Synthesis of the porous activated carbon from end-of-life tire pyrolysis for CO_2 sequestration

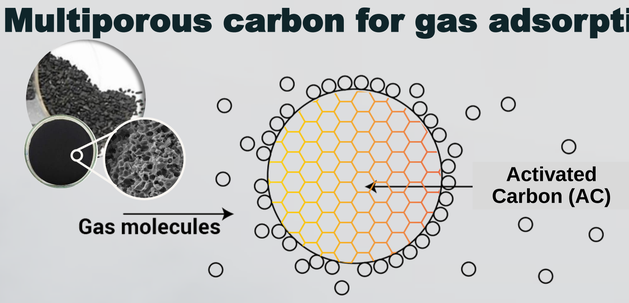
Sirinwaranon P.[1], Sricharoenchaikul V.[2], Atong D.[1]

[1]National Metal and Materials Technology Center (MTEC), Thailand Science Park, Pathum Thani, Thailand
[2]Faculty of Engineering, Department of Environmental Engineering, Chulalongkorn University, Bangkok, Thailand

This research aims to to produce micro-meso porous activated carbon from waste tire by the combination of chemical and physical methods in the fixed bed reactor for CO_2 adsorption. The chemical activation method is impregnation in acid (H_3PO_4) or base (KOH). These methods can drastically improve the porosity and specific surface area of AC from waste tire pyrolysis product. The experimental consists of 2 parts; (i) char can be obtained by pyrolysis of waste tire at 700°C with heating rate of 10°C/min for 1 h under inert atmosphere. Char sample was sieved into 0.125-0.425 mm size. (ii) activation 3 g of char by immersion in 1 M H_3PO_4 at 60°C for 3 h and subsequently carbonized at 700°C for 2 h in horizontal furnace. Afterwards, the powder was washed by deionized water to neutral pH followed by drying at 105°C in the oven. The obtain fine powder was characterized using X-ray diffraction (XRD), and Fourier transform infrared spectrometry (FT-IR) and N_2 adsorption-desorption isotherms. The cross-linkage between C-C bonds of waste tire could be broken down by pyrolysis at temperature of 700°C. The XRD pattern shows broad peak around 2θ of 24° indicated the amorphous. The broad band of FT-IR spectra at 3600-3200 cm^{-1}, 3100-2900 cm^{-1}, 1649 cm^{-1}, and 1469 cm^{-1} are O-H stretching of hydroxyl groups, C-H stretch from carbonyl groups, C=O stretching of carboxylic groups, respectively. For both CT and PT treating with chemical activation either H_3PO_4 or KOH yield highest surface area of 106 and 137 m^2/g, respectively. The results indicate that char from waste tire pyrolysis has suitable properties to be utilized as porous carbon in CO_2 adsorption process. Further application of this work can help solving the challenge of disposal of waste tire and establishing the policy of Sustainable Development Goals (SDGs) and Thailand Bio-Circular-Green (BCG) economy model.

