Engineering Biochar for Catalytic Applications

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Western Engineering

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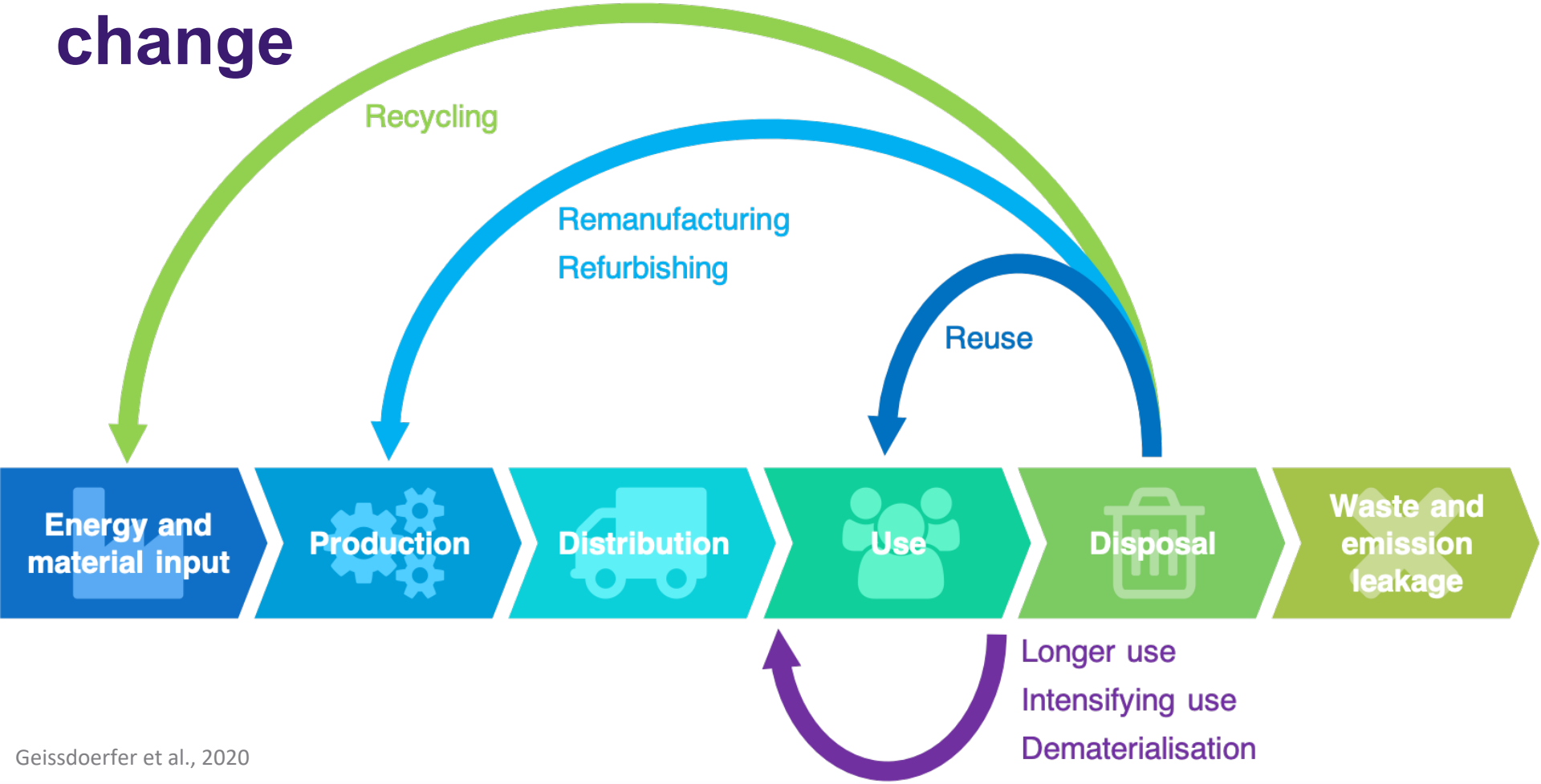
Outline

1. What is a circular economy?
2. What is biochar?
3. How can we modify biochar properties to improve its catalytic ability?
4. How can biochar contribute to a circular economy?
5. What's next?

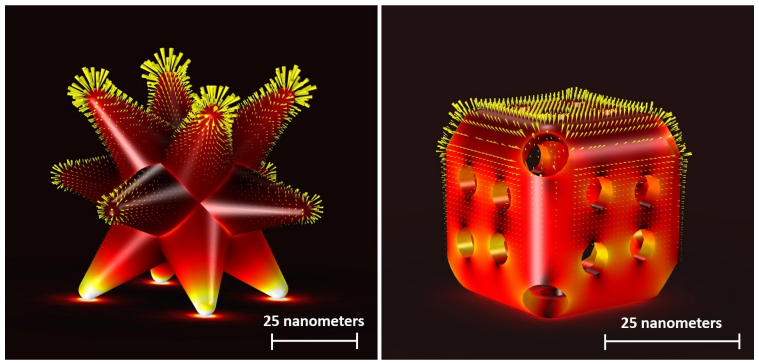
What is a circular economy?

