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Biochar: Production, Characterization and Applications

Proceedings

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Carbon sequestration using bio-refinery residues

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Carbon Sequestration Using Bio-Refinery Residues

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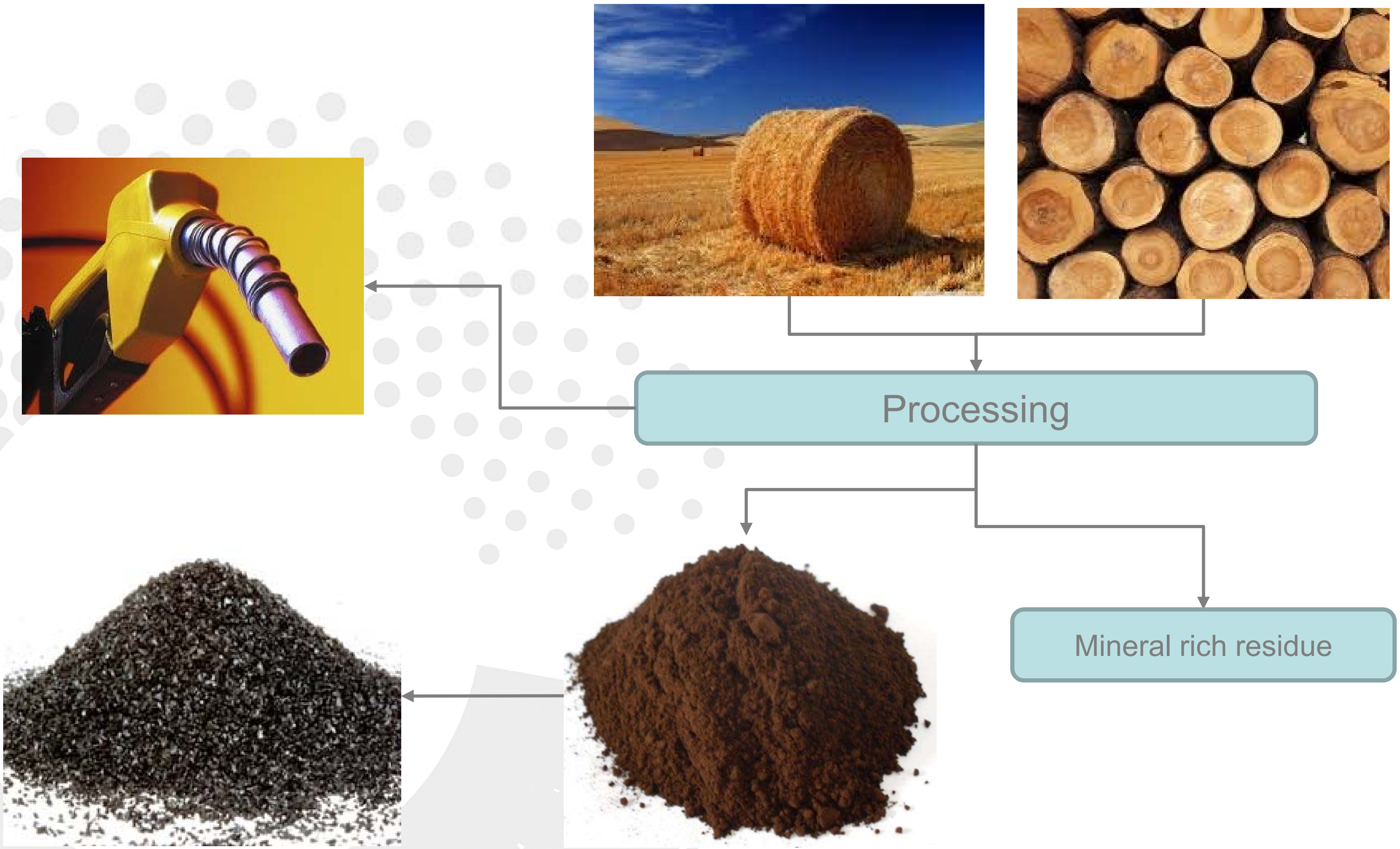
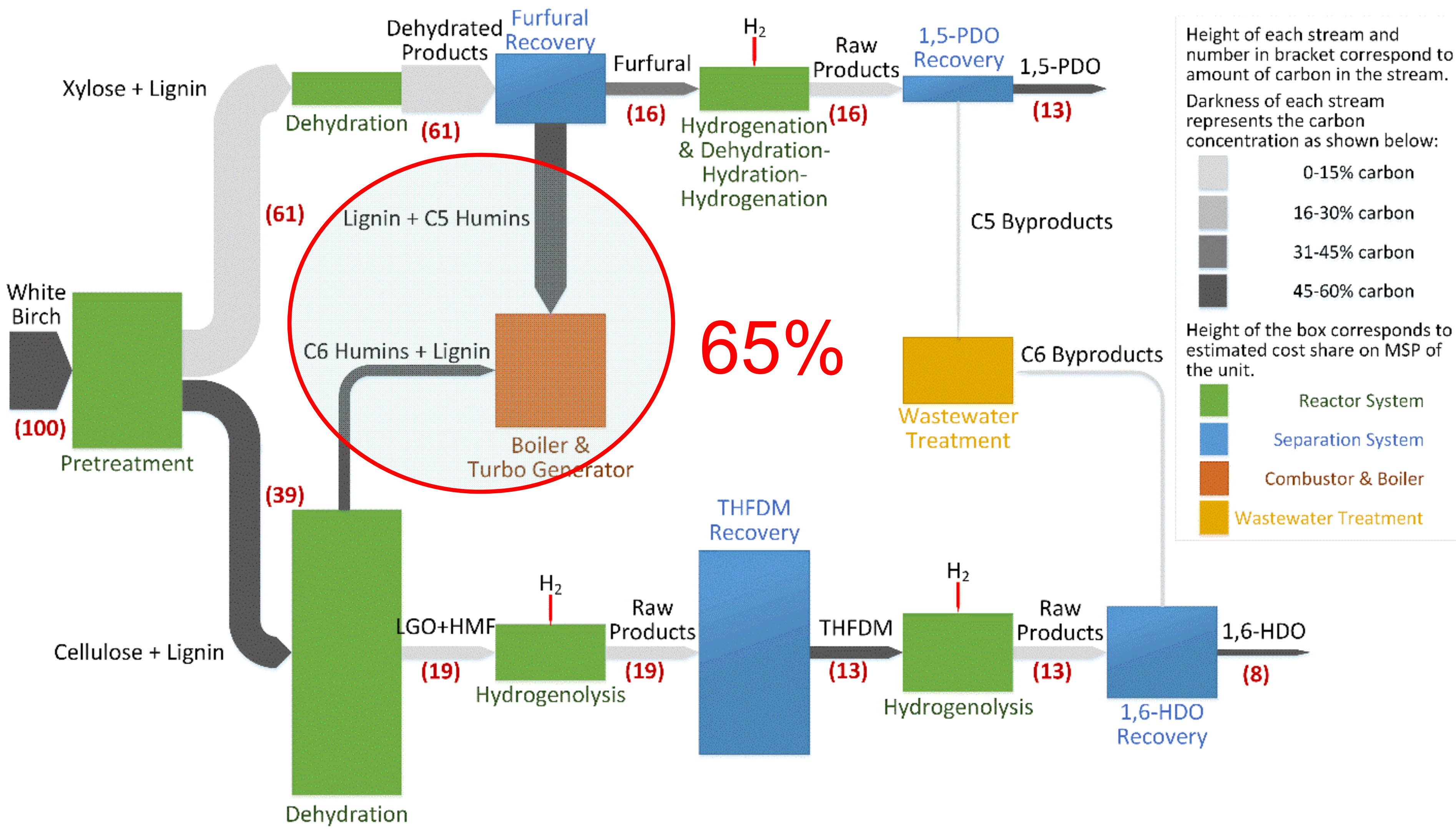
2nd generation biorefinery

