Lodz University of Technology (TUL)
Faculty of Process & Environmental Engineering

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The influence of temperature and residence time on hydrothermal carbonization of food waste

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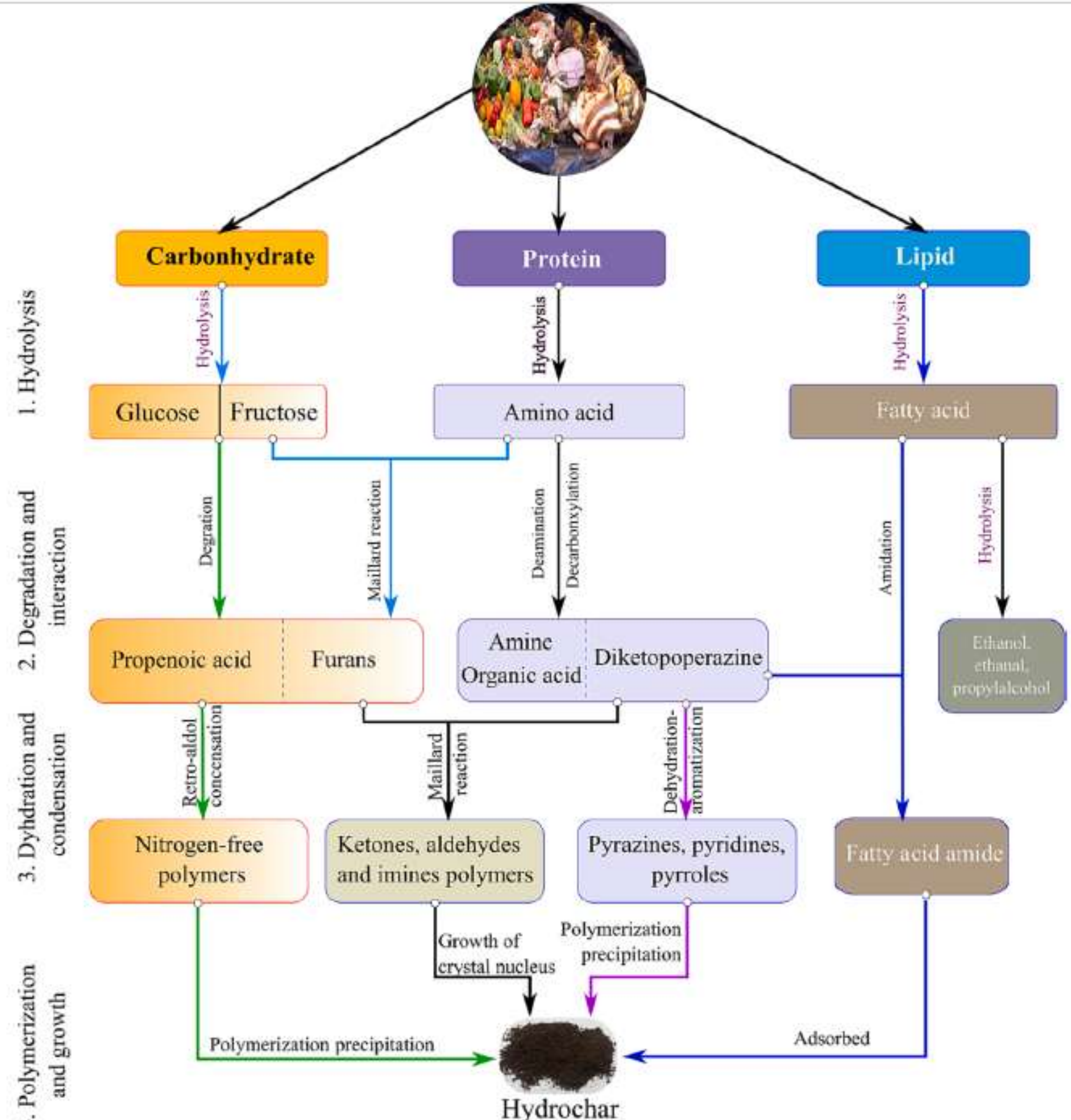
Mechanism of HTC proces



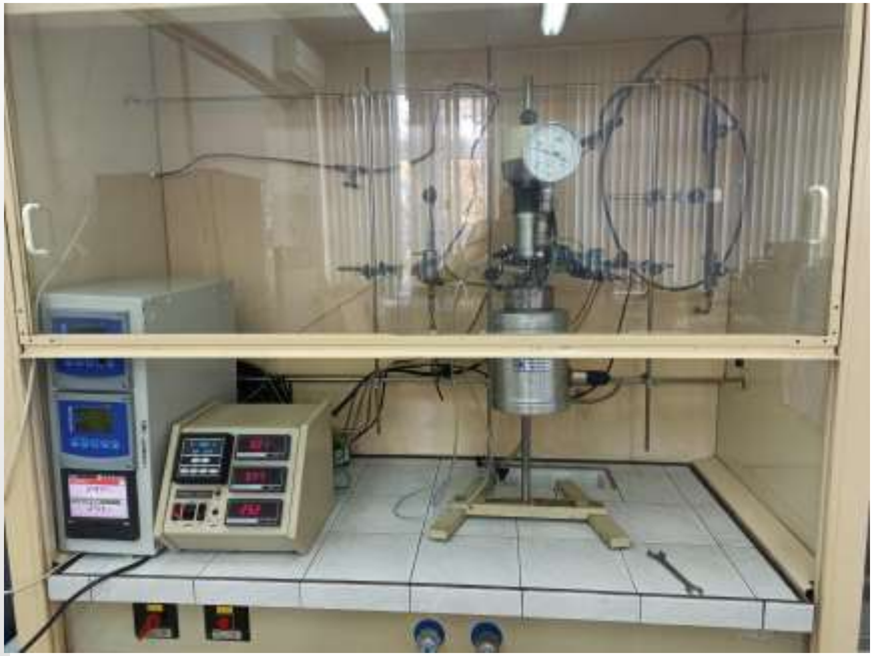
Source: Yang, G., Liu, H., Li, Y., Zhou, Q., Jin, M., Xiao, H., Yao, H., 2022. Kinetics of hydrothermal carbonization of kitchen waste based on multi-component reaction mechanism. Fuel 324, 124693.

