources, 2001, 100, (1), pp. 2-17

[2]Kondamudi, N., Mohapatra, S.K., and Misra, M.: ‘Spent coffee grounds as a versatile source of green energy’, Journal of Agricultural and Food Chemistry, 2008, 56, (24), pp. 11757-11760

[3]Yang, L., Nazari, L., Yuan, Z., Corscadden, K., and Xu, C.C.: ‘Hydrothermal liquefaction of spent coffee grounds in water medium for bio-oil production’, Biomass and Bioenergy, 2016, 86, pp. 191-198

[4]Manju, S., and Chadha, B.S.: ‘Production of Hemicellulolytic Enzymes for Hydrolysis of Lignocellulosic Biomass-Chapter 9’

[5]Passos, C.P., and Coimbra, M.A.: ‘Microwave superheated water extraction of polysaccharides from spent coffee grounds’, Carbohydrate polymers, 2013, 94, (1), pp. 626-633