Production of antipollutan mask based activated carbon from wasted coconut shell

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Abstract. Indonesia is one of the countries with the highest levels of air pollution in the world. Air pollution in Indonesia, especially in Jakarta due to the number of private vehicles increased at least 10% every year. This air pollution can have an impact on public health. One effort to do as a protection of people health is to use a mask. Activated carbon can be coated to mask in order to improve the effectiveness in reducing the pollutants. One good material used as material for activated carbon is coconut shell. Selection of coconut shell as the raw material of activated carbon is also based on cellulose content of 26.06%, hemicellulose content 27.07% and a lignin content of 29.40% in the dry state. This research was done in some variation such as activation methods, activated carbon mass, and adhesive material types. Based on pollutants adsorption test, mask with 6 grams of activated carbon, chemically activated, and used *TEOS* as adhesive is the best variation that able to adsorb as much 76,25% of CO_2 Pollutants. Mask made in this research, has saturation time as long as 4 hours under high CO_2 concentration.

1 Introduction

The use of motor vehicles have an impact on public health as motor vehicles emit harmful substances such as lead / pb, suspended particulate matter (SPM), nitrogen oxide (NO_x), hydrocarbons (HC), carbon monoxide (CO), carbon Dioxide (CO_2) and sulfur oxide (SO_x). Among of these hazardous substances, carbon dioxide gas (CO_2) has the greatest composition on motor vehicle emissions of 14% [5]. In addition, carbon dioxide (CO_2) levels in 2014 have reached the highest record for 30 years since 1984 at 400 ppm [2]. Based on previous research, carbon dioxide gas levels will continue to increase as human consumption of energy increases [5].

Along with the increasing emission of air pollutant gas, it is necessary to prevent the bad aspects on health. Prevention widely used today is the use of it is relatively cheap, but their effectiveness still questionable. The commonly widespread mask can only adsorb airborne particulates, whereas harmful gases such as NO_x, SO_x, CO, and CO_2 cannot be adsorbed [1]. The current mask development is to use activated carbon as a coating material. In this case, coconut shell is used to produce activated carbon. The use of coconut shells is also useful to reduce coconut waste. Need to be studied further to evaluate its effectiveness in reducing the pollutants. However, coating coconut shell activated carbon with dip coating method on a mask is a new way to decreasing the concentration of various air pollutants, especially CO_2 which has the highest concentration among other harmful emission gas.

2 Methodology

Methods applied in this study was started by activated carbon preparation and characterization then continued by adsorption test. Some variations were done such as activation methods, activated carbon mass, and types of adhesive used in purpose to get the best variation to be coated on mask. Adsorbent capacity to adsorb pollutant gas that contains carbon dioxide and pressurized air was examined. Moreover, the saturation time of activated carbon mask was also studied by using the best mask variation.

2.1 Adsorbent Preparation

Coconut shells were washed by water to release dirt then dried in oven at 120ºC for 5 hours to reduce moisture content. The dried samples were then crushed and sieved to a particle size of 150 mesh. Carbons were activated by two methods. Physical activation was done on reactor by flowing CO_2 at 200 ml/minutes and increasing the temperature from room temperature to 850ºC. Chemical activation was done by impregnating materials in 5M $ZnCl_2$ solution with impregnating ratio 3/1, then pirolized materials in reactor under the stream of N_2 at 200 ml/minutes and increasing the temperature from room temperature to 650ºC [6,7]. Those temperature was held for an hour and then the reactor was cooled down to 30ºC. The resulting product from the reactor was rinsed with distilled water until the pH was around 7. The activated carbon then was dried at 120ºC for an hour to release the moisture content. Activated carbon was dissolved on solution containing water and adhesive for coating

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process. Two types of adhesive used, were *Sodium Silicate* and *TEOS*. Coating solution was stirred by hot plate magnetic stirrer at 85°C for 30 minutes. Flannel was soaked in coating solution for 10 minutes, then being dried on vacuum oven at 120°C for 4 hours before added to mask.

