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RESEARCH ON THE ABILITY OF HANDLING AMMONIA CONTAMINATED AIR STREAM BY ACTIVATED CARBON MATERIALS FROM COCONUT FIBER (AC-1) AND PEANUT HUSK (AC-2), IMPREGNATED WITH $ZnCl_2$

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ABSTRACT

This research aimed to investigate the ability of handling ammonia emission from waste gas by adsorption methods. The absorbents were activated carbon materials, which were made from coconut fiber (AC-1) and peanut husk (AC-2), impregnated with $ZnCl_2$. Both of these materials have shown their abilities to remove NH_3 (over 90 % efficiency) at the concentration of about 9000 ppm, while the removal efficiency of commercial activated carbon (AC-3) was 70 %. At the inlet concentration of about 3000 ppm, the maximum ammonia removal efficiency was 96.23 % when using AC-1 and 97.74 % using AC-2. The saturation time of each activated carbon was also examined. At inlet concentration of 2800 – 3200 ppm with gas flow rate was 0.4 $L.min^{-1}$ and 5 g in mass material, the ammonia removal efficiencies of AC-1 and AC-2 were maintained at 80 % lasting for 600 minutes, but the efficiency of AC-3 rapidly decreased to 30 %. In all experiments, the activated carbon that made from peanut husk (AC-2), impregnated with $ZnCl_2$ showed higher performance than one made from coconut fiber (AC-1) and commercial activated carbon (AC-3).

Keywords: ammonia, adsorption, activated carbon.

1. INTRODUCTION

In the natural environment, ammonia (NH_3) is produced by the decomposition of animals and plants or from N_2 in the air under the catalyzation of nitrogenases enzyme. This amount of NH_3 is negligible and contributes to neutralize the acidity of the atmosphere. The metabolism process inside animal body also produces NH_3 and it immediately converts to urea [1, 2, 3]. However, NH_3 is nowadays considered because its effects on the environment become seriously.

NH_3 widely discharges from agricultural, industrial, animal husbandry, composting, sludge treatment and landfill. In agricultural production, the emission of ammonia is range from 10 to 60 ppm [4]. In industry, ammonia is emitted from wastewater treatment plants, fertilizer plants and chemical manufacturing industries. In the organic fertilizer production from solid waste

plant, the concentration of NH_3 is up to 394 ppm (at 30 °C) [5], while the concentration of NH_3 from the organic fertilizer producing plants is up to 1023 ppm (at 30 °C) [6, 7].

In Viet Nam, NH_3 is classified in the category of Odorants and concentration of NH_3 in ambient air according to the National Technical Regulation on some hazardous substances in ambient air (QCVN 06: 2009/BTNMT) is 200 $\mu g/m^3$ [8]. Although not classified as a chemical that can cause cancer, NH_3 can be considered as a harmful toxin to human health depending on the concentration and duration of exposure. At low concentration, NH_3 creates a feeling of bitterness, while high levels can even cause blindness, the smell of it can cause severe. Therefore, ammonia is considered to be a long-term cause of bronchitis. In industry, NH_3 gas leakage will corrode the equipment, thereby clogging the production process.

NH_3 can be removed by adsorption methods with different materials such as activated carbon, composite materials or the Granite oxide. In addition to environmental benefits, this method also has many economic ones because it can recover the substances after adsorption, the treatment system is relatively simple, saving investment costs, simple in operation and start-up time is shorter than the biological method.

Coconut fiber and peanut husk are two popular materials in Vietnam. Previously, coconut fiber was mainly used as a material for burning while peanut husk was used as oil extract. Nowadays, with the development of science, technology and the pressure of the economy and agricultural by-products are utilized radically to serve a variety of purposes, including the air pollution control engineering. Vietnam's national environmental protection strategy has set a target that by 2020, the waste recycling industry should be formed and developed. Therefore, the utilization of agricultural waste to produce activated carbon not only brings economic and social benefits but also important in environmental protection. Moreover, as waste products in agriculture, coconut fiber and peanut husk are low cost, easy to find and especially having good absorption abilities. For all of these reasons, coconut fiber and peanut husk should be selected as raw material in this study. After cut into pieces of about 2 - 3 cm in order to be uniformly in size, they were impregnated with $ZnCl_2$, carbonized at 700 ^oC and then used to investigate the ability of handling ammonia emission from waste gas by adsorption method. The saturation time of each activated carbon was also examined.

