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INVESTIGATION OF INNOVATIVE AND CONVENTIONAL PYROLYSIS OF LIGNEOUS AND HERBACEOUS BIOMASSES FOR BIOCHAR PRODUCTION

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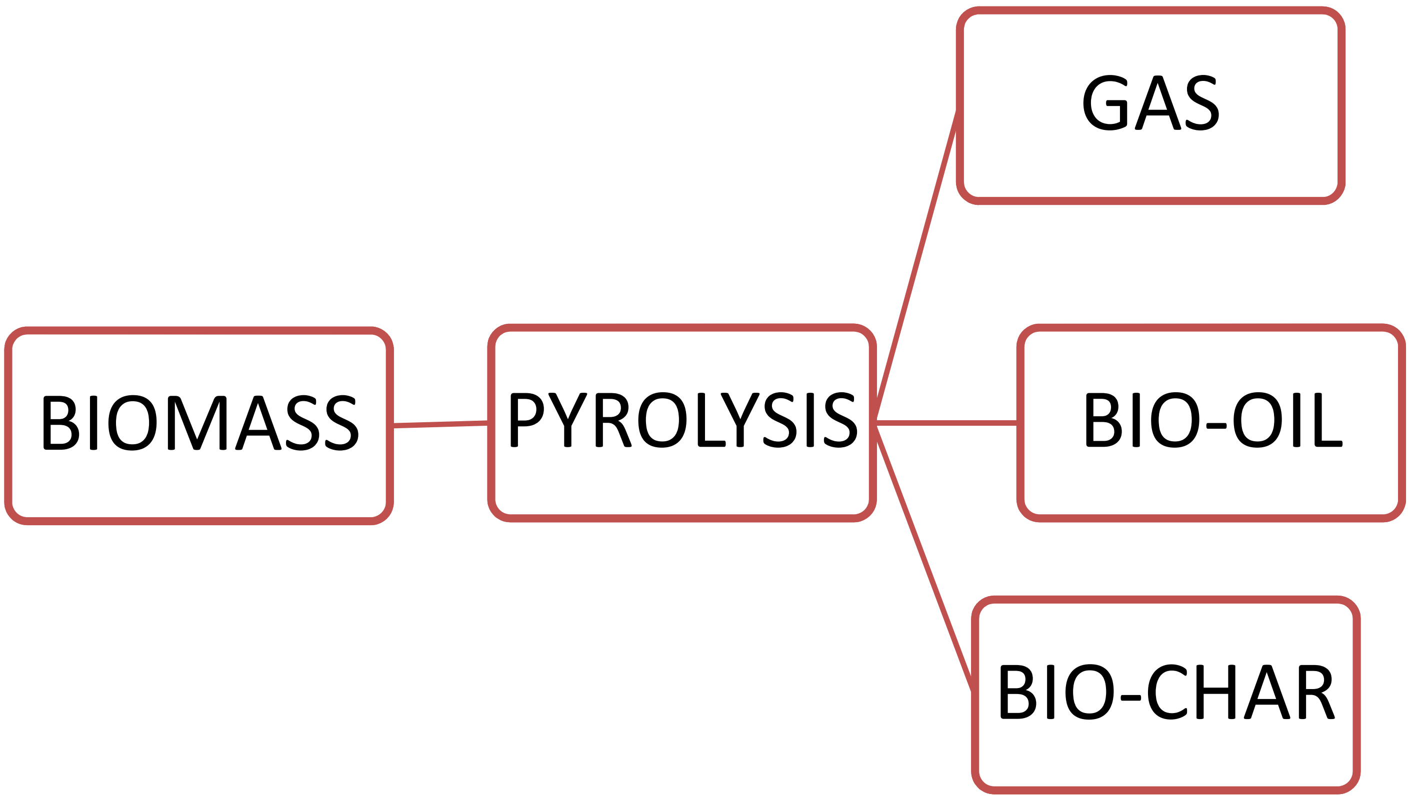
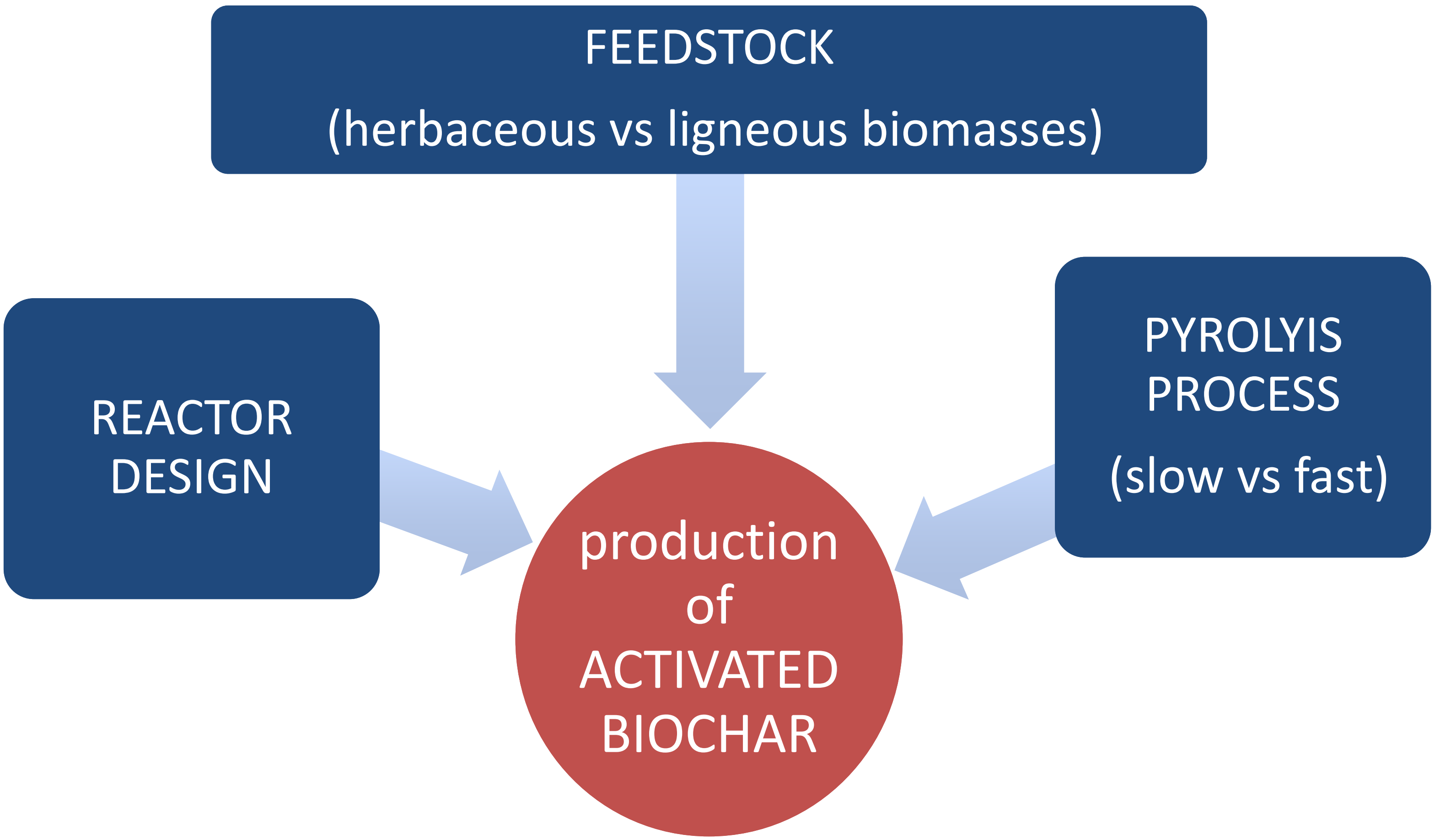
PYROLYSIS AS A TERMOCHEMICAL PROCESS



