RESEARCH ARTICLE

Engineering Low-Cost Banana Peel Derived Biochar for the Highly Adsorption Capacity of Metformin Hydrochloride Drug from Aqueous Solution on Chemical Activation

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ABSTRACT

Adsorption is one of the easiest and best ways to purify water. In recent years, the adsorption process has been adopted to purify drinking water. Using adsorption technology to remove the most dangerous types of pharmaceuticals in drinking water, such as (metformin hydrochloride MF-HCl drug), and a primary goal of this empirical study utilizing banana peels as derived biochar activated carbon (ACBP) to remove MF-HCl drug. The FTIR, FE-SEM, XRD and TEM technique was utilized to estimate the surface characteristics before and after the adsorption process. The adsorption capacity Qe mg/g and percentage removed E% increase with increasing equilibrium time and, solution temperature and pH. The adsorption capacity Qe mg/g Qe mg/g decreases with increasing of adsorbent dosage. Thermodynamics including (ΔH), (ΔS) and (ΔG) are found to be endothermic and spontaneous. Results show that the MF-HCl drug adsorbed amount on ACBP was 147.59 mg/g. The adsorbent was treated via several acids like as (H_3PO_4, HNO3, HCl and H_2SO_4). The obvious from the results the best removal percentage E% when the adsorbent was treated via HCl. This is may be due to the increase in acid acidity caused by reactivating the active sites for the adsorbent surface. From the results obtained, ACBP are eco-friendly, extensive, and effective as an adsorbent, giving a promising prospect for removing wastewater.

Keywords: Adsorption, Thermodynamic, Pharmaceutical, Metformin hydrochloride, Isotherm.

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INTRODUCTION

Water pollution with many liquid wastes, including dyes, medicines, heavy metals, radioactive materials, and organic and inorganic materials, the most important bacteria deposited in drinking water. Wastewater and water from factories for dyes or medicines are responsible for causing damage to the aquatic environment and negatively impacting human health. This polluted water leads to the deposition of harmful bacteria that are considered very dangerous on the water's surface and affect living organisms because of their various negative effects that cause cancer.[1-3] Therefore, there are many techniques to remove these toxic pollutants, including precipitation, filtration, photocatalytic, photo-oxidation and adsorption. The adsorption process is one of the most important modern methods used to get rid of pollutants in the aquatic environment. The most dangerous are dyes, pharmaceuticals, pesticides, and organic and inorganic compounds, including bacteria present in sewage water.

Many surfaces are used as natural adsorbents that are easily available and don't cause any harmful effects to the environment. These may be agriculture and biological wastes, including pumpkin seed husks, sawdust, pomegranate peels, Banana peels, grape stems and cotton stalks.[4-7]

Metformin hydrochloride (MF-HCl) drug is a member of the iguanids family, which includes (phenformin, metformin, and buformin). MF-HCl has been used as a hypoglycemic agent for the last century. Metformin, a traditional herbal remedy derived from sheep's feet, is the first-line treatment for T2D because it is the safest and most effective hypoglycemic agent with the lowest risk of cardiovascular disease and other side

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effects, including weight gain. The main effect of metformin is to inhibit hepatic glucose production, increase muscle uptake of glucose, and reduce intestinal absorption of glucose. It can be used to treat many other diseases.[8,9] This research was based on using activated carbon as an effective, inexpensive, available absorbent material, banana peels for removing drugs from aqueous solutions. Also, thermodynamics and adsorption isotherms have been studied.

MATERIAL AND METHODS

Preparation Activated Carbon

In this study, banana peel waste was prepared as activated carbon (ACBP), washed several times with distilled water, and dried. The banana peels dry and ground to obtain the powder and sift before hydrochloric acid treatment. The peels were soaked in 40% HCl at 30°C for 3 hours. This was to remove the color and substances in soluble. Excess of hydrochloric acid was drying. The husks was washed with distilled water and soaked in 20% solution of sodium bicarbonate for 24 hours to remove the residual acid from pores of the carbon and dried at 65°C overnight. The powder was sitting and stored in an airtight container.

