Self-Activation Process for Biomass Based Activated Carbon

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Producing Activated Carbon

Biomass → Thermal Treatment (➢ Carbonization ➢ Self-activation) → Activated Carbon

Self-Activation takes the advantage of the gases emitted from the thermal treatment process of the biomass materials, such as sawdust, kenaf, sugarcane, and other wood and agricultural residues, to activate the converted carbon.

- **Effective** – One-step process
- **Economical** – No activation agent needed (reducing the cost)
- **Environmental** friendly – no chemicals added, and less gas emitted

Theory

$$2.21C_{3.37}H_{5.14}O_{2.21}(s) \xrightarrow{1{,}000°C,\ 1atm} 2.58C(s) + 5.59H_2(g) + 4.82CO(g) + 0.0311H_2O(g) + 0.0278CH_4(g) + 0.0164CO_2(g) + \cdots$$

FactSage thermochemical software and databases

Self-Activation Process

Biomass → One step, no agent/gas added: CARBONIZATION + SELF-ACTIVATION → Activated Carbon

Revolutionary Improvement

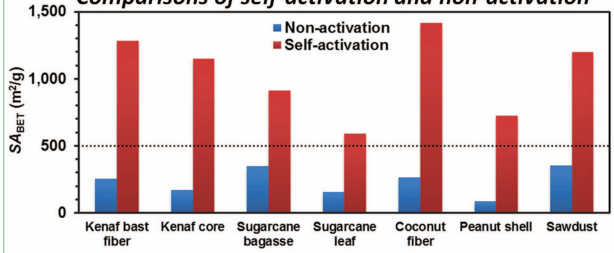
Traditional Activation Process

Raw Materials → CARBONIZATION → Carbon → ACTIVATION → Activated Carbon

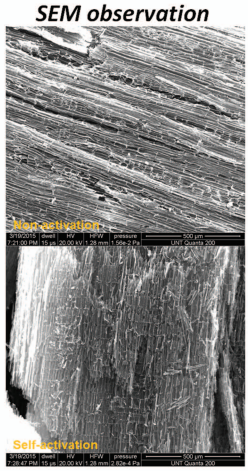
- *Physical/thermal activation* e.g. CO_2, water steam
- *Chemical activation* e.g. acid, strong base, or salt

Results and Discussion

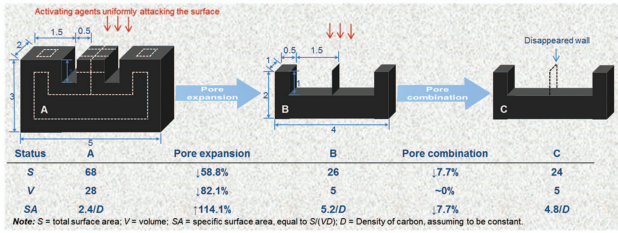
Comparisons of self-activation and non-activation



SEM observation



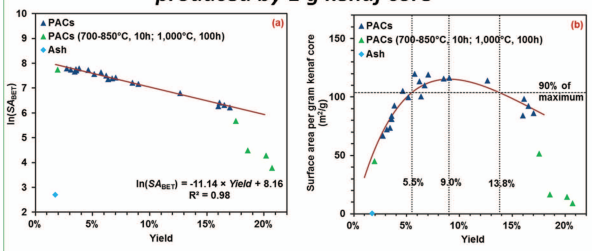
Activation model



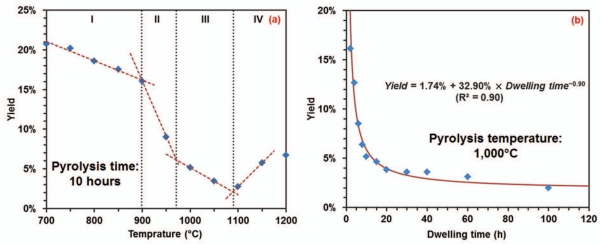
Status	A	Pore expansion	B	Pore combination	C
S	68	↓58.8%	26	↓7.7%	24
V	28	↓82.1%	5	~0%	5
SA	2.4/D	↑114.1%	5.2/D	↓7.7%	4.8/D

Note: S = total surface area; V = volume; SA = specific surface area, equal to S/(VD); D = Density of carbon, assuming to be constant.

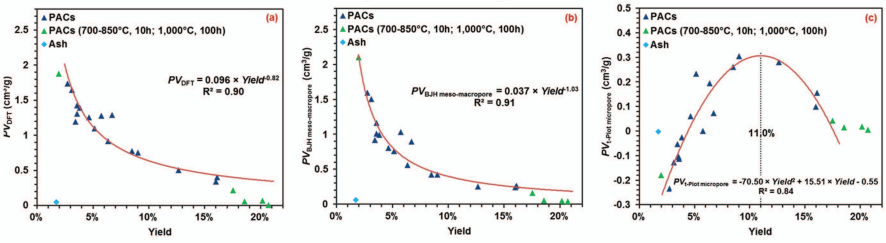
Yields vs. a) ln(SA_{BET}) and b) total surface area produced by 1 g kenaf core



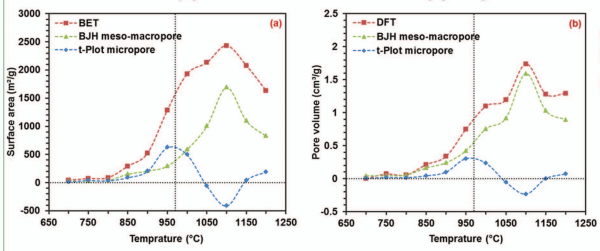
Yields vs. a) pyrolysis temperature and b) pyrolysis time



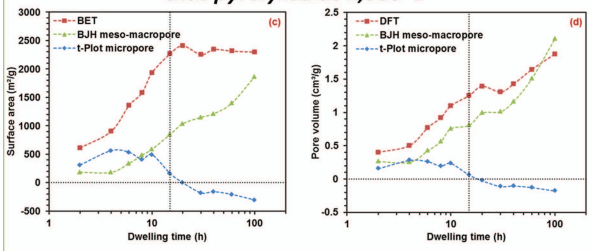
Yields vs. pore volumes from the theories of a) DFT; b) BJH adsorption; and c) t-Plot micropore



Temperature-dependent changes of a) surface area and b) pore volume with 10 h pyrolysis



Kinetics of a) surface area and b) pore volume that pyrolyzed at 1,000°C



Conclusions

- Self-activation is an effective activation process for activated carbon from biomass without any additional activating gases or chemicals.
- A model of activation process was developed to understand and explain the activation process.
- The suggested pyrolysis temperature for the self-activation process is between 970–1,090°C.
- A lineal fitting for ln(SA_{BET}), power fittings for PV_{DFT}, $PV_{BJH\ meso\text{-}macropore}$, and a second-order fitting for $PV_{t\text{-}Plot\ micropore}$ with yields.
- Kinetics showed the changes of surface areas and pore volumes with the pyrolysis temperatures and durations, which was consistent with the model.
- The study of effective showed that the yield of 9.0% received a maximum surface area per using gram kenaf core, and the yields between 5.5% and 13.8% were recommended for more than 90% of effectiveness.

References

- Shi, Sheldon Q., and Changlei Xia. "Porositization process of carbon or carbonaceous materials." U.S. Patent Application 14/211,357, filed March 14, 2014.
- Xia, Changlei, and Sheldon Q. Shi. "Self-activation for activated carbon from biomass." (In Submitting)

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