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Activated biochar prepared from plaintain peels: Characterization and Rhodamine B adsorption data set

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ABSTRACT

The surface morphology and Surface Chemistry of plantain peel activated biochar (PPAB) viz-a-viz PPAB efficacy in Rhodamine B (RhB) dye adsorption is presented in this data article. The surface morphology shows pores of various shapes and sizes consequence of activation. Surface Chemistry revealed functional groups such as –OH and C = O of amide. Adsorption of RhB was observed to increase with increased pH and optimum adsorption was observed at pH of 7 with percentage removal of 54.78%. Increase in temperature had negligible effect on RhB removal. RhB uptake increased with increase in PPAB dosage up to 0.3 mg/L and increased contact time aided RhB removal with optimum adsorption of 84.41 mg/g at 120 min.

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Specifications Table

Subject area	Chemical Engineering
Compounds	plaintain peels activated biochar (PPAB), Rhodamine B (RhB)
Data category	Spectral, Images, graphs, modification procedure
Data acquisition format	SEM, FTIR, RhB adsorption data
Data type	Analyzed data
Procedure	*Characterization data of PPAB were obtained from SEM, EDX, FTIR and other physicochemical parameters.* *Batch adsorption studies* - *pH was varied between 2 and 10,* - *Temperature was varied between 293 and 393 K* - *Contact time was 120 min*
Data accessibility	Data accessible herein

1. Rationale

Adsorption using activated carbon is a preferred choice over other conventional wastewater treatment methods. It is characterized by simplicity of operation and efficient in the removal of very low concentration of pollutants [1]. However, the cost of activated carbon is a major disadvantage of the adsorption technique in wastewater treatment. The major source(s) of cost accumulation on activated carbons is usually from their precursors and treatment/preparation technique [2]. Hence,

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alternative precursor and methods of activated carbon preparation will go a long way to reduce cost thus making adsorption technique an economically friendly and efficient wastewater treatment technique [3].

The carbonaceous and lignocellulosic characteristic of agro wastes qualifies them both as lowcost adsorbent and a precursor for activated carbon preparation [4]. Interestingly, their carbon content can be enriched via carbonization and subsequent activation may create well developed pores which enhances adsorption efficiency [5]. Temperature, carbonization time and rate, chemical content in precursors and precursor types influence biochar porosity [6]. The chemical activation technique saves energy hence produces cheaper activated carbon compared with physical activation [7]. Chemically activated biochar also gives better yield, improved surface area and have the tendency of yielding biochar with surface functional group(s) [8]. Treated waste materials of many kinds have been found effective in the removal of inorganic metals [9, 10], organic dyes [11,12] and pharmaceutical contaminants [13].

Plantain peel (PP) which is rich in carbon is about 30% of the plantain fruit [14]. Huge volume of plantain peel is generated particularly in the southern part of Nigeria. PP is a waste without any economic value and it generally constitute environmental nuisance. Acids, bases and salts can be used as chemical activating agents. While several reports exist for biomass treatment with acids [11, 15], bases [16, 17], and salts such as sodium chloride [18] and Zinc chloride [19]. The use of salt such as Ferric nitrate is scarcely reported. Considering the capacity of iron in dye degradation [20] and the capacity of ferric salts to effectively enhance porosity [21] we activated PP biochar using Ferric nitrate (PPAB). This novel adsorbent which combines the effect of dye degradation with enhanced porosity is prepared for efficient treatment of RhB dye containing wastewater. Hence, prepared activated biochar was used for the removal of RhB from aqueous solution. The characterization and adsorption data is herein presented.

2. Procedure

2.1. Biochar preparation

Plantain peels (20 g) was transferred into silica crucible and heated in an air-tight furnace (Garbolite CWF 1300) operated at 500 °C for 5 hours. Obtained carbon material were carefully transferred to an airtight container, labelled PPB and kept for further treatment.

2.2. Biochar activation

Equal mass/volume ratio of PPB and $Fe(NO_3)_3$ were mixed in a crucible. The crucible with its content was heated at 750 ± 50 °C for five min. Activated PPB samples were allowed to cool to room temperature, it was subsequently washed with distilled water until neutral pH was obtained. It was dried in an oven operated at 110 °C for 8 hours. Activated biochar was labelled PPAB.

2.3. Adsorption studies

The characteristics and nature of adsorbate in solution is greatly influenced by various adsorption operational parameters. Here, we varied the solution pH, contact time, adsorbent dosage and temperature. 1 g/L dosage, 30 mg/L concentration, 150 revolution per minute (rpm) were fixed conditions. pH was varied between 2 and 9, temperature between 303 and 333 ^{o}K and contact time ran from 1 to 120 min. 30 cm^3 adsorbate solution was agitated with the specified mass of adsorbent in an Erlenmeyer flask, this was placed in a temperature controlled water bath shaker and agitated until equilibrium. The unadsorbed dye molecules were separated from the adsorbent by centrifuge and unadsorbed and residual concentration was determined using a Beckman Coulter Du 730 Life science UV–Visible Spectrophotometer operated at 554 nm.