A circular economy is a crucial contributor to our fight against climate change

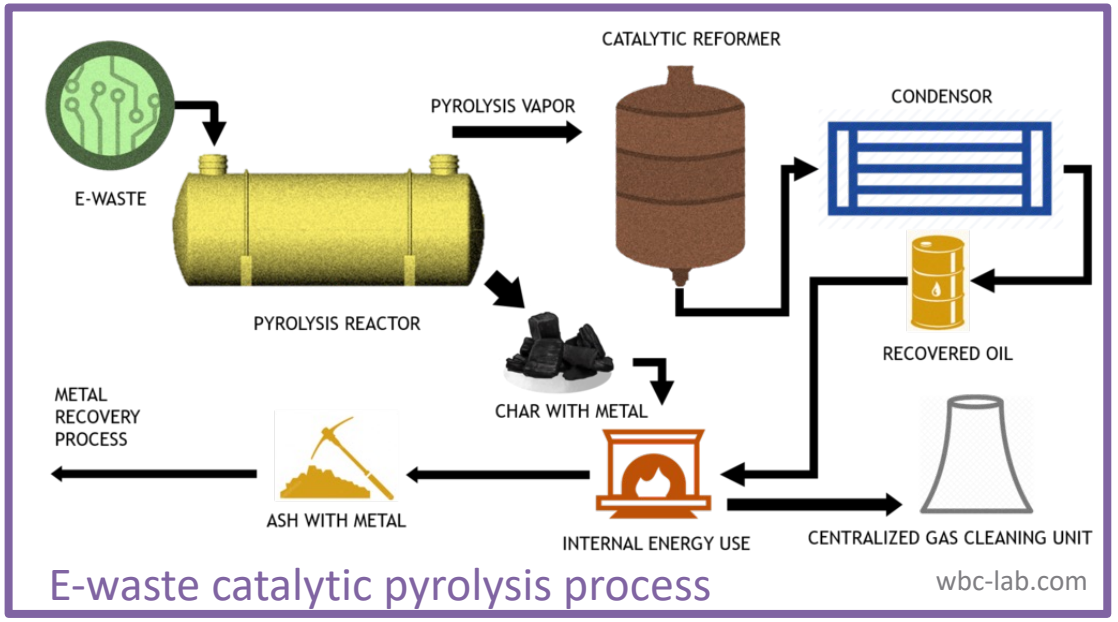


Geissdoerfer et al., 2020

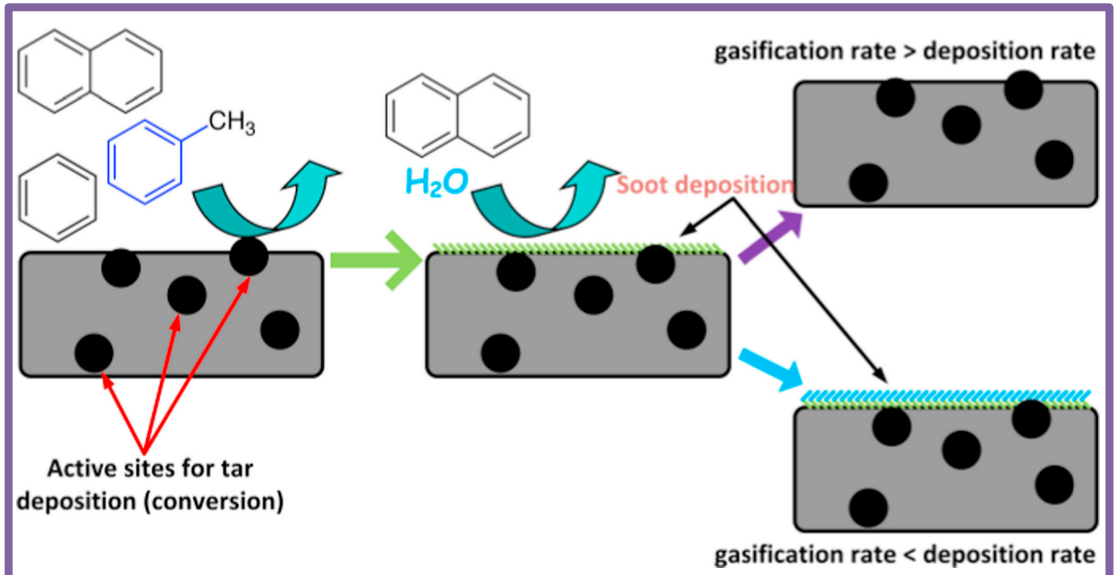
Several green conversion processes require the use of expensive, environmentally straining catalysts