- Non-food feedstock can be converted to ethanol or other liquid biofuels, leaving behind lignin-rich and mineral-rich residues that can be utilised in biochar production.



Lignin

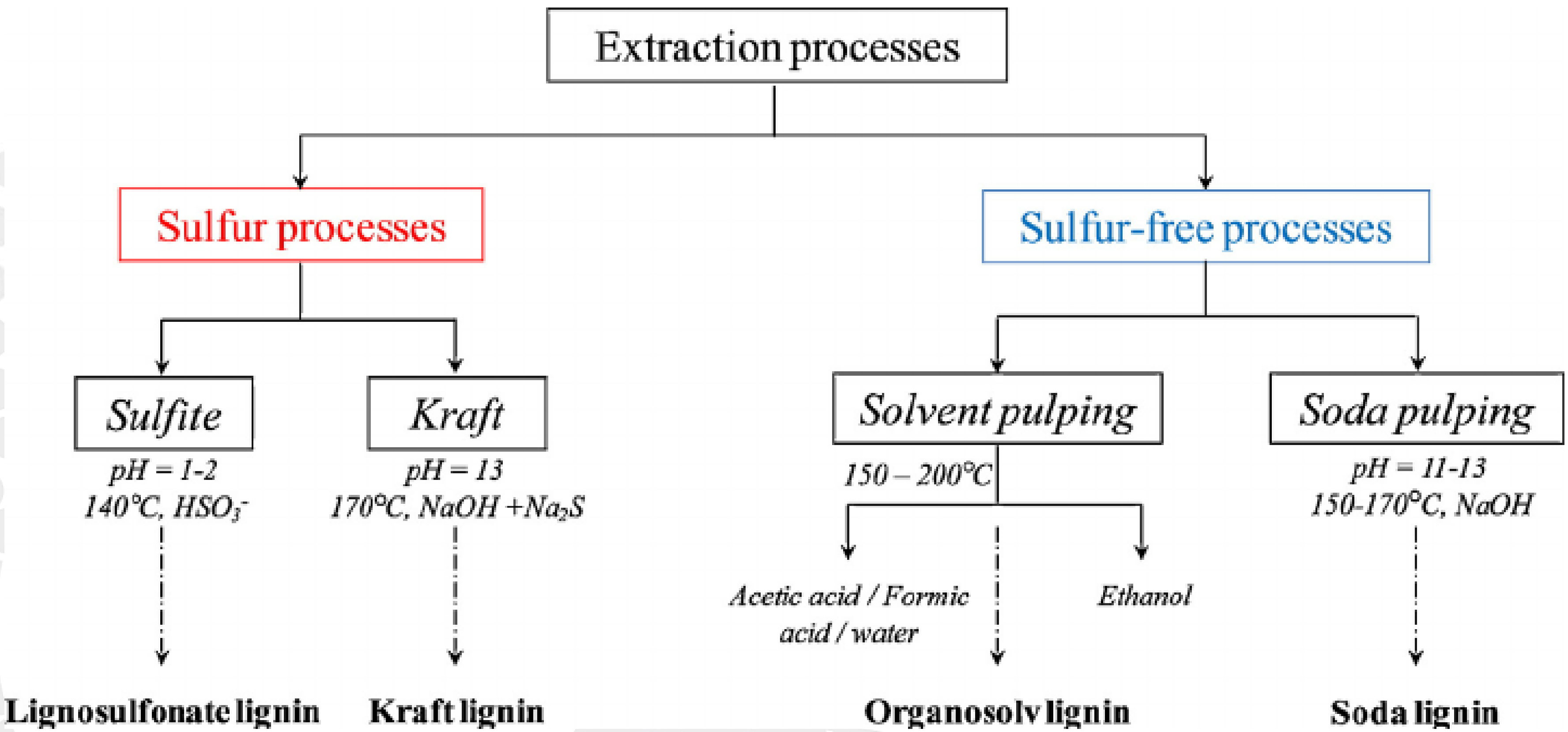
Carbon flows in lignocellulosic biorefinery