2. MATERIALS AND METHOD

2.1. Experimental setup

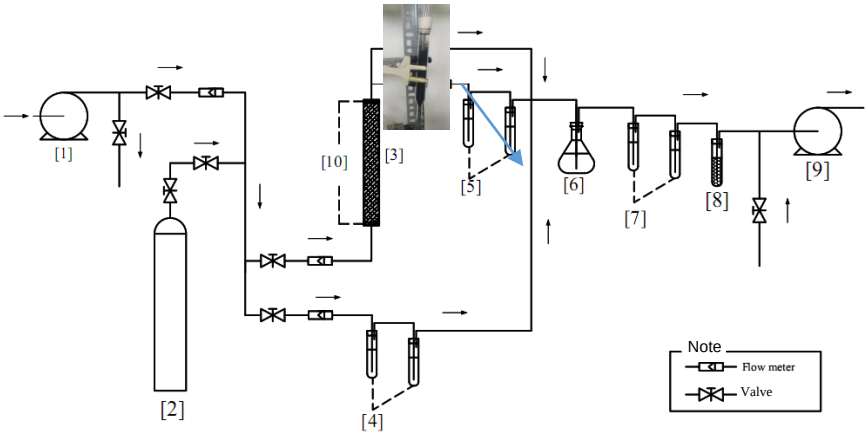


Figure 1. The schematic diagram of the adsorption experimental set up:
1. Clean air pump;
2. Gas cylinder;
3. Activated carbon tube;
4. Inlet sampling system;
5. Outlet sampling system;
6. Absorption solution;
7. Protection impinger;
8. Silica gel;
9. sampling pump;
10. Fiber glass.

The ammonia concentration in the inlet was generated by mixing pure air from clean air pump (1) with concentrated ammonia air stream from gas cylinder (2). After that, waste air was led to the bottom of the activated carbon tube (3). This tube was made from glass with 20 mm diameter and 80 mm height. The inlet and outlet concentration of ammonia was measured by inlet and outlet sampling system (4, 5).

2.2. Preparation of activated carbon from coconut fiber and peanut husk

Coconut fiber and peanut husk were pre-prepared, cut into pieces of about 2 - 3 cm in order to be uniformly in size before impregnated. After cut into pieces, coconut fiber and peanut husk were sequentially impregnated in $ZnCl_2$ (10 %) solution in 1h. Then they were drained and dried in air at 60 ^oC in 12 h to remove water and volatile substances. The resulting materials were carbonized by heating at 700 ^oC in an anaerobic furnace under a flow of nitrogen in 1 h. After cooling down, materials were washed again with HCl 1 M to acidify the surface. The excess of $ZnCl_2$ and HCl was removed by washing with diluted water and dried out at 60 ^oC. Activated carbon from coconut fiber (AC-1) and peanut husk (AC-2) were formed.

2.3. Sampling and analyzing method

The removal efficiency was appreciated by measuring the concentration of ammonia in the inlet and outlet streams. Two sampling systems were placed at the beginning and the end of the activated carbon tube. Each sampling system consisted of two impingers, which contained 25 mL H_2SO_4 0.05 N solution. Ammonia was absorbed to this solution and analyzed by photometric method.

