Biochar as a Nature-Based Solution for Carbon Capture and Storage

From Biomass Conversion to High-Value Carbon Materials

Prof. Shu Zhang | Nanjing Forestry University

November 13, 2026, Bangkok

The story

BIOMASS TO BIOCHAR

NBS and CCS

WHAT WE DO

Technology and Fundamentals

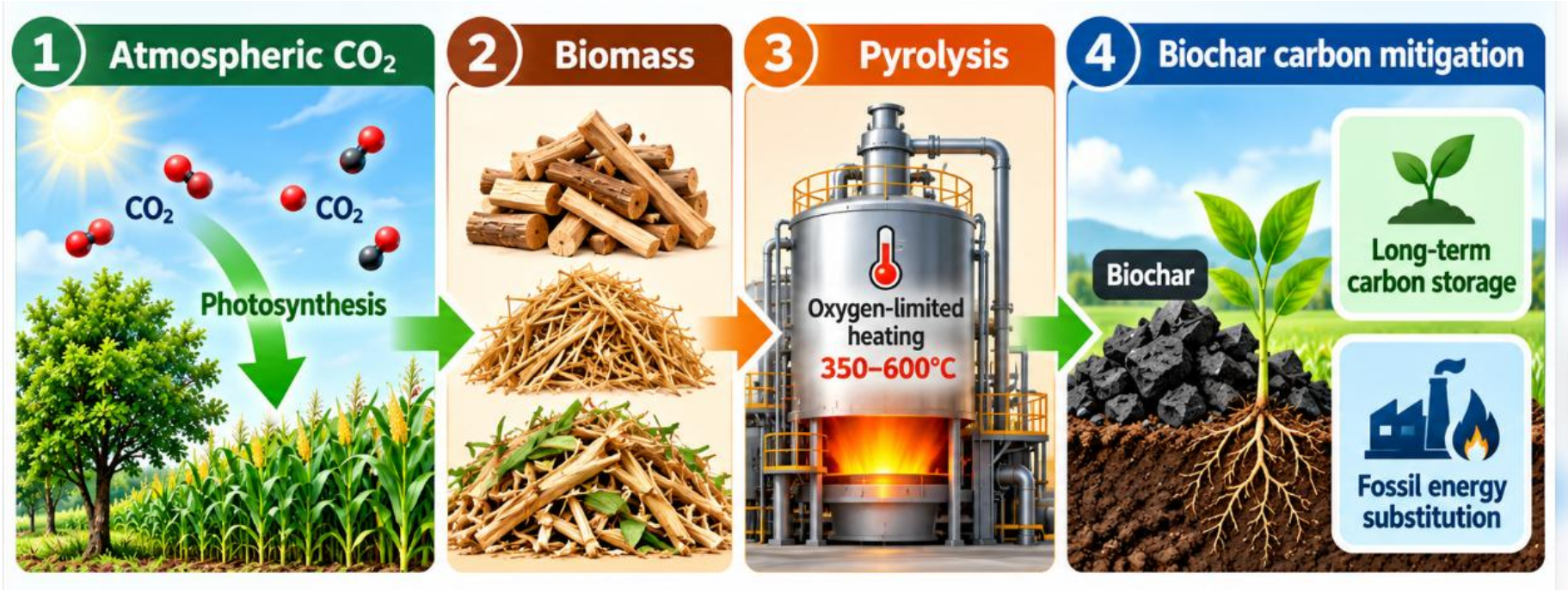
Technology/Equipments/Products /Bioenergy

Fundamental study on Biochar

- ✓ Applications-Properties-Structures
- ✓ Methods for regulating structures
- ✓ Typical examples

BIOMASS to BIOCHAR

NBS and CCS



Carbon neutral or negative for sure?

Feedstock

Biomass residues, bamboo, coconut shell and other biogenic resources

→

Conversion

Thermochemical transformation in an oxygen-limited environment

→

Product

A carbon-rich solid with properties shaped by feedstock and processing

Biomass Utilisation in China: Current Practices and Opportunities

870 Mt/year

Annual crop straw generation in China (2024)

54.6%	24.4%	8.0%
Fertiliser / Soil Return	Animal Feed	Energy

Future opportunity: Converting sustainably available biomass residues into stable biochar for long-term carbon storage and high-value material applications.

Percentages are based on collectable crop straw resources, not total biomass generation. Source: Ministry of Agriculture and Rural Affairs of China, 2025.

WHAT WE DO

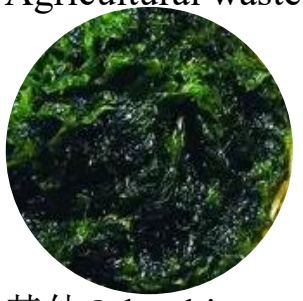
Technology and Fundamentals



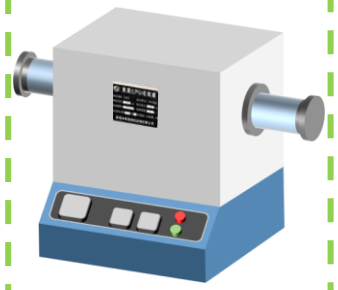
林业废弃物
Forestry waste



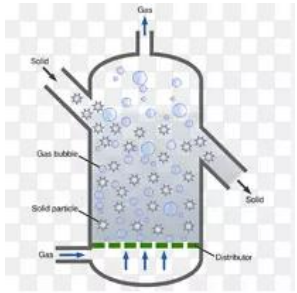
农业废弃物
Agricultural waste



其他Other biomass



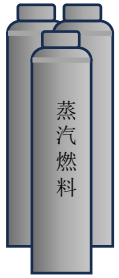
热解
Pyrolysis



气化
Gasification



水热
Hydrothermal



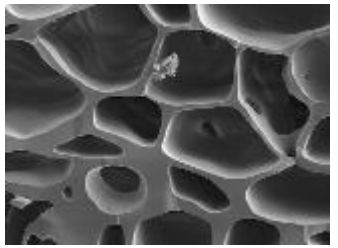
生物气
Biogas



生物油
Bio-oil

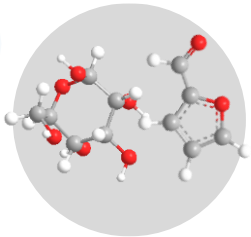


生物炭
Biochar



材料
Materials

协同利用
Synergistic Utilization



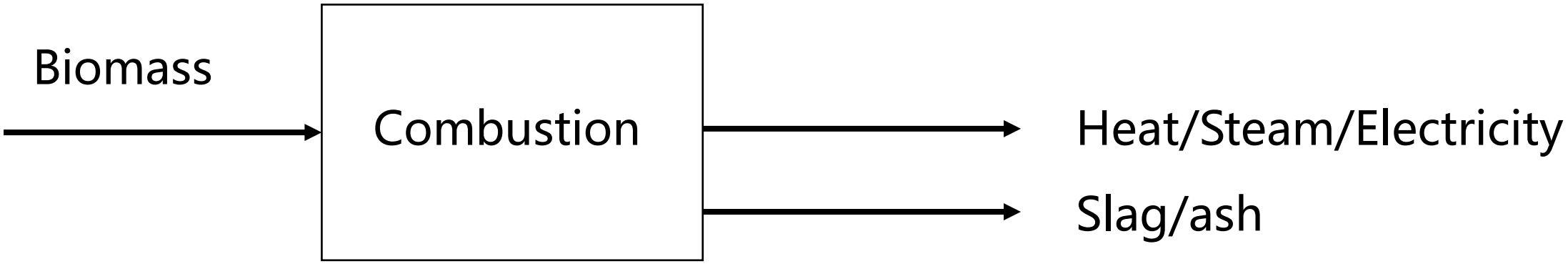
化学品
Chemicals



能源
Fuel & Energy

What products we want?

