Porosity enhancement of biochar derived from rubber sawdust using steam injection at low temperature

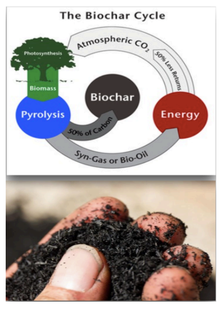
[a] The Joint Graduate School of Energy and Environment, King Mongkut's university of Technology Thonburi, Bangkok,10140 Thailand

[b] College of Nanotechnology, King Mongkut's Institute of Technology, Ladkrabang, Bangkok, 10520 Thailand

Napat Kaewtrakulchai [a] , Apiluck Eiad-Ua [b], Patrick Rousset [a]

E-mail address : knapat.kara@gmail.com

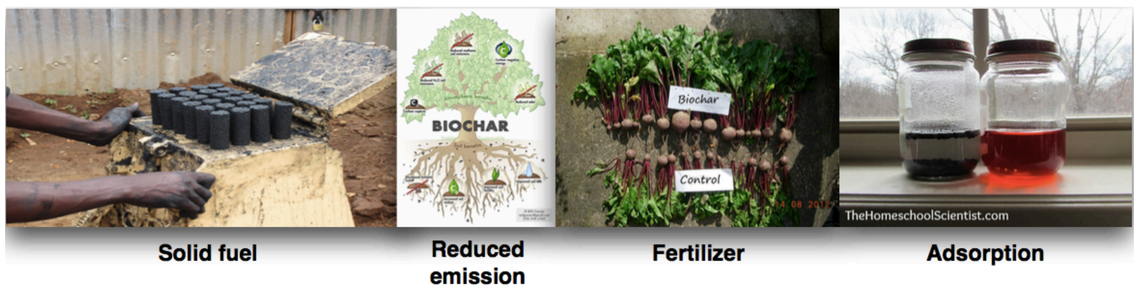
Introduction



Biochar is a stable solid, rich in carbon produced from biomass (woody or non-woody biomass) via pyrolysis process in the **absence of oxygen** (Temperature >300 °C)

