Ammonia Adsorption of Four Thailand White Charcoals for Air Purification Application

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Abstract. The goal of this work was to study the efficiency of ammonia adsorption of four white charcoals include Bamboo, Coconut spathe, Coconut shell and Miscellaneous woods. The ammonia 20 mL was used as the odour sample for adsorption, 0.1 grams of each white charcoal was used as adsorbent and adsorption time were studied in 20, 40, 60, 80, and 100 min. The gravimetric method was used as method for study ammonia adsorption. The results show all white charcoals have saturated adsorption in range 40-60 min. The sequent of ammonia adsorption with white charcoal from descending were Miscellaneous > Coconut spathe > Coconut shell > Bamboo. A statistical test with Paired Samples T-Test, the result of four white charcoal to absorb the odour of ammonia in the all adsorption times have difference statistically significant at the 95% confidence.

1. Introduction
Thailand is agricultural country many where have wastes of wood from many activities such as miscellaneous woods from construction building, bamboo from basketwork and coconut spathe and coconut shell from food production process [1]. These are a big problem because of no enough storage places [2]. Maximizing the value of these materials is very important [3]. Nowadays, there are a lot of pollution types and intensified even more in everyday. All pollutions are problem on humans directly. Especially, the odour problem is one of the important issues that affect the ecological environment and also affects on respiratory tract of humans [4]. Currently, there are two kinds of charcoal include the ordinary "black charcoal" and "white charcoal". These charcoals are made by different technical method of burning [5]. Although, they are produced in a basically similar manner, the quality of the charcoal differs totally depending on how the fire is extinguished. The method for producing white charcoal is hard compared to ordinary black charcoal [6]. This technology is applied mostly in Japan, and some parts of China and Korea. Nowadays, the world admires the charcoal-making techniques of Japan and applies it in the field of apply science [7-9]. White charcoals are produced from natural raw materials waste such as wood, bamboo, coconut that the waste from the basketwork or residue waste wood for other applications [10-15]. White charcoal is a good of materials for adsorbing an odour because it has a high adsorption capacity. Many researchers reported about adsorption gases such as ethylene [16], hydrogen [17] and some work studied adsorption of acetic acid vapour [18]. Therefore, in the study is the investigation on the efficiency of four white charcoals, (bamboo, coconut spathe, coconut shell and miscellaneous wood) for ammonia absorption to reduce these wastes wood and remove odour. This study can be used as a model for adsorption odour in environment and air purification in the future work.
2. Materials and Methods

2.1. Materials

Analytical grade of ammonia solution 25% was purchased from Merck KGaA, Darmstadt, Germany. The wastes of miscellaneous woods were collected from construction site, the bamboo was collected from basketwork, and coconut shell and coconut spathe was collected from the fresh market in Prachinburi province, Thailand. Each materials wood was carbonized at >1000 °C for more than three hours to change as white charcoal.

2.2. Method

Ammonia adsorption in this work were studied by Gravimetric method using recording the initial weight of white charcoal before testing compared to the final weight of white charcoal after testing. For ammonia adsorption test, theses step were followed this following; (1) carefully weighting 0.1 g of white charcoal before testing, (2) preparing ammonia solution 20 mL into bottle test and record starting weight before testing (3) testing ammonia adsorption in various adsorption times for 20, 40, 60, 80, 100 min., (4) recording weight after adsorption testing of all samples, (5) calculating of percentage of adsorption follows equation 1, (6) observing microstructure of all white charcoal using scanning electron microscope (SEM, JSM 5410 JEOL, Japan), (7) measuring of specific surface area using A Flowsorb II 2300, Micromeritics, USA, and (8) comparing and discussing results.

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\text{\% Adsorption} = \frac{W_A - W_B}{W_B} \times 100
\]

Where; \(W_A\) is weight after adsorption testing, and \(W_B\) is weight before adsorption testing.

3. Results and Discussion

Microstructure of four white charcoal were observed using SEM with magnifications of 35X. The pore of white charcoal could be observed but the fine structure requires higher than this magnification. The SEM images revealed pore wide smaller than 1 mm as shown in Figure 1.

![SEM images of white charcoal](image)

**Figure 1.** SEM of (a) Bamboo, (b) Coconut spathe, (c) Coconut shell, and (d) Miscellaneous wood

| Time (min) | Bamboo     | Coconut spathe | Coconut shell | Miscellaneous |
|-----------|------------|----------------|---------------|---------------|
| 20        | 112.02±7.82| 129.22±7.27    | 118.11±16.94  | 136.96±9.57   |
| 40        | 145.76±10.55| 141.14±6.78    | 140.92±9.52   | 145.14±23.26  |
| 60        | 121.84±6.96| 136.25±17.86   | 127.57±14.43  | 149.50±15.17  |
| 80        | 108.13±11.09| 130.19±24.19   | 125.18±4.30   | 153.91±10.78  |
| 100       | 92.43±8.70 | 120.53±27.12   | 121.14±7.65   | 154.42±15.31  |

**Table 1.** Percentage of ammonia sorption of four white charcoals in various adsorption times
The 0.1 g of bamboo white charcoal powder was used as adsorbent for ammonia adsorption in 20, 40, 60, 80 and 100 min. Percentage of ammonia adsorption of four white charcoals in various adsorption times are concluded in Table 1. This table found that a white charcoal from bamboo, coconut spathe, coconut shell and Miscellaneous had ammonia adsorption around 118 %, 131 %, 121 % and 148 %, respectively. These results related with specific surface area of white charcoal in Table 1. The results show that all of white charcoal had specific surface area more than 3100 m$^2$/g. All white charcoals powder was used as adsorbent for ammonia adsorption in 20, 40, 60, 80 and 100 min. Figure 2(a) was the line graph with standard error of percentage ammonia adsorption all white charcoal. It was clear that percentage of ammonia adsorption more than 100 % of its weight almost all. At adsorption time in 40 min was highest adsorption at adsorption of bamboo, coconut spathe and coconut shell. After that the percentage continuously decreased with increasing of adsorption time. This may because this time is saturated adsorptive of these white charcoals [19]. However, miscellaneous white charcoal continuously increased with increasing of adsorption time. This may be caused by high specific surface area. When concern only average percentage of adsorption, it is indicated that miscellaneous wood has highest percentage of ammonia adsorption. The sequent of ammonia adsorption with white charcoal from descending were Miscellaneous > Coconut spathe > Coconut shell > Bamboo follow Figure 2(b). These results may be caused by density, pore volume and specific surface area of each white charcoal [20] and related specific surface area from this study.

|          | 118.04±9.20 | 131.47±16.64 | 121.14±10.57 | 148.12±15.31 |
|----------|-------------|--------------|--------------|--------------|
| Surface area (m$^2$/g) | 3,189 | 3,230 | 3,205 | 3,280 |

Figure 2. Ammonia adsorption of four white charcoals (a) in various times and (b) in average value

4. Summary
It can be conclude that every white charcoal have adsorption nearly the same value at adsorption time 40 min. Miscellaneous wood white charcoal has highest percentage of ammonia adsorption. The sequent of ammonia adsorption with white charcoal from descending were Miscellaneous > Coconut spathe > Coconut shell > Bamboo. These results can used as model for odor removal and can reduced these waste wood from environmental of Thailand because of using the waste wood from wicker (Bamboo), cutting wood for building house (Miscellaneous wood), and cooking (Coconut spathe and Coconut shell).
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6. References
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