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Pineapple Peel Waste Adsorbent for Adsorption of Fe(III)

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Abstract. The current study discovers the capability of pineapple peel, which is an agricultural effluent, to be converted into adsorbent to be used in the removal of Fe(III). The adsorbent was prepared from pineapple peel waste using a chemical activation method impregnated with zinc chloride ($ZnCl_2$), and the morphological and functional characterisation of the adsorbent was performed using FTIR and SEM. SEM images show rough surfaces of raw pineapple peel with creases. After the chemical treatment, substances in the pineapple peel waste such as pigments and acid-soluble oligosaccharides were removed, leading to the porous structure. Raw pineapple peel contained more functional groups, including the O–H stretching vibration at 3300 cm^{-1} and the C–H vibration at 2917 cm^{-1}, compared to the adsorbent with the fading of some characteristic peaks. The ability of the adsorbent to remove Fe(III) ions at different contact times and adsorbent dosages was studied. As the contact time and adsorbent dosage were increased, the adsorption capacity also increased. The results show the potential use of pineapple peel waste as an effective adsorbent for the treatment of wastewater in removing of Fe(III) ions
Keywords: Pineapple peel, Activated Carbon, Adsorption, Iron Removal.

1. Introduction

Industrial wastewater containing iron (Fe) has harmful effects on the environment and human health. Iron will remain in human tissues for a long time, and it can cause retinitis, choroiditis, and conjunctivitis upon contacts. A high concentration of iron present in the water changes colour, taste, and odour, leaves stains on clothes, and corrodes water pipelines [1]. According to Malaysia's Environmental Law, Environmental Quality Act 1974, the acceptable amount of iron in industrial effluent must be below 5 ppm. Therefore, it must be treated before it can be discharged.

Adsorption is known to be the most commonly used and effective method in treating heavy metals in water. Activated carbon, calcium carbonate based materials, and iron oxide are some types of adsorbent typically used in treating heavy metal in wastewater [2]. The effective technique that has been used to remove the heavy metals in trace concentration is adsorption by activated carbon. However, coal-based activated carbon is quite expensive. Thus, the use of local agricultural wastes could be an interesting substitute in the removal of Fe(III) from wastewater, such as pineapple peel waste which is inexpensive and abundance as raw materials to yield activated carbon with high adsorptive capacity, high surface area, good chemical and mechanical stabilities, and high reactivity [3].

The pineapple (*Ananas comosus*) from the family Bromeliaceae is one of the most important fruits in the world. After orange and apple, pineapple is the third most preferred worldwide. The increasing production of pineapple items results in huge waste generations. The selection and elimination of components which are unsuitable for human consumption resulting in a large amount of pineapple waste

[4 - 5]. The pineapple peel fibre modified with succinic anhydride showed effective removal of Cu^{2+}, Cd^{2+}, and Pb^{2+} from the synthetic aqueous solutions via adsorption [6]. A previous study showed that the pineapple peel waste could also facilitate the biosorption of Cd(II) and Pb(II) from aqueous solutions [4]. However, no report has been shown for the ability of activated carbon from pineapple waste to remove Fe(III) ions from the water for this time being.

Therefore, the aim of this study was to determine the potential and the effectiveness of activated carbon prepared from pineapple peel waste in removing iron from the water with the effect of contact time and amount of adsorbent.

2. Materials and Methods

2.1. *Materials.* The pineapple peel waste was collected from Pekan Pina Sdn. Bhd. All reagents and solvents were of analytical grade.

2.1.1. Preparation of Adsorbent. Pineapple peel waste was washed, dried, and ground. Thirty grams of ground pineapple peels was mixed with 1.0 M of $ZnCl_2$. The mixture was stirred using a magnetic stirrer for 24 h at room temperature. The filtered peels were dried in an oven at 105 °C for a night. Then, the sample was placed into an enclosed crucible and carbonised in a furnace at a heating ramp of 2 °C/min, and held at the final temperature, referred to as the carbonising temperature of 800 °C for 1 h. After pyrolysis, the sample was cooled to room temperature. The activated sample was immersed in 0.5 M of HCl for 30 min to remove the excess zinc chloride, filtered, and rinsed with deionised water until the pH of the wash water achieved 7. After washing, the sample was dried in an oven at 105 °C for 24 h. The prepared samples were stored in airtight plastic and kept in a desiccator to avoid contact with moisture in the atmosphere.