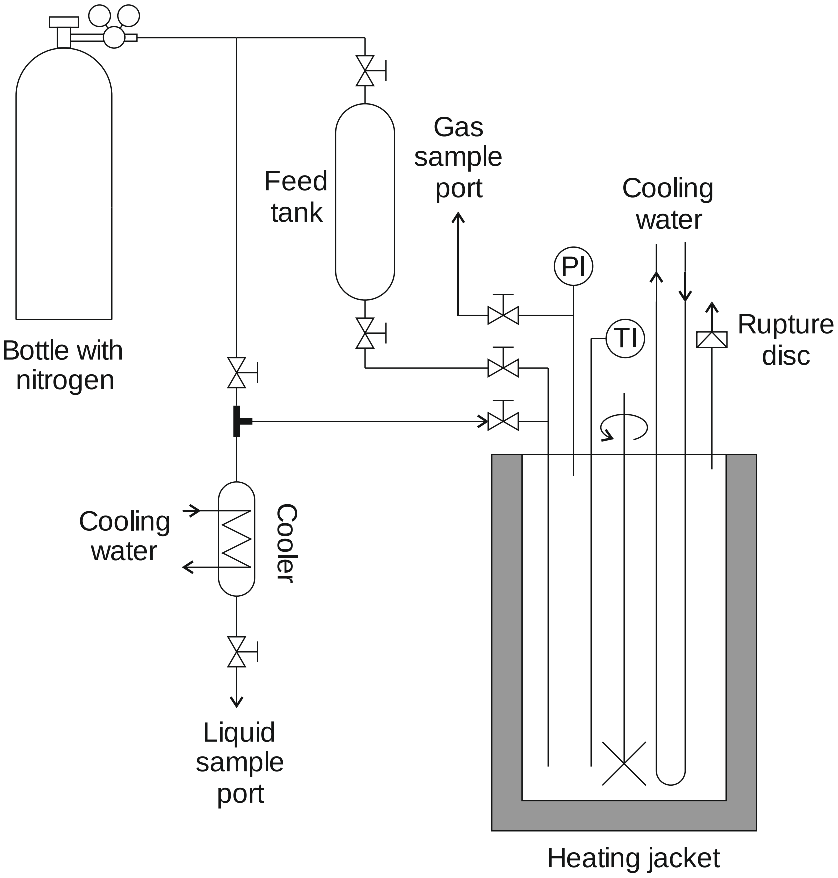
Hydrothermal carbonization process

Infuence of process paramter:

- temperature of the proces,
- residence time of reaction,
- water content,
- pH of environment
- pressure

Experimental set-up of HTC process





Reactor 4563M with unit 4842,
Parr Instrument Company.