Nanoscale electrocatalysts Li et al., 2021

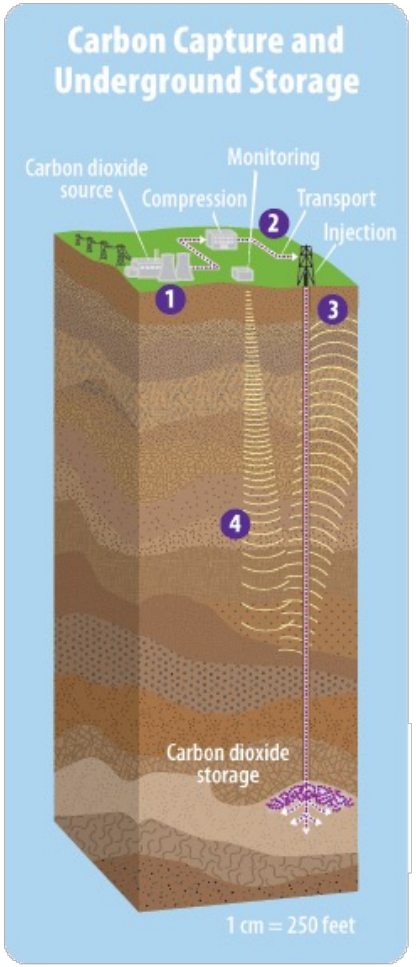


E-waste catalytic pyrolysis process wbc-lab.com

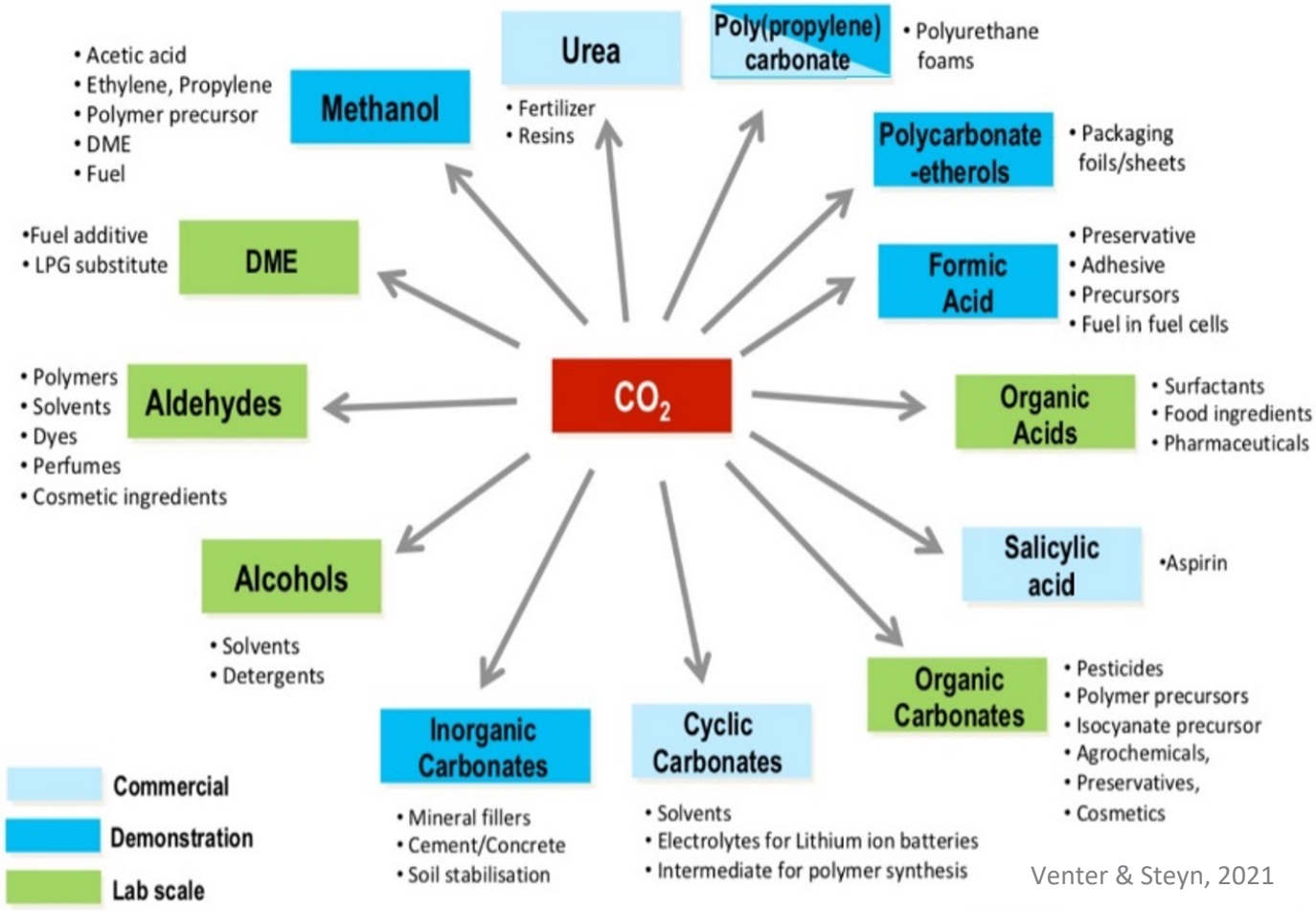


Catalytic gasification tar reduction Shen, 2015

Carbon capture and utilization requires catalysts to convert CO_2 into useful products



