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Fabrication of Activated Rice Husk Charcoal by Slip Casting as a Hybrid Material for Water Filter Aid

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Abstract. Activated charcoal has been widely used as an odor absorbent in household and water purification industry. Filtration equipment for drinking water generally consists of four parts, which are microporous membrane (porous alumina ceramic or diatomite, or porous polymer), odor absorbent (activated carbon), hard water treatment (ion exchange resin), and UV irradiation. Ceramic filter aid is usually prepared by slip casting of alumina or diatomite. The membrane offers high flux, high porosity and maximum pore size does not exceed 0.3 μm. This study investigated the fabrication of hybrid activated charcoal tube for water filtration and odor absorption by slip casting. The suitable rice husk charcoal and water ratio was 48 to 52 wt% by weight with 1.5wt% (by dry basis) of CMC binder. The green rice husk charcoal bodies were dried and fired between 700-900 ^{o}C in reduction atmosphere. The resulting prepared slip in high speed porcelain pot for 60 min and sintered at 700 ^{o}C for 1 h showed the highest specific surface area as 174.95 m^2/g. The characterizations of microstructure and pore size distribution as a function of particle size were investigated.

1. Introduction

Thailand is the agriculture country. One of the most important is rice farming and the last product from the rice mill is rice husk. There are many ways to increase value rice husk such as using as a fuel in power plant, using for growing plant, and using for preparing activated charcoal. Rice husk charcoal can be activated in two ways which are chemical activation and physical activation. Chemical activation's stimulator is chemical solution such as calcium chloride or phosphoric acid which can infiltrate throughout the carbon then burn it in reduction atmosphere at 600-700 ^{o}C. After that, chemicals can be removed by washing and drying. This process has high cost and possible chemicals impurity included in the products. Thermal activation is stimulating by steam or carbon dioxide at 750 ^{o}C - 950 ^{o}C in reduction atmosphere with suitable time and pressure. Efficiency of activated charcoal depends on specific surface area, structure of pore and functional group at the surface.[1,2] Filtration equipment for drinking water generally consists of four parts, which are microporous membrane (porous alumina ceramic or diatomite, or porous polymer), odor absorbent (activated carbon), hard water treatment (ion exchange resin), and UV radiation. The membrane offers high flux, high porosity and maximum pore size does not exceed 0.3 μm.[3,4] Ceramic filter aid is usually prepared by slip casting of alumina or diatomite.[5]

The objective of this study is to investigate the fabrication method of a hybrid activated charcoal tube for water filtration and odor absorption by slip casting.

2. Experimental procedure

The rice husk was burnt in an incineration furnace below 700 ^{o}C, in order to achieve the quality of carbon in the rice husk charcoal. The burnt rice husk was then practically ground using a wet ball mill for 6 h and was then sieved through a #100 mesh and removed water by filter press. Rice husk charcoal prepared into slip by wet ball milled in a high speed porcelain pot for 5, 15, 30, 45 and 60 min. Particle size distribution was determined by a laser particlesizer (Mastersizer 2000, Malvern). The ratio of rice husk charcoal and water was varied in ratio 50-70% and 50-30% to control the viscosity between 500-1000 cp. CMC (carboxy methyl cellulose) was used as a binder varied 1-2 wt%. The slip was then sieved through a 100 mesh and was then measured density and viscosity before casting in a plaster mould. The slip in plaster mould will set after 2 h (about 3 mm. thickness) after that drain slip from plaster mould and keep it at room temperature for 12 h before remove rice husk charcoal bodies from the mould. The green rice husk charcoal bodies were dried at 60 - 100 ^{o}C and were then fired at temperatures 700, 800 and 900 ^{o}C in reduction atmosphere using a closed steel box filled with rice husk charcoal. Surface area of the fired bodies is characterized by BET (Coulter SA3100) and phase composition is characterized by XRD (Bruker, D8, Cu-Kα, 40kV and 40mA). The properties including flexural strength by 3-point bending (Model HT-811) with a cross speed head of 5 mm/min and shrinkage were also examined. Pore size was determined by mercury porosimetry analyzer (Quantachrome Pore Master-60). Microstructure of green and fired bodies was observed using SEM (JSM-6480LV, JEOL). Flow chart of samples preparation is shown in Fig. 1.