Combustion: Energy



Commercialized in large scale

Ash/slag issues

Carbon neutral?

Gasification:Syngas/Chemicals

Biomass

Carbonization
(250-300 °C)

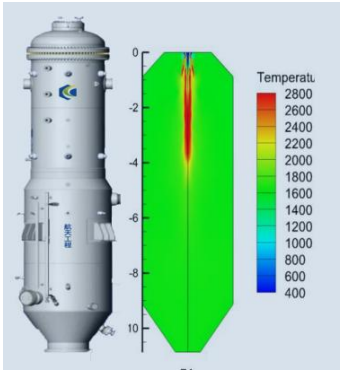
Light Gases/Hydrocarbons



Steam/Hydrocarbons

High Yields of Biochar

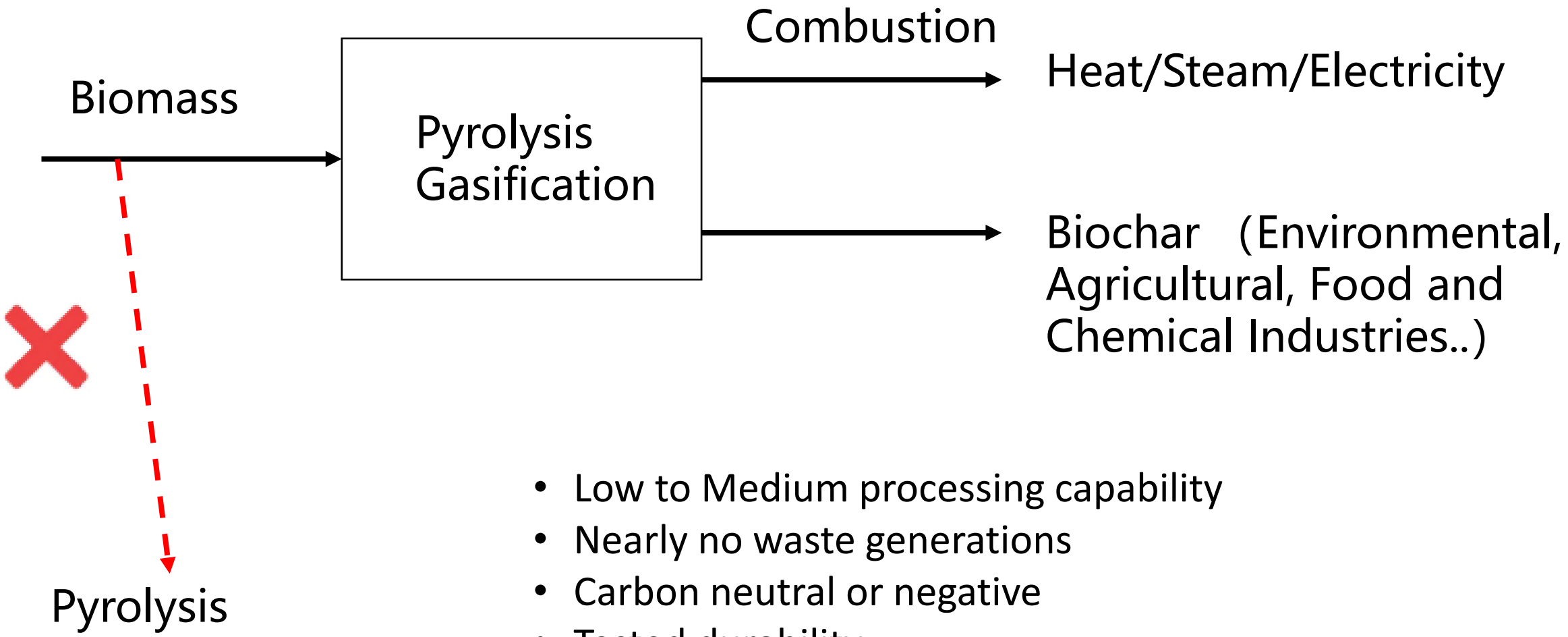
Gasification feedstock



Chemicals etc.

Abundant and uniform raw materials

Pyrolysis&Gasificaton: Energy & Biochar



- Low to Medium processing capability
- Nearly no waste generations
- Carbon neutral or negative
- Tested durability
- Good flexibility

Commercial Equipments and Products

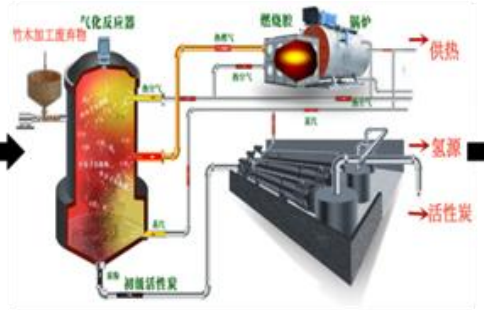
















竹木加工剩余物

零碳气化联产生物燃气和生物质炭

生物燃气

生物质炭

- 1–4 t/h biomass processing capacity
- ~3 t steam produced per tonne of biomass
- ~0.25 t biochar produced per tonne of biomass

Energy Self-sustaining system for high value carbon materials

Shandong Lechen Energy Saving and Environmental Protection Technology Co., Ltd.





