THE STUDY OF LPG ADSORPTION ABILITY USING CARBON ADSORBENT TEST BED FOR CARBON ADSORBENT PREPARED FROM WASTE MATERIALS

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Abstract

The ability of adsorption can determine an excellent carbon adsorbent, which can be used as a gas storage media. The primary objective of this research is to derive a coconut and oil palm shell-based carbon adsorbent that can be applied for liquefied petroleum gas (LPG) storage. Other concern is to design and develop a carbon adsorbent test bed that is connected with a hydrocarbon gas detector, which can determine the LPG adsorption ability. The sample was prepared at a laboratory scale fixed-bed reactor, which is blanketed by a vertical furnace and heated up to peak temperature of 600°C, 700°C and 800°C. The results from the carbon adsorbent test bed showed that the adsorption of LPG for both prepared oil palm shell and coconut shell carbon adsorbent decreases due to the increment of peak temperature.

Keywords: LPG storage, carbon adsorbent, adsorption, carbon adsorbent test bed, waste materials.

Introduction

Coconut shell and oil palm shell can be found abundantly in Malaysia. Reprocessing these waste materials into a high value product such as a carbon-based adsorbent can be an attractive option. The carbon adsorbent could become a marketable product if its properties (e.g. surface area, porosity and pore size) can be tailored for a specific application [1]. Recently, it is well known that gases can be stored by adsorption in active carbons [2]. This is because, activated carbon has the most favorable gas storage density compared to other adsorbents. A key issue in commercial development of an adsorbed gas storage technology is the availability of low cost carbon adsorbents with high capacity of storage [3]. Hence, gas adsorption is regarded to be the primary methods of characterization for activated carbon [4].

LPG is a hydrocarbon products produced by the oil and gas industries and widely use for domestic and commercial applications. LPG is gaining increasing support as an environmentally friendly automotive fuel. LPG engines are quieter, cleaner and economical [5]. Compared to petrol, LPG are 63% less of CO, 40% less of HC, 82% less of NO_x, 13% less of CO_2 and 50% less of particulates. Compared to diesel, LPG are 70% less of HC, 99% less of NO_x and 98% less of particulates [6]. Therefore, LPG is the most practical way to reduce air quality problems in the urban environment.

The purposed of this research was to produce carbon adsorbent from coconut shell and oil palm shell for application in LPG storage technologies. Secondly, to develop a carbon adsorbent test bed that can be use to determine the LPG adsorptions capacity.

Methodology

We have designed and developed the experimental rig to prepare the carbon adsorbent. This experimental rig is consisted of a reactor, tube furnace, suction blower and some accessories (Figure 1) [7].

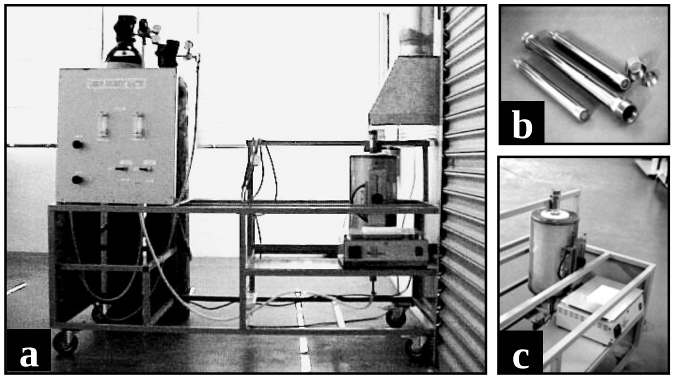

Fig. 1. The experimental rig for producing carbon adsorbent (a), reactor (b) and tube furnace (c).

To produce the carbon adsorbent, we used the waste material such as coconut shell and oil palm shell. These waste materials were crushed and sieved to a size of 250 - 425 μm separately. Then, ±50 grams of each formed particles were pyrolyzed and activated using a fixed bed reactor, which is blanketed by tube furnace. This followed by heated up each material at 10^{o}C/min of the heating rate to peak temperature of 600°C and repeated for 700°C and 800°C. Then, maintained for 60 minutes in 1.5 L/min of nitrogen gas (99.98% of purity from Linde) flow during pyrolysis. For activation process, CO_2 was then introduced into the reactor at 162 mL/min for 30 minutes.

