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Original Research Article

Removal of Phenylephrine Hydrochloride Drug Using Tea Waste Biosorbent from Aqueous Solutions

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ABSTRACT

Todays, activated carbon derived from biomass sources has wide applications. In this study, activated carbon of tea waste has been considered for adsorption of phenylephrine hydrochloride drug from aqueous solution via batch adsorption process. The adsorption tests were carried out under several conditions such as equilibrium time, pH, adsorbent dose, and temperature. FESEM, TEM, and EDX techniques applied for characterization of activated carbon of tea waste before and after adsorption. The equilibrium results fitted to Langmuir and Freundlich isotherm models and it has been described as well via Freundlich model with best multilayer adsorption efficiency. According to analyses and experimental data, activated carbon of tea waste as a low cost, economically feasible and abundantly available adsorbent has great potential to high removal efficiency for phenylephrine hydrochloride drug.

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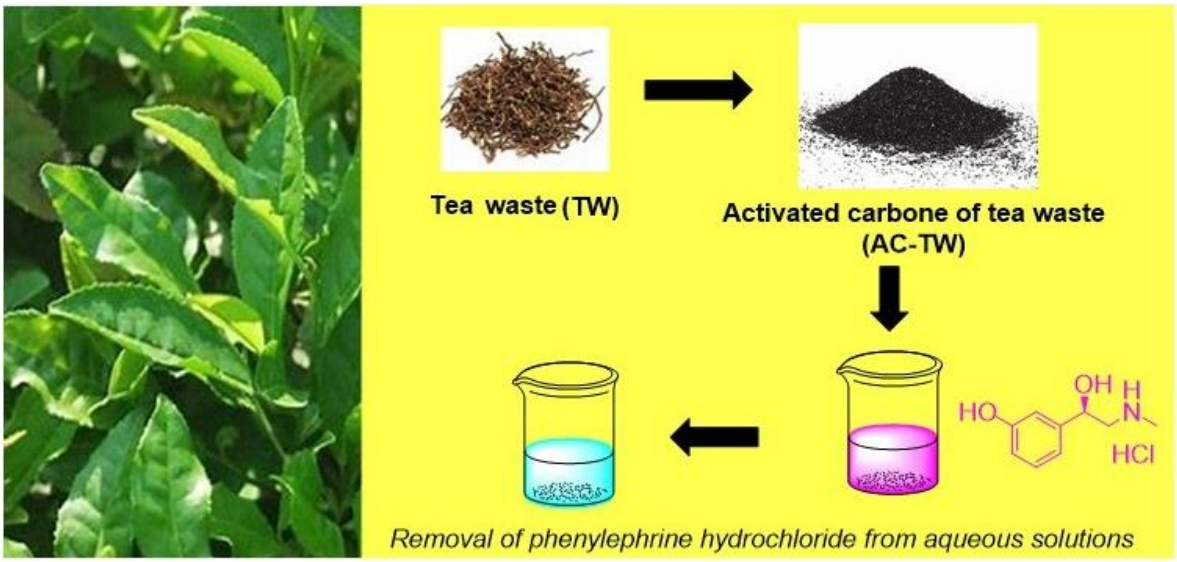
GRAPHICAL ABSTRACT



Introduction

In recent studies, there is increasing awareness of water contamination from a range of contaminants, which have prompted concerted efforts towards abatement. Water contamination is caused via accumulation of physical, biological, and chemical substances in certain concentration either via synthetic source, natural, or from industrial sectors, for example, textile, paints pulp, and paper [1]. Pharmaceutical, distilleries, food, plastics, leather and tannery, photographic, cosmetics, and printing utilize wide range of colored dyes to manufacture products, thus releasing massive quantity of effluents that affects the natural aesthetics of the environment, difficult to treat and are nonbiodegradable [2, 3]. Different adsorbents have been utilized to removal of pollutant in water like grapefruit shells, coniferous pinus bark powder, Cocoa shell, tamarind seed powder, waste tea leaves, rubber seed, coconut shells, coconut waste, waste newspaper, pumpkinseed shells, leaf date palm, cassava peels, coconut shells, dead biomass, timber waste, saw dust, groundnut shell Watermelon shell, rice husk, chitosan, etc. Agricultural bio-waste is constantly being explored to dispose of contaminants from pharmaceutical preparations due to its availability, high content of carbon and cellulose, and its ability to isolate organic molecules [4-14]. In addition, the agricultural materials are characterized by suitable chemical and physical specifications for the absorption of pharmaceutical preparations. Tea waste (TW) belongs to this category of agricultural by-products. Tea waste is the main by-product obtained from tea leaves, the most important crop grown in most countries around the world [15, 16].