2.1.2. Characterisation of the Adsorbent. The Fourier transform infrared spectroscopy (FTIR, Nicolet AVATAR 370 DTGS) was used to detect the presence of the functional groups in the adsorbent. Scanning electron microscopy (SEM, JSM-7800F) was used to analyse the morphology of the adsorbent.

2.1.3. Batch Adsorption Analysis. The adsorption Fe(III) ion was evaluated under different contact times and adsorbent dosages. The initial and final concentrations of Fe(III) ions in the aqueous solutions before and after adsorption were determined using an atomic absorption spectrometer (AAS) and the average value of the result is presented in the form of metal uptakes and amount of metal ions adsorbed. The uptake of Fe(III) was calculated using Equation 1:

$$Uptake\ (\%) = \frac{C_i - C_e}{C_i} \times 100\ \% \qquad \text{(Eq. 1)}$$

where, C_i is the initial Fe(III) ion concentration in the sample (mg/L) and C_e is the equilibrium Fe(III) ion concentration in the sample (mg/L).

3. Results and Discussions

3.1. *FTIR Analysis.* The FTIR spectra of the pineapple waste are shown in Figure 1. The wide absorption band in the range of 3,200–3,500 cm^{-1} is largely attributed to the hydrogen bond of the hydroxyl group or amino group symmetrical stretching differences. Besides that, the peak at 2,917 cm^{-1} is allocated to the aliphatic CH groups. However, some characteristic peaks such as the C–H vibration (2917 cm^{-1}) disappeared after the chemical activation. This result shows that during the activation and the carbonisation process, the hydrogen was largely removed [3].

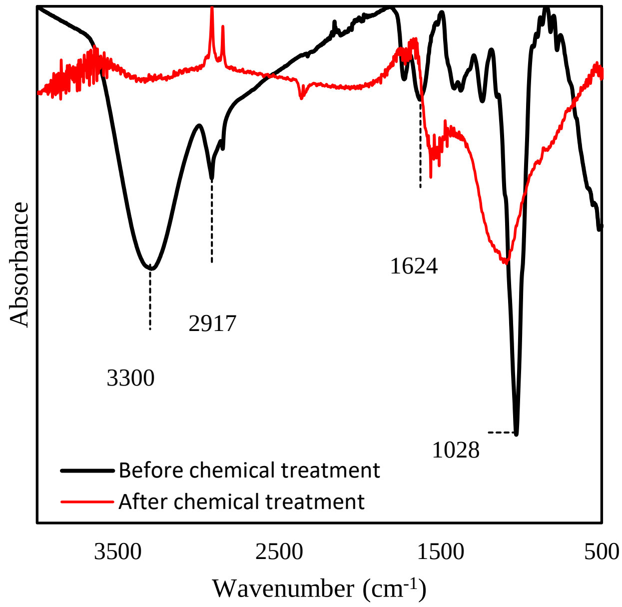

Figure 1. FTIR spectra of the pineapple peel waste before and after chemical treatment

3.2. *SEM Analysis.* Figure 2 presents the morphologies of the pineapple peel waste and chemically activated pineapple peel waste. Figure 2(a) shows the pineapple peel waste before chemical treatment with $ZnCl_2$, where the morphology is rough and has wrinkles. However, after the chemical treatment and carbonisation process, the surface of the adsorbent appears to be more porous, as shown in Figure 2(b). This may be due to the removal of substances in the pineapple peel waste such as pigments and acid-soluble oligosaccharides during the carbonisation process [4].

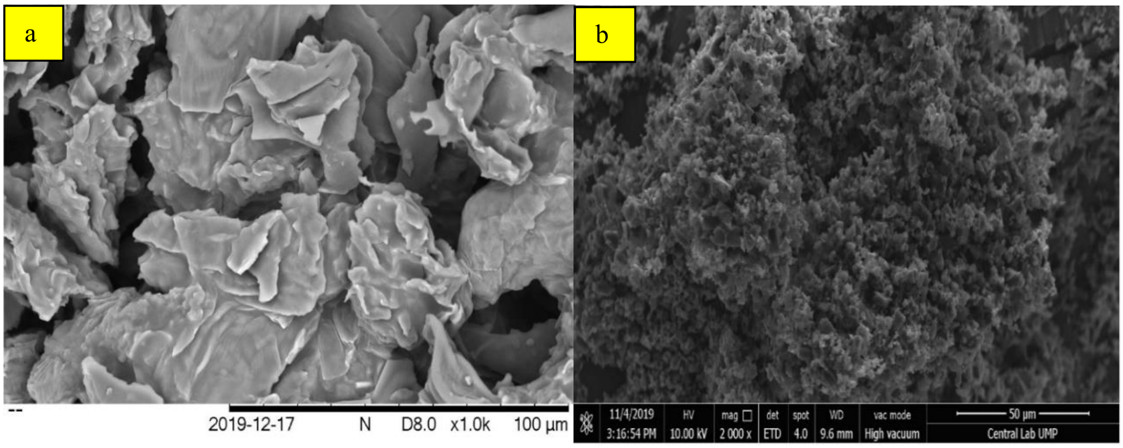

Figure 2. SEM images of the pineapple peel waste before and after chemical treatment