3. RESULT AND DISCUSSION

3.1. Effect of ammonia inlet concentration to the removal efficiency

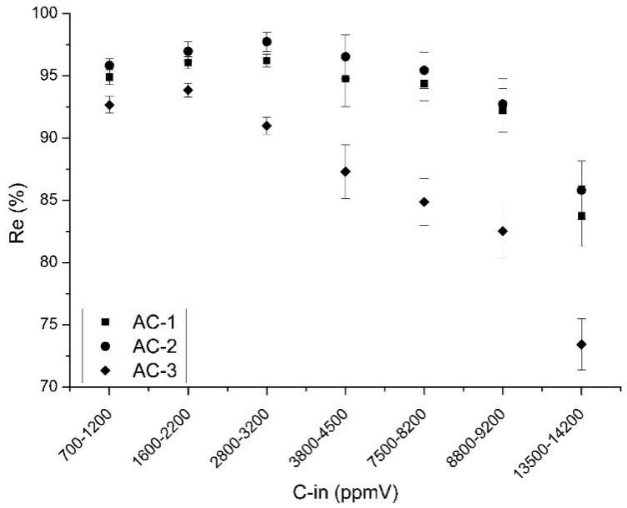


Figure 2. Effect of ammonia inlet concentration to the removal efficiency.

Figure 2 showed that the adsorption process with activated carbon made from coconut fiber (AC-1) and peanut husk (AC-2) had high ability on ammonia removal from waste air (over

80 %). At all concentration, the removal efficiency (Re) of AC-2 (about 94 %) was higher than AC-1 (about 92 %) and AC-3 (about 87 %). While the mass of adsorbent was 5g, the air flowrate was maintained at 0.4 $L.min^{-1}$, increasing the concentration of ammonia in the inlet air stream, the removal efficiency decreased to 85 % with AC-2, 83 % with AC-1 but the removal efficiency of AC-3 was rapidly decreased to 77 %. The results showed that the adsorption process with activated carbon made from coconut fiber (AC-1) and peanut husk (AC-2) could be applied to control ammonia contaminated air stream which emitting from composting plants [9]. The maximum removal efficiency was 96.23 ± 0.51 % with AC-1, 97.74 ± 0.77 % with AC-2 but with AC-3, the maximum removal efficiency was 93.86 ± 0.55 % when the inlet concentration was only 1600 – 2200 ppm.

3.2. Examining the saturation time of each activated carbon

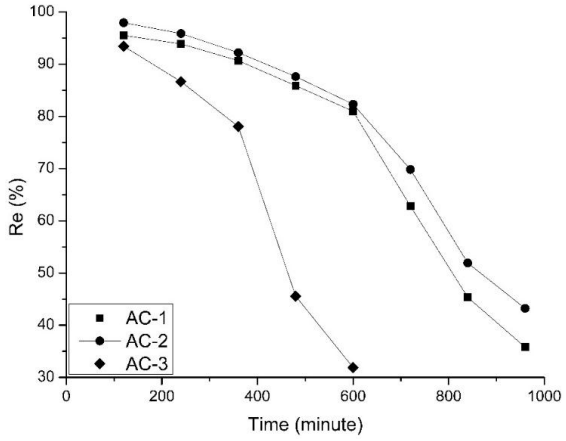


Figure 3. Examining the saturation time of AC-1, AC-2 and AC-3.

From Figure 3, it could be seen that within the first 4 hours (240 minutes), the NH_3 removal efficiencies of all 3 materials were very high (over 85 %) and when the time of experiment increased from 6 hours (360 minutes) to 10 hours (600 minutes), all dropped. During this period, the removal efficiencies (Re) of AC-1 and AC-2 decreased slowly to 80.99 % and 82.34 % respectively while the Re of AC-3 tended to fall faster to 45.58 %. The slope of the line was clearer when the experiment continued for 12 to 14 hours. The removal efficiencies of AC-1 and AC-2 dropped sharply to 45.33 % and 51.92 %, respectively. Particularly with the AC-3, the experiment was only surveyed up to 12 hours because at this time the Re of this material was only 31.89 %. Continuing the two-hour examined of AC-1 and AC-2, the Re of both materials were reduced to 35.78 % and 43.22 %, respectively. Therefore, it can be concluded that the saturation time for the two materials AC-1 and AC-2 were up to 16 hours, but the AC-3 was saturated in only 12 hours.