PYROLYSIS: SLOW OR FAST?

	SLOW PYROLYSIS	FAST PYROLYSIS
heating rate	<10 (°C/min)	>100(°C/s)
Temperature range (°C)	400-800	450-550
vapor residence time	minutes	<2 s
solid residence time	hours	seconds
bio-oil yield (%)	≈ 30	≈ 60-75
bio-char yield (%)	≈ 30	≈ 15-25
gas yield (%)	≈ 35	≈ 15
typical reactor configuration	fixed bed, kilns, auger	fluidized and circulating fluidized bed, ablative, vacuum

APPROACH and AIM OF THE RESEARCH



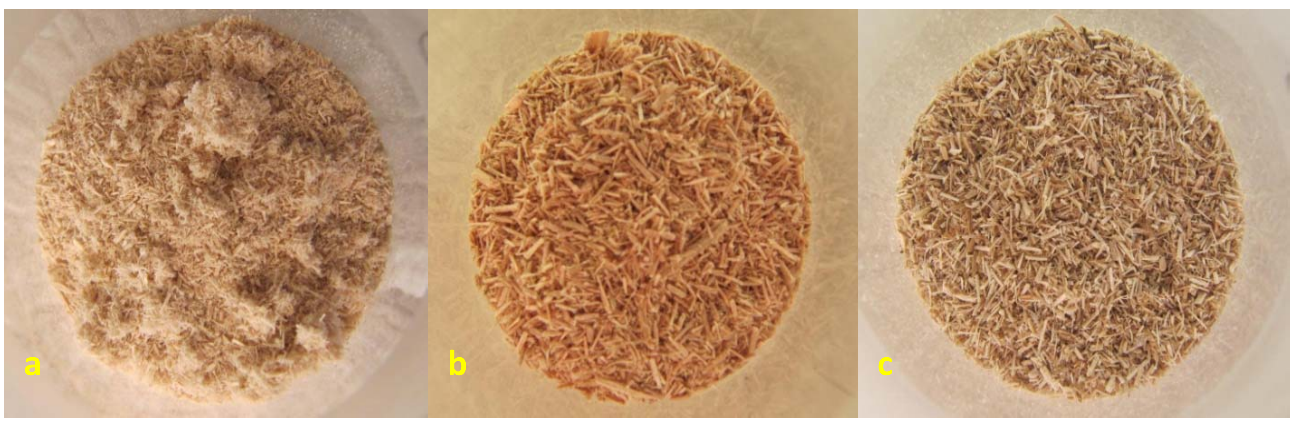
FEEDSTOCKS

ligneous

herbaceous

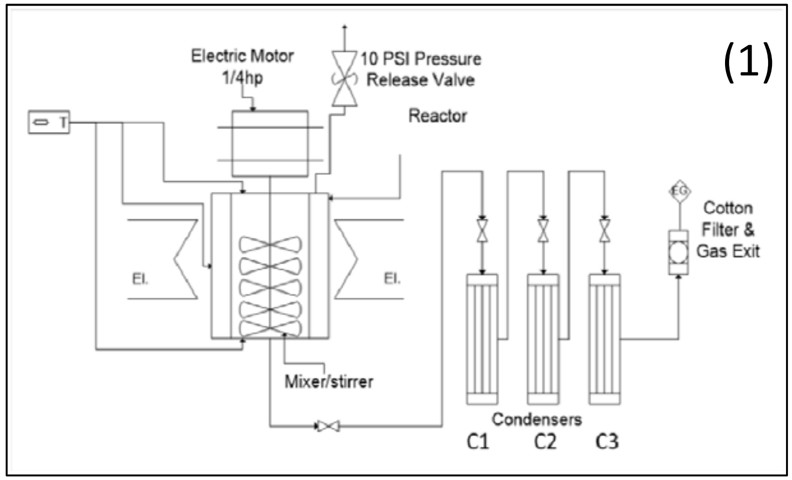
a. RUBBERWOOD **b. EUCALYPTUS**

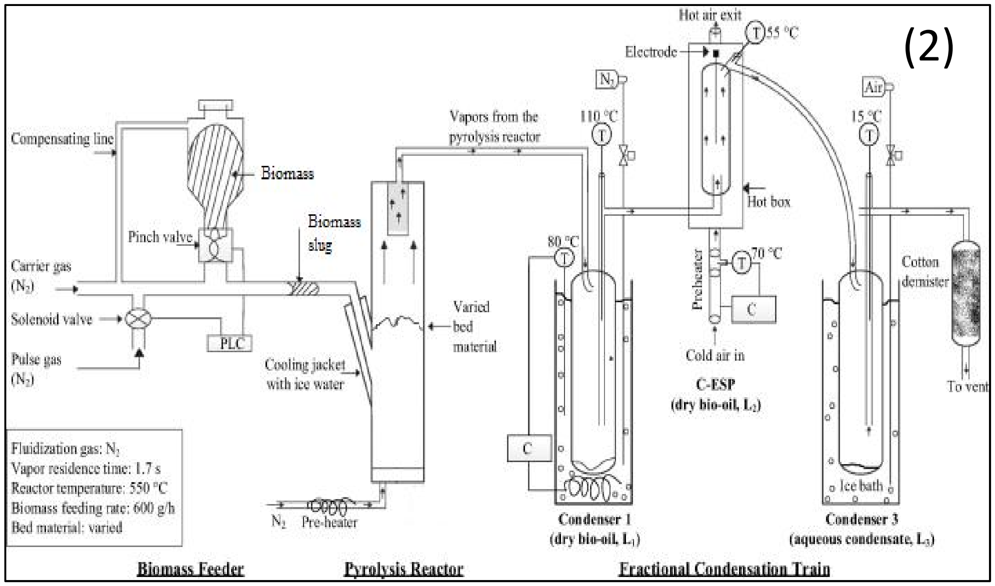
c. PHRAGMITES AUSTRALIS