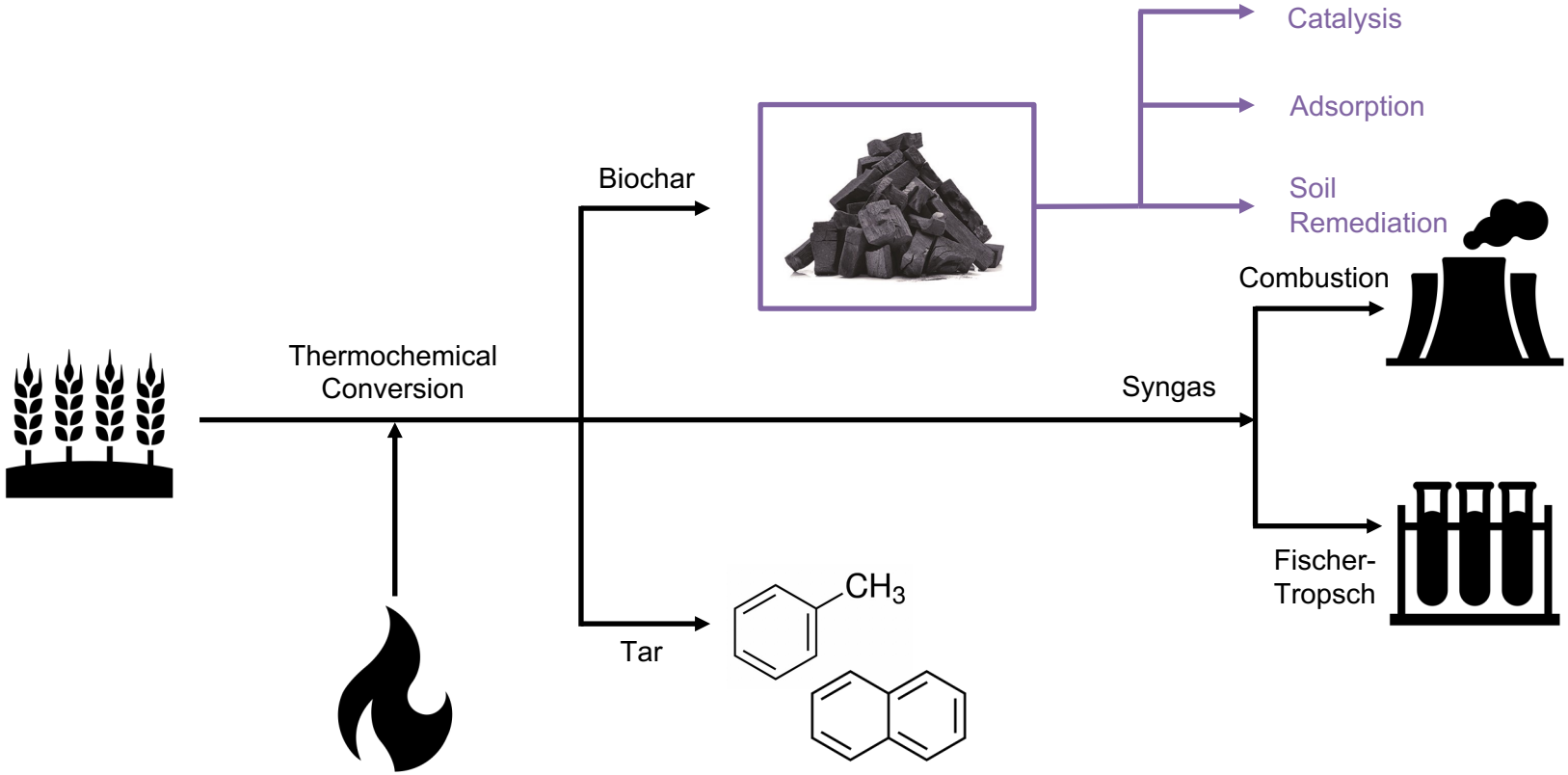
US EPA



Venter & Steyn, 2021

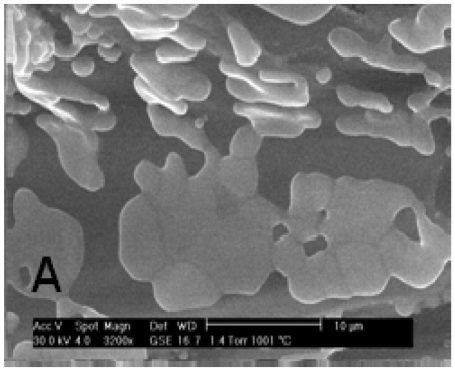
What is biochar?

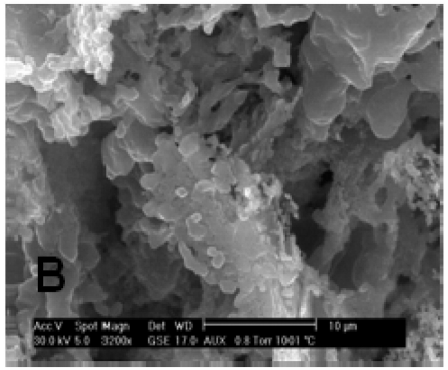
Biochar is a solid product of thermochemical conversion processes



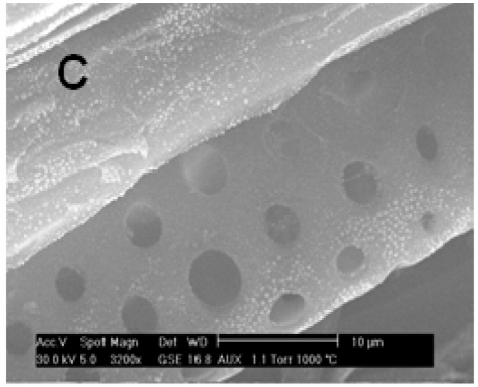
Biochar properties can be tuned by varying gasification medium, residence time, and temperature

Gasification Agent	Temperature (ºC)	Residence Time (min)	Char Yield (%)	BET Surface Area (m^2/g)	Micropore Volume (cm^3/g)
Steam	750	30	5.6	429	0.0
Steam	750	60	4.95	621	-
CO_2	750	30	15.4	435	0.18
CO_2	920	30	11.8	687	-