RESULT AND DISCUSSION

ACBP was diagnosed with FTIR technology before and after adsorption. Comparing the two shapes makes it noticeable that the beam is in the range between (3500–2800 cm^{-1}) and the return. To (OH, NH) overlapping band because of hydrogen bond before adsorption, the decrease in intensity clearly occurs due to the of after adsorption method. The peaks at 2920 and 2842 cm^{-1}, respectively, are caused by stretching the C-H link in the CH_2 group in asymmetric and symmetric ways. Several overlapping bands exist between 1732 and 1643 cm^{-1} in the 1800 to 1500 cm^{-1} region. The stretching of the C=O link is responsible for this set as shown in Figure 1.

Also, the composite was diagnosed before and after adsorption through field emission-scanning electron microscopy (FE-SEM), where, as is evident in Figure 2, the ACBP has a smooth surface consisting of layers compacted on each other as a result of the van der waals force that binds the layers together, as well as due to the treated by hydrochloric acid that showed a wide range of surface smoothness. In

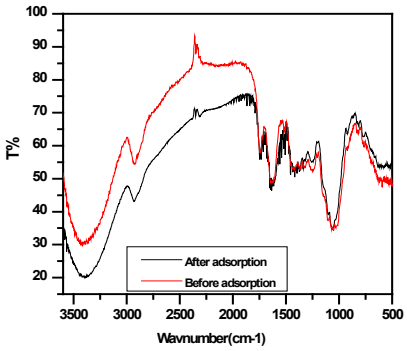

Figure 1: FTIR technology of ACBP before and after adsorption onto MF-HCl drug

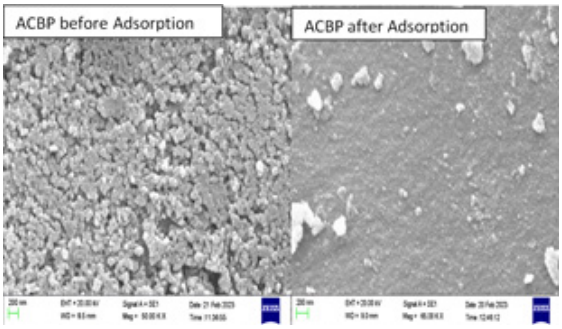

Figure 2: FESEM image of ACBP before and after adsorption onto MF-HCl drug

contrast, Figure 2 shows that the ACBP, after the adsorption method, has a rough surface morphology with pores of several sizes. These pores are useful for adsorption drugs.

The morphological, particle size, shape, surface structure, crystal structure, and crystal distribution of the surfaces ACBP by use of transmission electron microscopy TEM technique. Figure 3 shows ACBP exhibited a rough irregular surface with raised bumps and regular with longitudinal cylindrical prominent smooth and zigzags. These findings confirmed the efficient adsorption of drug molecules on ACBP.

Also, the analysis of ACBP using X-ray diffraction by XRD emitted from the Cu-Kα source with a wavelength of (1.5104 A°) and an angular range of (2θ = 0-80). It appeared to us clearly, as in Figure 4, that one wave of ACBP at (2θ = 20) with a non-nanoscale range amorphous (non-crystalline).[10]

Effect of Equilibrium Time

The equilibrium time was measured by fixing all optimum temperature conditions, solution concentration, and surface weight. The surfaces prepared ACBP in Figure 5. The reason is due to the occupation of the effective sites by the adsorbent material at the beginning, after which the increase is gradual until reaching the equilibrium time. We notice that after this time, there is no change in the amount of adsorption as the absorbance is almost constant, show the effect of time and the amount of adsorbent for ACBP was 148.55 mg/g.[11,12]

Effect of Weight of ACBP

Effect of several weight of ACBP on the removal MF-HCl drug. The weights taken were 0.025–0.15 g. They were placed at (100 mL) of MF-HCl drug solution at a fixed concentration (100 mg/L) until the completion of the equilibrium time of (60 minutes). The results show in Figure 6 that the decrease in the adsorption capacity Qe with the increase in the weight of ACBP can be attributed to the non-saturation of the adsorption sites of the surface through the adsorption method, in addition to the interferences that occur between the particles (like the occurrence of agglomeration) which occurs when utilized high weights of surface.[13,14]