Phenylephrine is classified as an antibiotic. It is used to dilate the pupil and as a nasal decongestant. It is used in the eye, to relieve hemorrhoids, and also to increase blood pressure. A Phenylephrine drug is taken intravenously in cases of septic shock, mouth, applied to the skin anesthesia, and low blood pressure, injection into a vein or muscle. Its chemical formula is $C_9H_{13}NO_2$, its molar mass 167.208 g·mol^{-1}, and also it is considered to relieve a blocked nose and a nasal decongestant. Furthermore, it reduces volume of the blood vessels nose and sinuses helping you to breathe easily [17].

Herein, through the archived results and measurements, it was confirmed the effectiveness of activated carbon of tea waste (AC-TW) to removal phenylephrine hydrochloride (PHC) drug and improve the factors affecting the adsorption process. Characterization of AC-TW before and after adsorption trough FESEM, TEM, and EDX revealed it is a good option for removal of pharmaceutical pollutant.

Experimental

Chemicals

The drug utilized in this research was phenylephrine hydrochloride (PHC) drug purchased from factory samara, Iraq. A stock solution (100 mg/L) of PHC drug was prepare via dissolving 0.1 g in 1000 mL distilled water. All solutions were prepared via diluting the standard solution with distilled water.

Preparation of Tea Waste

Spent tea black bags as tea waste were collected and boiled several times with distilled water. This process was repeated the color original was completely removed and tea water became colorless, filtered, and and then dried in oven at 60 ˚C for 48 hours.

The dried Tea Waste (TW) sample were taken crushed, and sieved to obtain a powder sized 50 nm. The TW are stored in a bottle and used in all experiments. The tea waste was not treated with any chemical before the adsorption experiments.

Preparation of Activated carbon of Tea Waste (AC-TW)

100 g of Tea Waste (TW) was impregnated with H_3PO_4 (0.2 N) with stirring for 30 minutes of ratio of (W:V) % 1:2. After that, filtered and washed by distilled water to reach of neutral pH and dried in an oven, for 24 hours. The tea waste was carbonized in a furnace under N_2 gas (98.98%) until 300 °C and for 3 hours. The Activated carbon of tea waste (AC-TW) was cooled, washed, and dried in oven. The Activated carbon of Tea Waste (AC-TW) are stored in a bottle and used in all experiments.

Results and Discussion

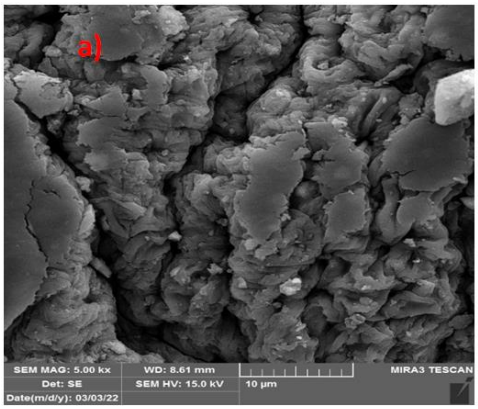
Characterization

The scanning electron microscope (SEM) technique was used as an important and essential method to clarify the morphology of the prepared surface and the basic physical properties of the adsorbent. SEM of the prepared surface before and after the adsorption process (Figure 1a) shows a good possibility of trapping and absorbing the contaminant (drug) within the surface pores. According to the results shown in the SEM images, the adsorbed material shows dark spots with the presence of active sites, evidence of the surface effectiveness.