Volume: 0.6 L; P_{max} = 90 bar at 300°C

Speed of mixing: 400 rpm

Experimental set-up of HTC process

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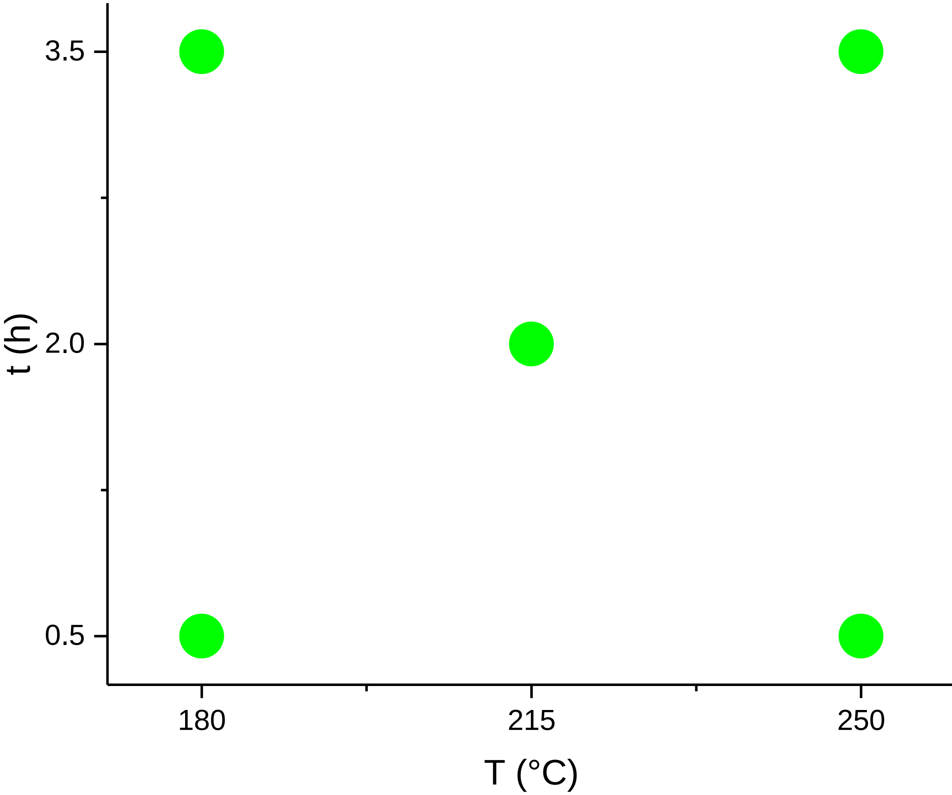
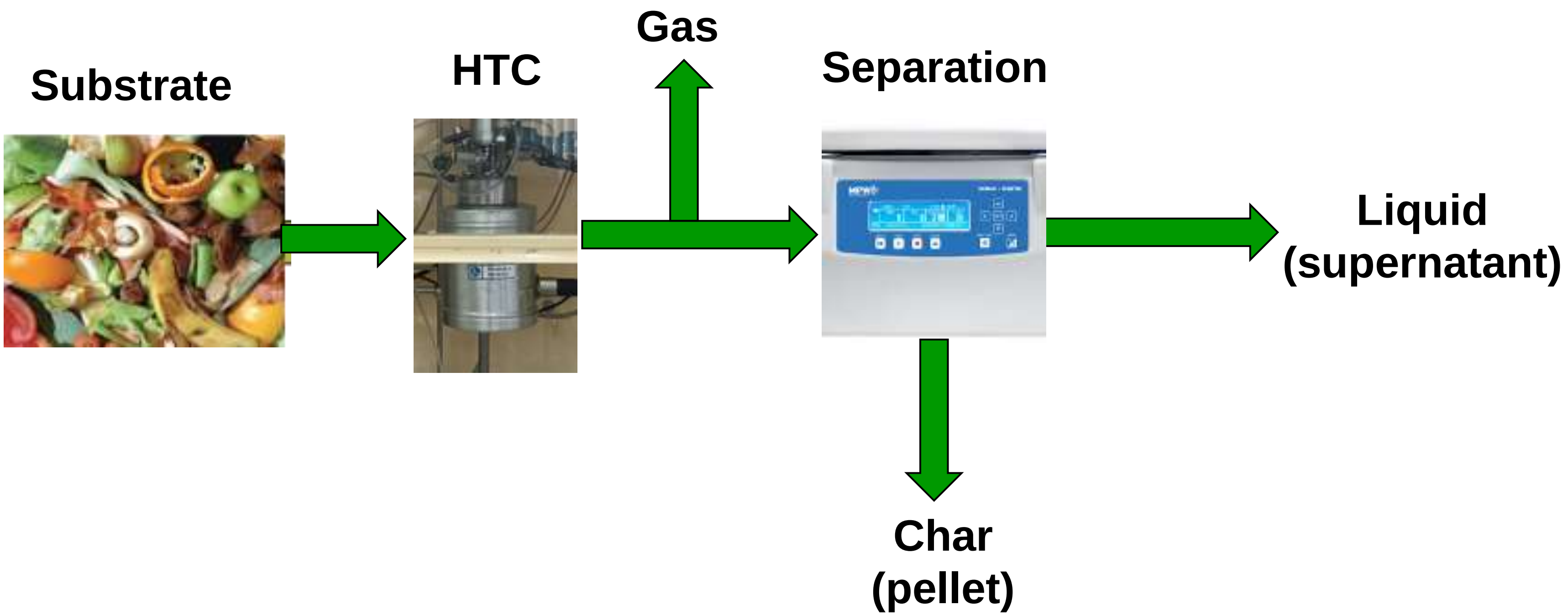
Substrate – Food waste (FW)

FW – 40 g DM (dry matter)
Water – 360 g
Without pH adjustment

Process parameters



Experimental set-up of HTC process



Each experiment was performed in duplicate and the arithmetic average was taken for data interpretation.

Analyses performed

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Solid phase:

- proximate analysis (Mettler Toledo, TGA/SDTA 851eLF),
- ultimate analysis (CE Instrument, NA 2500),
- combustion (Mettler Toledo, TGA/SDTA 851eLF).

Liquid phase:

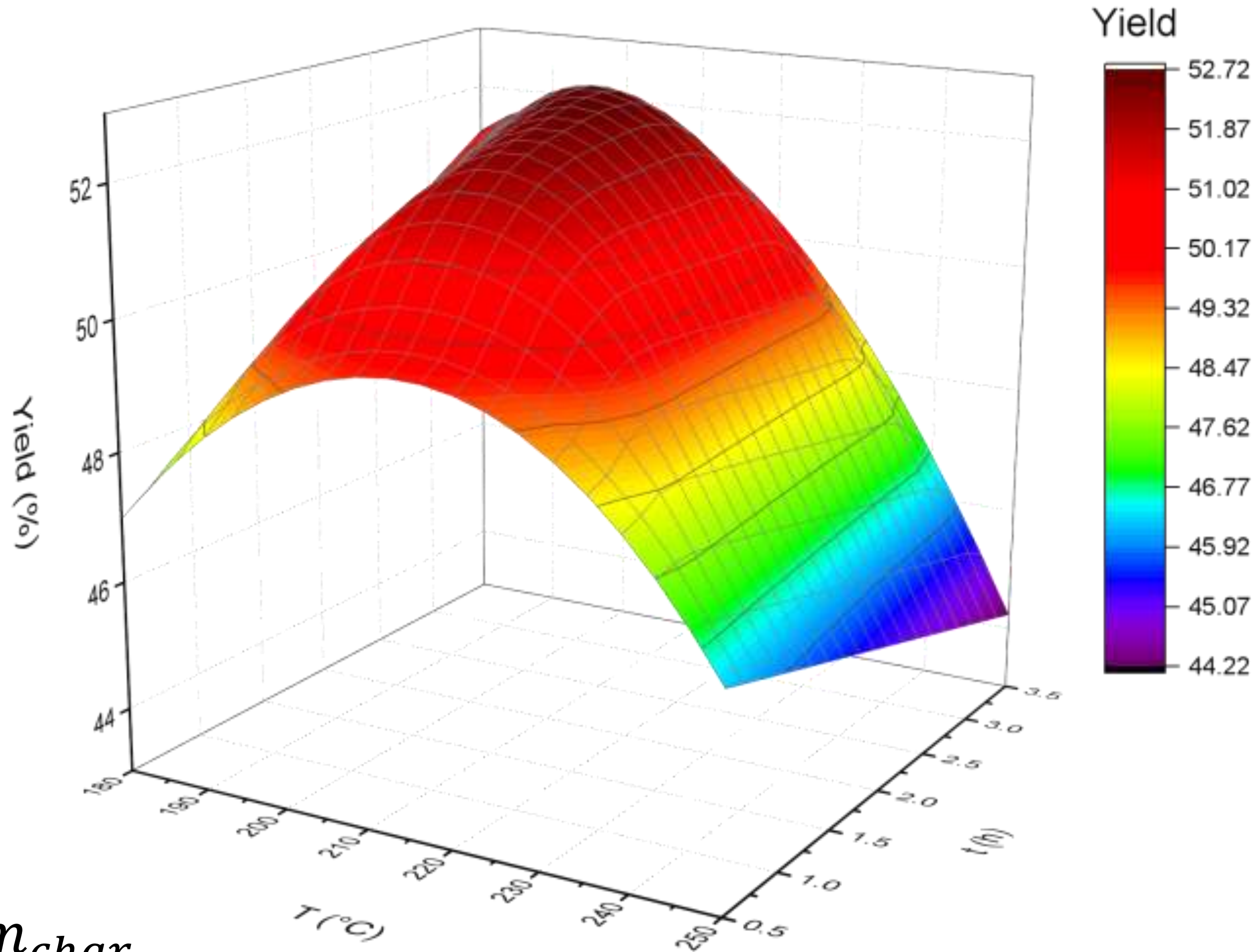
- pH (WTW, pH 540 GLP),
- total organic carbon (TOC) (Lachat Instruments, IL550 TOC-TN),
- total nitrogen bound (TN_b) (Lachat Instruments, IL550 TOC-TN),
- carboxylic acids (GC Varian, CP 3800, column BP21, detector FID).

Gas phase:

- volumetric analysis (water displacement method),
- gas composition (H_2, CH_4, CO, CO_2) (GC SRI Instrument 8610C, column: molecular sieve, silica gel detector TCD).

Each analyses was performed in triplicate and the arithmetic average was taken for data interpretation.

Char production - yield



$$Y_{char} = \frac{m_{char}}{m_{sub}} \cdot 100\%$$

Char production – proximate analysis

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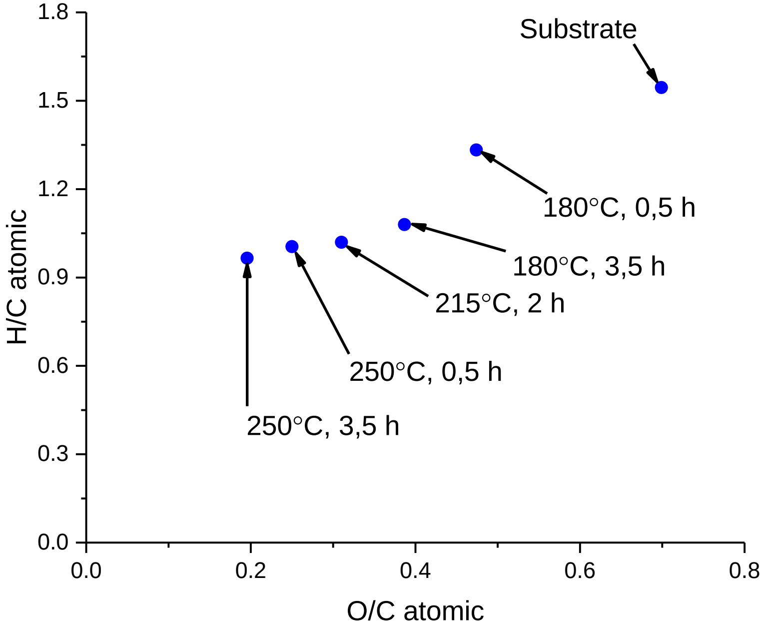
T(°C)	t (h)	M (%)	VM (%)	FC (%)	A (%)	FR (-)
180	0.5	1.15	75.59	21.15	2.11	0.28
180	3.5	1.24	65.35	30.7	2.71	0.47
215	2.0	1.27	60.76	34.16	3.81	0.56
250	0.5	0.73	58.46	34.98	5.83	0.60
250	3.5	0.64	53.2	40.29	5.87	0.76
Substrat (FW)		0.58	70.07	25.02	4.33	0.36