2.2 Adsorbent Characterization

The characterizations were done to determine surface area and iodine number of resulting coconut shell based activated carbon. BET method was used to measure the surface area using 0.3 gram of activated carbon samples. Iodine characterization was also done to determine the iodine number, a characterization that indicates ability to adsorbed amount of iodine per gram activated carbon (mg iodine/g activated carbon). 0.1 gram of sample was stirred and heated with 10 ml of iodine solution for 1 hour. After that, 5 ml of the mixed solution was titrated by $Na_2S_2O_3$. The volume of $Na_2S_2O_3$ used for titration then was inputted to iodine number calculation.

2.3 Adsorption Test

Adsorption test was carried on modified compartments for 1 hour for each mask variations. Carbon dioxide concentration were collected every 10 minutes. Adsorption test also used on determine the best variations of mask. There are five adsorption tests done in order to determine the effect of methods used in carbon activation process, the effect of activated carbon mass on mask, the effect of adhesive being used, the effect of initial CO_2 concentration, and measurement of the saturation time from the best mask variation.

The experimental equipment is schematically shown on Figure 1. The inlet gas, carbon dioxide and pressurized air was controlled by check valve, and flowmeter. Flowmeters were adjusted until reached the desired initial concentration. Initial CO_2 concentration (C_{in}) could be measured on section A by read CO_2 concentration (ppm) from CO_2 detector. The gas flows through section B because of driving the existing of exhaust fan. Between section A and B activated carbon mask were placed, and final concentration of CO_2 (C_{out}) was measured by CO_2 detector in section B.

The amount of adsorbed CO_2 was determined by

$$\%\,Adsorption = \frac{C_{in}\text{-}C_{out}}{C_{in}} \times 100\% \qquad (1)$$

Where C_{in} = initial concentration of CO_2, and C_{out} is final concentration of CO_2

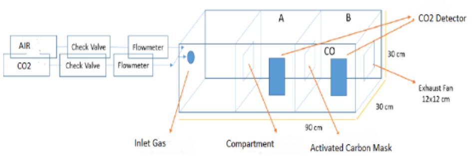

Fig. 1. Schematic Diagram for Adsorption Test

3 Results and Discussion

Adsorption test occurred in modified compartments by using CO_2, N_2 and O_2 as inlet gas to simulating real atmosphere condition. The operation conditions are 1 bar, 25°C, and flow rate (L/min) depends on initial concentration. Therefore, based on operational condition adsorption that happened is physical adsorption.

Results of five adsorption test is graphically shown by Figures 2 – 6.

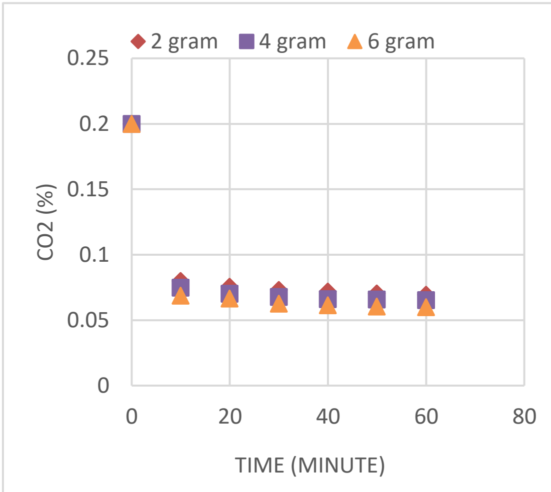

Fig. 2. Effect of activated carbon mass

Based on the graph in Figure 2 it has been shown that 6 gram activated carbon on mask is capable of reducing CO_2 by 70.00% (from 2000 ppm to 600 ppm), 4 gram activated carbon on mask is capable of reducing CO_2 by 67.30% (from 2000 ppm to 654 ppm), 2 gram activated carbon on mask is capable of reducing CO_2 by 65.25% (from 2000 ppm to 695 ppm). This indicates that higher amount of activated carbon coated into the mask will increases the CO_2 adsorption capacity because more adsorbent can adsorb more adsorbate at the same time unit and volume of space.