Chemical composition: fixed carbon >60% , volatiles, ash

Utilisation of biochar

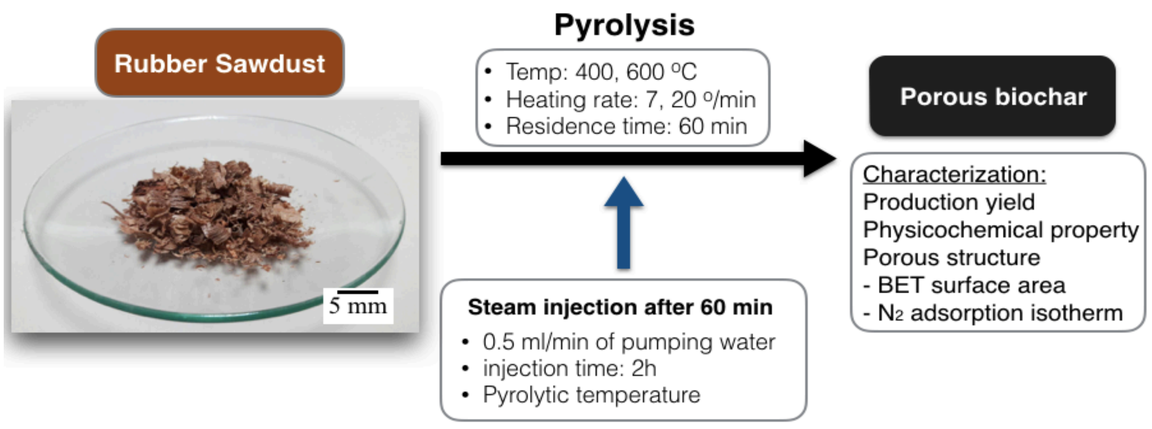


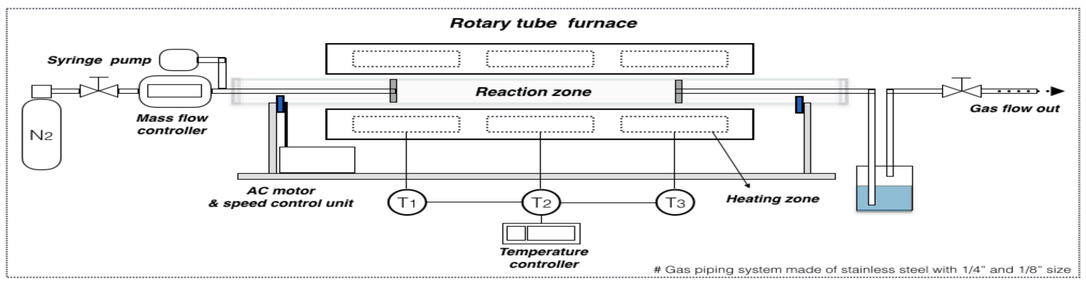
source: http://www.agmrc.org/renewable_energy/biofuelsbiorefining_general/biochar-a-multitude-of-benefits/
https://theawhitman.wordpress.com/what-is-biochar/
Dr. Patrick rousset, JGSEE

Objective

To study the effect of pyrolytic parameters and steam injection on the pore characteristic of biochar at low temperature

Experimental





Results and Discussion

Table1: Properties of rubber sawdust.

Property	Value
Proximate analysis (as-received, wt%)	
Moisture	2.7
VM[a]	84.1
FC[b]	12.9
Ash	0.3
Ultimate analysis (db, wt%)	
C	48.6
H	8.3
N	0.4
O*	42.7

** Calculated by difference, [a]Volatile matter, [b]Fixed carbon*

Table2: Characterization of biochar samples.

Property	bc400-7	bc400-20	bc600-7	bc600-20
Proximate analysis (db, wt%)				
VM[a]	38.5	35.6	15.1	14.9
FC[b]	59.8	62.8	82.1	82.6
Ash	1.7	1.6	2.8	2.5
Ultimate analysis (d.a.f, wt%)				
C	69.5	73.3	83.8	83.9
H	5.5	5.9	3.1	2.9
N	1.4	1.2	1.3	1.6
O*	23.6	19.3	10.8	11.6
yield (db,wt%)	33.1	31.5	25.2	22.6

** Calculated by difference, [a]Volatile matter, [b]Fixed carbon*

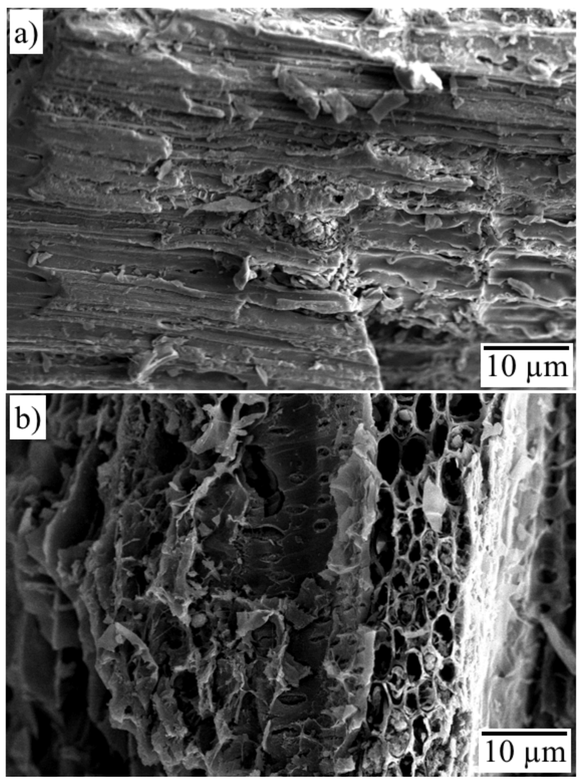


Figure 1: SEM image of (a) bc400-20S and bc600-20S biochar.

SEM photograph of (a) bc400-20S and (b) bc600-20S biochar treated by steam injection of 2h is displayed in Figure 1 with 1000× magnification. The appearance showed various porous structure on bc600-20S surface and less porosity in bc400-20S structure. Additionally, the pore characteristics of untreated biochar and biochar enhanced porosity through the steam injection at different pyrolytic conditions were report in Figure 3. Regarding the specific surface area calculated by BET method, it was found that the specific surface areas increase in the temperature range 400 to 600 °C. The heating rate doesn't affect significantly the porosity. The maximum specific surface areas found in bc600-20S was 497.24 m^2/g. In addition, the total pore volume calculated at the relative pressure (P/P_0) range between 0.05 to 1.0., is showed in Figure 3. However, the total pore volume rised up with an increase in the pyrolytic temperature and the effect of steam injection.