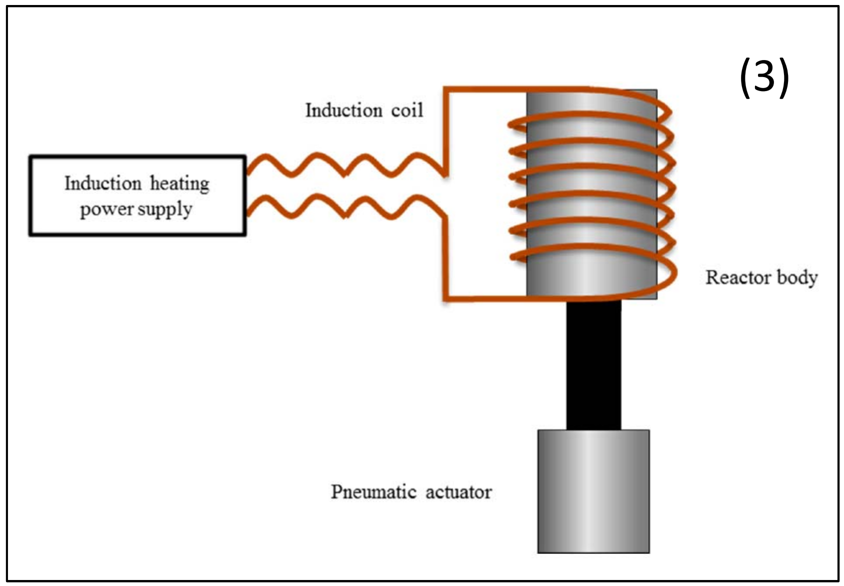


REACTORS DESIGN: slow vs fast pyrolysis

1. Mechanically Fluidized Reactor (MFR)
2. Bubbling Bed Reactor (BBR)
3. Jiggled Bed Reactor (JBR)







JIGGLED BED REACTOR (JBR)

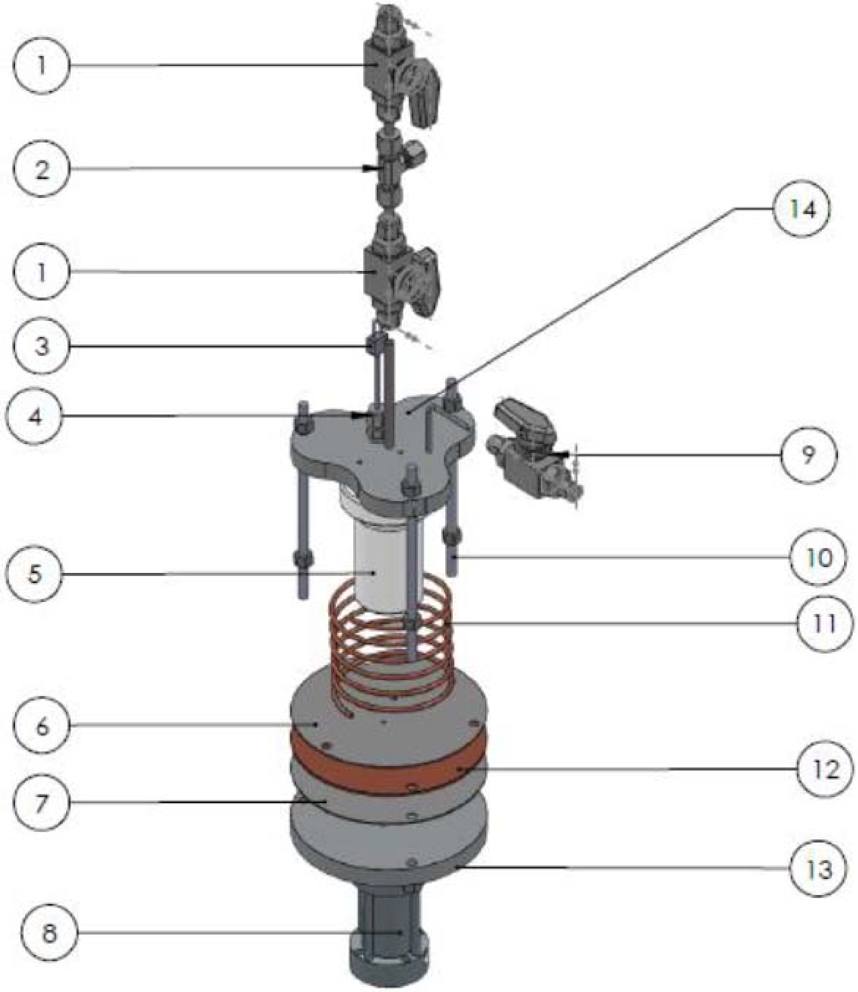


Figure 16 Diagram of the Jiggled Bed Reactor: 1. on/off feed valves 2. Inlet of carrier gas 3. Thermocouple 4. Inlet of feed and carrier gas 5. Ceramic crucible with insulation 6. Insulation disk 7. Insulation disk 8. Linear pneumatic actuator 9. Outlet gas valve 10. Stainless steel support rods 11. Copper coil 12. Copper disk 13. Aluminum disk mounted on the actuator 14. Stainless steel scalloped disk [45]