Source: https://maravelias.che.wisc.edu/?page_id=734

2^{nd} generation biorefinery

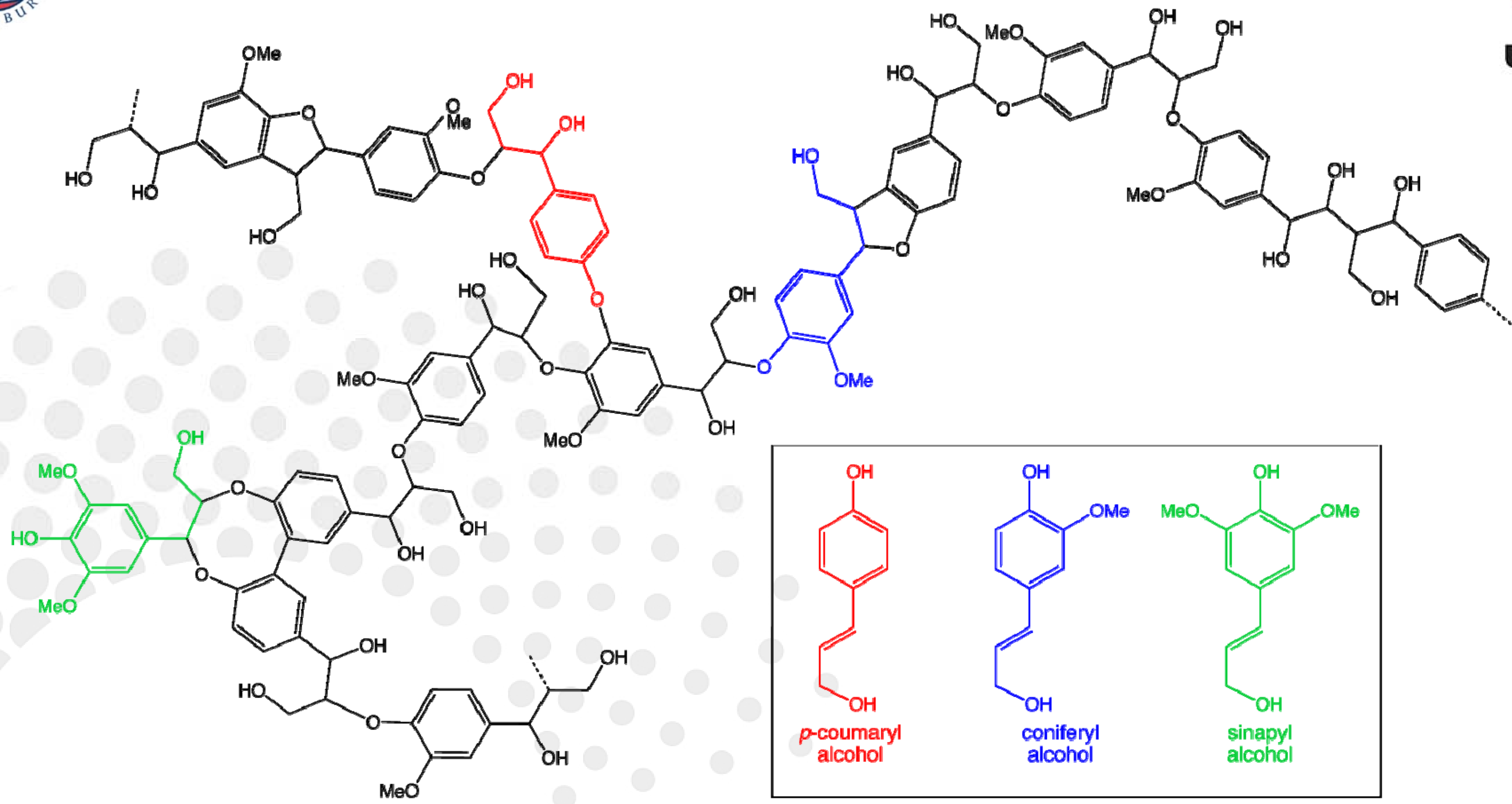
- There are a number of different pre-treatment processes used and under development that yield lignin or lignin-rich residues.



Source: DOI: 10.1016/j.progpolymsci.2013.11.004

- Lignin properties are dependant on feedstock as well as extraction process used

Lignin composition

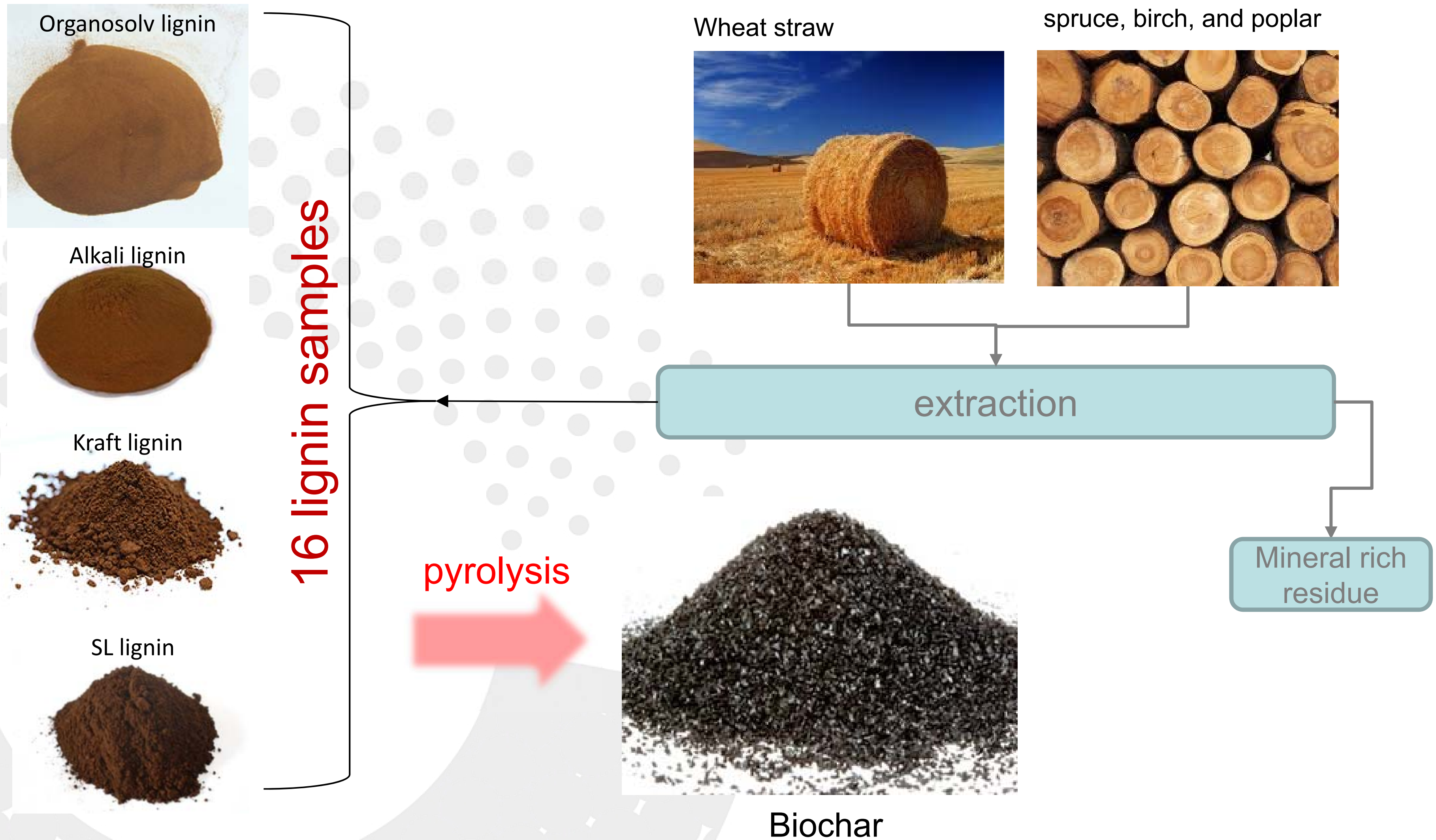


Source:https://www.e-education.psu.edu/egee439/node/665

Lignin Sources	Grasses	Softwood	Hardwood
p-coumaryl alcohol	10-25%	0.5-3.5%	Trace
coniferyl alcohol	25-50%	90-95%	25-50%
sinapyl alcohol	25-50%	0-1%	50-75%

2nd generation biorefinery residues

- Non-food feedstock can be converted to ethanol or other liquid biofuels, leaving behind lignin-rich and mineral-rich residues that can be utilised in biochar production.