2.4. Data analysis

Quantity adsorbed and removal efficiency was calculated with equation I and 2 respectively.

$$\boldsymbol{q_t} = \frac{(\boldsymbol{C_i} - \boldsymbol{C_t}) \times \boldsymbol{V}}{\boldsymbol{M}} \tag{1}$$

$$\%\ \boldsymbol{Removal} = \frac{\left(\boldsymbol{C_i} - \boldsymbol{C_f}\right)}{\boldsymbol{C_i}} \times 100 \tag{2}$$

C_i, C_t and C_f are initial adsorbate concentration, adsorbate concentration at time t and final adsorbate concentration respectively, all in mg/L. V is the volume of adsorbate used in liters and M is the mass of adsorbent in grammes.

2.5. Data, value and validation

2.5.1. PPAB surface chemistry and surface morphology

Absorption peaks were observed at 3360 cm^{-1} charateristics of –OH vibrations, 1584 cm^{-1} which corresponds to C = O of amide and/or NH_2 scissoring and 1362 cm^{-1} which corresponds to CH_3 bending vibrations. Minor peaks which occurred at

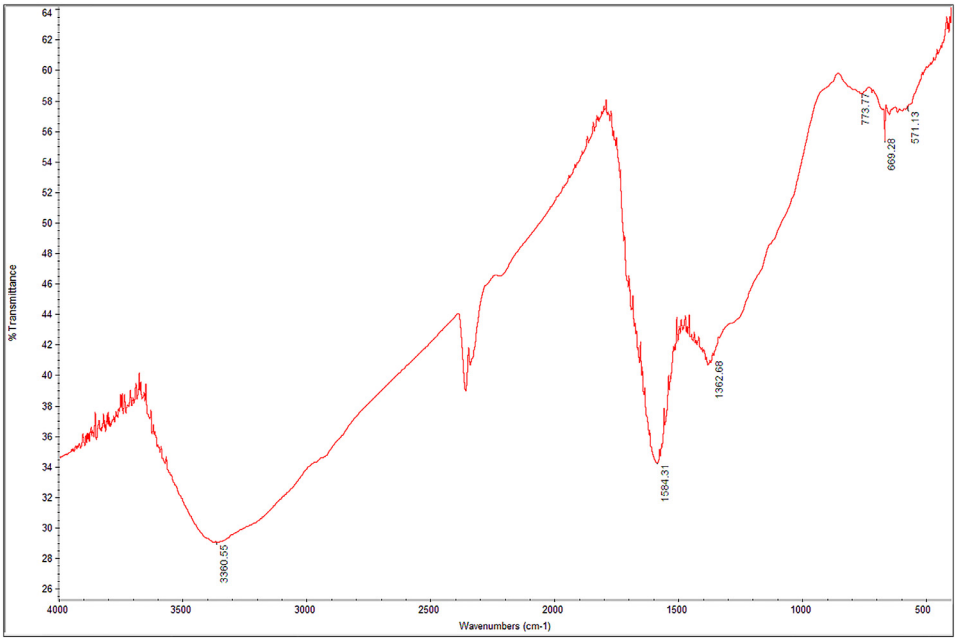

Fig. 1. FTIR spectrum of PPAB.

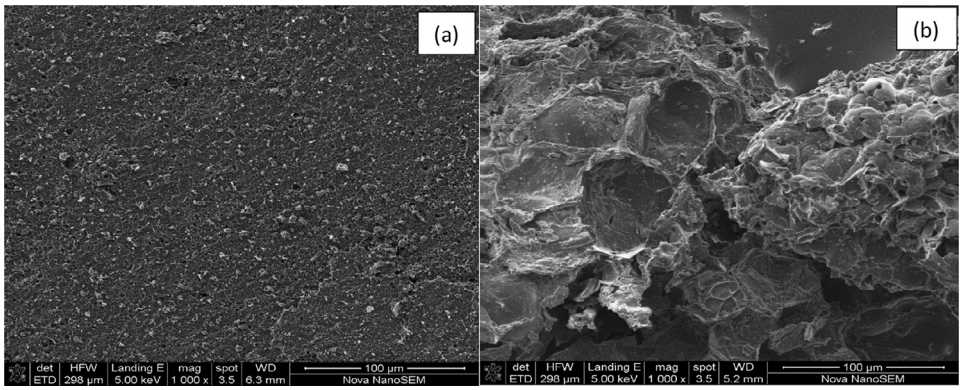

Fig. 2. SEM image of PPB (a) and PPAB (b).

773 and 667 cm^{-1} may be allocated to aromatic vibrations (Fig. 1). The surface morphology of PPB and PPAB is compared in Fig. 2. Pores of various shapes and sizes developed on adsorbent surface after activation. PPAB conains high carbon content with about 20% oxygen. Fe content was 2.3%, Fe may have been introduced via the activating agent. Other metals such as Na, Mg, Ca and K were also present in PPAB (Fig. 3).