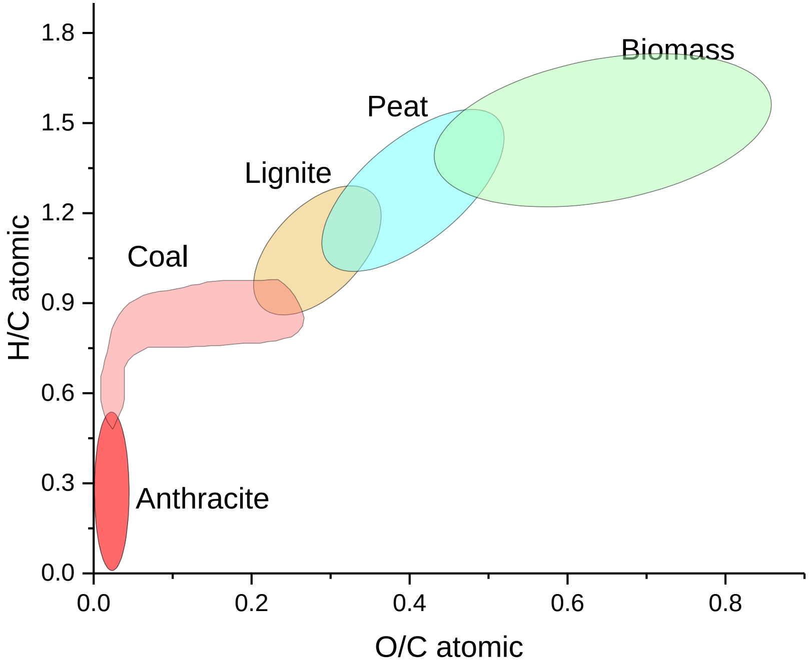
$$Fuel\ ratio\ (FR) = \frac{FC}{VM}$$

M – moisture, VM - volatile matter, FC – fixed carbon, A - ash

Char production – ultimate analysis

Van Krevelen diagram





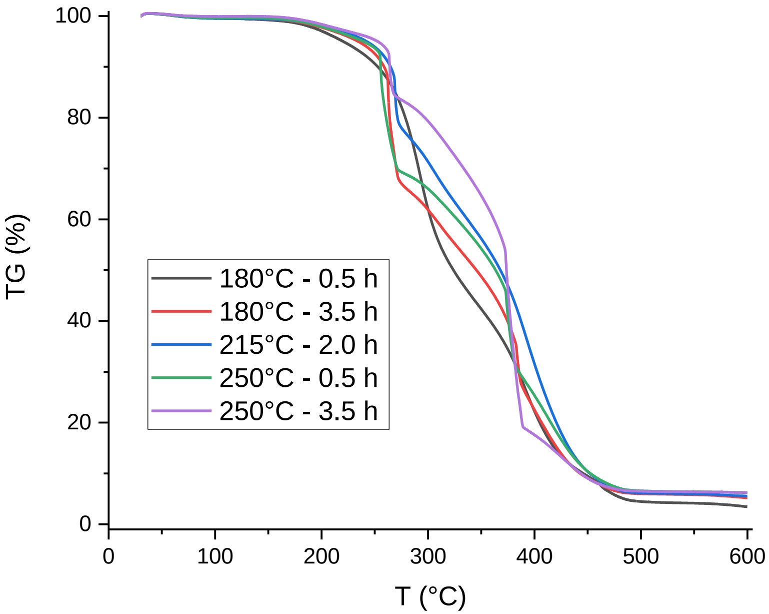
Char production – ultimate analysis

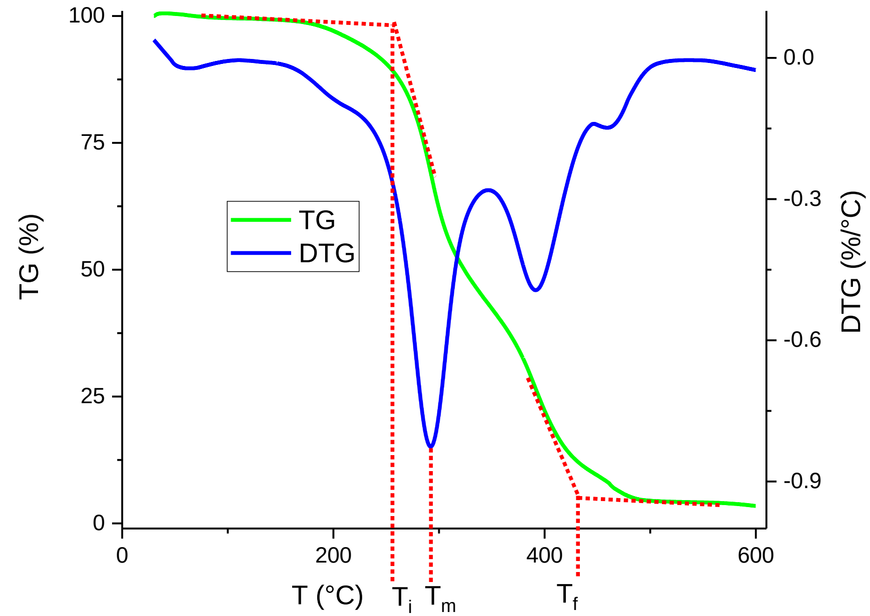
T(°C)	t (h)	HHV (MJ/kg)	ER (-)
180	0.5	22.6	0.58
180	3.5	23.7	0.67
215	2.0	25.5	0.73
250	0.5	26.8	0.68
250	3.5	28.5	0.69
Substrat (KW)		18.3	

