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Waste Tire Carbon Adsorbent for Active Removal of Paracetamol in Aqueous Solution

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Abstract. Waste tyre carbon adsorbent was prepared via three different calcination temperatures (500^{0}C, 700^{0}C and 900^{0}C) and activated by sodium hydroxide solution. The phase and crystallinity analysis of each adsorbent is determined using X-ray diffraction analysis. The study revealed that different crystallinity of prepared adsorbent were obtained when calcination temperature is varied. Next, the effect of calcination temperature was investigated on the removal of paracetamol in aqueous solution. The highest percentage removal (99.37%) was obtained when the waste tire carbon adsorbent is calcined at 900^{0}C for paracetamol initial concentration of 10 mg/L at pH 3 and 120 mins of contact time. In this case, the result obtained can be contributed to the production of adsorbent using waste tire with suitable calcination temperature for the paracetamol removal in aqueous solution.

1. Introduction

Nowadays, the rapid growth of population, along with increasing productivity and consumption, has aggravated waste production and accumulation. Automobile industry has been an emerging field with the increasing of population throughout the world. In returns of this, the disposal of vehicle tires has create an environmental problem where there are estimated around 1 billion tyres are withdrawn from used every year [1].

In the developing countries such as Malaysia, waste management is becoming an acute problem due to the emerging economic development, causing the requiring management for large amount of waste materials [2]. Some numbers of waste tires are reported to be dumped in an improper and illegal way. With respect to this, the illegal accumulation of waste tyres has created various kind of problem. For example, stockpiling of waste tyres can lead to a significant fire threat and provide a perfect breeding ground for mosquitoes.

The possible method to overcome the problem is by recycling the waste tyres for other alternative purposes. Waste tires with hydrocarbon based contain high content of carbon, high volatility and high heating value is suitable to act as the raw material for energy recovery by using appropriate technology [3]. The appropriate technology such as pyrolysis, gasification and incineration processes can be used to recover the energy while the by-product that produces from these processes is considered as a valuable product. This is because the by-product (carbon-besed) can be used as the adsorbent for adsorbing the organic and inorganic pollutants likes dyes and heavy metals, respectively [4].

Generally, carbon-based adsorbent is used as the important tools in water purification and air pollution control today. The increasing demand of clean water due to the increasing population in the world has encouraged this type of research. The carbon-based adsorbent is widely used in various applications in industry and more usage of this adsorbent is expected in the future. Therefore, this paper proposes the preparation of carbon-based adsorbent from waste tire to remove the paracetamol in aqueous solution. The effect of calcination temperature toward the properties as well as the performance of adsorbent will also been studied.

2. Materials and Methods

2.1. Reagent and Materials
Some text. Hydrogen Peroxide (H_2O_2), Ammonium Hydroxide (NH_4OH), Sodium Hydroxide (NaOH) and Hydrochloric Acid (HCl), were purchased from Evergreen Engineering and Resources, Malaysia. The paracetamol tablet was obtained from Pusat Kesihatan Universiti Teknologi Malaysia, Kuala Lumpur.

2.2. Method

2.2.1. Preparation of Adsorbent from Waste Tire. Waste tire is first cut into tiny pieces, soaks in 30 wt% H_2O_2 solution and sonicate for 2 hours to remove the impurities. Then, the mixture was filtered, washed with deionized water and dry in the oven at 110°C for 2 hr. Then, the dried waste tyres are put into the furnace to be calcined at three different temperatures which is 500°C, 700°C and 900°C. The outlet of the furnace was connected to the filter to ensure the released gases are safe to environment Next, the calcined waste tyres were activated by 1.0 M of NaOH solution, by soaking in the solution for 1 hour, before drying at 100°C for 1 hr. After the drying process, the waste tire carbon adsorbent will be grinded to become powdered adsorbent and donated as WTC_x (where x = 500°C, 700°C and 900°C)

2.2.2. Characterization of Adsorbent. The phase analysis of the adsorbent was determined using X-Ray diffraction (XRD). It was carried out using XRD machine Brand PANalytical, model Empyrean operated at 40mA and 45kV, copper anode and wavelength of 1.541 Å is used.

2.2.3. Paracetamol Removal from Aqueous Solution. The adsorption performance of the adsorbent was tested for the removal of Paracetamol. The experiments were performed in a batch reactor. In the reactor 0.2 g of adsorbent was added to the 10 mg/L Paracetamol solution at pH3 (200 mL) and stirred for 2 hr. During the adsorption process, aliquots of 2 mL were taken out at intervals of 15 min and centrifuged before being analysed by UV-Vis spectrophotometry (Shimadzu) at 244 nm.