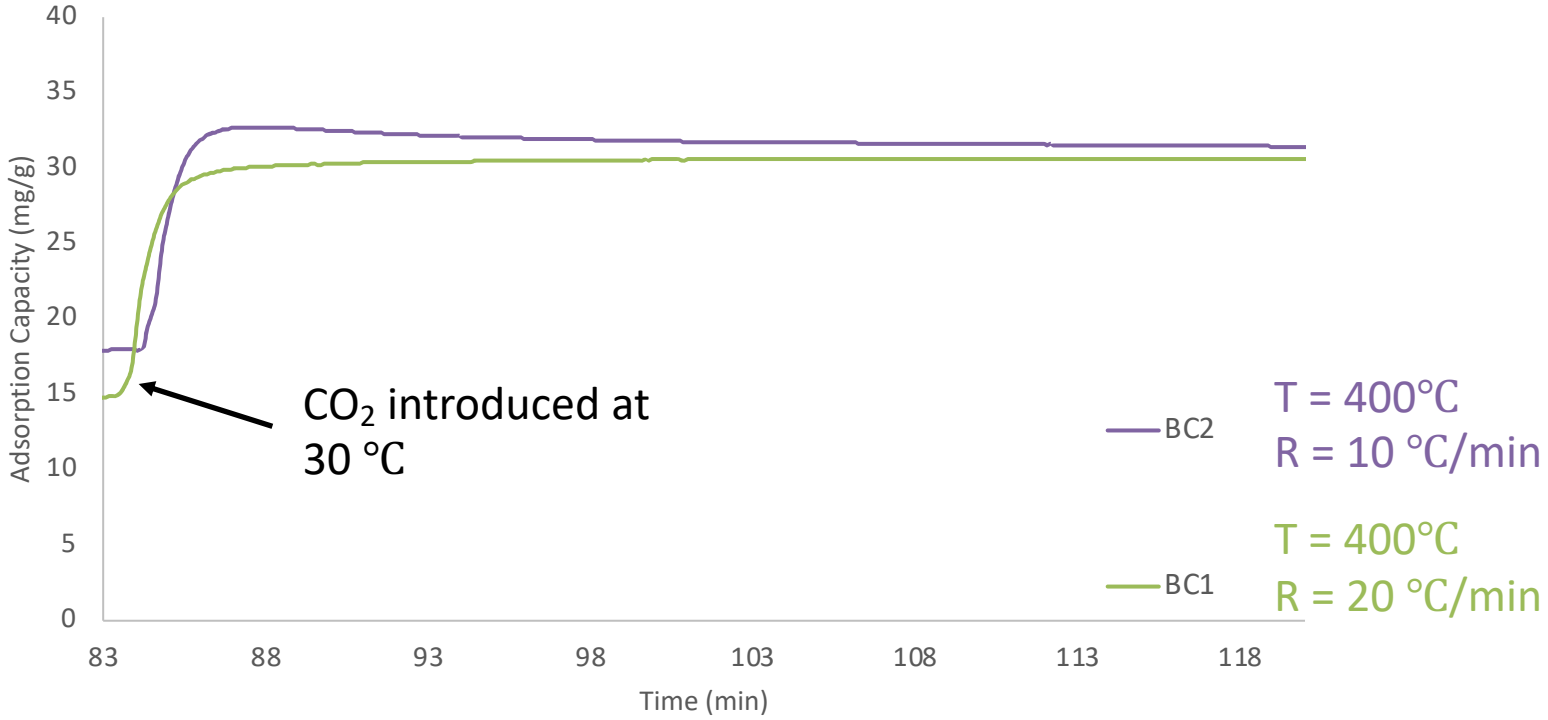
Steam gasification



CO_2 gasification

Klinghoffer et al., 2012

Different biochar production methods contribute to different CO_2 adsorption capabilities, indicating the tunability of biochar

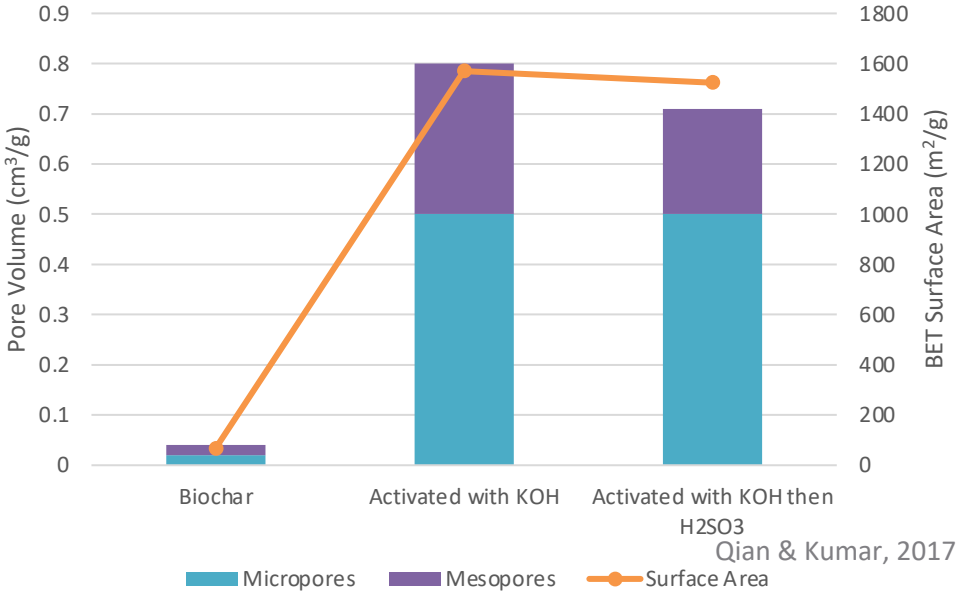


How can we modify biochar properties to improve its catalytic ability?