$$HHV\left(\frac{MJ}{kg}\right) = 0.3517C + 1.1626H + 0.1047S - 0.111O$$

$$Energy\ recovery\ (ER) = \frac{Y_{char} \cdot HHV_{char}}{HHV_{feedstock}}$$

Char production – TGA

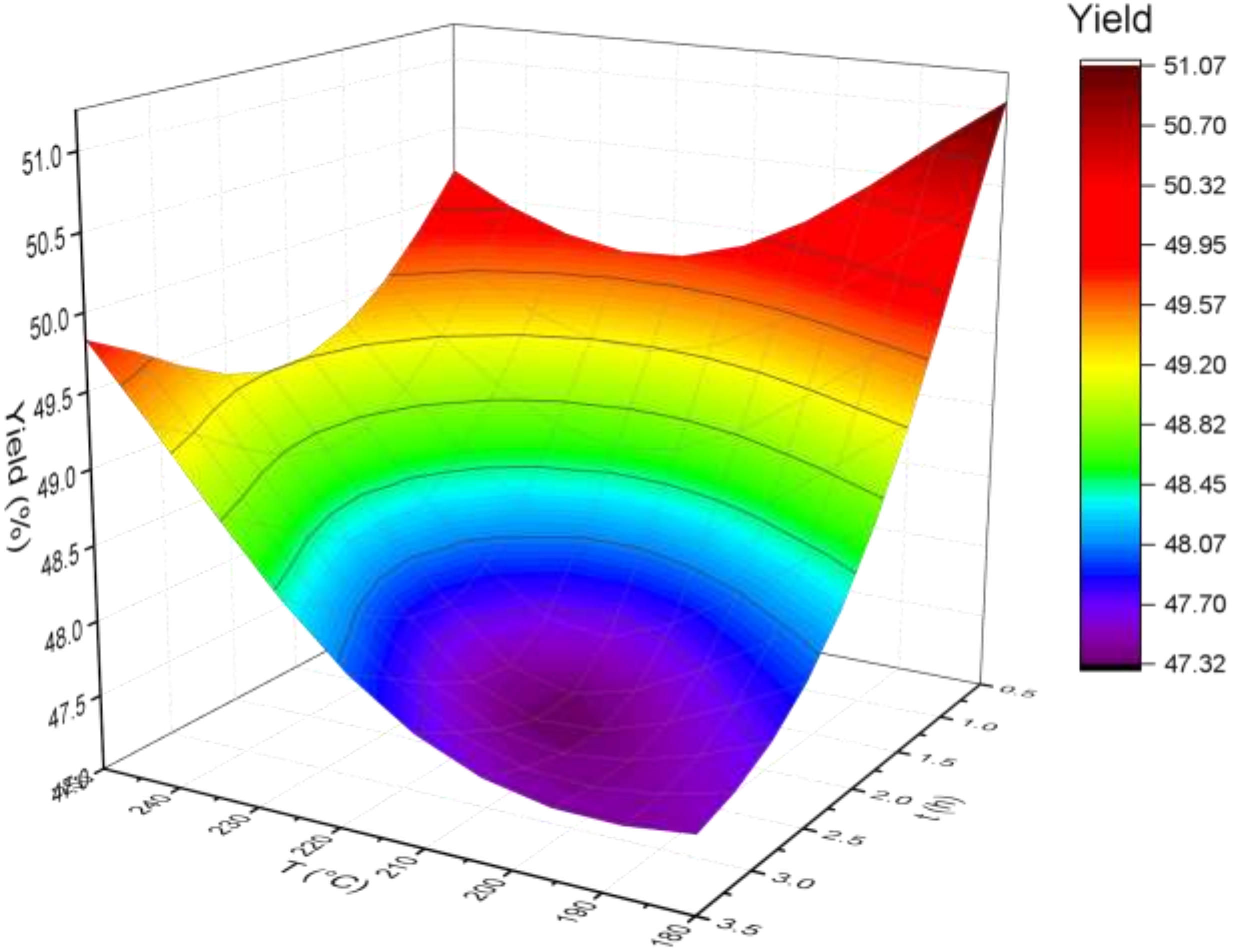




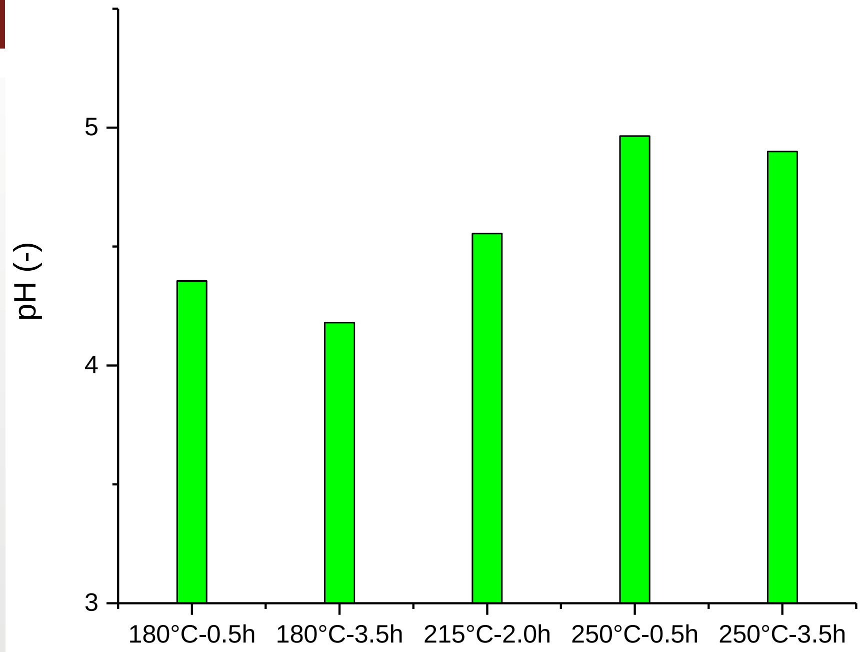
T(°C)	t (h)	T_i (°C)	T_m (°C)	T_f (°C)
180	0.5	262.1	292.3	490.8
180	3.5	266.7	265.1	451.2
215	2.0	273.3	269.9	446.3
250	0.5	259.7	260.4	455.0
250	3.5	269.3	378.1	464.8