The Figure 1b shows that after adsorption process, the surface became smooth and cloud-like, which can be considered evidence of the success of the adsorption process and high surface effectiveness of adsorption within the cavities and pores of this material.

The composition and purity of the results reveal that the peaks are for C and O samples. EDX analysis indicated that the desired phases of O and C are present in the MWCNTs with good purity [18-20]. Also, small amount of P is found resulted from activated by phosphoric acid, as displayed in Figure 1c.

To determine the shape, size, and particle distribution of tea waste, TEM analysis was performed. As shown in Figure 2, dark-colored semi-spherical aggregates enclosed within a matrix-like structure were obtained, which can be attributed to the process of activation and treatment with acid. The process of activation increases the surface porosity and also the active aggregates on the surface of the preparation [21, 22].



Elt	Line	Int	Error	K	Kr	W%	A%	ZAF	Formula	Ox%	Pk/Bg
C	Ka	439.0	2.8814	0.5328	0.2062	49.51	59.17	0.4165		0.00	57.85
O	Ka	373.7	2.8814	0.2605	0.1008	40.86	36.66	0.2468		0.00	50.79
P	Ka	379.4	13.8664	0.1444	0.0559	9.11	3.16	0.8203		0.00	12.29

c)

Figure 1. The scanning electron microscope (SEM) technique (a) before adsorption, (b) after adsorption, and (c) EDX of AC-TW

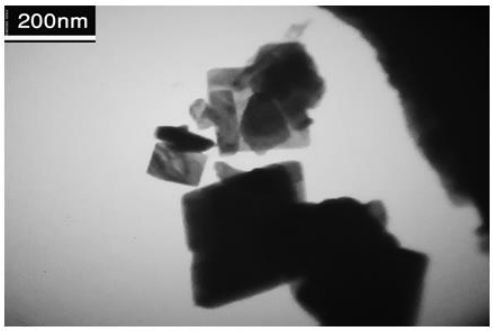


Figure 2. TEM image of AC-TW

Effect of contact time

Equilibrium time is one of essential limits for the assessment of practical use of adsorption method [23]. The experimental data of removal of PHC drug, onto adsorbent surfaces of AC-TW with equilibrium time. The contact result appears in Figure 3, which reveals that the adsorption efficiency rises with increase in equilibrium time to reach constancy, because active sites of the adsorption increased with increase absorbent surfaces, indicating that an apparent to reached equilibrium [24-26], and then the adsorption capacity will decrease. The equilibrium is established within 1 hour.

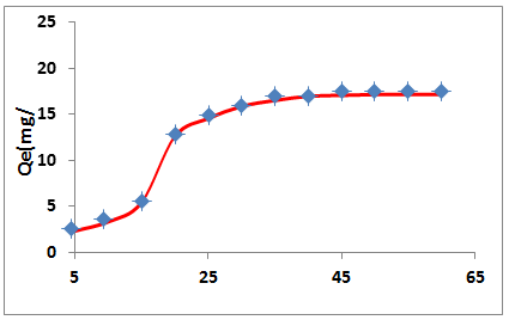


Figure 3. Effect of contact time onto adsorption capacity of drug.

Effect of pH

The pH of the drug solution has an important effect on the absorption of the adsorbent molecules, and it also has an effect on the surface properties of the adsorbent and the

ionization/dissociation of the adsorbent molecule, and this affects the changes that occur in the composition and surface structure.

The degree of ionization of the adsorbent depends on the pH of the drug solution. Accordingly, pH is considered one of the important factors in studying the adsorption process. The influence factor is pH. The effect of pH on the adsorption of a drug on the AC-TW was studied at the pH range (3-11), where the initial drug concentration was (20 mg/L) [19], as shown in Figure 4.