Biochar can be physically or chemically activated to enhance its properties

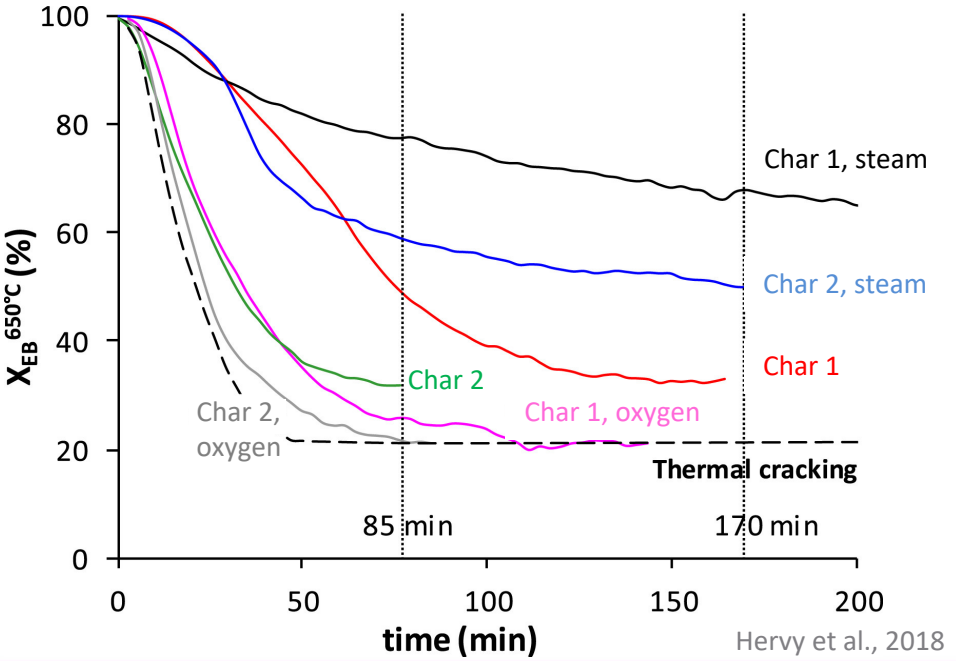
- Specific surface area
- Functional groups
- Metal distribution

