

EVALUATING THE BIOCHAR CREATION EFFICIENCY FROM SPENT COFFEE GROUNDS

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Abstract – *The spent coffee grounds are one of the biomass types that bring many benefits to production and life. The creation of biochar from spent coffee grounds has garnered significant interest in many studies. This article uses the slow pyrolysis method at 450°C, 500°C, and 550°C to create biochar from the spent coffee grounds and determine the biochar generation efficiency to select appropriate experimental parameters of this pyrolysis process. The results showed that, after the slow pyrolysis at 450°C for 30 minutes, the average value of the biochar creation efficiency from the spent coffee grounds is higher than that of the remaining pyrolysis process.*

Keywords: *biochar, biochar creation efficiency (BCE)/biochar yield, biomass, slow pyrolysis, spent coffee grounds (SCGs).*

I. INTRODUCTION

Biomass from agricultural waste products (such as leaves & branches, sawdust, grasses, straw, and spent coffee grounds (SCGs)) is applied to develop renewable energy, improving energy sustainability, the environment, and the global economy [1–3].

For a long time, coffee has been a widely used drink and many stores use pure coffee beans that are roasted, ground, and brewed by machine. After brewing, SCGs account for about 70% of the weight [4]. The composition of the SCGs contains about 91.1% biomass with 11.8% protein,

23.1% fat, 42.5 fiber, 7% ash, and 13% caffeine [5]. The SCGs have also been researched and applied to different areas of life and production: as additives for semi-biofuels [6], combined to reduce plastic waste [7], bio-oil production science [8, 9], improvement of soil & water contaminated with heavy metals [10], energy storage devices [11], flame retardants [12], and biochar [13–18].

Biochar created from SCGs has a porous structure and a high specific surface area, making it suitable for treating and removing polluting components that affect domestic water, including removing lead and fluoride from contaminated water [13], adsorbing and filtering lead in water [14], and filtering NH_4^+ [15].

Different methods used in biochar production include fast pyrolysis, slow pyrolysis, gasification, anaerobic fermentation, or hydrothermal carbonization [16, 17]. The pyrolysis process plays an important role in creating carbon source conversion reactions to synthesize biochar, improving the quality and performance of activated carbon [18].

The research of Nsamba et al. [16] shows that slow pyrolysis is the thermal conversion process of biomass by slow heating at a temperature of 450–650°C under no or rare oxygen conditions. And the heating time factor also affects the biochar creation efficiency (BCE). The results show that the BCE can reach 25–35% [16] and 35% [18].

In this study, the BCE of the biochar from the SCGs was determined after performing the slow pyrolysis process at 450°C, 500°C, and 550°C with holding times of 0.5 and 1 hour, respectively.

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II. MATERIAL AND METHODS

SCGs were obtained from coffee shops using pure beans and were roasted, ground, and brewed by machine in the Thu Duc area, Ho Chi Minh City, Vietnam.

The slow pyrolysis of the SCGs produces biochar and determining the BCE is performed in the Material Testing Laboratory at Ho Chi Minh City University of Technology and Education (HCMUTE).

Figure 1 describes some equipment and tools mainly used for experiments.

The general process of the slow pyrolysis of the SCGs to create biochar and determine the BCE includes eight steps.

Step 1: Wash and soak the SCGs with distilled water (Figure 2).

Step 2: Filter through paper (Figure 3).

Step 3: Dry at 105°C.

The SCGs after absolute drying and stored in the zipper bag (Figure 4).

Step 4: Weigh 40 grams of the SCGs after drying.

Step 5: Pour the SCGs into the pyrolysis box, press, and close tightly.

Step 6: Slow pyrolysis heating (T), holding time (τ), and cooling in the air to room temperature (Table 1).

Step 7: Remove the lid of the pyrolysis box and take out the biochar (Figure 5).

Step 8: Determine the BCE.

The BCE is determined according to the Equation (1).

$$BCE(\%) = \frac{M_B}{M_{SCGs}} \times 100\%$$

(1)

where MB is the mass of biochar and M_{SCGs} is the mass of the SCGs.

III. RESULTS AND DISCUSSION

Figure 5 shows some biochar from the SCGs after the slow pyrolysis process.

The BCE of the biochar from the SCGs is presented in Table 2 and shown in Figure 7.