JIGGLED BED REACTOR (JBR)

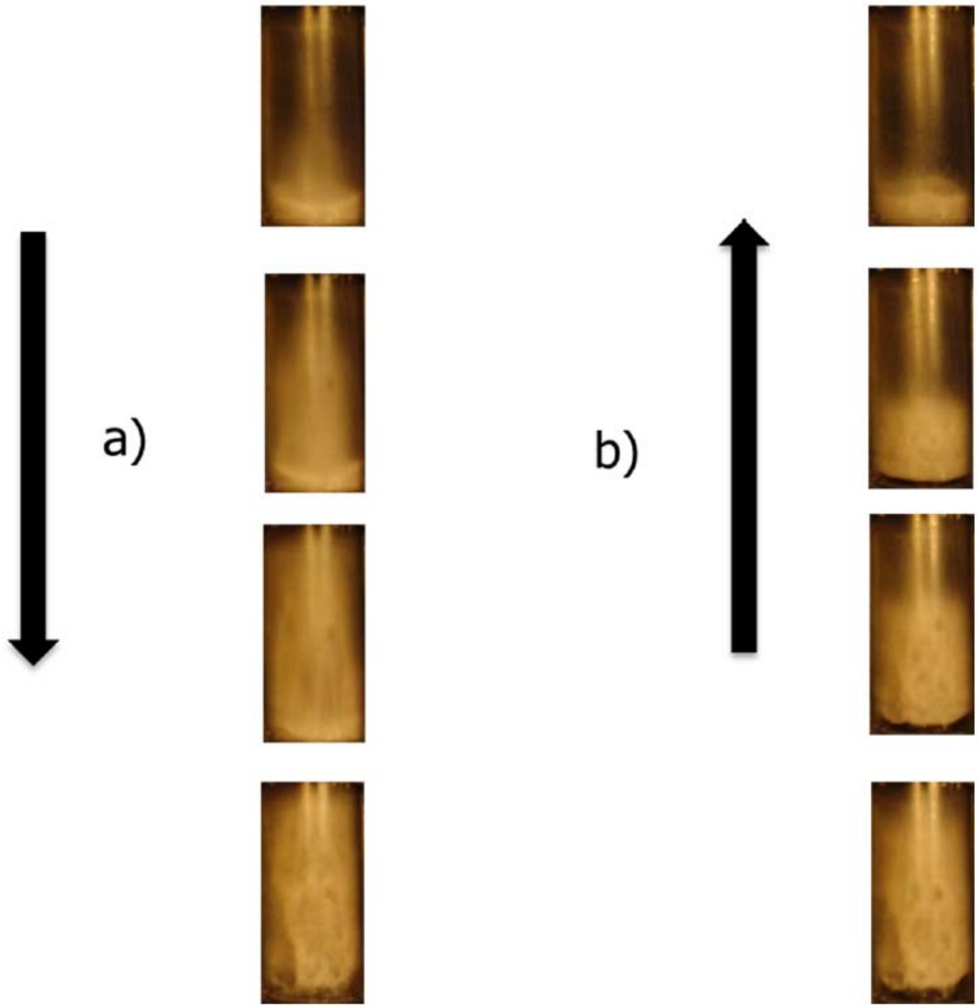