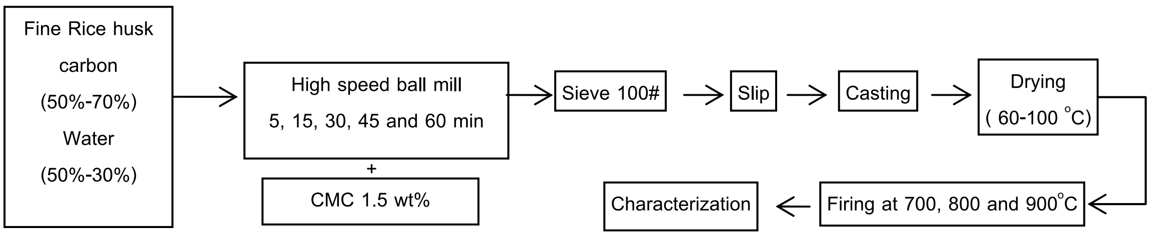


Fig 1. Flow chart of activated charcoal bodies prepared from rice husk by slip casting

3. Results and discussion

The results obtained from the experiments by water ratio (50-30 wt%) and rice husk charcoal (70-50 wt%). At a water ratio of 30% and rice husk charcoal 70%, slip has very high viscosity. The water ratio was increased up to 48% and rice husk charcoal 52% with CMC 1.5% solid (viscosity 800-1000 cp.). Green body doesn't break while taking it from plaster mould at this ratio. Result of preparing slip in any conditions and quality of green body is shown in Table1.

Table 1. Result of preparing slip in any conditions and quality of green body

Ratio of rice husk carbon and water	CMC (%Solid)	Density (g/cm^3)	Viscosity (cp.)	Casting	Green body strength
70 : 30	1%	-	Very high	×	-
60 : 40	1%	-	>2000	×	Very low strength
50 : 50	1%	-	800 - 1000	✓	More strength with some crack
	1.5%	-	1000 - 1200	✓	Strength grow and have less crack
48 : 52	1.5%	1.216	800 - 1000	✓	Perfect green body

After drying, total shrinkage increase follow the firing temperature as shown in Fig 2. Water absorption decreased while firing temperature increase. In Fig 3, at 800 and 900 °C, value of water absorption is nearly and highest at 700 °C. When firing temperature is high, bulk density and apparent density increase with the same tendency. The XRD patterns revealed the phase composition of rice husk charcoal before firing and after firing at 700 °C, 800 °C, and 900 °C. Only quartz peaks were observed as the impurity from porcelain pot in milling process which confirm from phase of rice husk charcoal before milling in porcelain pot.

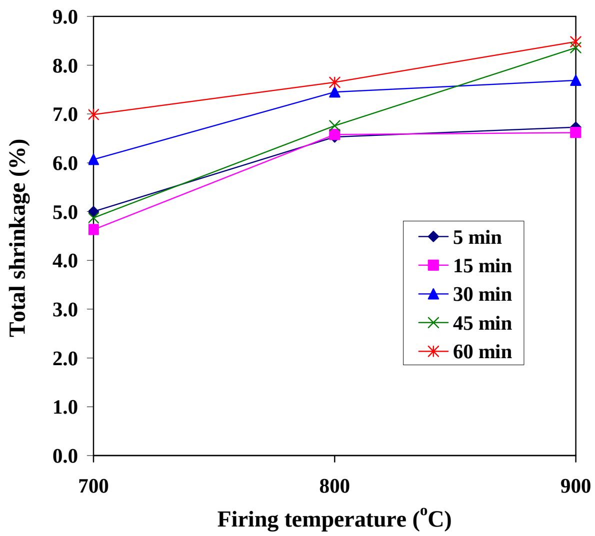


Fig 2. Effects of milling time from 5-60 min on the total shrinkage of rice husk charcoal bodies after firing at 700 °C, 800 °C, and 900 °C

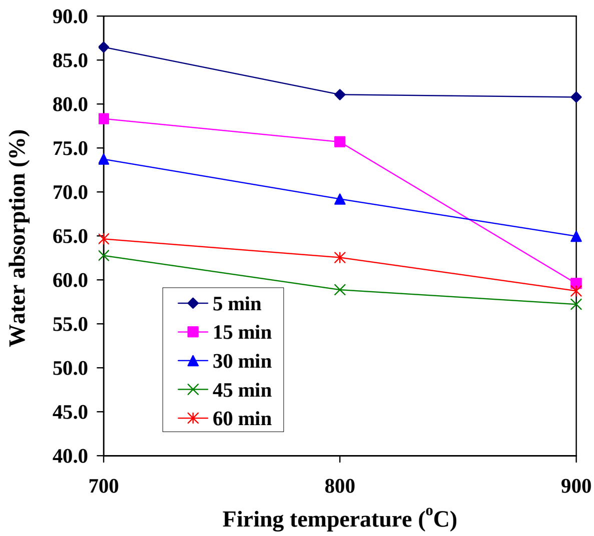


Fig 3. Effects of milling time from 5-60 min on the water absorption of rice husk charcoal bodies after firing at 700 °C, 800 °C, and 900 °C