WHAT WE DO

Technology and **Fundamentals**

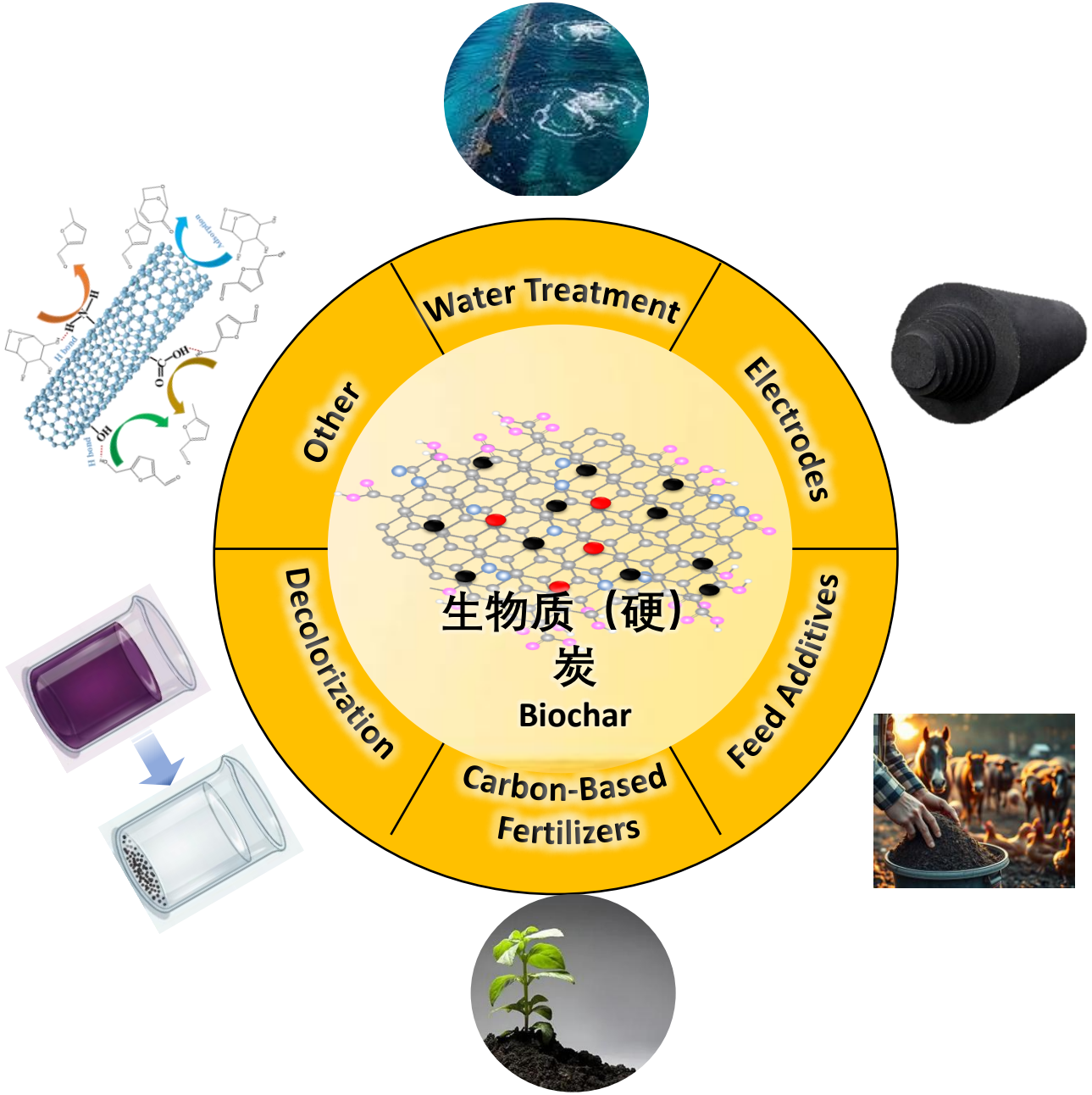
From bioenergy to high-value biochar

Applications of Biomass Char

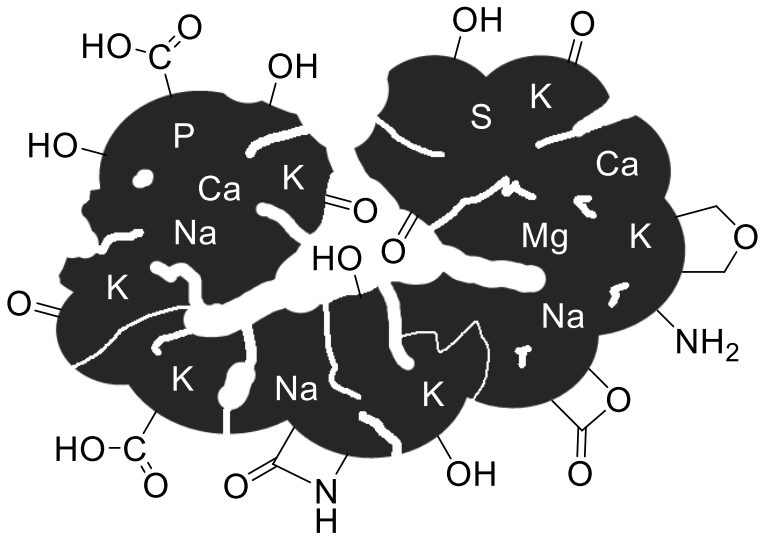
Applications

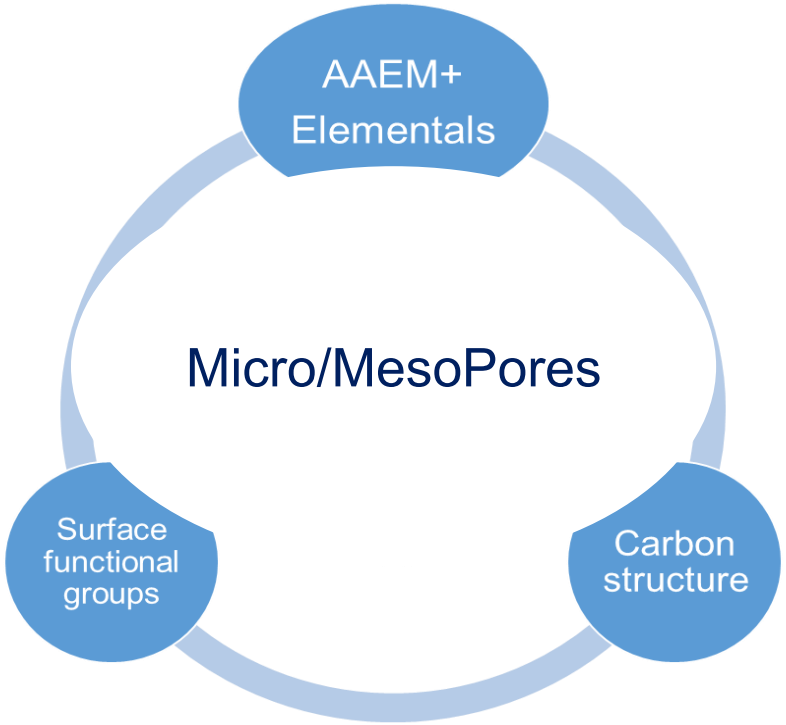
Properties