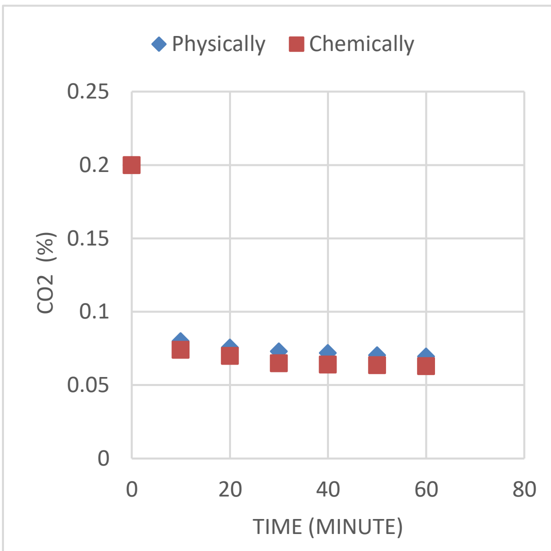

Fig. 3. Effect of activation method

Based on the graph in Figure 3 it has been shown that activated carbon mask which chemically activated is capable of reducing CO_2 by 68.50% (from 2000 ppm to become 630 ppm). Activated carbon mask that physically activated is capable of reducing CO_2 by 65,25% (from 2000 ppm to become 695 ppm). Result indicates that activated carbon mask which chemically activated give higher adsorption capacity than physically activated. This is because in chemical activation, $ZnCl_2$ compounds remove the impurity components that block the pores and pyrolysis using N_2 gas which will open more pores than with physically activation. In addition, BET test results also show that the activated carbon that chemically activated has a surface area of 432.26 m^2 / g. This value is greater than the activated carbon that physically activated with a surface area of 323.57 m^2 / g. The larger surface area of active carbon will increase the adsorption capacity of the activated carbon.

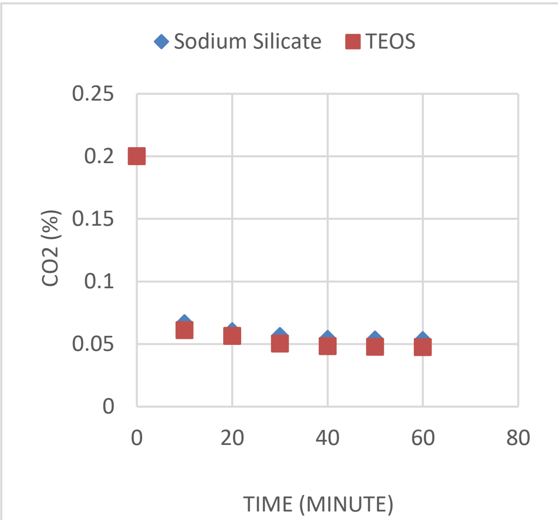

Fig. 3. Effect of adhesive type

Figure 4 been shown that activated carbon mask which used *TEOS* as adhesive is capable of reducing CO_2 by 76.25% (from 2000 ppm to 475 ppm). Activated carbon mask which used *Sodium Silicate* as adhesive is capable of reducing CO_2 by 73.40% (from 2000 ppm to 532 ppm). These results show that *TEOS* is more suitable to applied as an adhesive in activated carbon coating process than *Sodium Silicate*. This is because *Sodium Silicate* has a greater viscosity than *TEOS*, so the addition of *Sodium Silicate* will potentially block the pores of the activated carbon resulting in reduced adsorption capacity. *Sodium Silicate* actually has a stronger adhesion but adhesion is more suitable when applied to harder, larger and non microporous materials. In this experiment the activated carbon used is a powder type that has micropores so application of *Sodium Silicate* is not suitable. Based on previous research, the application of *TEOS* in nano sized particles can increase the surface area [3]. So the application of *TEOS* in this research is appropriate because *TEOS* has the ability as to increase the surface area besides as an adhesive.