Effect of pH

The effect of the solution pH was studied in the adsorption of MF-HCl drug onto the adsorbent surface as ACBP at a concentration of (100 mg/L) at different pH (2–10) under

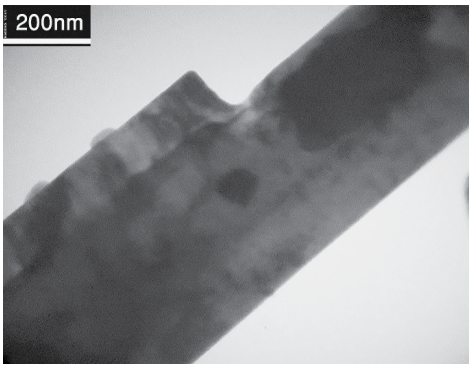

Figure 3: TEM image on ACBP after adsorption onto MF-HCl drug

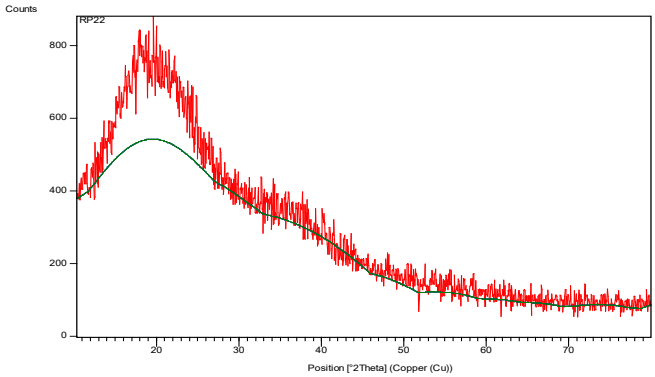

Figure 4: X-ray diffraction of ACBP

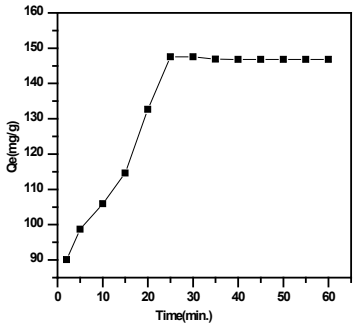

Figure 5: Effect of equilibrium time for onto ACBP

optimum conditions. The results appear in Figure 7, the effect of the acid medium on the adsorbent and the adsorbent surface on the one hand, the adsorption capacity of MF-HCl drug onto the adsorbent surface increases with the increased pH solution. At high values pH, repulsion will occur between the negatively charged functional aggregates on the adsorbent surface. Expansion will occur, allowing the drug molecules to spread within the surface, thus increasing adsorption capacity.[15, 16]

The Effect of Temperature

An important part of the adsorption process depends on the temperature of the solution. The effects of temperature solution were carried out at different temperatures (15–40°C). Figure 8 shows the increase in Q_e mg/g of adsorbate with increased solution temperature. Adsorbent surfaces are not affected by the molecules' adsorption of kinetic energy, which is why increasing the temperature of the solution may lead to

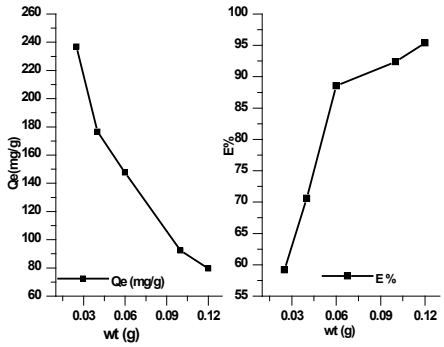

Figure 6: Effect of weight ACBP to removal MF-HCl drug

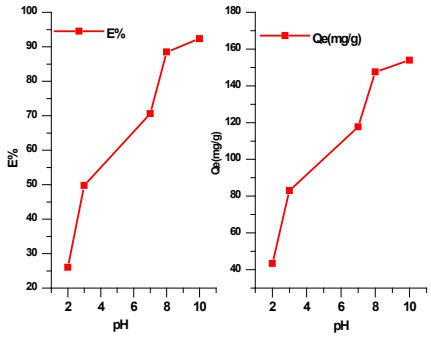

Figure 7: Effect of pH solution onto ACBP

the breakdown of some active functional groups on the rim surface composite, resulting in a reduction in the number of active sites.[17,18]

$$\ln X_m = \frac{-\Delta H}{RT} + \text{constant} \qquad (1)$$

$$\Delta G = -RT \ln K \qquad (2)$$

The thermodynamic parameter, that is to say, the (ΔH), (ΔG) and (ΔS), were calculated in eq. (1 and 2), and Table 1 and Figure 9 show these calculations.