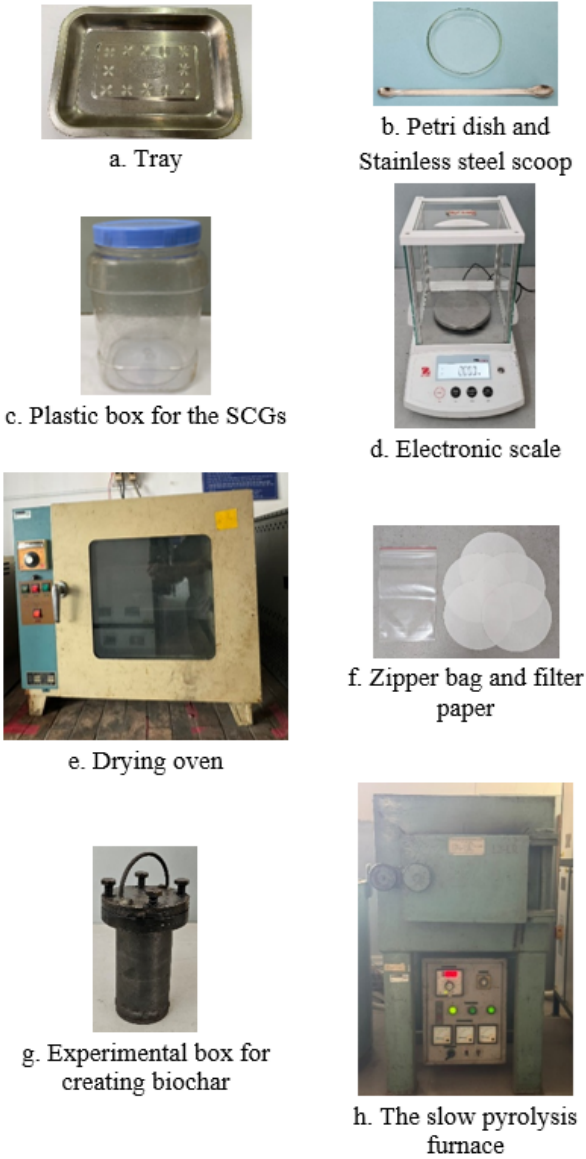


Fig. 1: Images of equipment and tools used for experiments

Figure 6 shows weighing the sample of the SCGs before the slow pyrolysis process and the biochar.

The results in Table 2 and Figure 7 show that the BCE_{AVE} of the biochar from the SCGs with a holding time of 30 minutes (samples A, C, and E) is higher than those with a holding time of 60 minutes (samples B, D, and F), and the BCE_{AVE}



Fig. 2: The SCGs in the soak box



Fig. 3: The SCGs are filtering



Fig. 4: The SCGs after drying

Table 1: Parameters of the slow pyrolysis process to create biochar from the SCGs

Biochar samples	Parameters	T (°C)	τ (mins)
A		450	30
B		450	60
C		500	30
D		500	60
E		550	30
F		550	60

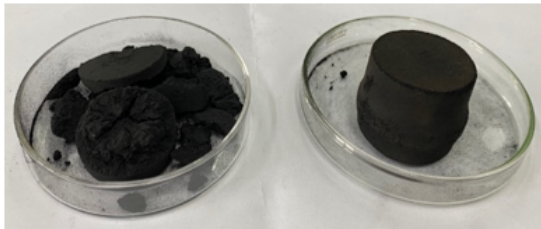


Fig. 5: The biochar from the SCGs after the slow pyrolysis process

of the A biochar sample is the highest.

At the same time, the average value of the BCE is higher, but not too much, than the value mentioned in the study conducted by Duku et al. [18].

IV. CONCLUSION

This article presents the determination of BCE in the biochar from the SCGs. The biochar from the SCGs is produced by the slow pyrolysis process at 450°C, 500°C, and 550°C with holding times of 0.5 and 1 hour, respectively. Next is to weigh the biochar and determine the BCE. The result shows that the BCE_{AVE} of the biochar sample after the slow pyrolysis process with $T = 450^{\circ}C$, $\tau = 30$ mins, and cooling in the air to room temperature is the highest.

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Table 2: The BCE results in biochar samples from the SCGs

Parameters Biochar samples	M _{SCG5} (grams)	M _B (grams)	BCE (%)	BCE _{AVE} (%)
A	40	14.774	36.94	36.97
		13.813	34.53	
		15.781	39.45	
B		12.892	32.23	31.87
		13.124	32.81	
		12.231	30.58	
C		11.622	29.06	29.70
		11.861	29.65	
		12.158	30.40	
D		10.965	27.41	27.80
		10.963	27.41	
		11.436	28.59	
E		11.612	29.03	28.81
		11.452	28.63	
		11.513	28.78	
F		11.162	27.91	27.63
		10.964	27.41	
		11.024	27.56	

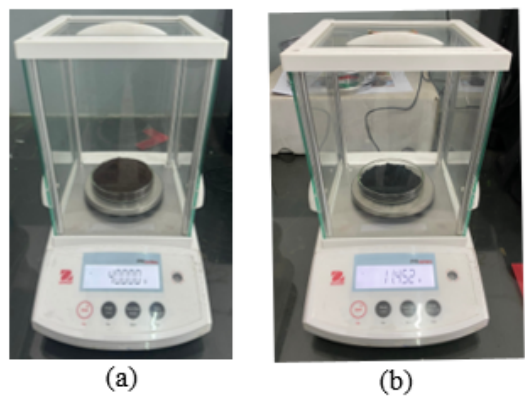


Fig. 6: Mass of the SCGs before the slow pyrolysis process (a) and the biochar (b)

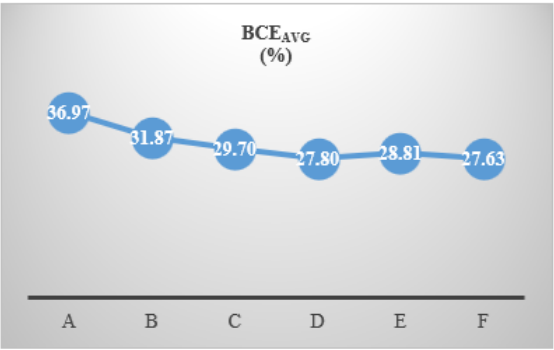


Fig. 7: The BCE_{AVE} results in biochar samples from the SCGs

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