The above results demonstrated the theoretical argument given when $ZnCl_2$ was chosen to impregnate. $ZnCl_2$ showed its ability to dissolve the cellulose content of coconut fiber and peanut husk, thereby creating a porous structure for activated carbon surface, increasing the surface area of the adsorbent. It helped the material to absorb more NH_3. The acidic surface helped ammonia could easily be adsorbed and Zn could complex with NH_3 so that NH_3, after adsorbed, would be retained longer on the material. Consequently, the saturation times of AC-1 and AC-2 were longer than AC-3.

3.3. SEM pictures of AC-1 and AC-2

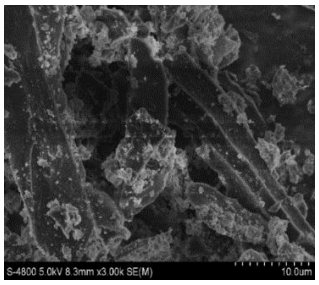
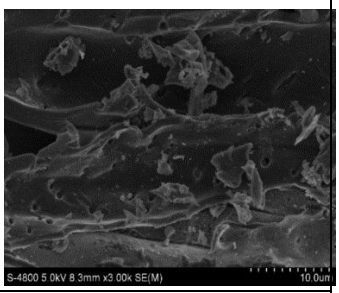
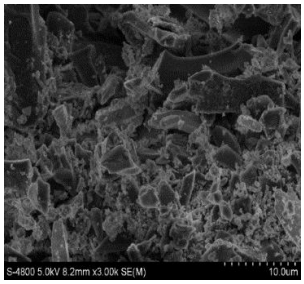
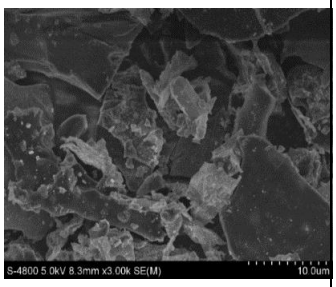
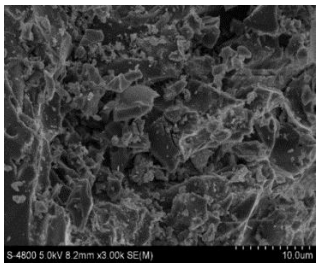
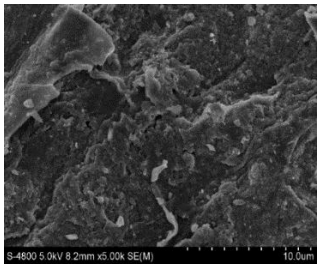
	Coconut fiber (AC-1)	**Peanut husk (AC-2)**
a) Surface of activated carbon(no impregnated with $ZnCl_2$)		
b) Surface of activated carbon (impregnated with $ZnCl_2$), before adsorption		
c) Surface of activated carbon (impregnated with $ZnCl_2$), after adsorption		

Figure 4. SEM capture on the surface of the two materials without impregnated with $ZnCl_2$ (a), impregnated with $ZnCl_2$ before adsorption (b) and after adsorption (c).

The results of SEM capture on the surface of the two materials showed that there were significant changes between the materials without impregnated with $ZnCl_2$ (a), impregnated with $ZnCl_2$ before adsorption (b) and after adsorption (c). Without impregnated with $ZnCl_2$, the surfaces of all materials were rough. After impregnated with $ZnCl_2$, the zinc salts were sticky on the surface of the materials, many pieces and holes appeared beneath the salt. The material after adsorption had a different surface than the previous two because most of the voids were filled and salts which were adhering to the denaturation material reacted with NH_3 in the contaminated air stream.

4. CONCLUSION

The model of ammonia removal by adsorption with 3 materials: Activated carbon made from coconut fiber (AC-1), peanut husk (AC-2) and commercial activated carbon (AC-3) showed its high performance (over 80 %). In particular, AC-2 gave higher performance and

stability than AC-1 and AC-3. Impregnation with $ZnCl_2$ showed high potential for improving and stabilizing the treatment efficiency while prolonging the saturation of the materials. The results of this study showed its high applicability in the control of NH_3 containing emission. Moreover, the purchase of agricultural residues, especially coconut fiber and peanut husk, for the production of activated carbon not only brought many practical economic benefits but also brought many environmental ones.

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