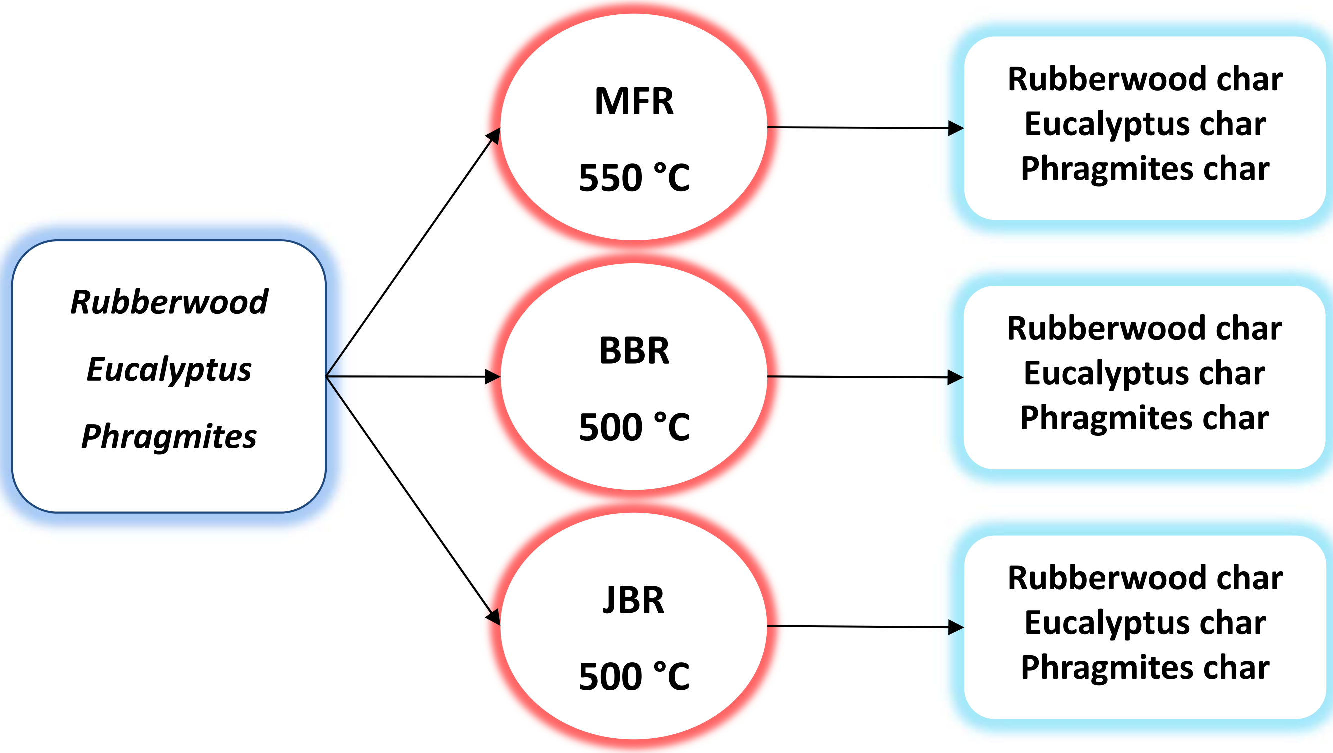
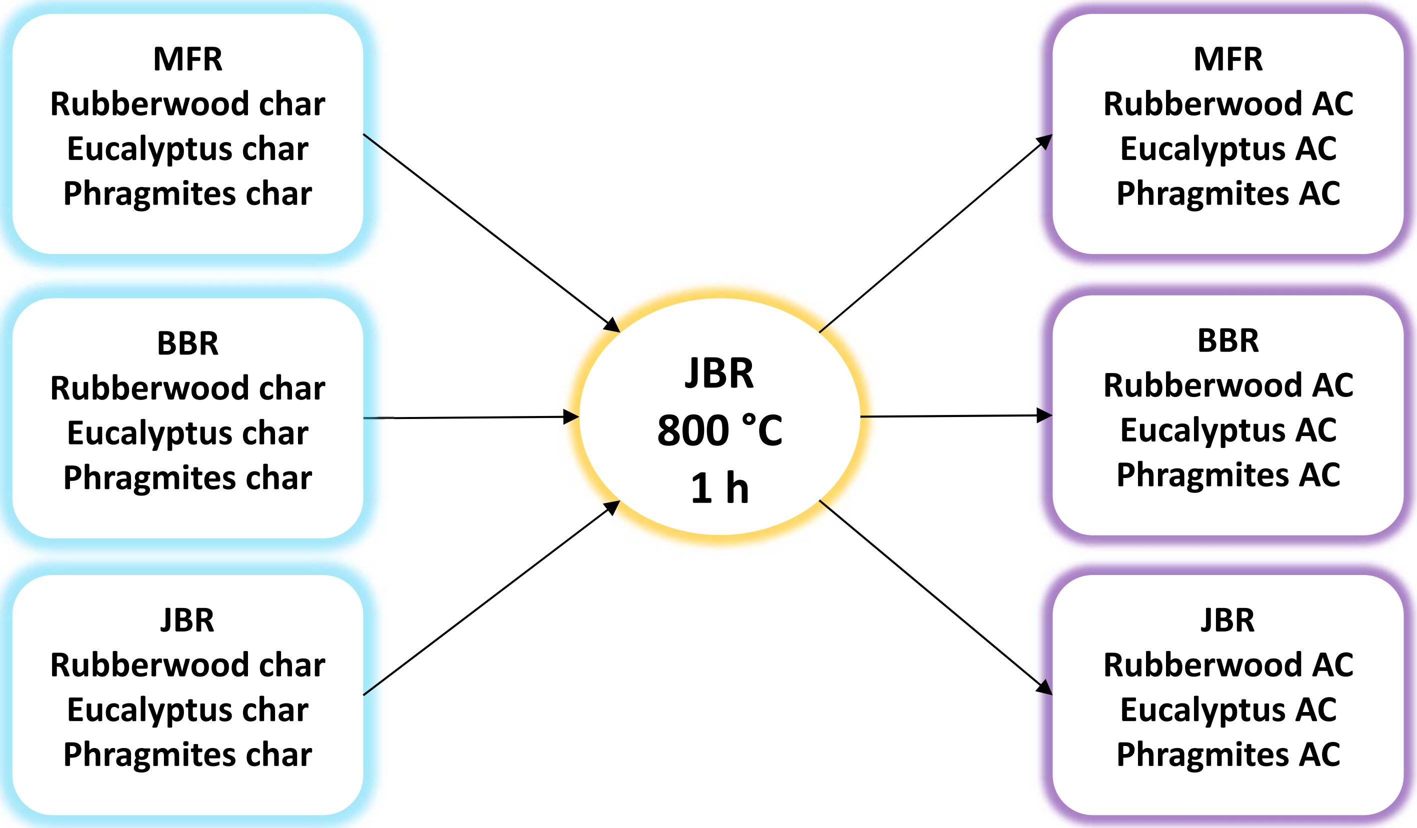