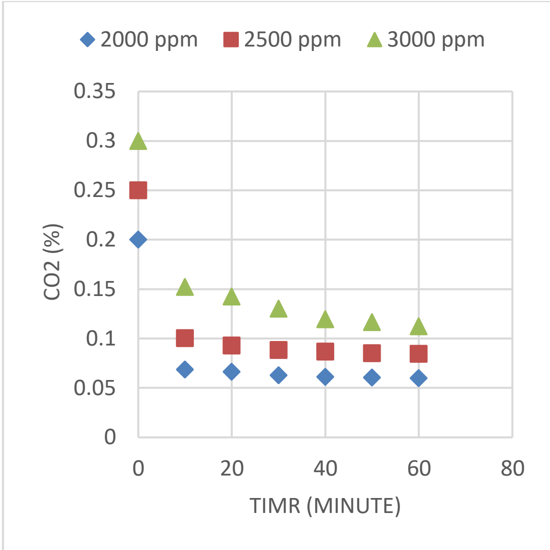

Fig. 4. Effect of increased inlet

Figure 5 indicates that the activated carbon mask remains capable of adsorbing CO_2 despite an increase in initial CO_2 concentration. At an initial concentration of 2000 ppm, the activated carbon mask has adsorption capacity of 70.00% with a final concentration of 600 ppm. At an initial concentration of 2500 ppm active carbon mask has adsorption capacity of 66.20% with final concentration of 845 ppm. At an initial concentration of 3000 ppm the activated carbon mask has adsorption capacity of 62.53% with a final concentration of 1124 ppm. From these results it appears that the final concentration of CO_2 increases with increasing initial CO_2 concentration. This is because the activated carbon mask has the same adsorption capacity so the more CO_2 adsorbed at one time will have certain limitations. In addition, an increase in the initial concentration of CO_2 decreases the adsorption capacity because an initial increase in CO_2 concentration requires a greater flow rate as well. Based on previous research, the greater flow rate in the adsorption process the shorter contact time between adsorbate with adsorbent, so that adsorption process becomes unoptimal [4]. It is proven in this research, at the initial CO_2 concentration of 2000 ppm adsorption capacity of activated carbon mask is 70.00% while at concentration of 3000 ppm adsorption capacity decreased to 62.53%.

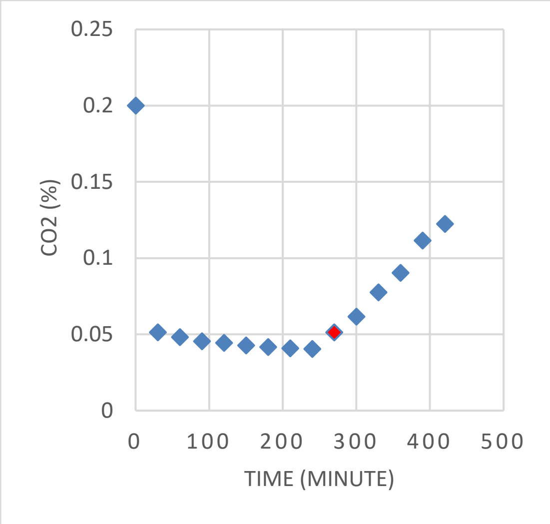

Figure 5 Saturation Time Measurement

Figure 6 been shown that the activated carbon mask becomes saturated over a span of time between 240 - 270 minutes. This means that the saturated time of activated carbon is approximately 4 hours. This results was under high CO_2 concentration of 2000 ppm. A high concentration will speed up the saturated process of activated carbon as more pores of activated carbon adsorb CO_2. In addition, the amount of activated carbon coated also affects the saturation time. The amount of activated carbon and TEOS attached to this activated carbon mask is 0.99 grams, a relatively small amount thus accelerating the saturated process of activated carbon

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4 Conclusion

– Coconut shell activated carbon has surface area of 432.26 m^2/g for chemically activated, and 323.57 m^2/g for physically activated
– Antipollutan mask that contain 6 gram of chemically activated carbon, and using TEOS as adhesive has the best adsorption rate of 76.25%
– Activated carbon in the mask has saturated time of 4 hours

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