Chemical Activation



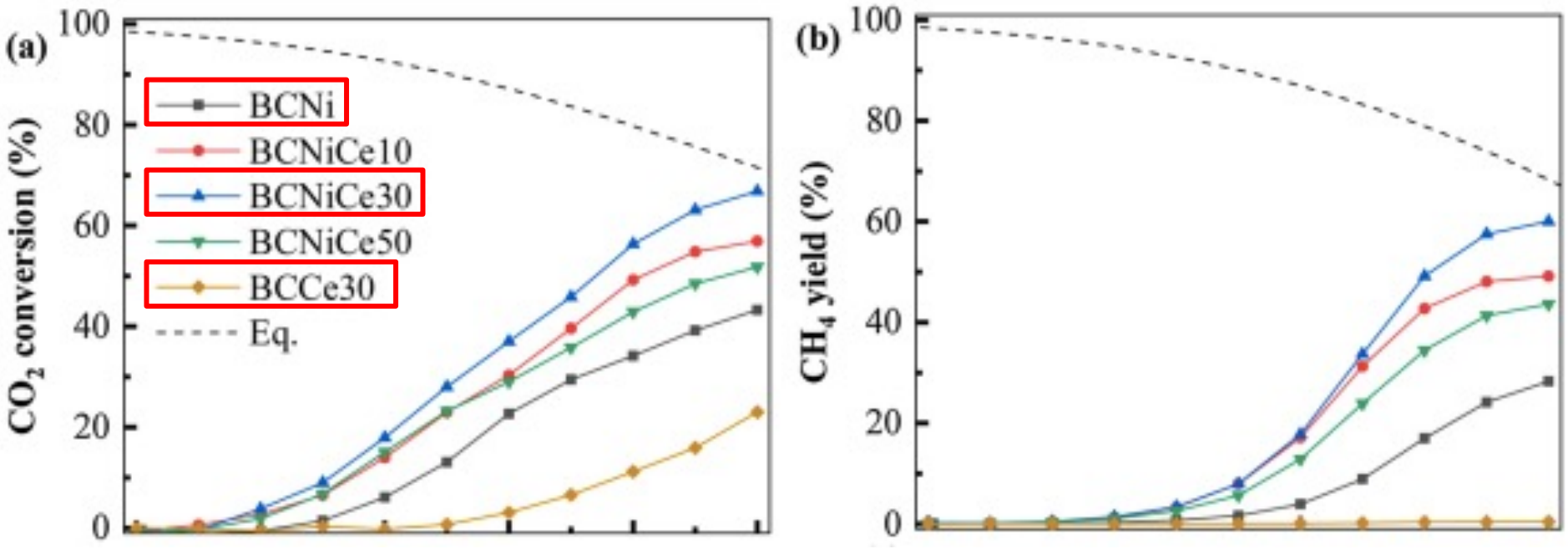
Qian & Kumar, 2017

Physical Activation



Hervy et al., 2018

Biochar can act as a support for common metal catalysts

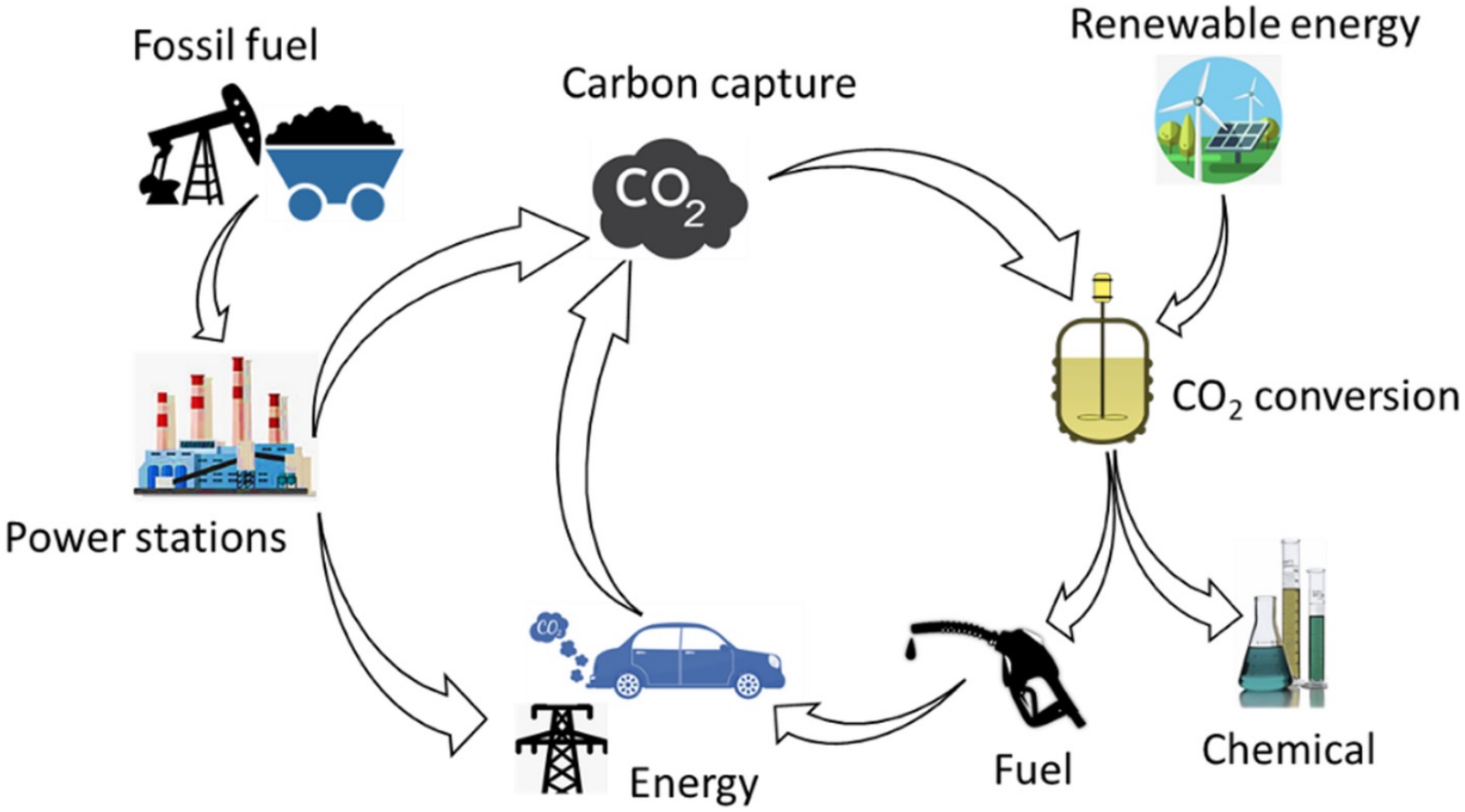


$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$$

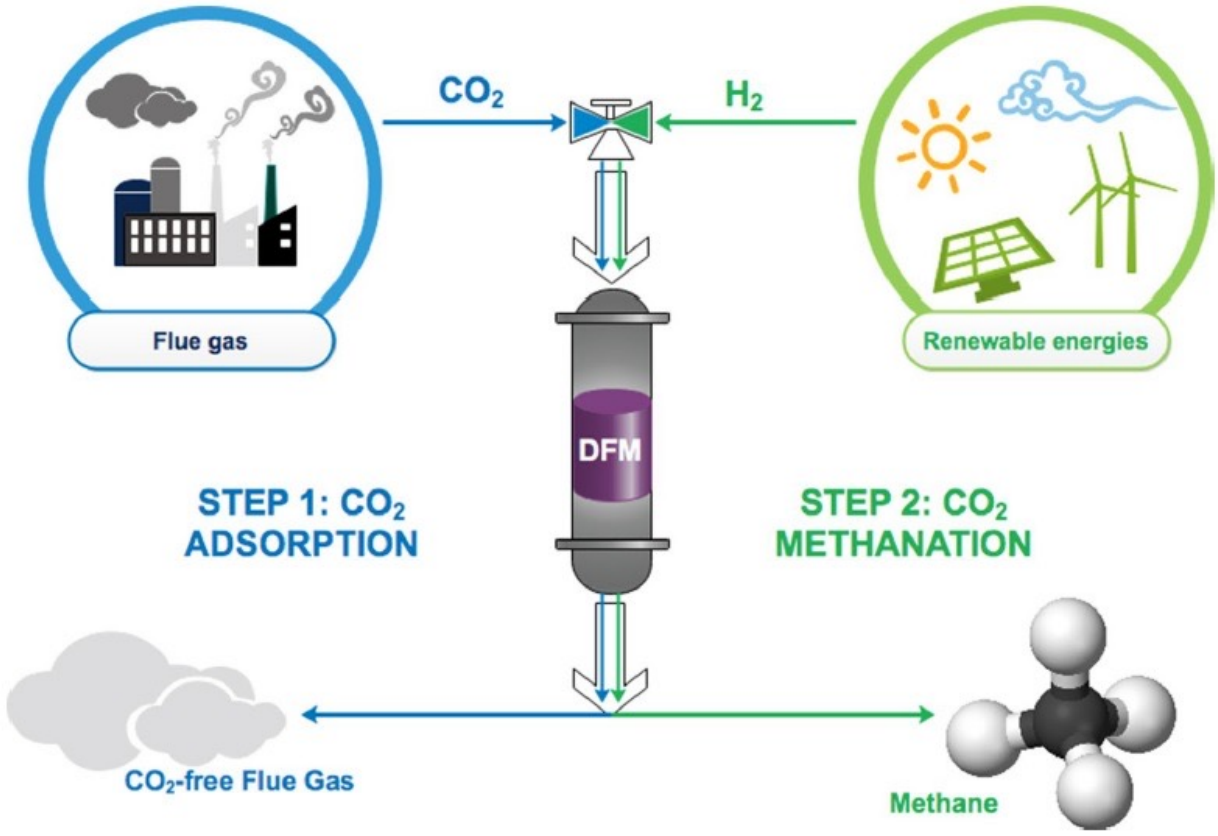
Renda et al., 2021

How can biochar contribute to a circular economy?

Catalytic waste CO_2 utilization is integral to a circular economy



Methanation is an easy to produce model reaction that allows CO_2 to be converted into synthetic natural gas



Debecker Lab, 2019