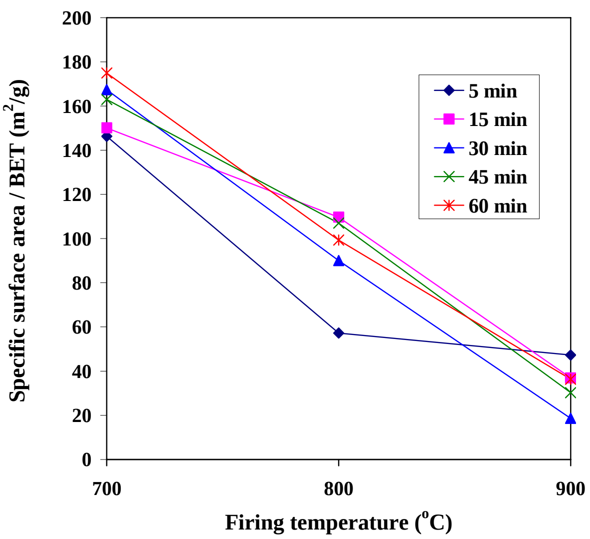


Fig 4. Specific surface area of fire rice husk charcoal specimens by BET method

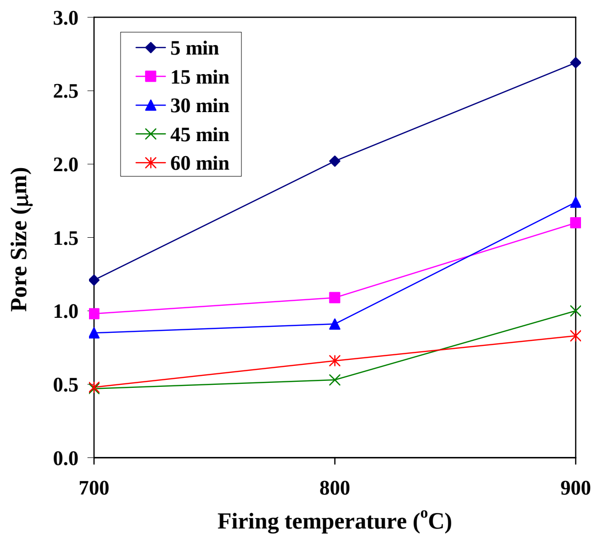
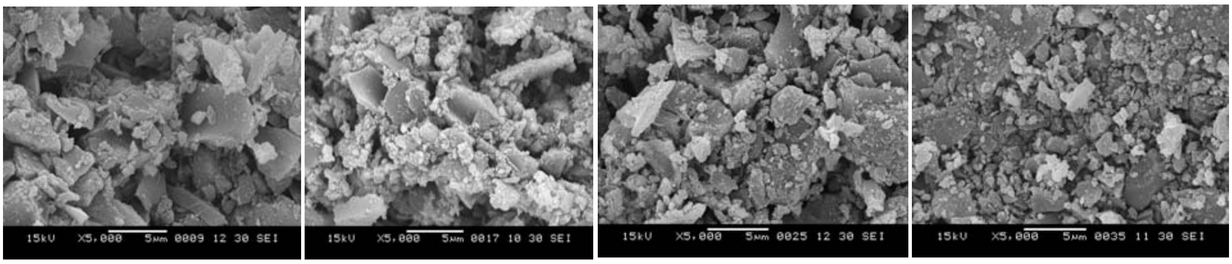


Fig 5. Average Pore Size of fired rice husk charcoal specimens



Before firing **Firied at 700 °C** **Firied at 800 °C** **Firied at 900 °C**

Fig 6. SEM micrograps of fracture surface of rice husk charcoal after firing

Three-point bending strength of casted rice husk charcoal samples in five conditions have low strength (0.1-0.4 MPa) which may caused by defect on the surface of rice husk charcoal body.

Specific surface area of the rice husk charcoal after firing is higher than that of the rice husk charcoal before firing because the firing is a thermal process which activates the rice husk charcoal by exploding the structure. Specific surface area after firing at 700 °C is highest as shown in Fig 4. At 900 °C has the least specific surface area due to the reaction of impurities occurred and covered the pore structure. Pore size increased follow the firing temperature and decreased while time of milling process increased as shown in Fig 5. Microstructure of activated carbon was observed by SEM as shown in Fig 6. Particle size distribution from 60 min of milling shows the finest particle as about 5 μm.

4. Conclusions

From the experimental water absorption decreases while firing temperature is increasing. The resulting prepared slip in high speed porcelain pot 60 min and sintered body at 700°C for 1 h showed the highest specific surface area as 174.95 m^2/g and have satisfied attribute.

Acknowledgements

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