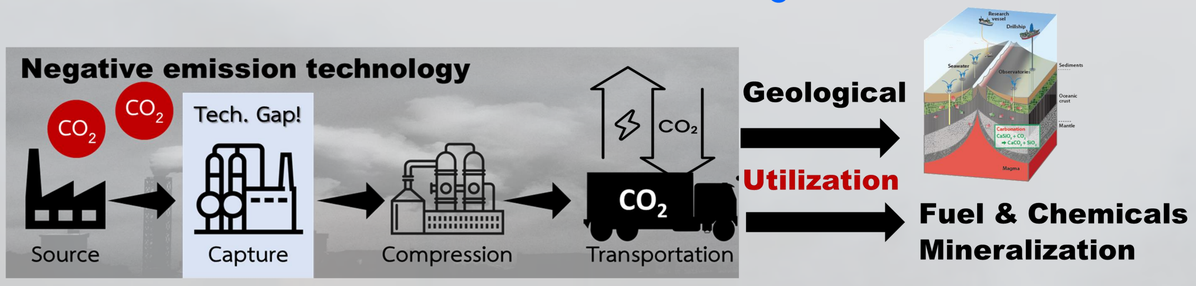
Introduction

Multiporous carbon for gas adsorption



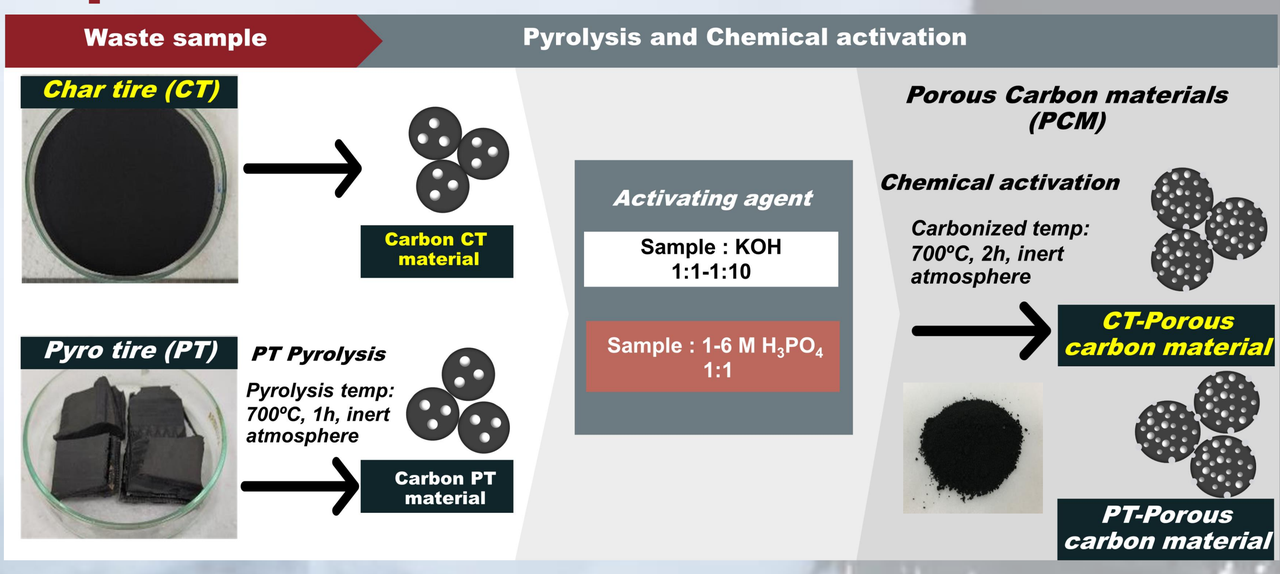
- High surface area 800-1,100 m^2/g
- Pore diameter <2-50 µm
- Surface modification

Multi purpose use case



Aim: To produce micro-meso porous activated carbon from waste tire by the combination of chemical and physical methods in the fixed bed reactor for CO_2 adsorption.

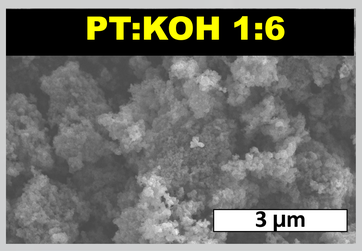
Experiment



Results and discussions

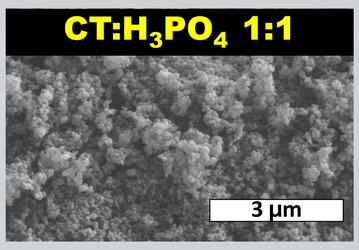
Textural analysis — Activation with KOH

	Activation ratio	Surface area (m^2/g)	Average pore diameter (nm)	Total pore volume (cm^3/g)
CT				
As received	-	90.26	25.53	0.58
	1:2	71.65	21.68	0.39
	1:4	79.07	23.47	0.46
KOH	1:6	120.20	18.15	0.55
	1:8	124.02	16.03	0.50
	1:10	*136.90*	*16.89*	*0.58*
PT				
Pyrolyzed	-	*78.21*	*23.05*	*0.45*
	1:2	59.32	21.45	0.32
	1:4	94.98	12.83	0.30
KOH	*1:6*	*114.70*	*12.54*	*0.36*
	1:8	106.73	14.01	0.37
	1:10	93.65	13.28	0.31



Textural analysis — Activation with H_3PO_4

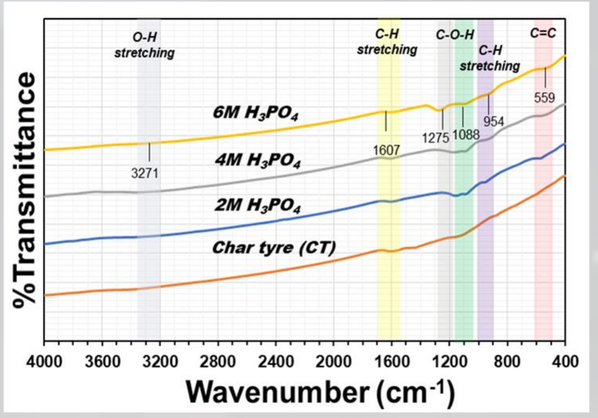
	Activation Conc.	Activation Ratio	Surface area (m^2/g)	Average pore diameter (nm)	Total pore volume (cm^3/g)
CT					
	1M		*106.50*	*18.98*	*0.51*
H_3PO_4, 60°C, 3h	2M	1:1	80.41	25.03	0.50
	4M		85.68	13.34	0.29
	6M		57.35	17.93	0.26
PT					
	1M		57.74	21.11	0.30
H_3PO_4, 60°C, 3h	2M	1:1	59.17	19.58	0.39
	4M		63.07	20.84	0.33
	6M		35.71	24.77	0.22