Figure 2.2- Sequence of mixing during a) downward actuator retraction, b) upward actuator extension (Latifi, 2012)

METHODOLOGY: PYROLYSIS



METHODOLOGY: BIOCHAR ACTIVATION



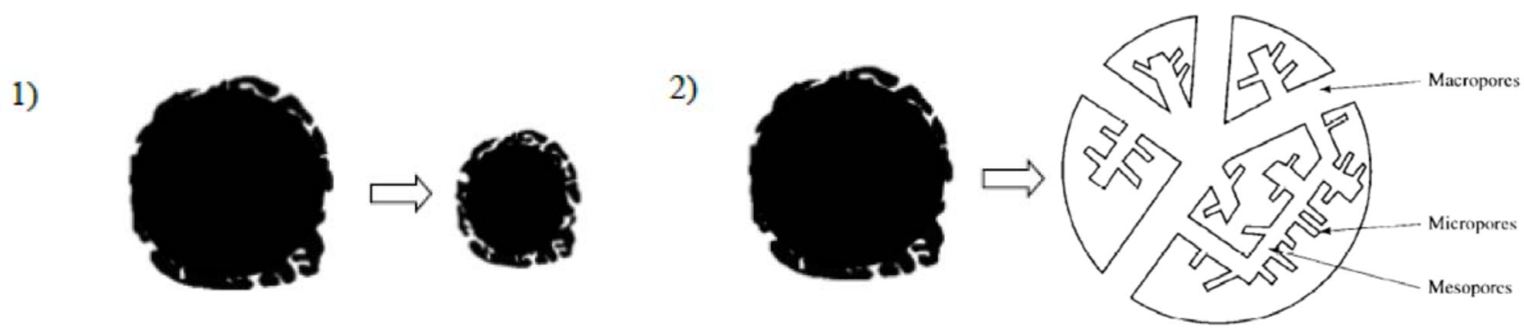
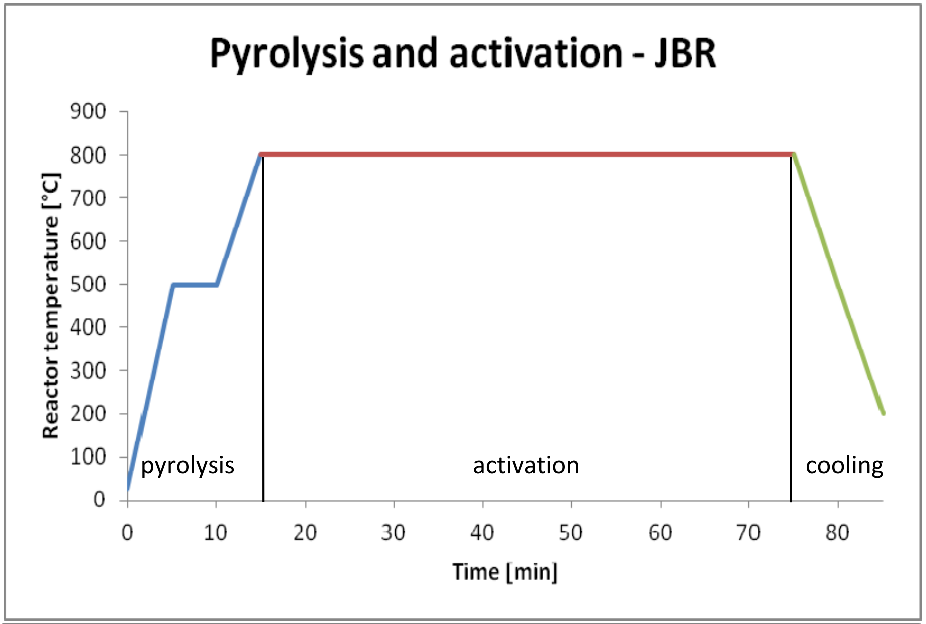
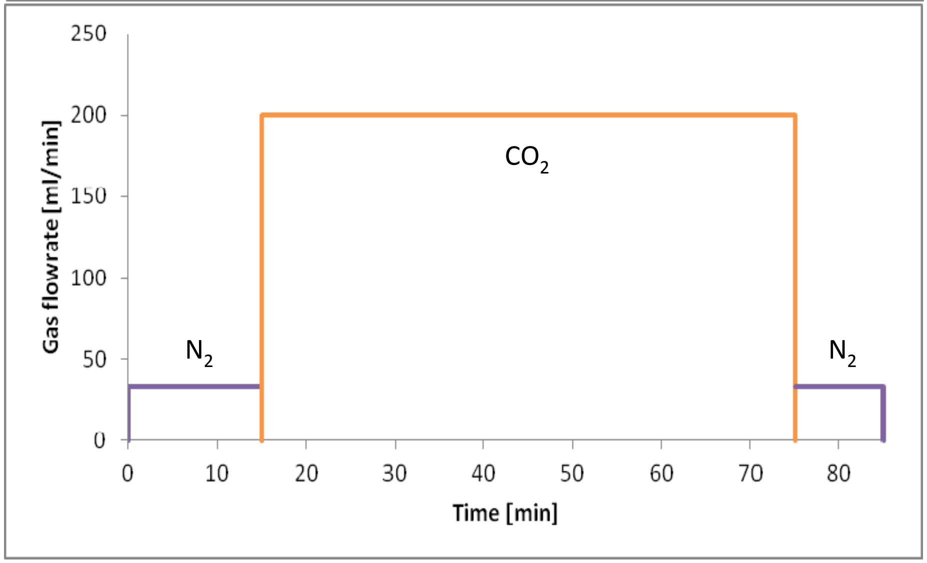


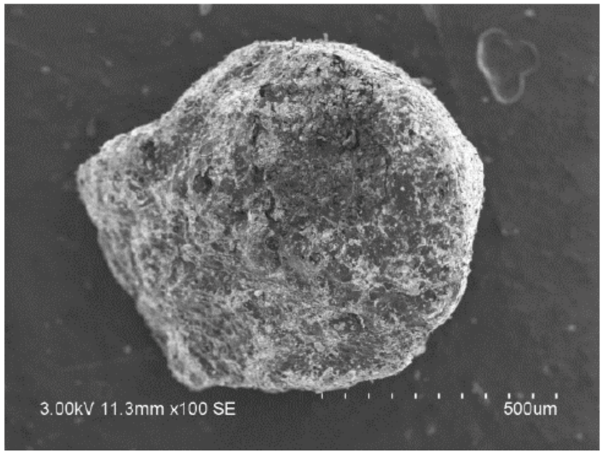
Figure 3 Reactions occurring within a char particle during activation [23]