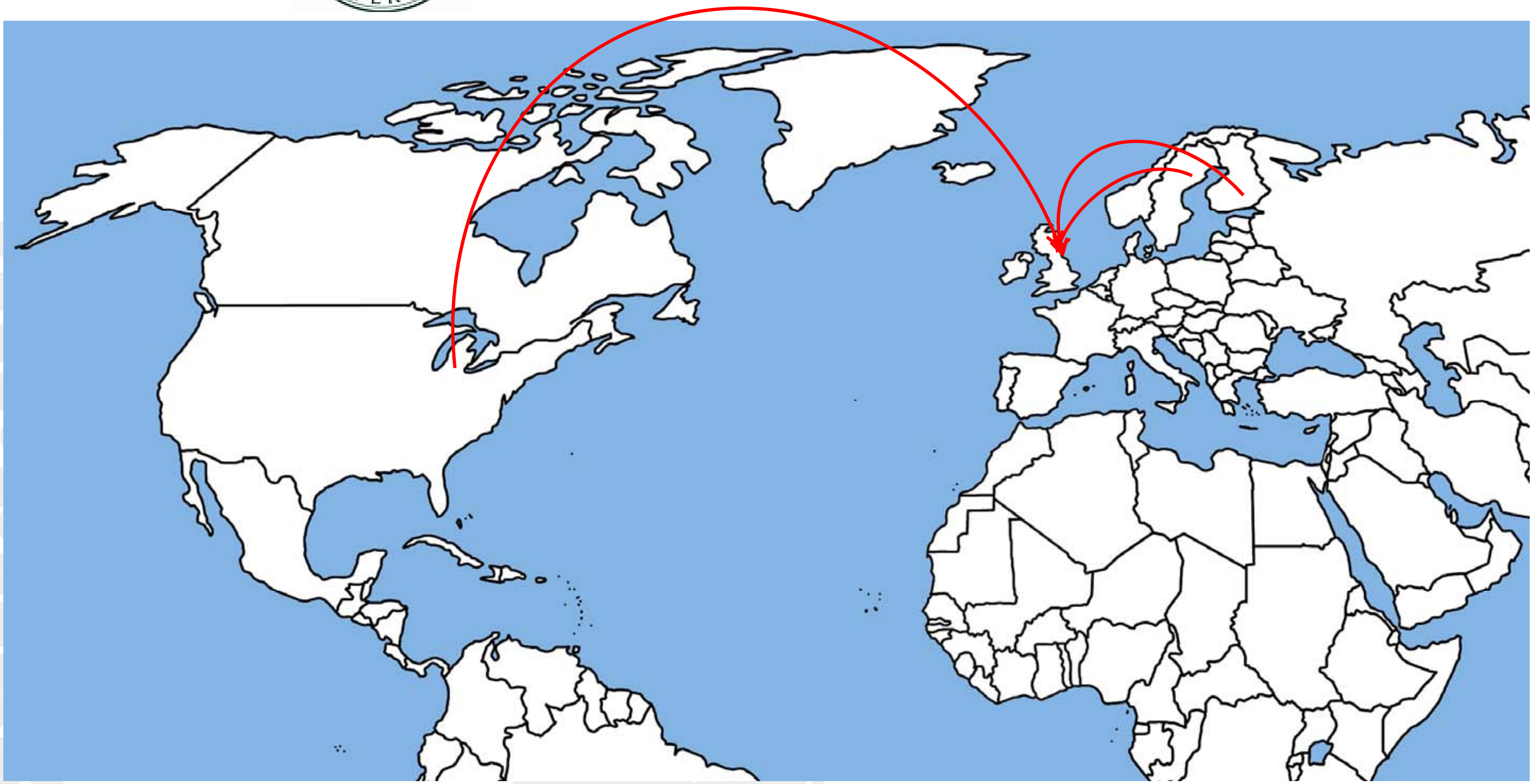
Lignin sources

UKBRC

David Hodge

Ulrika Rova

Tarja Tamminen



Pyrolysis and biochar production research at UKBRC

Scale

STAGE III

Pilot-scale continuous pyrolysis unit with capacity of up to **50 kg/h** of biomass, mean residence time 5-60 min., and temperature range up to 850 °.

STAGE II

Continuous pyrolysis unit with capacity of up to **2 kg/h** of biomass, mean residence time 5-60 min., and temperature range up to 850 °.

STAGE I

Bench-scale batch pyrolysis with capacity of up to **100g**, operating temperature range up to 1100 °C and heating rate from <1°C/min to >100 °C/s.

TGA/ DSC

Automated TGA/DSC instrument for biomass pyrolysis and biochar characterisation, capacity up to **5g**.

