

# Preparation of Carbon Adsorbent by Utilizing Waste Materials for LPG Gas Storage

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## Abstract

Coconut shell and oil palm shell are an agricultural waste material found abundantly in Malaysia. Since the characteristics of coconut shell and oil palm shell were found suitable for preparing activated carbon, these materials also have the potential to be prepared into other useful and valuable products. This research, the concern is to make use of coconut shell or oil palm shell which it mixed with plastic bag to prepare the carbon adsorbent, which applied for LPG storage. This sample was prepared at a laboratory scale fixed-bed reactor, which is blanketed by a vertical furnace where pyrolysis took place. Nitrogen gas was used to obtain an inert atmosphere in the reactor. A suction blower was used to remove volatile matter as well as other gases during carbonization process. The samples were prepared in the different peak temperature and amount of the plastic bag which it mixed with them. This research work will attempt to find a suitable solution to solve the environmental problems by utilizing the waste materials and to look into the industrial aspect of adsorption process for gas storage.

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**Keywords:** Waste materials, carbon adsorbent, LPG, gas storage.

## Introduction

Carbon adsorbent is a type of carbon produced through exposing a source material such as wood or bone to very high temperatures in the presence of steam, air, or carbon dioxide. Activated carbon is very good at removing or adsorbing contaminants and is used in water filters, to decolor solutions, and is sometimes administered to poisoning victims.

The waste materials that are mixed of coconut shell or palm shell and plastic bag are found in large quantities will be used as a carbon adsorbent. Carbon adsorbent has been shown to be applicable for treatment of a wide variety of environmental contaminants. When properly applied, the adsorption process will remove pollutants for which it is designed [9].

Shepherd, A.(2001) also stated that the activated carbon will function as a carbon adsorption where the contaminated gas will be attracted to and accumulated on its surface. In evaluating the effectiveness of the carbon adsorption by using the waste material, the characteristics of the application will be considered first. This will help in obtaining a strong adsorption. In this case, the researcher will take into consideration where the molecules of a contaminant tend to adsorb most strongly in areas where the pore diameter of the adsorbent is close to the molecular diameter of the compound.

The importance of its role has been looked as a demolition of a clean environment. With these characteristics, studies will be carried out to investigate its adsorption capacity as a fuel carbon adsorbent that is applicable for hydrocarbon gas storage that is widely used in the automotive area [2]. For example, utilizing the activated carbon in controlling pollutants emissions in natural gas storage tank [6], Liquefied Petroleum Gas (LPG) and Gasoline storage tank [1] and Proton-Exchange Membrane (PEM) Fuel Cell Vehicle [5].

From CATF Review Newsletter (1995), two researchers reported that results indicate adsorbents may become a practical means of on-board fuel storage and the work on these adsorbents for natural gas has been going on since the early 1980s. Robinson stated that the Absorbed natural gas (ANG) is an interesting alternative to Compressed Natural Gas (CNG) since the same amount of natural gas can be stored at much lower pressure (500 psi or 30 atm) in a thinner walled tank filled with activated carbon and this provides more energy than gasoline on a weight basis.

### **Liquefied Petroleum Gas (LPG)**

LPG is a natural occurring and refined hydrocarbon which is most often stored as a liquid under pressure. It is usually transported in bulk and pressurized vessels. It is a naturally occurring material and is also produced through the refining process for other hydrocarbon such as petrol and diesel [3].

Researchers used LPG in application of alternative vehicle fuel, which have benefits include total elimination of smoke and virtual elimination of smell. It also contributes to a much quieter and smoother running engine. As well as the environmental benefits, compared to other alternative fuels LPG combines high performance with economy, making it the best current alternative to petrol or diesel fuels [3].

Carbon adsorbent as a gas storage for LPG is an alternative way to overcome the disadvantages of pressurized vessel such as high pressure flammable gas content, dimension of gas tank, and other dangerous aspects.

### **Materials**

The waste materials as a raw material are oil palm shell, coconut shell, and plastic bag. Oil palm shell or coconut shell was carbonized for producing the char and another sample was mixed it with plastic bag then was carbonized again. Some of sample was then activated with CO<sub>2</sub> (99.98% of purity from Linde) flow. The number of samples are four and the details of these samples were described elsewhere [7].

### **Methodology**

Carbon adsorbent test bed has been developed, which consists of two column (empty column and carbon adsorbent bed, which is blanketed with heating tape), temperature control for heating the sample due to desorption process, timer for calculating the adsorption time up to saturated condition, and gas detector in %Gas to detect the flue gas after exposes to the sample. The LPG gas was used to introduce to carbon adsorbent at 5 ml/min. The detail of the methodology was described elsewhere [7].