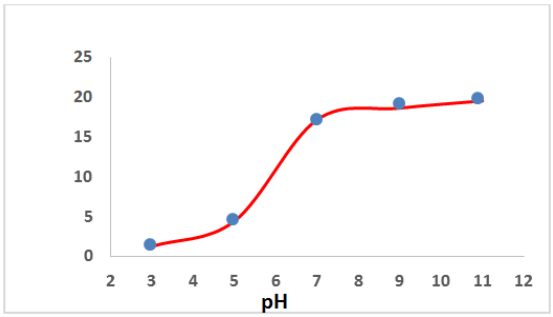


Figure 4. Effect of pH solution onto adsorption capacity PHC drug.

Effect of weight of AC-TW

The quantity effect of the adsorbents was essential to observe the smallest probable quantity, which illustrations the best adsorption stoichiometric. The quantities of adsorbent were different 0.025 to 0.12 g/100 mL of AC-TW, as depicted in Figure 5. An increase in E% of removal drug with adsorbent weight was related to rises in the adsorbent surface areas, improving the number of adsorption sites available for adsorption as reported already in other cases [24, 27-29]. The rise in elimination of drug with weight of AC-TW due to the introduction of more binding sites for adsorption. The initial parameter explaining this characteristic is that adsorption sites continue un-saturated through the adsorption method while the number of sites available for adsorption method site rises via increasing the weight of AC-TW [14, 16].

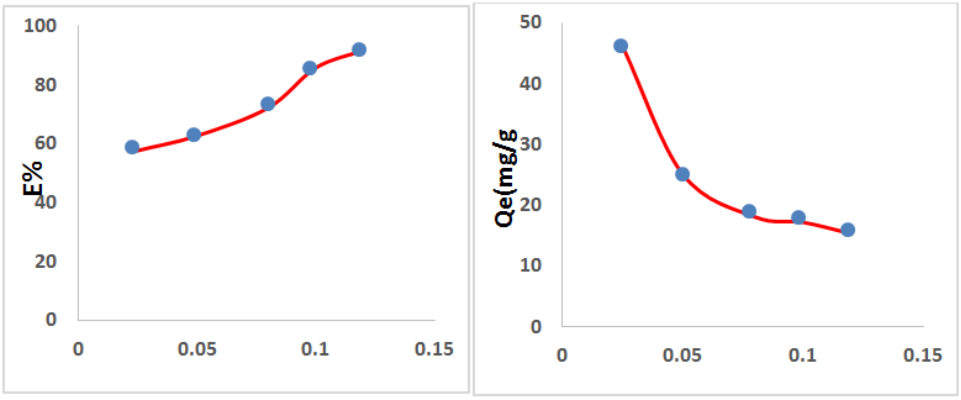


Figure 5. Effect of weight of AC-TW onto removal percentage PHC drug

Effect of Temperatures

The drug removal percentage was estimated at temperatures 10 °C to 40 °C. As the temperature has a significant impact on the process of adsorption and removal of the pollutant through a change in the temperature solution, this leads to changes in the efficiency of adsorption and the balance of the adsorbent and the absorbed material. Drug absorption decreases with decreasing solution temperature, but adsorption efficiency increases with increasing solution temperature. This results from the endothermic presses of the reaction, while a decrease in temperature results from the exothermic nature of the absorption reaction. It turns out that with an increase in temperature, the physical bonding between the pharmaceutical (drug) and the surface active sites is considered as weak [16].

Also, the active adsorption sites and the degree of freedom of the adsorbed species were decreased, as shown in **Figure 6**.