LPG storage capacity of the prepared samples was determined using carbon adsorbent test bed (Figure 2). It consists of two column which are empty column and carbon adsorbent bed column (blanketed with heating tape), temperature controller for heating the sample due to desorption process, timer for calculating the adsorption time up to saturated condition and gas detector (in % of gas) to detect the flue gas after exposed to the sample. The breakthrough curve can be used to obtain the data on the capacity and selectivity of the adsorption happened. The experiment will stop when the curves show the breakthrough (inlet = outlet concentration) for LPG at 5 mL/min of feeding.

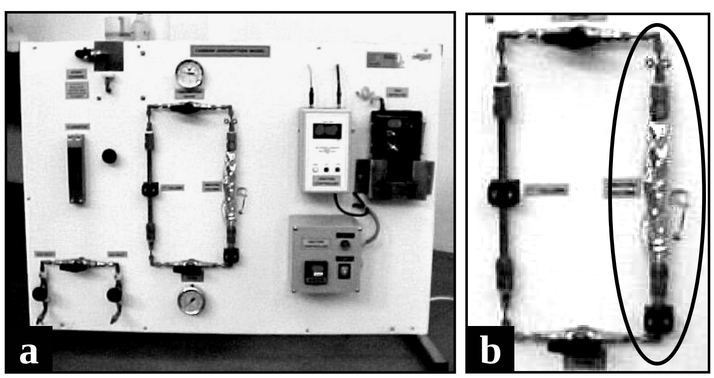

Fig. 2. Carbon adsorbent test bed (a), Carbon adsorbent bed column (b)

Results and Discussion

The high quality of carbon adsorbent can be produce by using two-step process consisting of pyrolysis and activation [1]. Pyrolysis is a common process to convert solid carbonaceous materials into liquid and gaseous hydrocarbons and solid char residue. Meanwhile, activation of the chars is used to increase the microporosity and surface area of the carbon materials [1].

The results obtained from carbon adsorbent test bed are summarized in Figure 3. More time to reach inlet concentration (C_o) mean that more LPG is adsorbed in carbon adsorbent. The more LPG adsorbed means this carbon adsorbent has a better adsorption capacity.

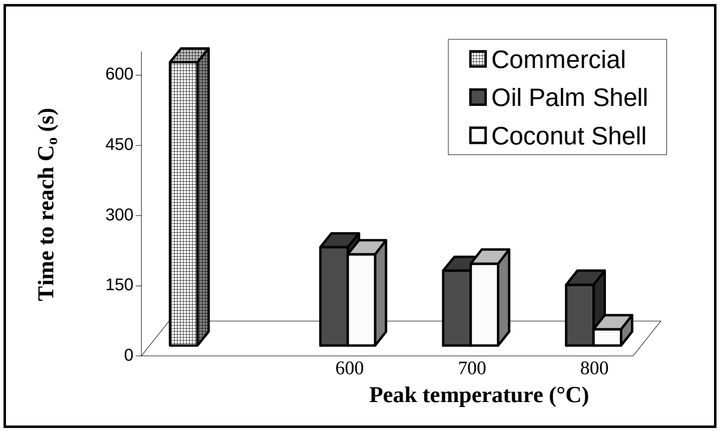

Fig. 3. Time to reach C_o for commercial, oil palm shell and coconut shell carbon adsorbent at various peak temperatures

The graph from Figure 3 showed that the adsorption of LPG for both prepared oil palm shell and coconut shell carbon adsorbent decreases due to the increment of peak temperature. The increment of peak temperature can grow the particle size due to the agglomeration process and diminish the surface area [8]. In principle, it also might shrink or enlarge the pore size of the samples. Molecules of gases tend to adsorb most strongly in area where the pore diameter of the adsorbent is in similar size [9]. Therefore, this phenomenon may derogate the adsorption efficiency and most likely not suitable for adsorbing LPG.

The carbon adsorbent test bed experiment has proved that the commercial carbon adsorbent has better adsorption ability. The result showed that it can adsorb LPG almost three times longer compared to the prepared samples. It can be assumed that the commercial carbon adsorbent has an optimum pore size with high surface area, which is fit and able to adsorb more LPG.

Conclusion

The prepared carbons adsorbent have a capability to adsorb LPG even though it is not as good as the commercial product. Even though the results is not so promising, this research have introduces an alternative technique to examine the adsorption ability of LPG by using the carbon adsorbent test bed. Nevertheless, work is still in progress to increase the LPG storage capacity in the carbon adsorbent by improving the preparation techniques and testing device.

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