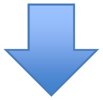
JBR OPERATING CONDITIONS



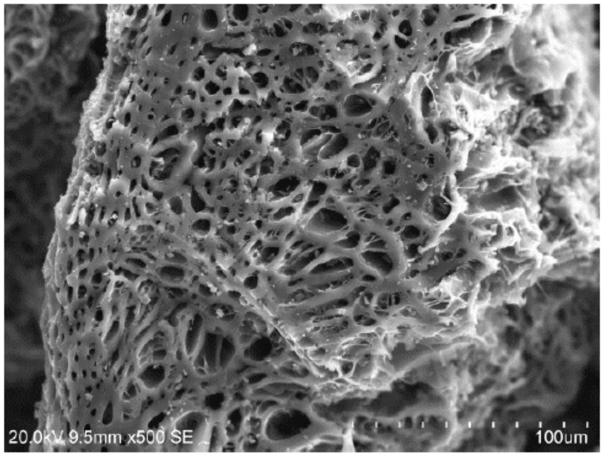


biochar





activated biochar



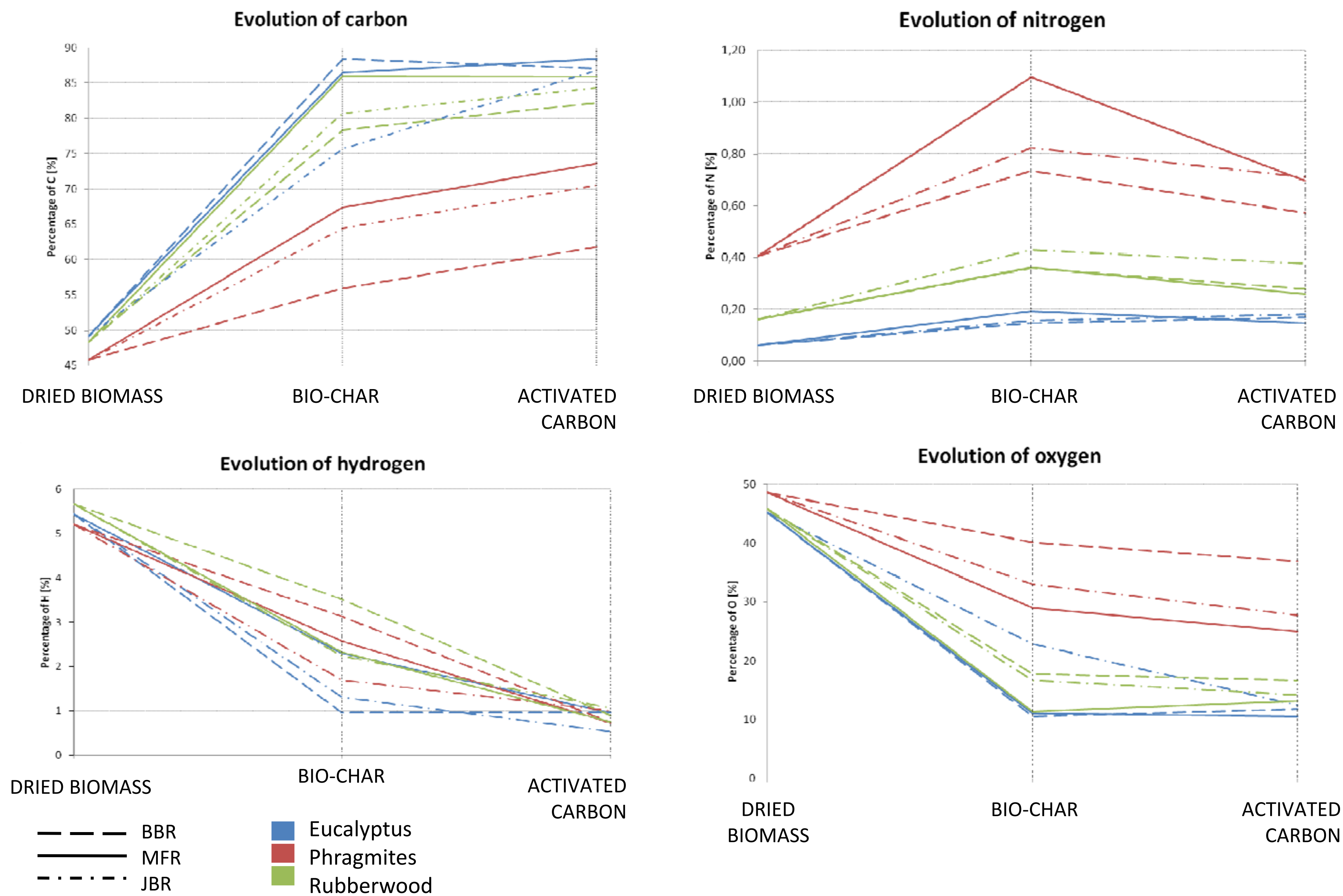
RESULTS: BIOMASSES CHARACTERIZATION AND YIELDS

	Moisture content [%]	Proximate analysis		
		VOC [%]	Fixed carbon [%]	Ash [%]
Rubberwood	5.9	19.4	72.9	1.8
Eucalyptus	9.1	26.2	63.4	1.3
Phragmites	9.0	31.9	52.7	6.5

CHAR YIELDS [%]	BBR	MFR	JBR
Eucalyptus	22.8	22.4	23.8
Phragmites	27.9	34.5	26.9
Rubberwood	20.9	18.4	23.1

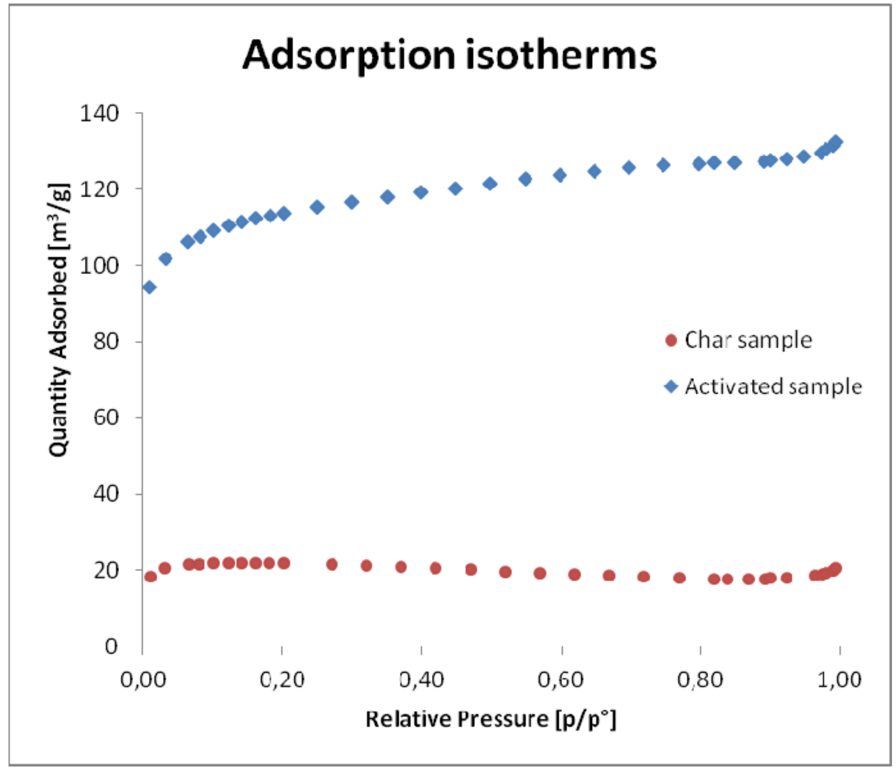
ACTIVATED CARBON YIELDS [%]	BBR	MFR	JBR
Eucalyptus	71.1	72.8	95.5
Phragmites	68.3	77.3	98.2
Rubberwood	75.8	84.7	87.2