3.3. Batch Adsorption Analysis. The study was conducted to determine the potential of adsorbent in the adsorption of Fe (III) ions by analysing the Fe(III) ions uptake at different contact times and adsorbent dosages. Figure 3(a) shows that as the contact time was increased to 120 min, the adsorption of the Fe(III) ions increased by 27.28%, due to more time was available for the ions to attach onto the active sites on the adsorbent [7]. This result shows that the adsorbent has a good adsorption capacity for the metal ions [8].

Adsorbent dosage is another factor which affects the ability of the adsorbent to adsorb the metal ions. Figure 3(b) shows a sharp increase in the removal of Fe(III) ions with increasing adsorbent dose. As the amount of adsorbent was increased from 1 to 4 g, the removal increased from 27.28% to 55.26%. At a higher amount of adsorbent, there are plenty of available binding sites for metal ions to bind [7, 9].

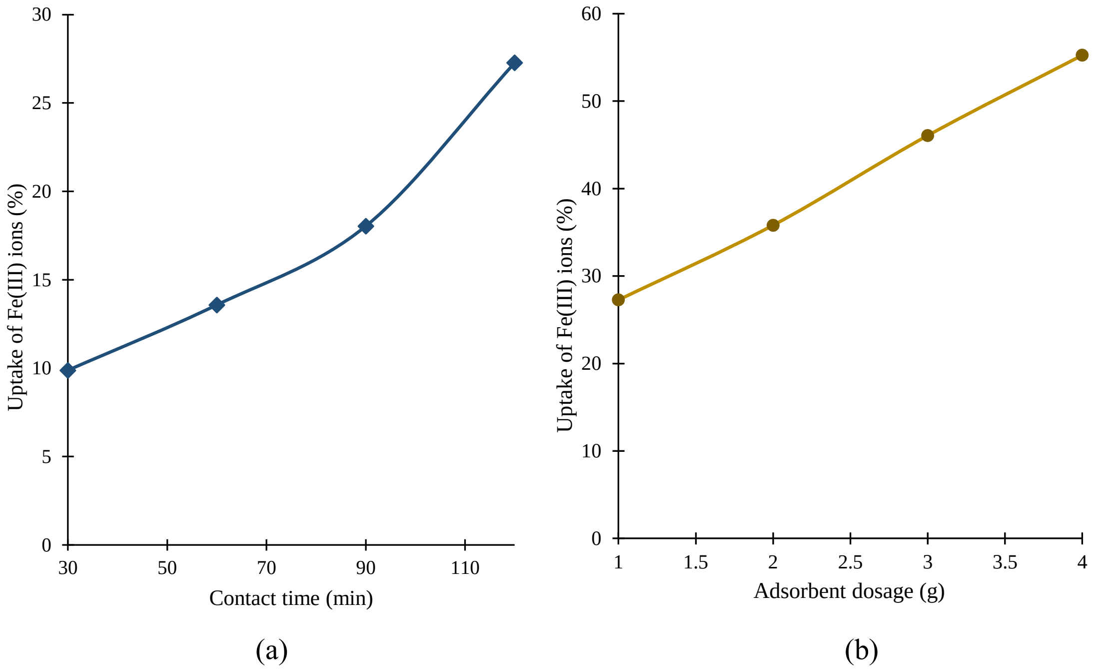

Figure 3. Effect of (a) contact time and (b) adsorbent dosage on the adsorption of Fe(III) ions

4. Conclusion

This study deals with the activated carbon prepared from pineapple peel waste and the preliminary outcomes presented that the prepared activated carbon adsorbent can be used for the adsorption of Fe(III) ions. The high removal (55.26 %) was achieved when 4 g adsorbent was used. The ability of the adsorbent to adsorb Fe(III) ions shows that it is a promising alternative material to replace the commercially available adsorbents for the removal of Fe(III) ions.

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