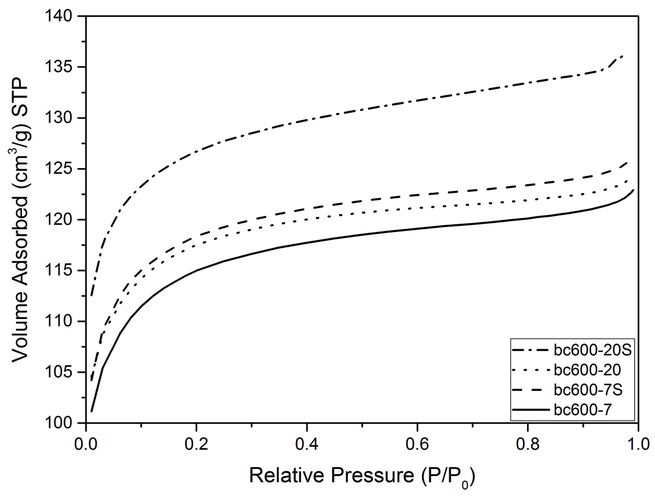


Figure 2: N_2 adsorption isotherm of bc600-7, bc600-7S, bc600-20, bc600-20S.

Biochar produced at 600°C with heating rate of 20°C/min has higher total pore volume. While, bc400-7, bc400-7S, bc400-20 and bc400-20S biochar show low porosity. Moreover, Figure 2 shows the N_2 adsorption isotherm of bc600-7, bc600-7S, bc600-20 and bc600-20S. All isotherm curves are type I, which concern specifically the monolayer adsorption due to the presence of micropore structure [21]. Additionally, The average pore size (approximately 3.02 to 3.21 nm) reported in Figure 3 also related to the adsorption isotherm.

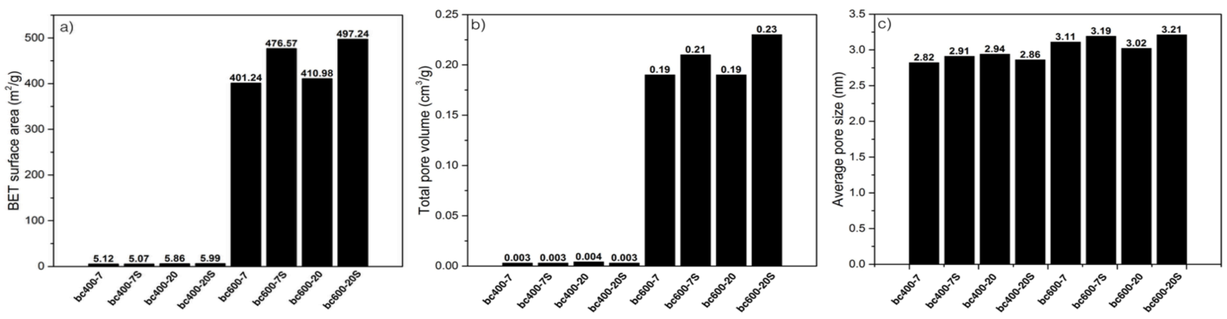


Figure3: Pore characteristics of sample (a) BET surface area, (b) Total pore volume and (c) Avarage pore size .

Conclusion

In this work, biochar was prepared from rubber sawdust at the range of low pyrolytic temperature (i.e. 400 to 600°C) with different heating rate of 7 and 20 °C/min. The porosity of biochar could be enhanced by operating the pyrolytic conditions. Steam injection also enhanced biochar porosity at the experimental condition of 600°C. The result revealed that steam injection combined to high temperature increased significantly the porosity. Regarding to the chemical composition of rubber sawdust biochar characterized by thermogravimetric method, The result showed the high fixed carbon content resulted in BC600-7, BC600-20 about 82.1, 83.9 wt%, respectively.

Acknowledgment

I acknowledge The Joint Graduate School of Energy and Environment (JGSEE), King Mongkut's University of Technology Thonburi (KMUTT) and College of Nanotechnology King Mongkut's Institute of Technology Ladkrabang (KMITL) for assistance.