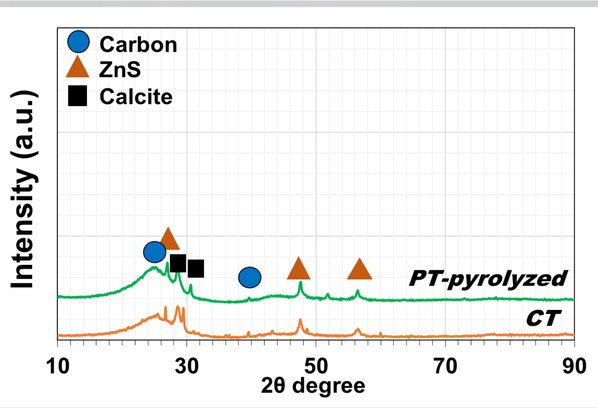


Results and discussions

Composition of PCM

Composition	CT	PT
Proximate analysis (%wt)		
Moisture	2.07	0.91
Volatile matter	6.31	65.84
Fixed C	57.73	28.15
Ash	33.88	5.10
Ultimate analysis (%wt)		
C	70.07	84.27
H	6.20	7.52
N	1.01	0.33
S	1.33	1.83
O (by diff.)	2.78	9.67

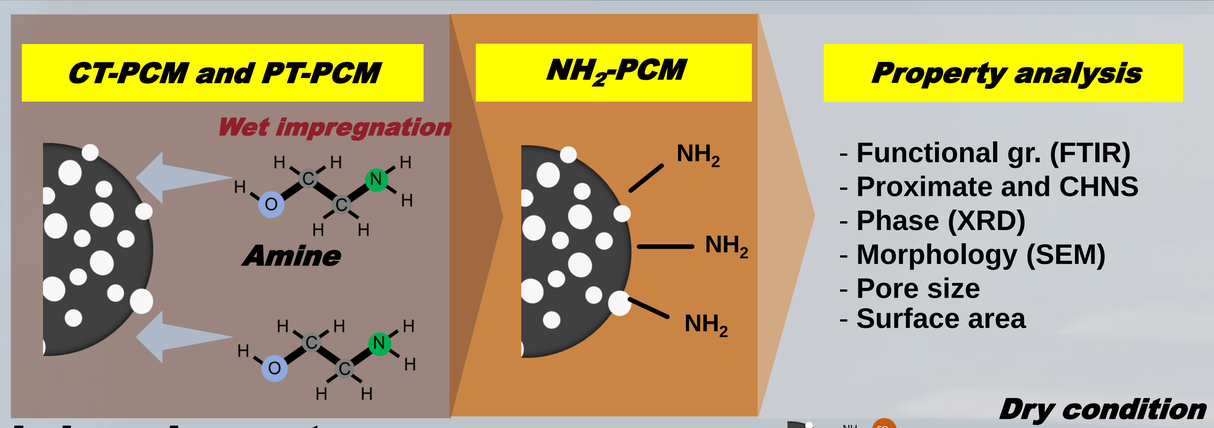




- O-H stretching vibration (3271 cm^{-1}), aromatic ring C-H stretching vibration (1607 cm^{-1}), and C-H out-of-plane bending (559-954 cm^{-1})
- The amorphous carbon with the small peak around 24° due to imperfect formation of graphite as broad peak around 2θ 20-30°.
- Minute impurities, zinc sulfide and calcite, probably from the additive components for tire production.

Future work

The upcoming mega trend → **CO_2 adsorption capacity**



Conclusions

- Porous Carbon Materials (PCM) from waste tire activated with KOH exhibited superior adsorption properties than H_3PO_4 activated char.
- Char tire (CT) activated by KOH possessed favorable intrinsic properties as CO_2 adsorbent from surface area (SA) of 138.90 m^2/g with mesopore structure (2-50 nm).
- Pyrolysis tire (PT-pyrolyzed) activated with KOH displayed satisfactory intrinsic properties as CO_2 adsorbent from surface area (SA) of 114.70 m^2/g.
- Char tire has surface area of 70-90 m^2/g with high ash and sulfur from addition of $CaCO_3$ (as extender) and sulfur (as vulcanizing agent) during tire production.

Acknowledgement

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