Physiochemical Structures



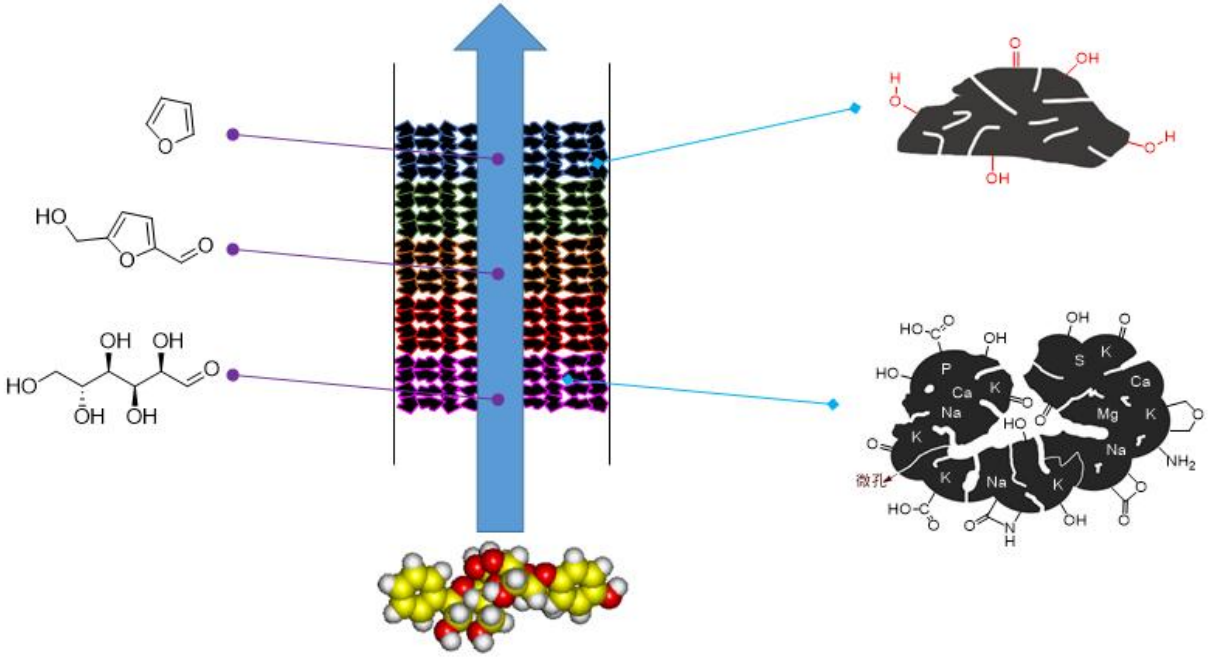
Physiochemical Structures

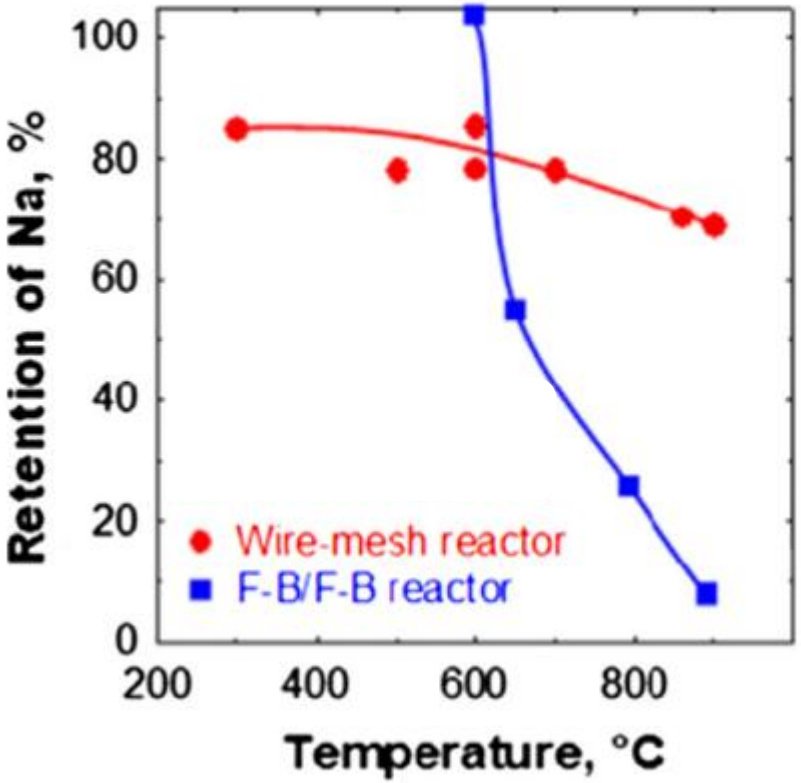




Methods for regulating biochar structure

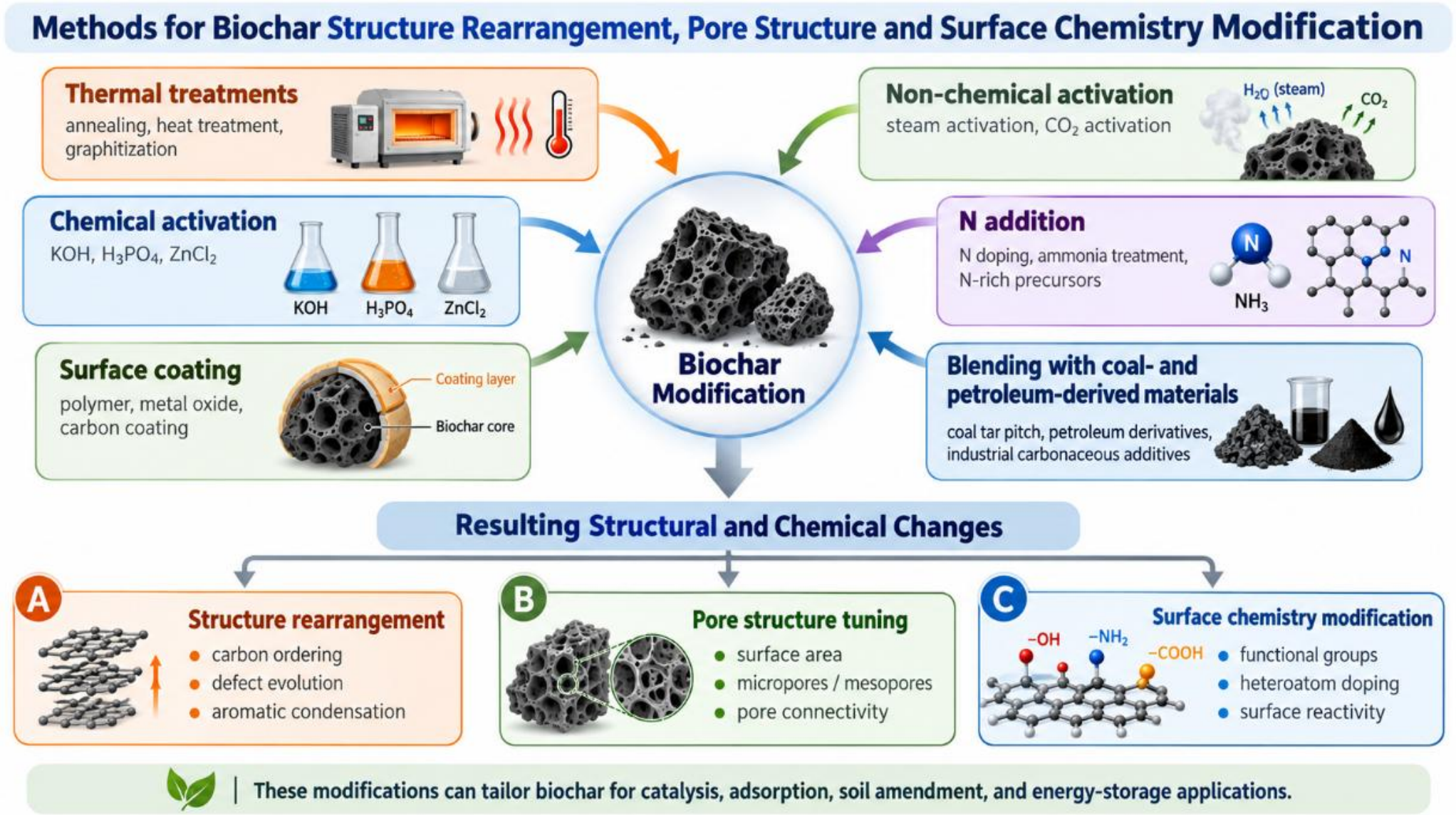
In-situ: Volatile-Char Interaction