2.5.2. Adsorption data

The effects of various operational parameters on RhB removal using PPAB is shown in Fig. 4. Percentage adsorption increase with increased pH and reached maximum at pH of 7 then slightly decreased (Fig. 4a). Protonation of the adsorbent surface occurs at low pH hence repulsion between the cationic dye RhB and positively charged adsorbent surface. As solution pH increased, the adsorbent surface is continuously deprotonated and attraction between the negatively charged adsorbent surface and cationic dye results in increased adsorption. This data agrees with previously reported work [22]. Continuous bombardment of RhB molecule on the surface of the adsorbent aids adsorption hence RhB removal increased with time (Fig. 4b). Rapid adsorption was observed within the first 40 min followed by a gradual RhB uptake and then negligible increase in quantity adsorbed was observed. Increased adsorption surface sites results in increased percentage removal between 0.1 mg/L and 0.3 mg/L dosage (Fig. 4c). Further increase in adsorbent dosage yielded no increase in percentage adsorption. This may be attributed to overlay of adsorbent as well as saturation of adsorption sites [23]. Percentage RhB removal slightly increased with temperature (Fig. 4d). Activation of adsorption site via increased temperature may have been responsible for this increase [24].

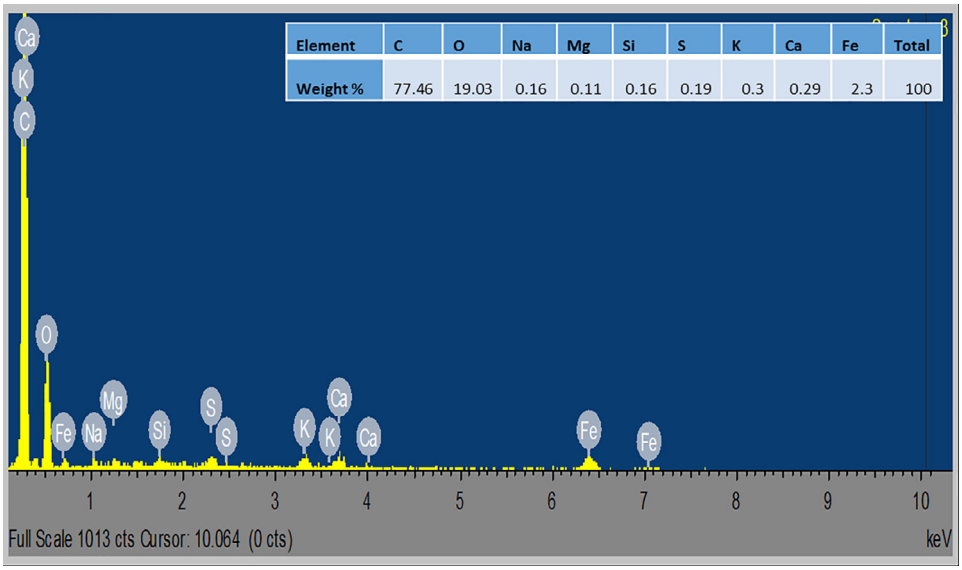

Fig. 3. EDX spectrum of PPAB.

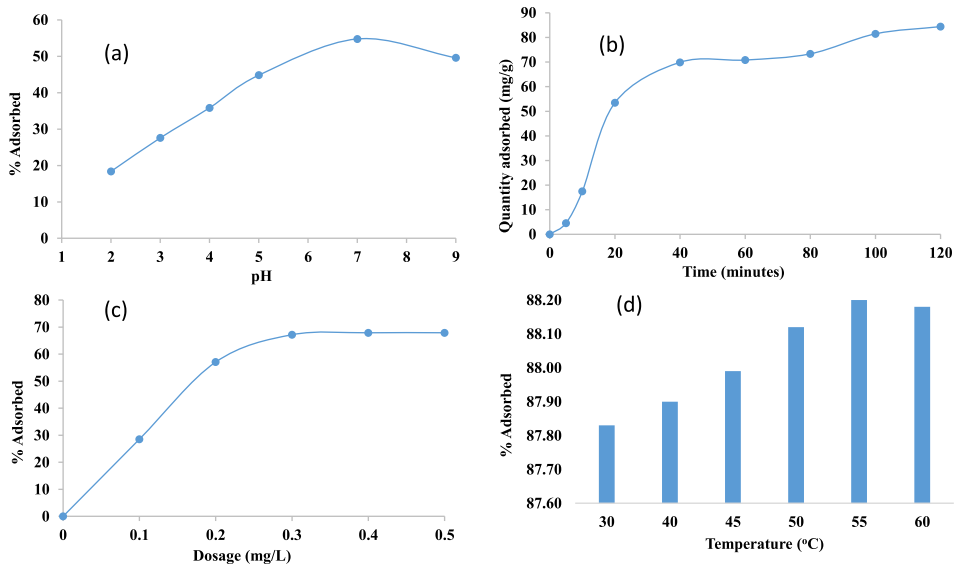

Fig. 4. Effects of pH on RhB uptake (a), time on RhB uptake (b), dosage on RhB uptake (c) and temperature on RhB uptake (d) onto PPAB.

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