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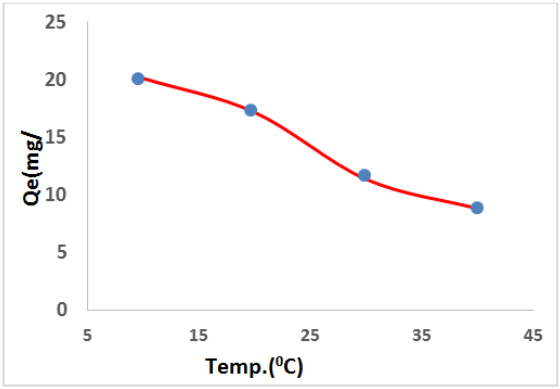

Figure 6. Effect of solution temperature onto removal PHC drug

Adsorption Isotherm

To investigation the parameter necessity of the adsorption capacity two equilibrium isotherms were analyzed, including Isotherm Langmuir and isotherm Freundlich. The isotherm imitation using an iterative procedure founded on a linear least squares algorithm. The isotherm Langmuir model calculate, as described in Equation (1) [29,30].

$$\frac{C_e}{q_e} = \frac{1}{q_m K_L} + \left(\frac{1}{q_m}\right) * C_e \quad (1)$$

Where, q_e indicates the use at equilibrium (mg/g), K_L the constant Langmuir (L mg^{-1}), q_{max} the mono-layer adsorption capacity (mg/g), and C_e equilibrium concentration (mg L^{-1}). And the Freundlich equation is related for multi component adsorption method [32]. The model Freundlich isotherm is clauculated as presented in Equation (2) [33,34]:

$$ln q_e = ln K_f + \frac{1}{2} C_e \quad (2)$$

Where, K_f denotes Empirical Freundlich constant or parameter efficiency ($L.g^{-1}$) and n is exponent.

The data of the isotherms are shown in Figure 7 and Langmuir and Freundlich constants are presented in Table 1.

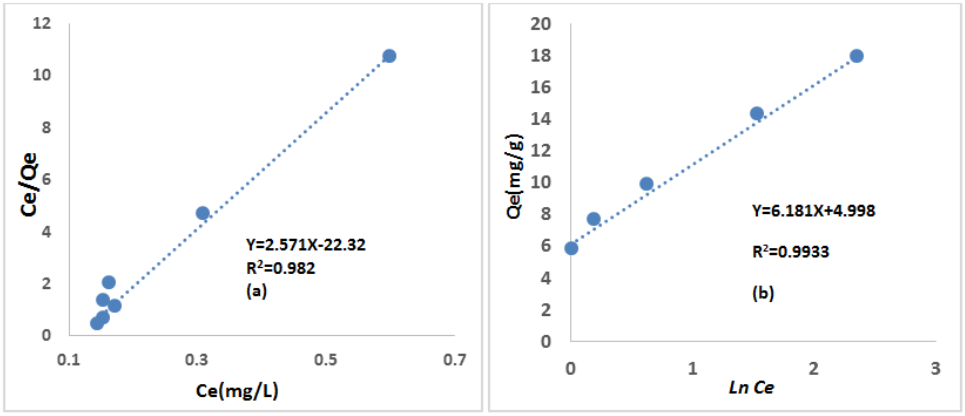

Figure 7. Adsorption models of Isotherm (a) Langmuir model (left) and (b) Freundlich model drug (right)

Table 1. Langmuir and Freundlich Isotherm model parameter for PHC onto AC-TW

Isotherm models	Parameters	Drug
Langmuir	qm ($mg.g^{-1}$)	**39.65**
	KL($L.mg^{-1}$)	**0.112**
	R^2	**0.982**
Freundlich	KF	**97.7**
	1/n	**0.14**
	R^2	**0.9933**

Conclusion

Activated carbon of Tea Waste (AC-TW) has been proven to be higher effective ecological adsorbent for the elimination of drug from aqueous solution. Batch studies of best conditions like equilibrium time, concentration of drug, biosorbent does, pH solution, and temperature that appear varied effect on adsorption method. The maximum removal of drug was recorded solution pH 11 and adsorbent dose 0.1 g, at 25 °C. The equilibrium result was analyzed using the Langmuir and Freundlich isotherm models. The adsorption equilibrium fitted well via Freundlich models with the maximum multilayer adsorption efficiency. The data revealed that AC-TW, used as an ecofriendly, low-cost, and available to removal drug from aqueous solutions.

Disclosure statement

The authors declare that they have no conflict of interest.

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