ID-3 Hydrothermal carbonization of spent coffee ground: Application of pretreatment for activated carbon synthesis

*Shiming Qin, Osamu Sawai, Teppei Nunoura
The University of Tokyo, Japan

Introduction

Spent coffee ground (SCG)

- The global coffee consumption almost doubled in these 30 years
- About 6,500,000 tons of SCG were generated in 2018

Greenhouse gas generation | About 90% SCG ends up to landfill | Underground water contamination

Research Objective

- Investigate the effect of operating conditions in HTC process on hydrochar precursor and activated carbon property
- Evaluate activated carbon for their adsorption capacity of zinc ion in water solution

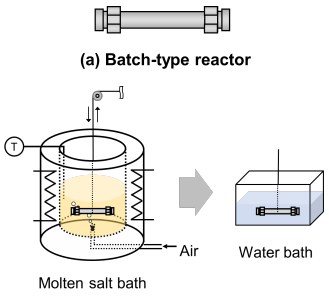
Methodology

Hydrothermal experiment

■ **Reactor: Batch type**
Material: SUS316
Inner volume: 29.3 mL

■ **Raw materials**
SCG from student cafeteria in Kashiwa Campus

■ **Experimental Condition**
Temperature: 180-300 ℃
Reaction time: 2 h
SCG/water ratio: 1:2
HNO_3 addition: 0%, 5%



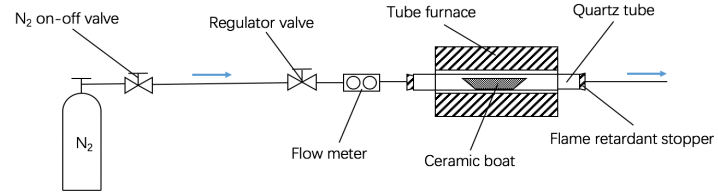
Hydrothermal experiment set-up

KOH Activation experiment

■ **Reactor:**
Tube furnace with ceramic boat

■ **Raw materials:**
Well mixed 2 g SCG hydrochar and 6 g KOH

■ **Experimental Condition:**
Temperature: 600 ℃, Reaction time: 1 h,
N_2 flow rate: 400 mL/min, heating rate: 4 ℃/min



KOH activation experiment set-up

Result and Discussion

Morphology analysis of hydrochar precursor

- 240HC (Fig (b)) retained the lignocellulosic appearance of raw material (Fig (a))
- Hydrochar microspheres were observed on 240HC (Fig (b))
- Cluster of hydrochar microspheres was observed on m240HC (Fig (c)), where HNO_3 addition facilitated the formation of hydrochar

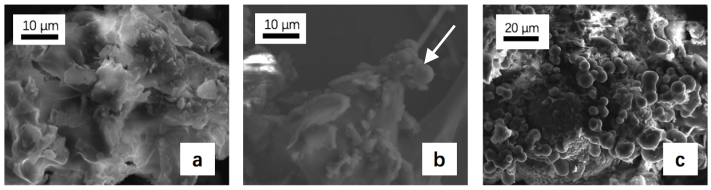
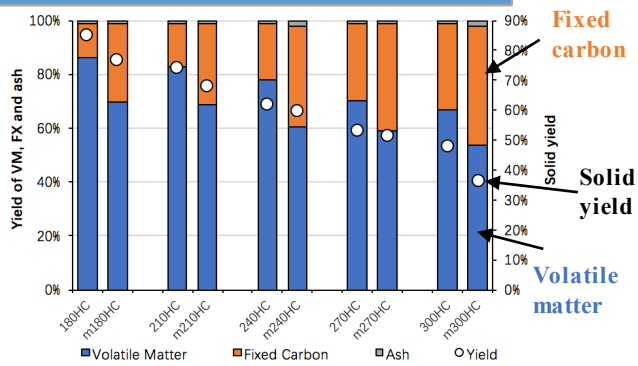


Fig (a) raw SCG | *Fig (b) 240HC* | *Fig (c) m240HC*

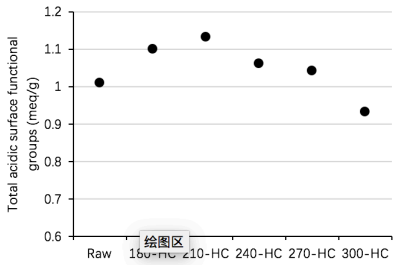
Proximate analysis of hydrochar precursor



- At lower temperature, most of the biomass substance were difficult to be decomposed (most of VM remained).
- At higher temperature, carbonization progressed more (FC content increased), but extensive gasification of SCG lowered the yield of solid product.
- Addition of HNO_3 enhanced fixed carbon content

Surface functional groups of hydrochar precursor

When HTC temperature exceeded 210 ℃, the amount of acidic functional groups began to decrease because of extensive dehydration and condensation of hydrochar which enhanced its chemical stability



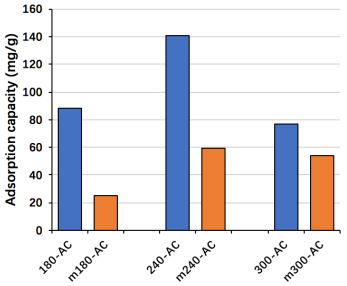
Porous structure of activated carbon products

- Activation of 240HC resulted in the highest porosity.
- HNO_3 modification during HTC did not give higher porosity in activated carbon.

Sample name	Pore volume (cc/g)	BET surface area (m^2/g)
180-AC	0.311	542
240-AC	0.485	916
300-AC	0.451	793
m240-AC	0.405	765

Zinc ion adsorption performance

- 240AC showed the best adsorption performance.
- HNO_3 modification in HTC resulted in lower performance of AC.



Zinc ion adsorption capacity

Conclusion

- ✓ **Hydrothermal carbonization temperature highly affected the hydrochar product and the activated carbon prepared from it**
- ✓ **HNO_3 modification did not improve the pore development during KOH activation**

Reference
[1] Guilherme Nunes Torga, Eduardo Eugênio Spers (2020), "Coffee Consumption and Industry Strategies in Brazil, Chapter 2 - Perspectives of global coffee demand"