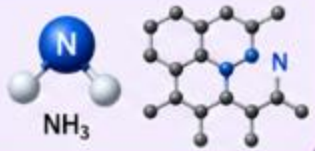
A number of publications on the topic

Ex-situ biochar engineering and modification



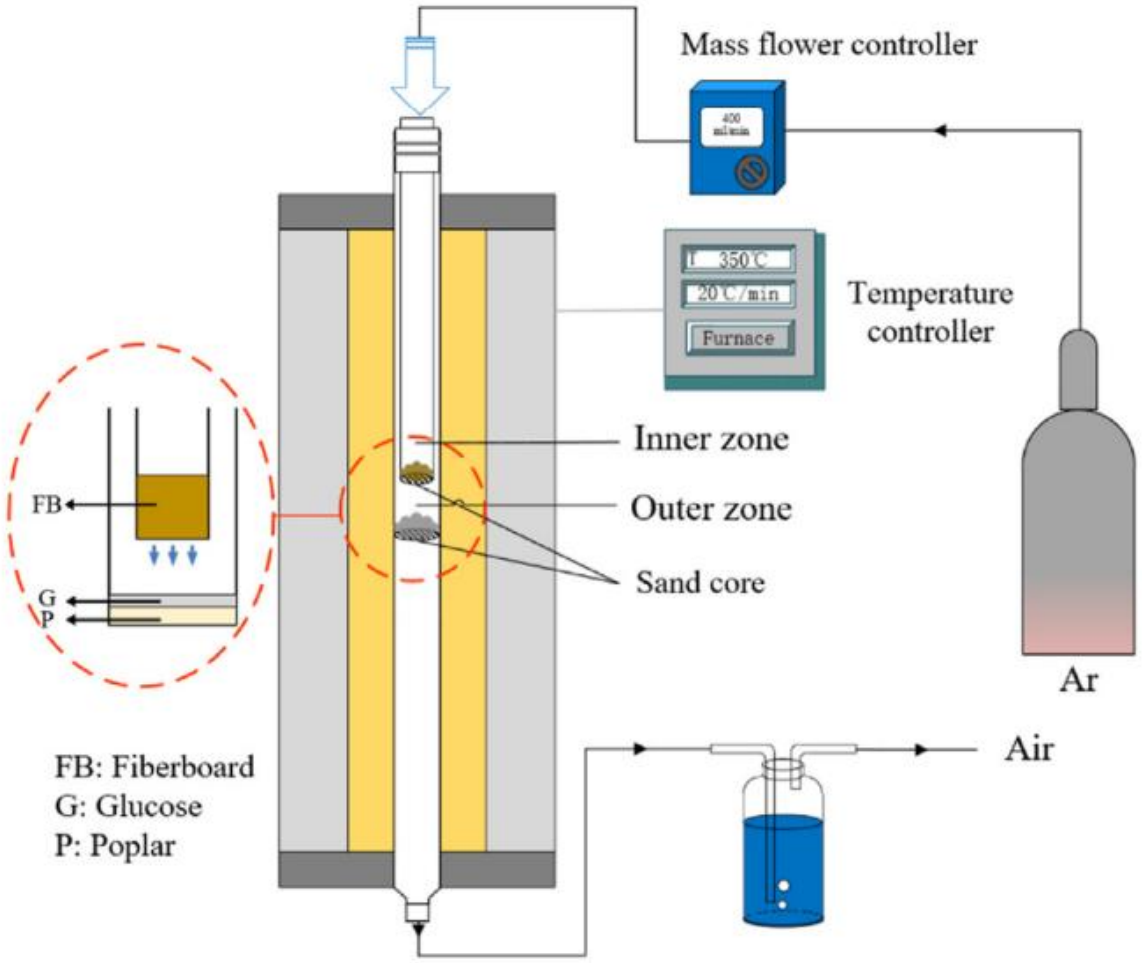
N addition

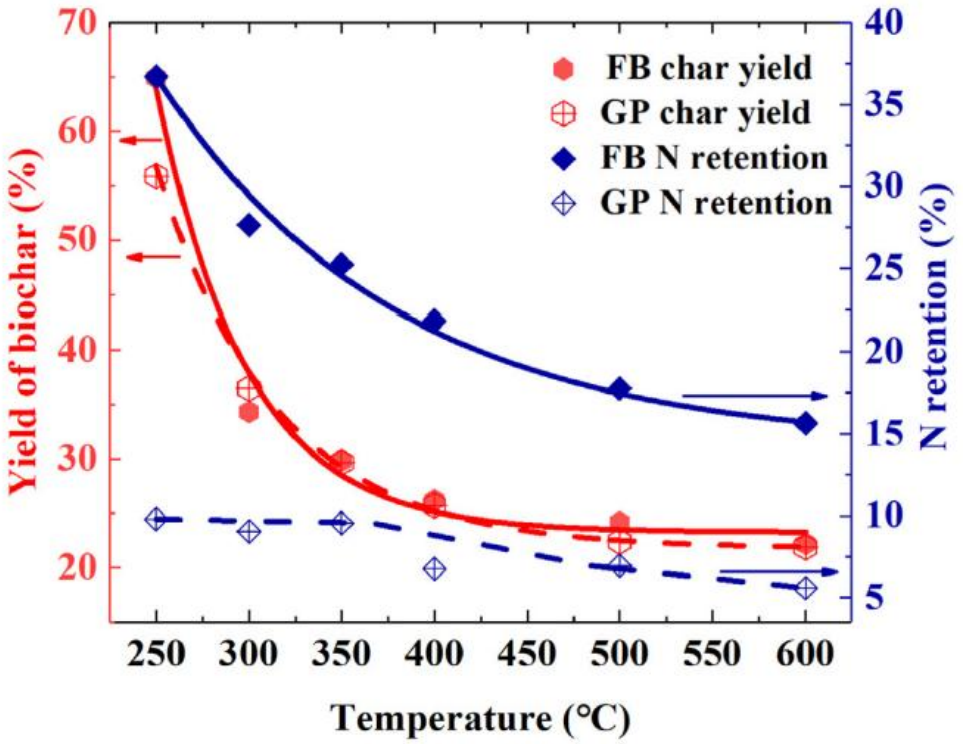
N doping, ammonia treatment, N-rich precursors