3. Results and Discussion

3.1. Characterization of the adsorbent
Figure 1 below showed the XRD pattern of the WTC adsorbent prepared under three different temperature. The diffractograms of broad band around 25.0° and 42.5° for all the adsorbent are representing amorphous carbon and graphite structure [5]. This confirmed that carbon is present in waste tire which will play role in adsorption of paracetamol. At the higher temperature, specifically for WTC900, a series of peaks at 26.93°, 28.52°, 30.53°, 39.65°, 47.55°, 51.79°, 56.4°, and 57.8° had appeared. These peaks were corresponds to Zinc Sulphide, ZnS. The presence of ZnS was resulted from the decomposition of originally present Zinc Oxide (ZnO) with Sulphur (S) during the calcination

process [6]. The sharper peaks appeared in the adsorbent with higher calcination temperature. This suggests that the higher temperature causes more crystallinity to the adsorbent

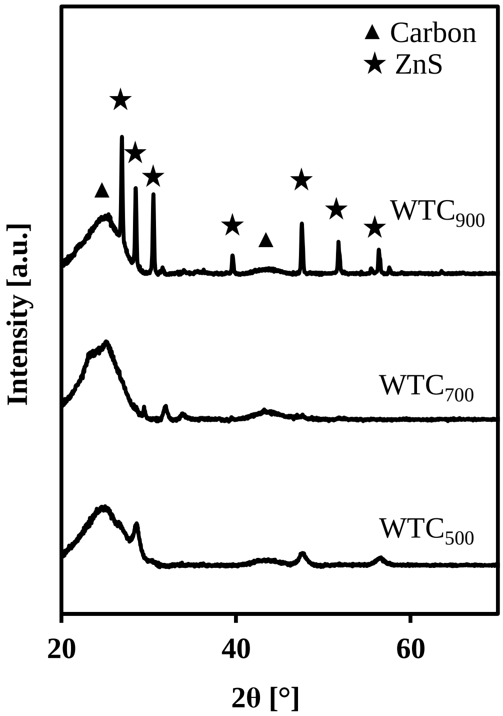

Figure 1. XRD pattern of Waste Tire Carbon Adsorbent

3.2. Adsorbent Performance for Removal of Paracetamol

The adsorption performance of WTC adsorbent was evaluated using 0.2 g of adsorbent for the removal of 10 mg/L Paracetamol solution at pH3. The pH of paracetamol solution was adjusted to pH3 using 0.1 M of hydrochloric acid (HCl). As demonstrated in Figure 2, after 120 mins of adsorption process, WTC_{900} shows the highest percentage removal (99.37%) followed by WTC_{700} and WTC_{500} with 88.72% and 5.48%, respectively. The different removal efficiencies were achieved for each adsorbent most likely due to the influence of the phase and crystallinity of the adsorbent. At higher temperature for WTC_{900}, more crystalline adsorbent was prepared (Figure 1). Additionally, the appearance of additional peak of ZnS might also lead to the higher removal of paracetamol. As report by Qu et al (2014), the ZnS have a great adsorption capability to adsorb mercury ion from water [7].

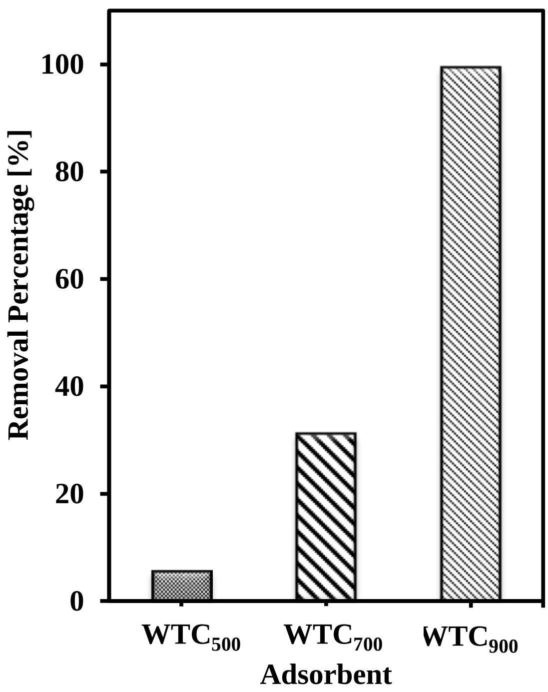

Figure 2. Adsorption performance of WTC adsorbent [0.2 g of adsorbent; pH3; 10 mg/L Paracetamol; 120 mins]

4. Conclusion

In this study, a series of adsorbent were prepared using waste tires. The phase properties of the adsorbents were studies by XRD. The result show that the high crystallinity of adsorbent was obtained when the temperature was increased from 500°C to 900°C. Moreover, the additional peaks corresponding to ZnS were also appeared which interaction led to the enhancement of removal performances of WTC_{900} compared to WTC_{700} and WTC_{500}.

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