Table 2 shows the values of the thermo-dynamic parameter of the drug adsorption on ACBP. The (ΔH) value indicates the endothermic adsorption method. One probable description of the exothermic city of adsorption is the drug and the ACBP are both solvated in water. For the drug to be adsorbed, they have to lose part of their hydration shell. The dehydration process of the drug and the adsorbent surface requires energy. So, the dehydration processes supersede the endotherm city of the adsorption process. The values ΔS negative, in addition to the values ΔG negative, have also been considered as the consequence of the diffusion of the drug to the chemical structure of the adsorbent.[19]

Effect of Acid Treatment onto ACBP

The study of the effect of acid treatment was necessary to show the best adsorption. The adsorbent was treated via several acids like as (H_3PO_4, HNO_3, HCl, and H_2SO_4). The results are shown in Figure 10. It was obvious from the results that the top removal percentage E% when the adsorbent treated via HCl.

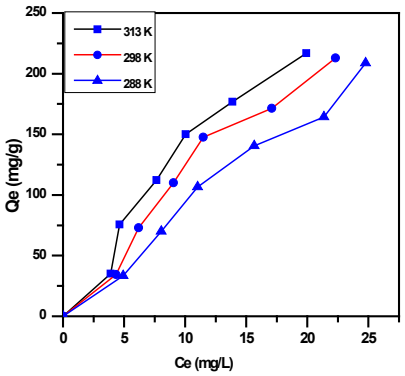

Figure 8: Adsorption isotherms of *drug* onto ACBP at several temperatures

Table 1: Influence of solution temperature on the maximum adsorbed quantity for adsorption of drug onto ACBP

$T(^oC)$	$T(K)$	$C_e = 20$	
		X_m	$ln\ X_m$
15	288	220	5.393628
25	298	218	5.384495
40	313	217	5.379897

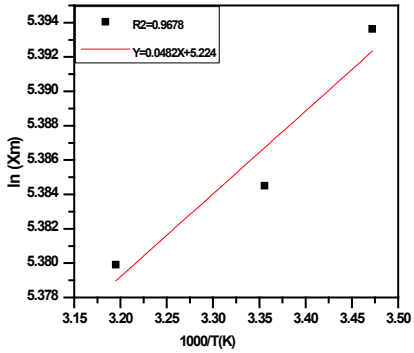

Figure 9: Van't Hoff plot for the determination of thermo-dynamic Factor

Table 2: Thermodynamic parameter for *drug* adsorption onto ACBP

$\Delta G/ (kJ.mol^{-1})$	$\Delta H/ (kJ.mol^{-1})$	$\Delta S/ (J.mol^{-1}.K^{-1})$	*Keq*
-6.96464	-4.014	43.4398	18.3326
-7.18384			18.16594
-7.53348			18.08261

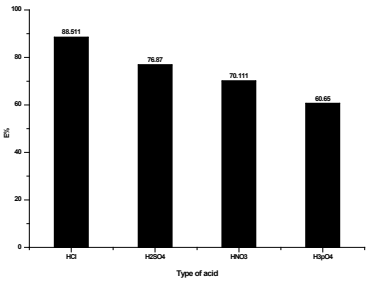

Figure 10: Effect of several acid treatments on the ACBP for the adsorption of MF-HCl drug

CONCLUSION

This work prepared the ACBP as an environmentally friendly and inexpensive absorbent material to remove MF-HCl drug from queues solution. The effect of temperature was studied. By increasing the temperature, the adsorption capacity decreased, and the reaction was spontaneous and endothermic and the values ΔS negative have also been considered as the consequence of the diffusion of the drug to the chemical structure of the adsorbent.

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