Dry method

Renewable Energy 191 (2022) 134–140

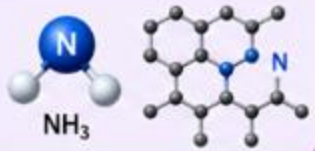




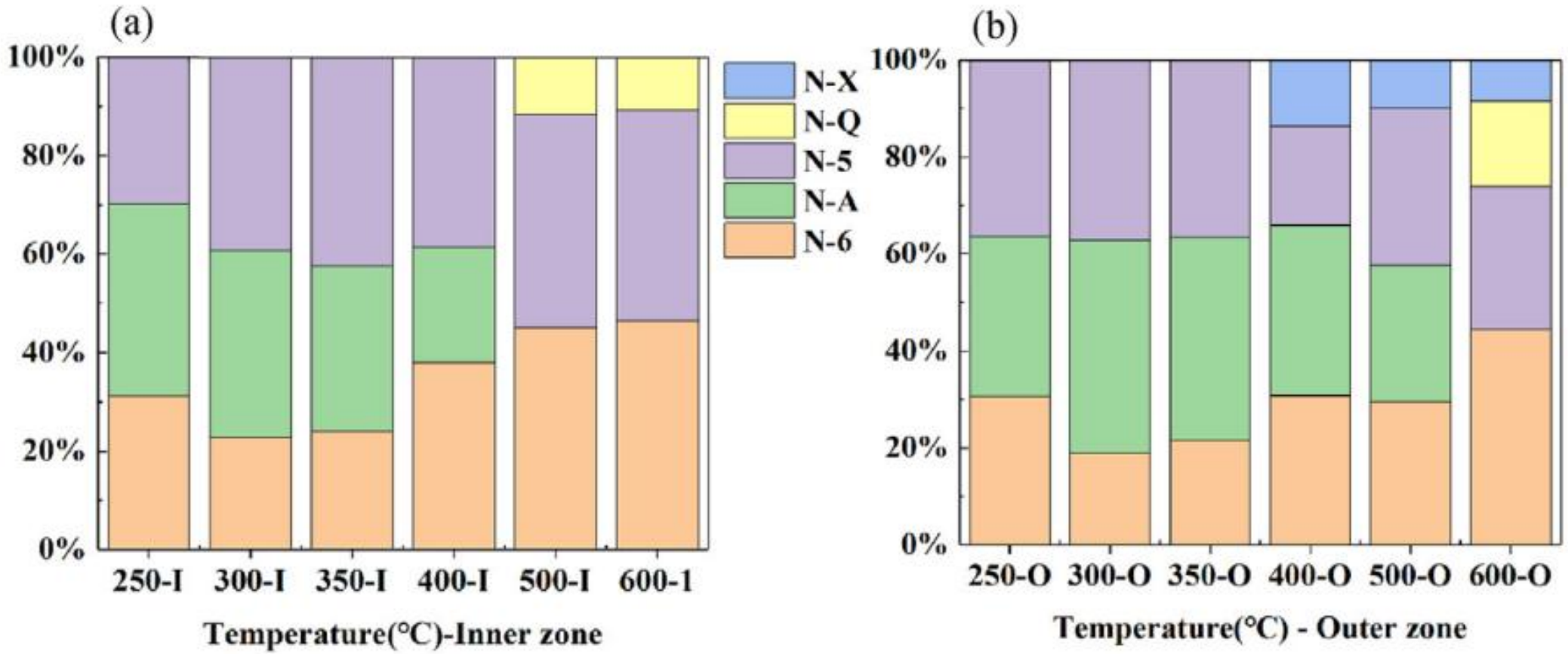
The changes in char yields and N retentions during the pyrolysis of fiberboard ıcose/polar wood in the double-bed fixed reactor at different temperatures.

N addition

N doping, ammonia treatment, N-rich precursors



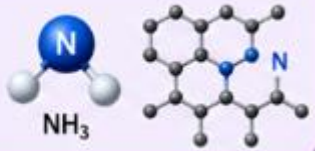
Dry method



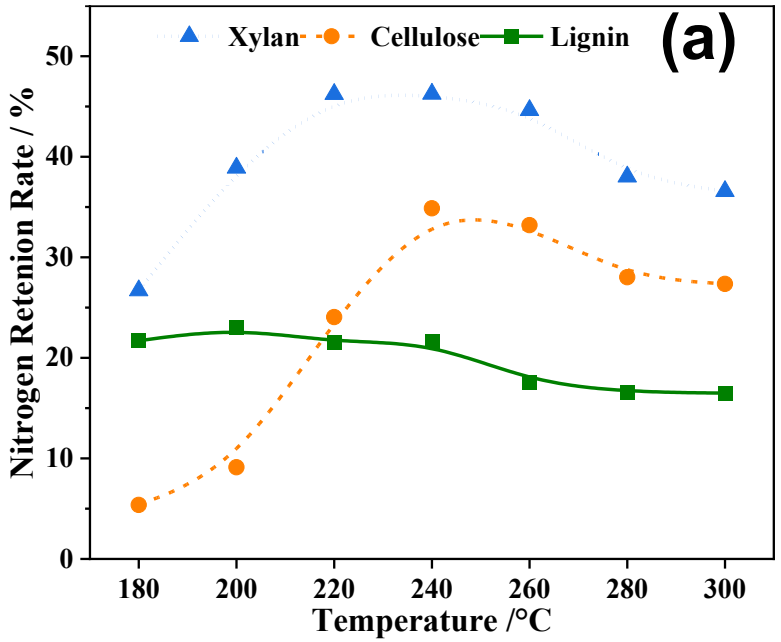
Changes of nitrogen functionalities (a) in inner zone (FB char layer) and (b) outer zone (GP char layer) as a function of temperature.