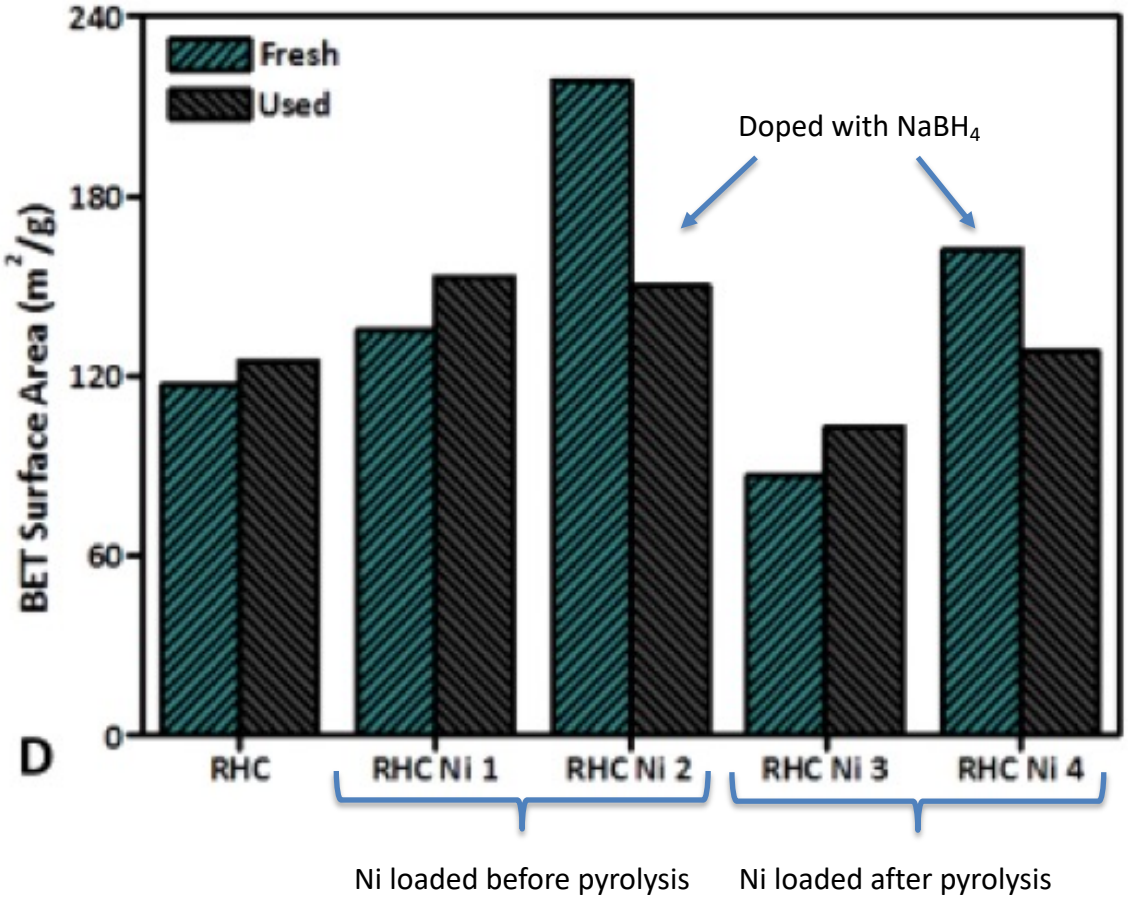
What's next?

Metal loading, pyrolysis temperature, feedstock, and heating rate can affect the efficiency of catalytic methanation

- Feedstock
- Pyrolysis Temperature
- Heating Rate
- Metal Loading

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$$

Biochar catalyst support properties can also be tuned through different metal loading techniques



Xu et al., 2019

Biochar is an environmentally benign catalytic support that can contribute to the CO_2 utilization aspect of a circular economy

Questions?

References

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