Lignin pyrolysis

TGA/ DSC

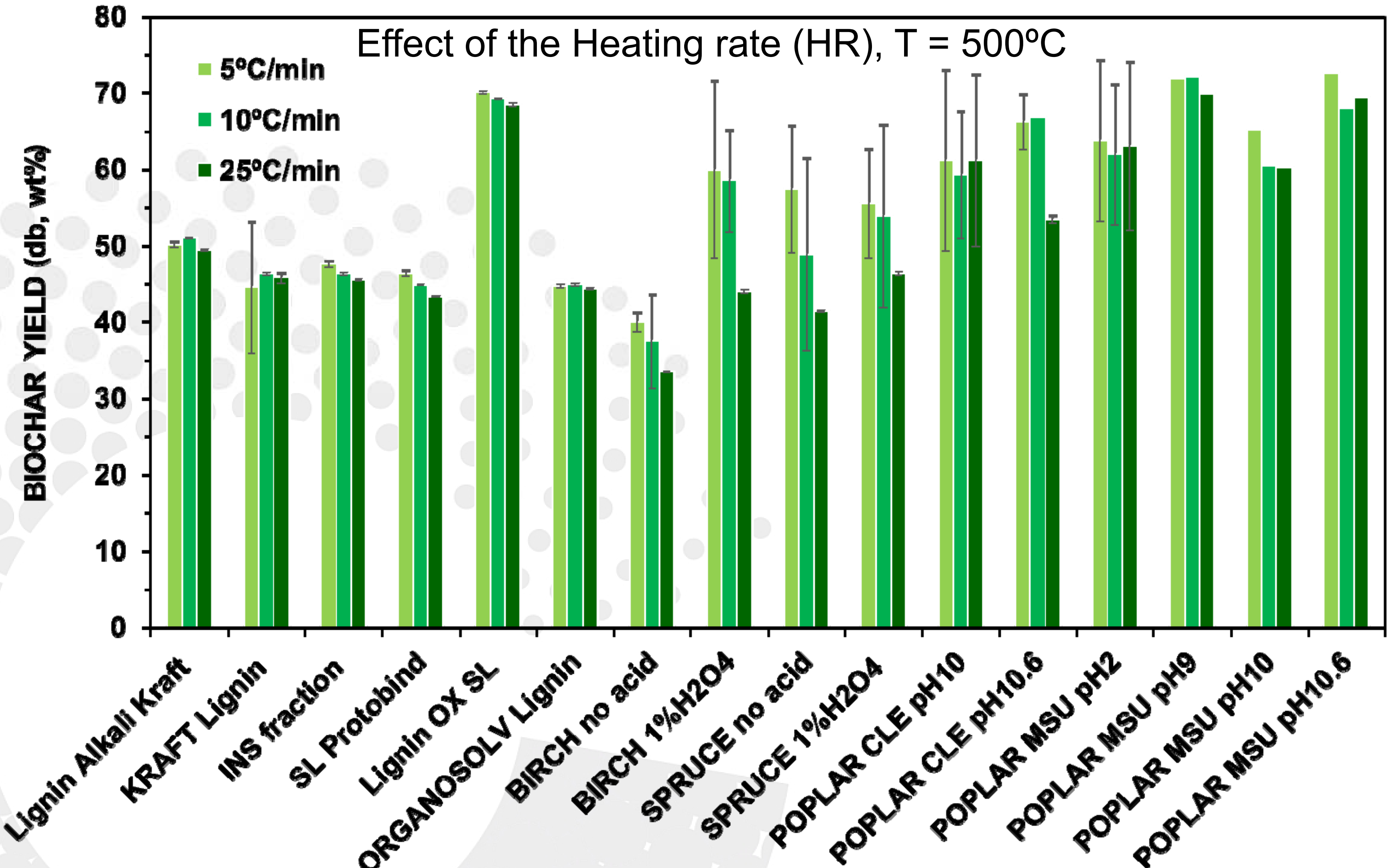
Automated TGA/DSC instrument for biomass pyrolysis and biochar characterisation, capacity up to **5g**.

The pyrolysis experiments in this study were carried out in duplicate in a thermogravimetric analyser (TGA) on 10-15mg samples in 70µl alumina crucibles under these conditions:

- under nitrogen atmosphere
- heating rates: 5, 10 and 25 ℃/min
- peak temperature: 500 and 600 ℃
- Holding time: 40 min.

Following pyrolysis, the biochar samples were subjected to proximate analysis using the same instrument.

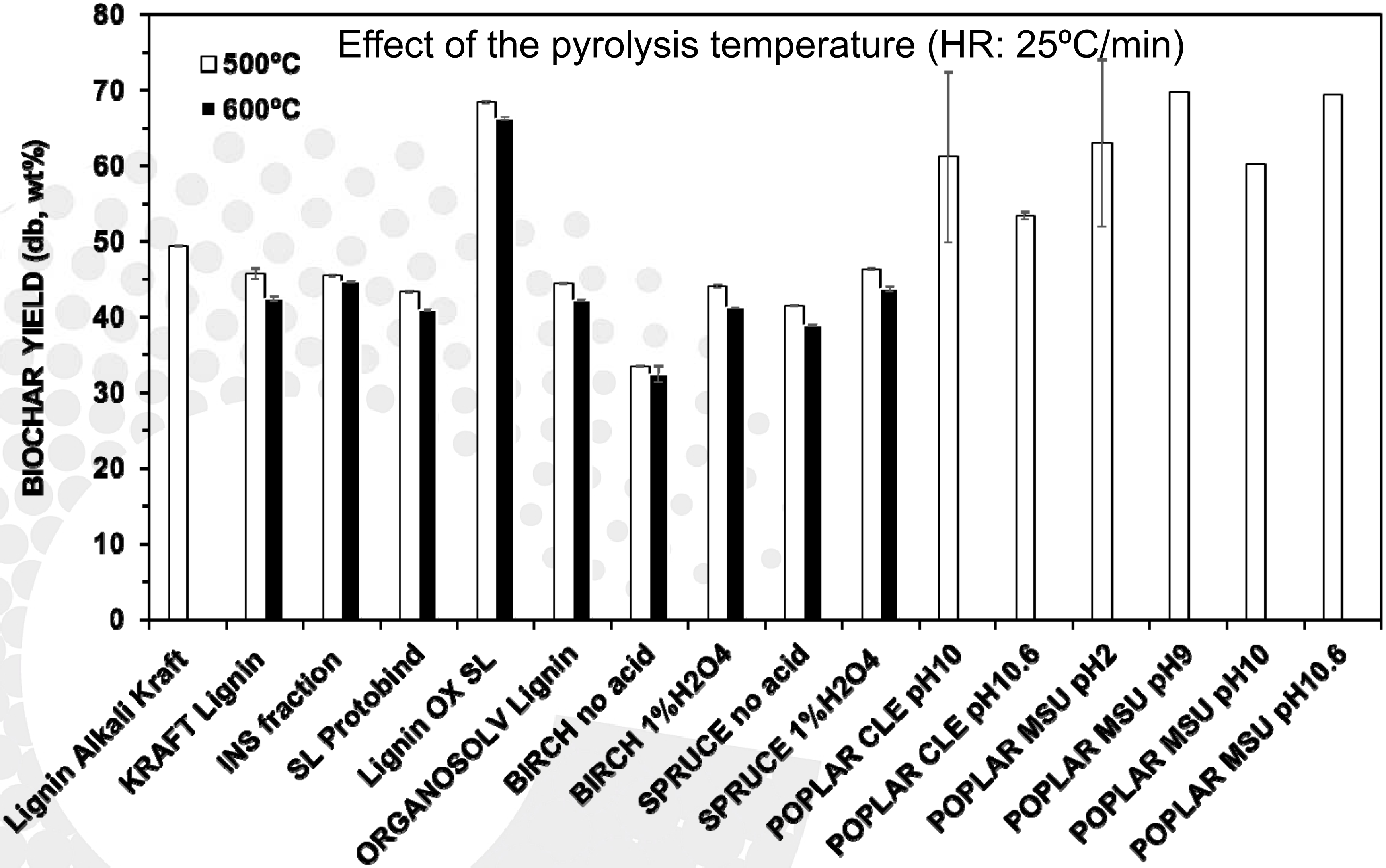
Carbon sequestration potential of biorefinery lignin residues – char yield



Yield of biochar from pyrolysis of lignin at 500 ℃ as a function of feedstock and heating rate (in range from 5 to 25 ℃/min.)