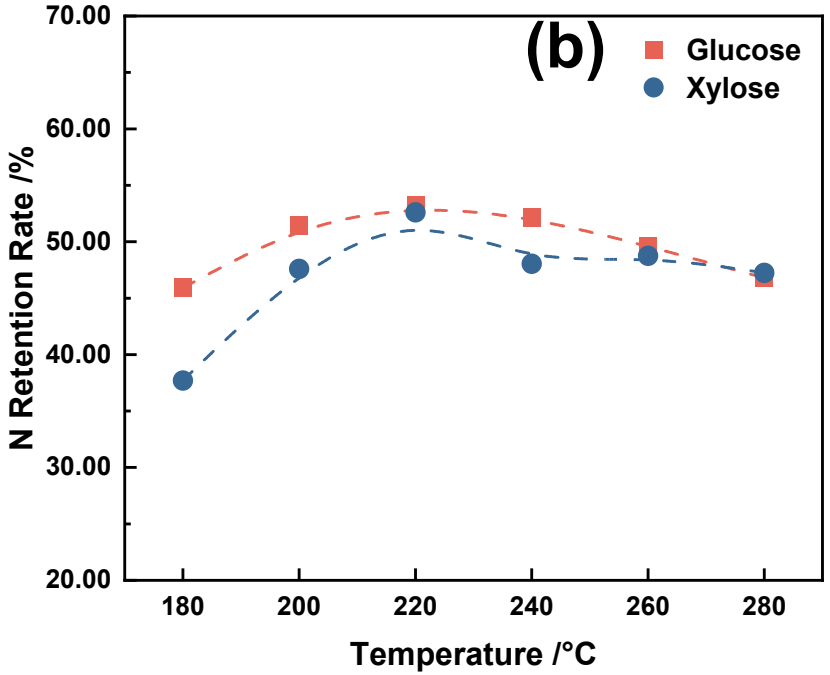
N addition

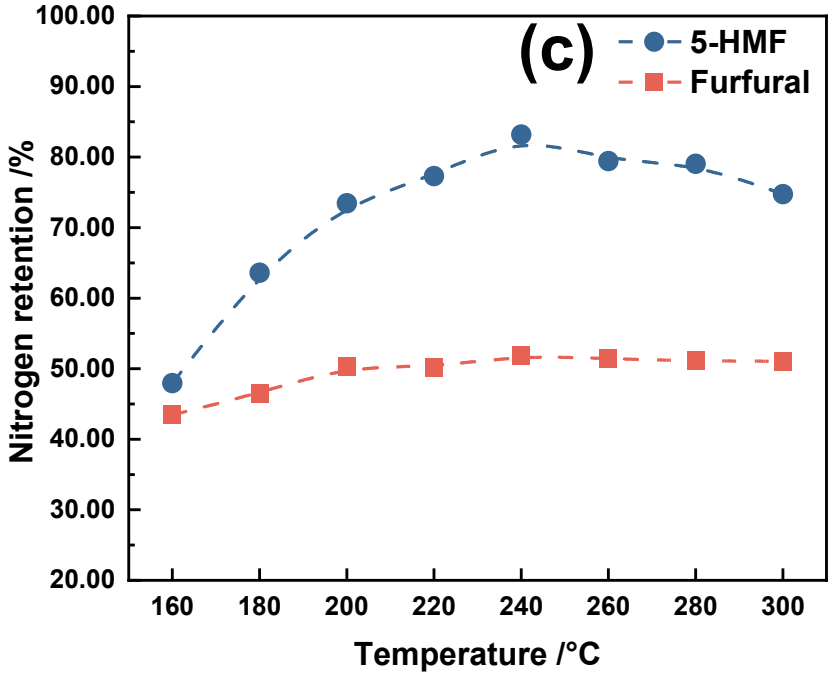
N doping, ammonia treatment, N-rich precursors

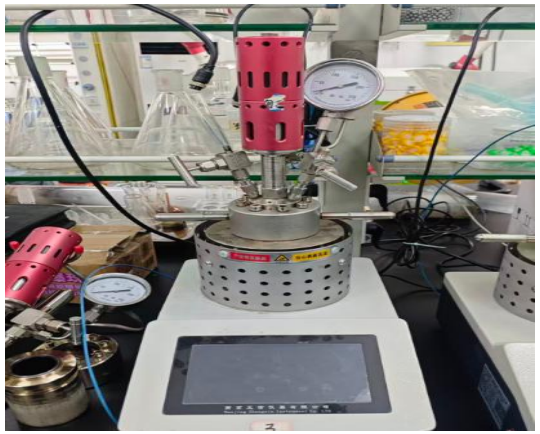


Wet method









- Cellulose and xylan and their hydrolysis products begin to exhibit strong nitrogen-retention capability at 200°C, and maintain a high nitrogen-fixation rate up to 260°C.
- The hydrolysis intermediates of cellulose exhibit stronger nitrogen-fixation capability.

Xu et al, 2025, Renewable Energy

Zhang et al, 2024 , Journal of Cleaner Production

Blending with coal- and petroleum-derived materials

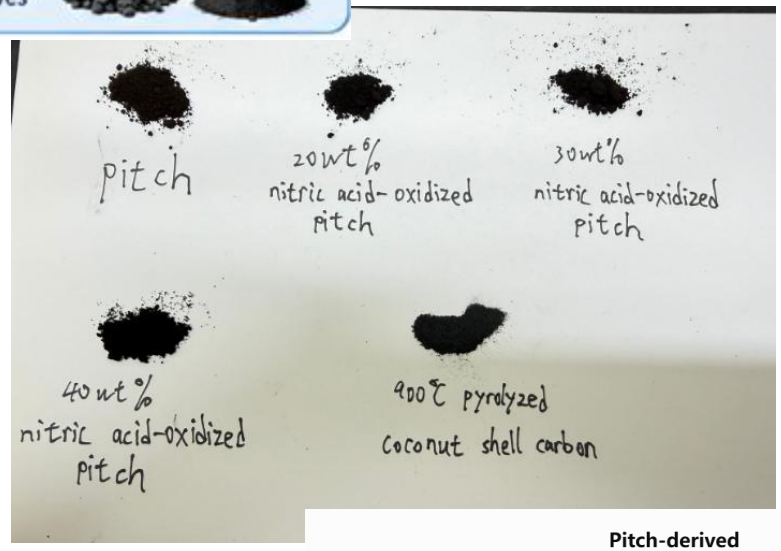
coal tar pitch, petroleum derivatives, industrial carbonaceous additives