RESULTS: ELEMENTAL ANALYSIS

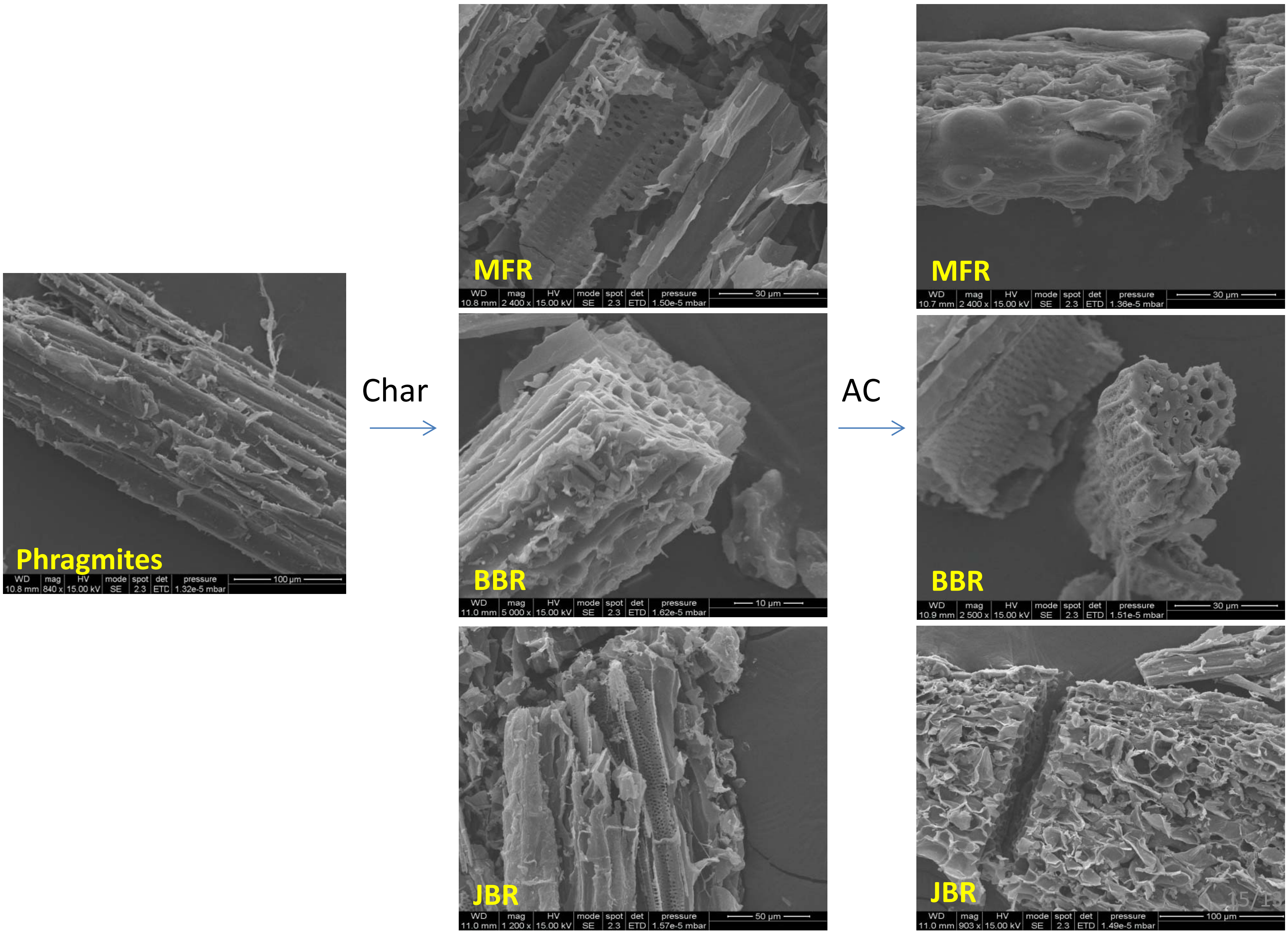


RESULTS: BET ANALYSIS (PHRAGMITES)

	SURFACE AREA		PORE VOLUME	PORE SIZE
Char	BET surface area [m^2/g]	t-Plot micropore area [m^2/g]	t-Plot micropore volume [cm^3/g]	Adsorption average pore width [Å]
MFR	63,59	57,07	0,03	17,31
BBR	~~2,11~~	~~1,83~~	~~0,00~~	~~66,84~~
JBR	73,32	75,31	0,03	16,09
Activated Carbon				
MFR	308,59	292,50	0,14	17,52
BBR	368,83	247,95	0,11	22,48
JBR	385,24	283,02	0,13	20,82



RESULTS: SEM IMAGES



CONCLUSIONS

- **JBR** is an **effective** reactor to **simulate different technologies**, to **optimize process conditions** and to **test activation processes** on different biomasses;

- **JBR** is a **valid alternative to conventional reactors** for the experimental investigation of biochar production;

- ***Phragmites australis*** showed an **interesting potential** as biochar and activated carbon feedstock, analogous to conventional ligneous biomasses.

further research is necessary to investigate:

- the **optimization of biochar production and activation** to enhance micropore area;

- the **adsorption capacity** of the produced activated carbons towards organic and inorganic pollutants.