O. Mašek et al., Alba, Italy, 23rd August 2017

Carbon sequestration potential of biorefinery lignin residues – char yield



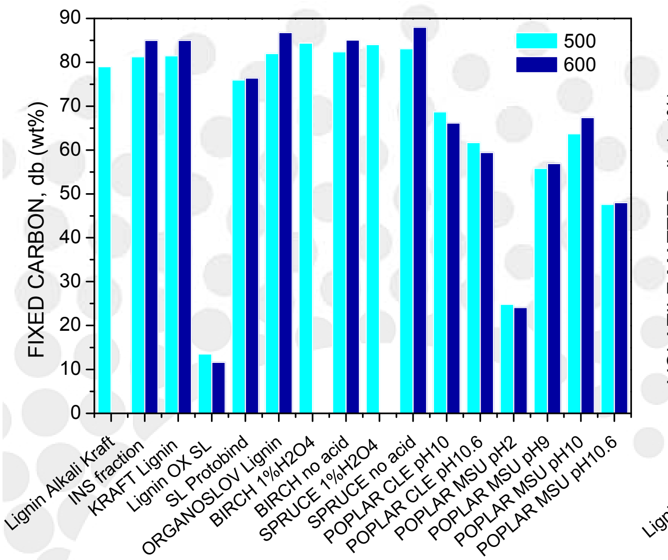
Yield of biochar from pyrolysis of lignin at 500 ℃ and 600 ℃, and heating rate of 25 ℃/min.

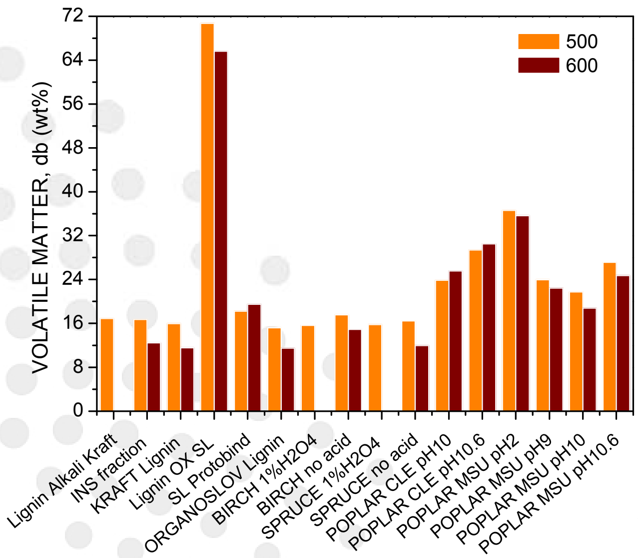
O. Mašek et al., Alba, Italy, 23rd August 2017

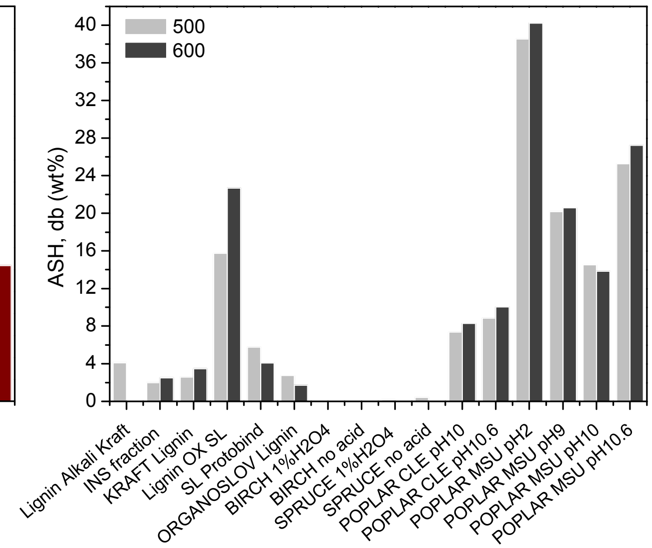
Carbon sequestration potential of biorefinery lignin residues – relative char carbon stability