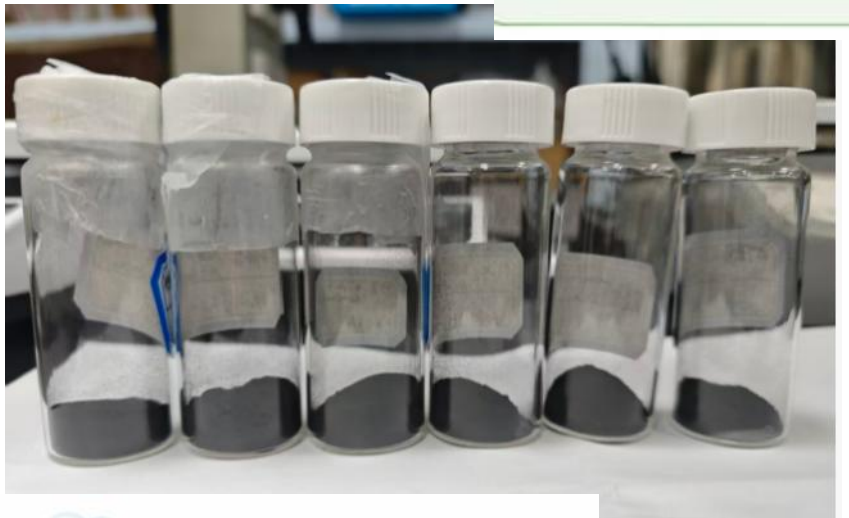


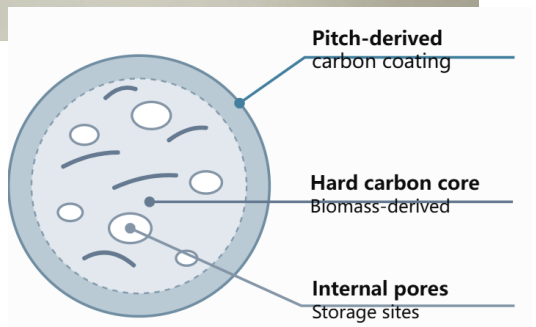
Non-chemical activation

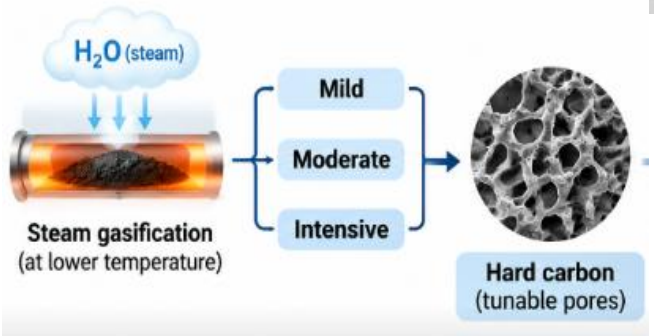
steam activation, CO_2 activation

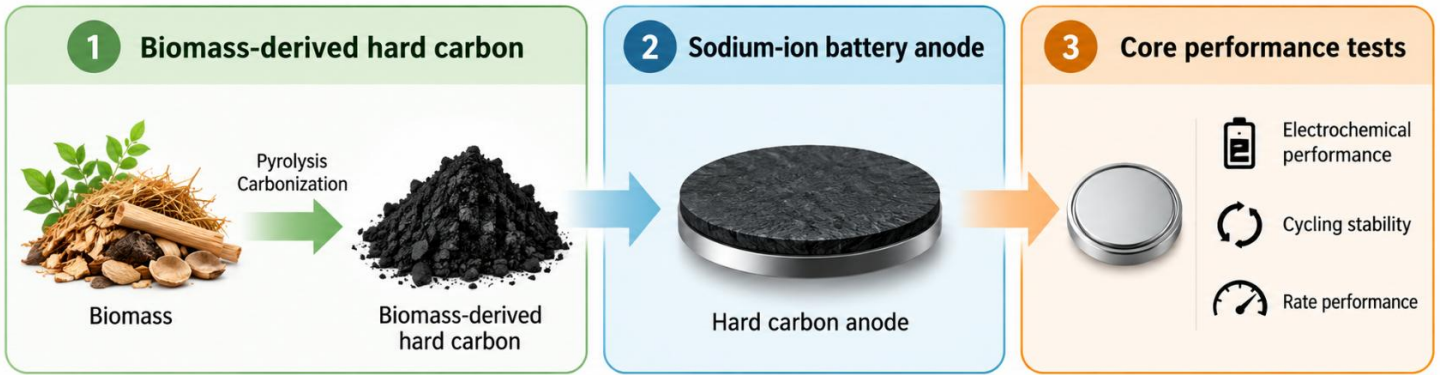










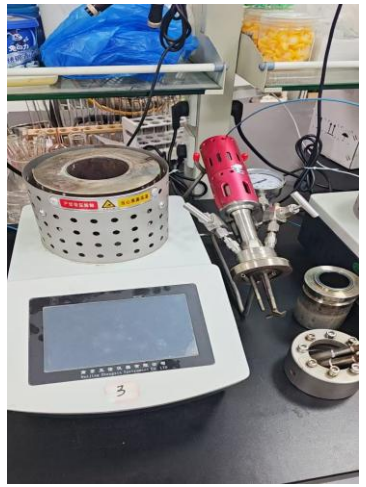











- ✓ Fixed-bed, fluidized-bed, autoclave, microwave-assisted reactors…
- ✓ Temperatures, heating rates, holding time, particle sizes…
- ✓ Various types of biomass

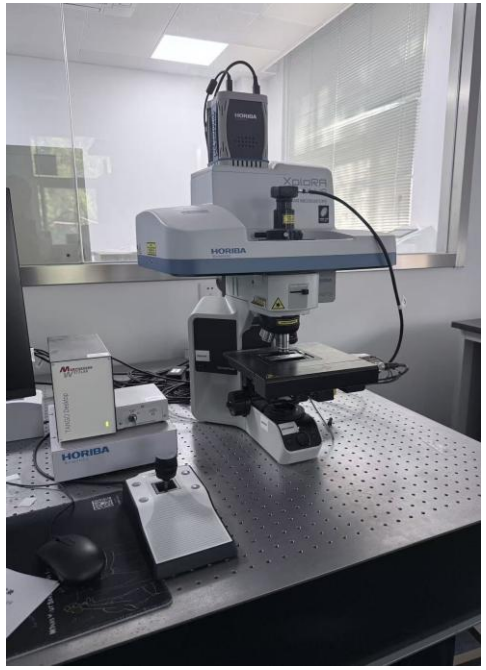
Analytical Facilities



X-ray Diffraction



GC-MS



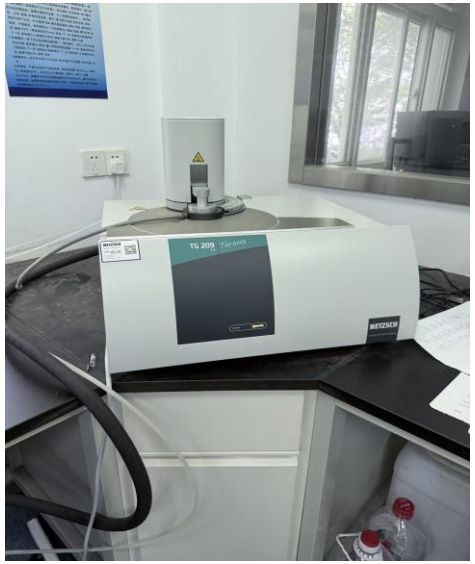
Raman Microscope



BET Analyser



Differential Scanning Calorimeter



TGA



Nano IR Spectrometer



SEM



Dynamic Vapor Sorption

Summary

- ✓ Biochar has a great potential for CCS, although not always.
- ✓ Biochar should be preferably used for materials rather than energy/fuels.
- ✓ Different “Biochars” are needed for different applications.
- ✓ Regulation of biochar structure is the key for its various high-value applications, such as for new energy materials.

Welcome to Nanjing Forestry University

A beautiful campus between Xuanwu Lake and Purple Mountain • Nanjing, China













You are warmly welcome to visit us at NJFU!

Acknowle

With sincere appreciat



01 **Funding**

02 **Researc**

03 **Researc**

Thank You!

Prof. Shu Zhang | Nanjing Forestry University

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