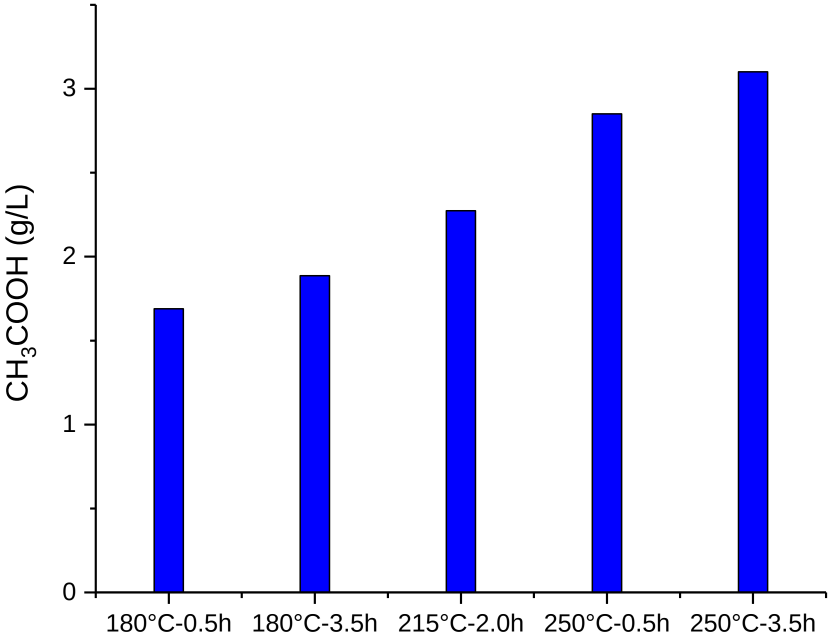
T_i – ignition temperature, T_m – maximum decomposition temperature, T_f – burnout temperature