UKBRC

PROXIMATE ANALYISIS (wt%, dry basis) of LIGNIN CHARS obtained at 500 and 600ºC



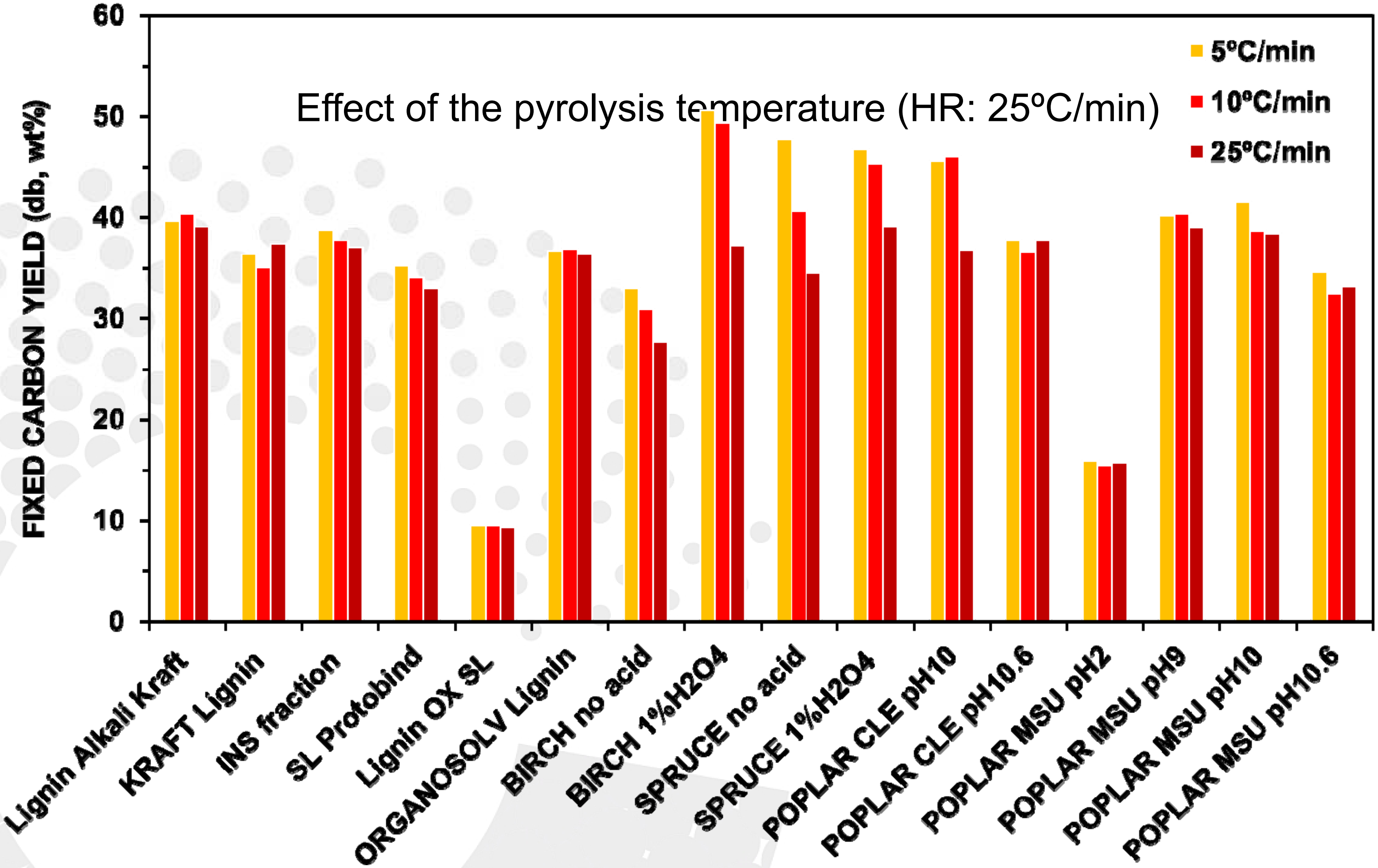




Proximate analysis showed significant differences in char composition from different types of lignin, in terms of ash content, volatile and fixed carbon content.

The ash content in biochar varied from under 0.2 wt% up to 40 wt%, while the content of volatile matter varied from under 15 wt% to over 70 wt%.

Carbon sequestration potential of biorefinery lignin residues – fixed carbon yield



Yield of fixed carbon from pyrolysis of lignin at 500 ℃ as a function of feedstock and heating rate (in range from 5 to 25 ℃/min.)

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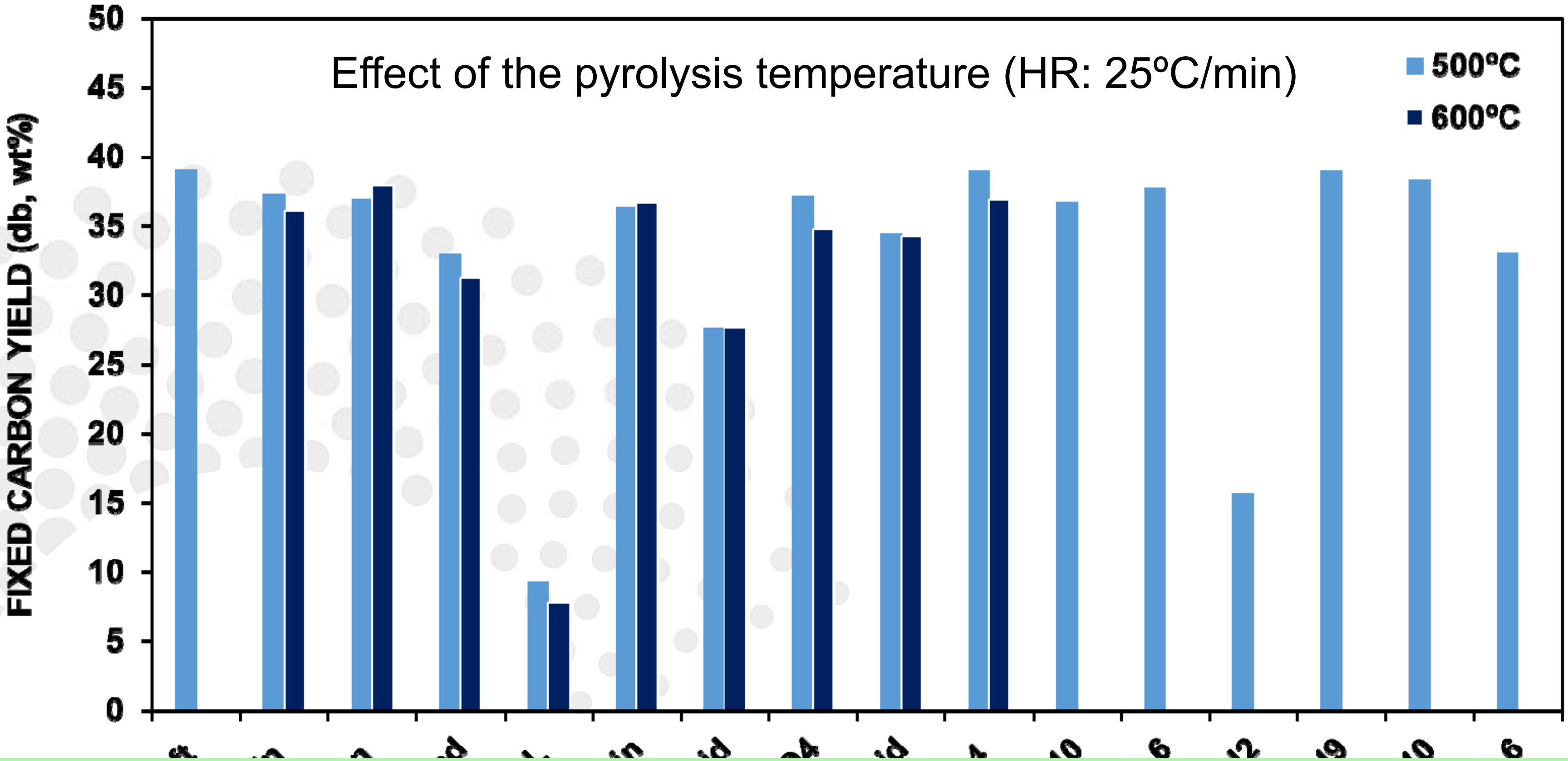
Carbon sequestration potential of biorefinery lignin residues – char yield



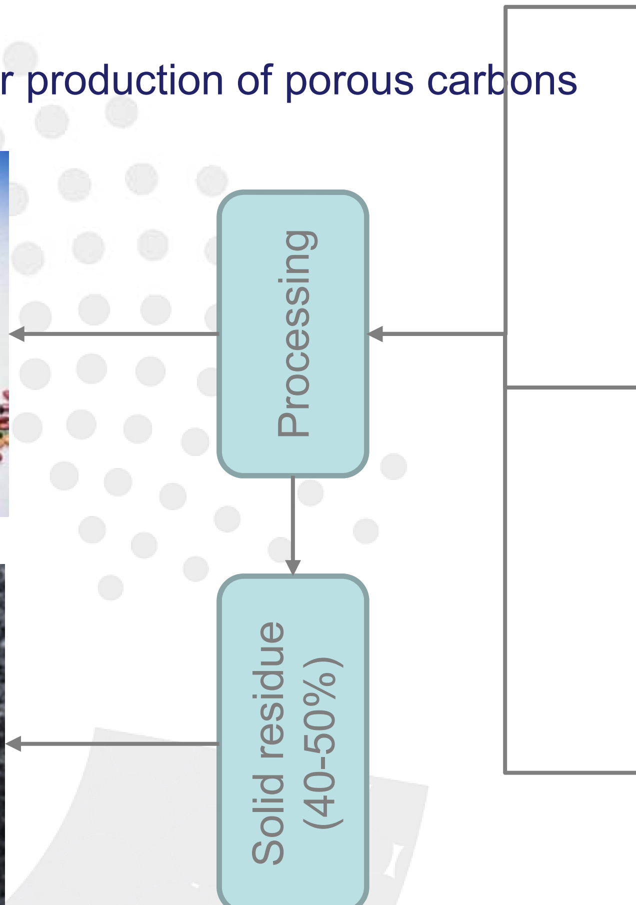
The yield of fixed carbon (FC can be considered a proxy for environmentally recalcitrant carbon) showed similar trends to biochar yields for all samples with the exception of two lignins that showed much lower yields of fixed carbon despite high biochar yields