### **Results and Discussion**

The results obtained from carbon adsorbent test bed which applied in the samples are summarized in Figure 3. More time to reach inlet concentration (Co) can be concluded that more LPG is adsorbed in carbon adsorbent. As shown in Figure 3, the time to reach Co decreases from 600°C to 800°C in correspondence with increasing peak temperature for both chars of oil palm shell and coconut shell. The increasing peak temperature actually can shrink the pore structure of char [9], therefore the smaller pore structure of char is not suitable for adsorbing LPG.

However, the adsorption of LPG at coconut shell char dramatically decreases from 700°C to 800°C as comparison with oil palm shell char. It might be concluded that the adsorption of LPG do not appropriate with higher peak temperature for coconut shell char especially and both of them generally.

The time to reach Co (0.30% of gas detector) four carbon adsorbents are displayed in Figure 4, which shows the time of carbon adsorbents that are subjected to LPG. As shown in this figure, coconut shell

char adsorbs more LPG than oil palm shell char. The plastic bag indeed effect the both chars unfortunately in different results. The plastic bag in coconut shell char can increase the adsorption of LPG, however in case of mixed oil palm shell char; the adsorption of LPG dramatically decreases. This could be happened due to the pore structure of carbon adsorbent [9].

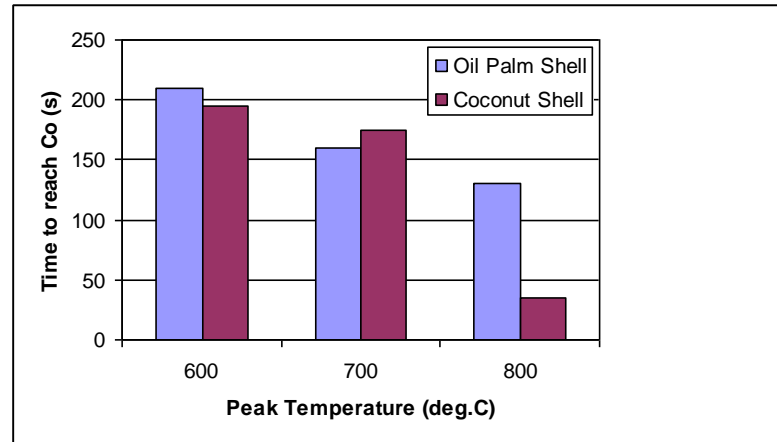


Figure 3: Time to reach Co for chars of oil palm shell and coconut shell at varies peak temperature

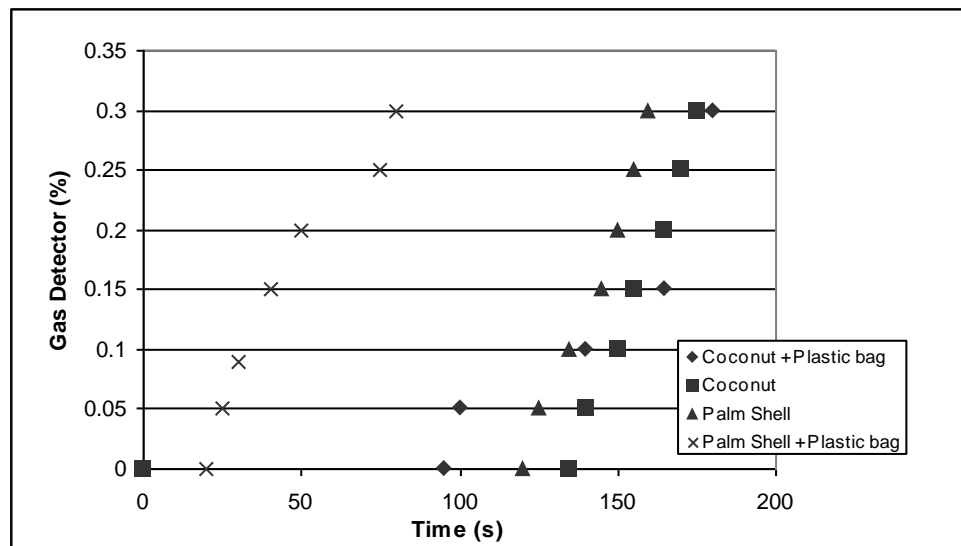


Figure 4: Time to reach Co for oil palm shell and coconut shell char, and both chars mixed with plastic bag.

The average pore diameter of coconut shell char is bigger than oil palm shell at the same procedure of preparation [9]; therefore the smaller pore size can reduce the capability to adsorb LPG. The plastic bag might block or shrink the pore structure of the char. For oil palm shell char, this effect results the reduction of LPG adsorption. Somehow, the existing of plastic bag in coconut shell char dedicates appropriate condition that can result the increasing capability for adsorbing LPG.

## Conclusion

Waste material (coconut shell, oil palm shell, and plastic bag) can be used for producing carbon adsorbent for LPG gas storage since all the samples show capability to adsorb LPG, unfortunately the capacity is still low. However, this research are still continue to explore more finding to achieve a better results. It is found that coconut shell mixed with plastic bag shows a higher capability to adsorb LPG than the other samples.

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