Oil production - yield

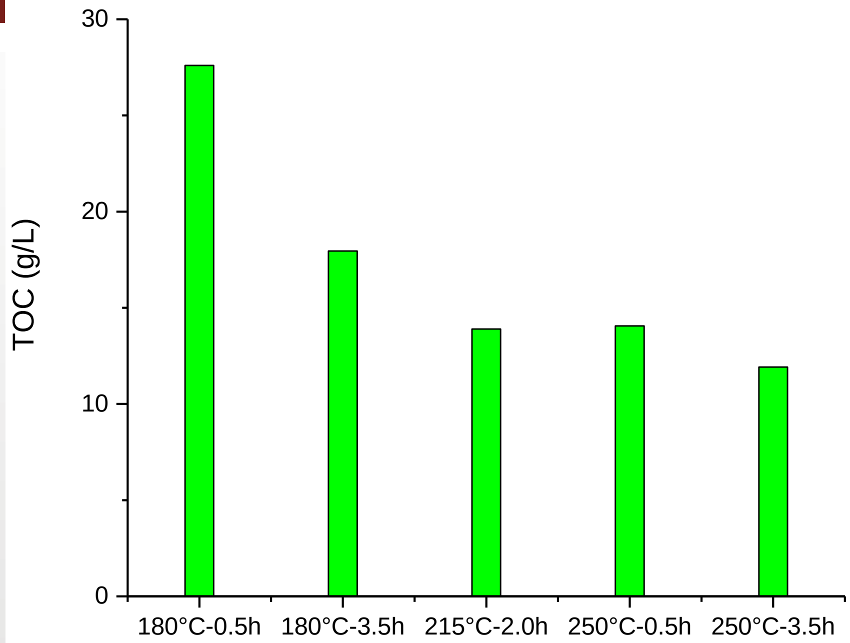


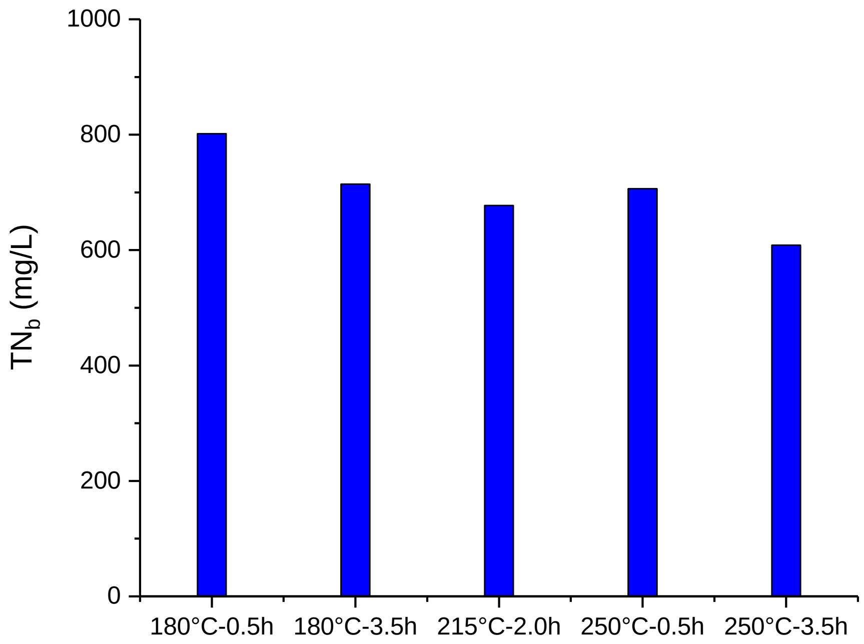
Oil production – pH, acetic acid



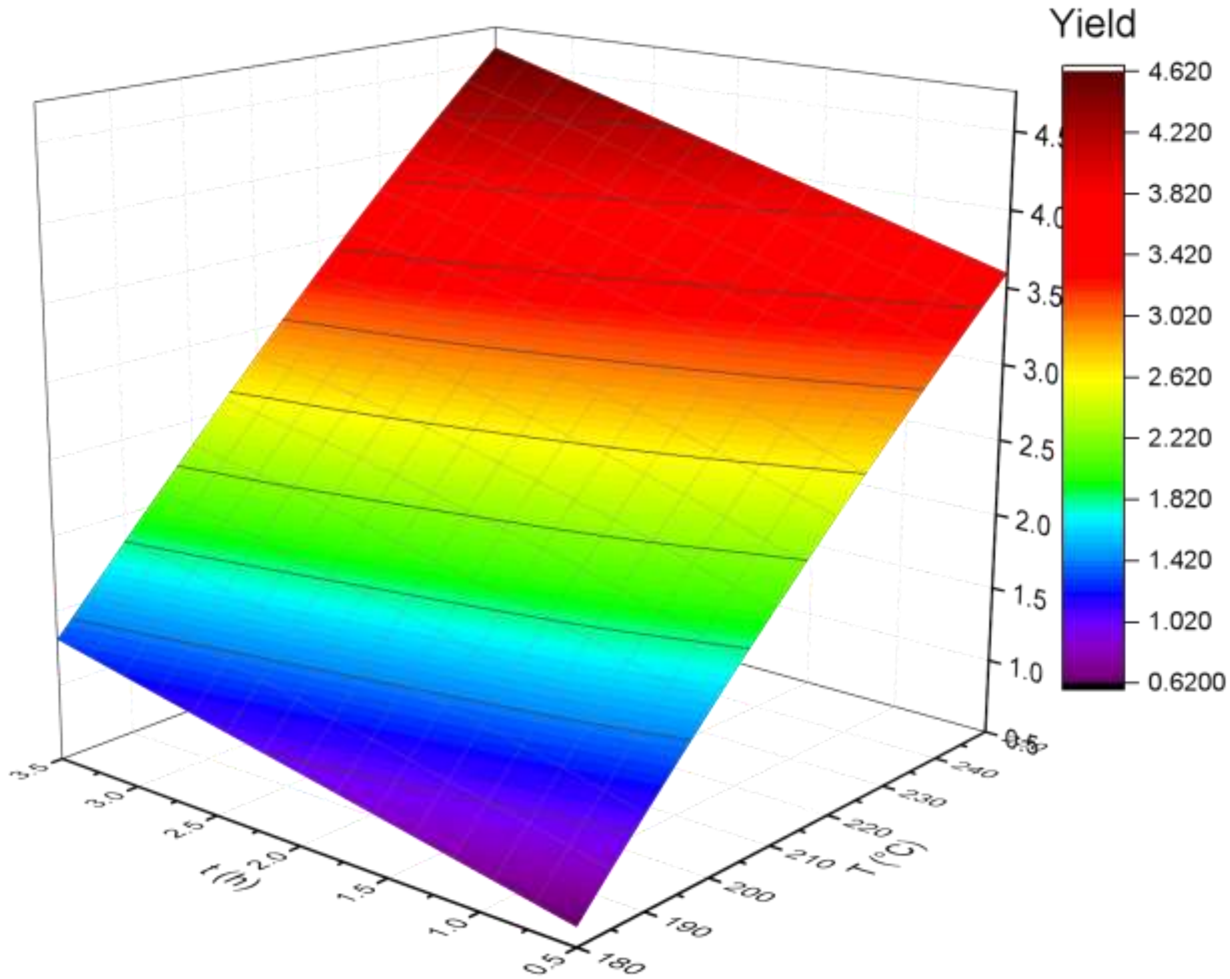


Oil production – TOC, TN_b





Gas production - yield



Conclusions

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Char

- T~ and t ~ yield production of char ↑.
- T↑ and t↑ volatile matter ↓ & fixed carbon ↑, C ↑ & O ↓.

Oil

- Carboxylic acids in liquid contain mainly acetic acid.
- T↑ and t↑ caused increased concentration of acetic acid.
- TOC↓ and TN_b↓ when T↑ and t↑.

Gas

- T↑ and t↑ yield production of gas ↑, containing mainly CO_2.

Thanks for your kind attention ☺

Acknowledgement

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