Yield of fixed carbon from pyrolysis of lignin at 500 ℃ and 600 ℃, and heating rate of 25 ℃/min.

Marine biomass (macro algae) biorefinery

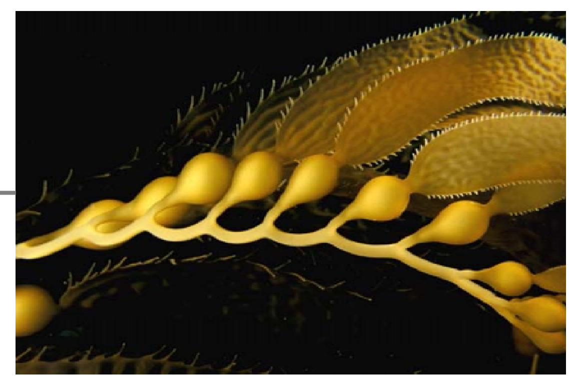
UKBRC

- Macroalgae are a rich source of valuable chemicals and materials, among other alginate
- Mineral rich residues after extraction of compounds of interest
- Very suitable feedstock for production of porous carbons



Laminaria hyperborea

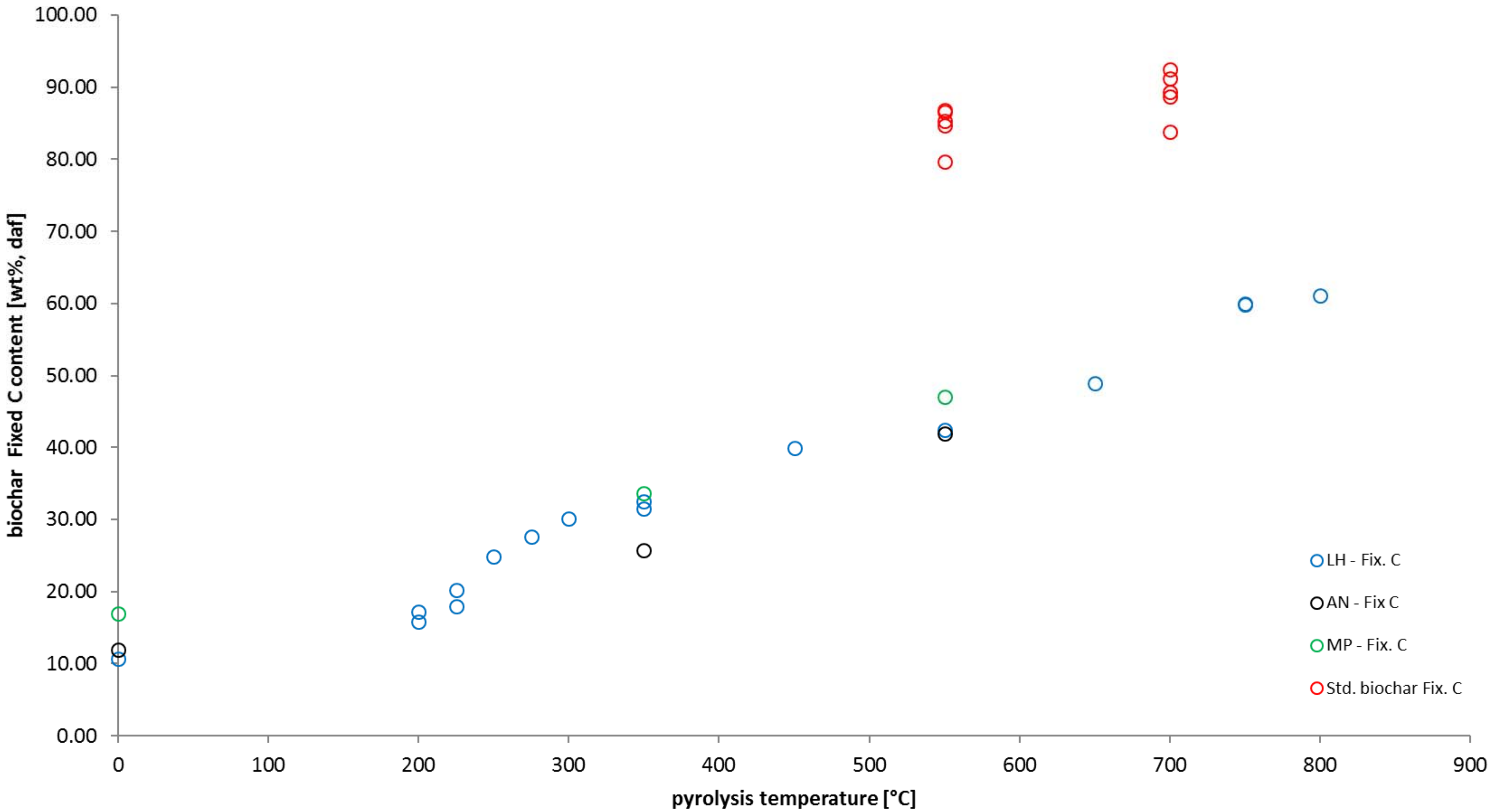
Ascophyllum nodosum



Macrocystis Pyrifera

Carbon sequestration potential of marine biomass biorefinery residues

- The fixed carbon content (stability of biochar carbon) increases with pyrolysis temperature
- The fixed carbon content of seaweed residue-derived biochar is considerably lower than that in biochar from terrestrial biomass, suggesting lower relative stability of contained carbon.



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Conclusions

- There are large differences among different lignin samples in terms of their thermal conversion and the product yield distribution
- Biochar yield and stability depend on the feedstock used and extraction process, and in some cases also on the pyrolysis conditions used (heating rate)
- From carbon sequestration perspective, lignin provides an excellent feedstock for biochar production due to the high yield and high carbon stability

Acknowledgement

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Thank you!

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