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Recovery of glucose from aqueous solutions by adsorption on green carbon

M Mini Margaret[1]

[1]Department of Chemistry, Pioneer Kumaraswamy College, Nagercoil-629003, Tamil Nadu, India

Abstract

Lignocellulosic wastes and agricultural waste materials contain multiple sugars. Large quantities of lignocellulosic wastes generated from agricultural residues, agro industrial practices are generally pollute the environment. This environmental waste can be minimized by converting them into valuable products. The aim of this study is more towards environmental friendly solutions by transforming the lignocellulosic waste into valuable material which improves and upgrades technology for waste management and minimization. Eco-friendly and economical adsorbents are desirable for removing pollutants from the environment. Production of natural adsorbents involves the use of waste from agricultural product which makes them cost effective and eco friendly. In the present study the glucose was adsorbed on Prosopis Juliflora Green Carbon (PJGC) and desorbed in water and ethanol. This method can be suggested to fractionate the glucose from lignocellulosic wastes. The adsorbent was charecterised by FT-IR and BET surface area studies. The maximum adsorption of glucose a on PJGC as analysed by adsorption studies in relation to contact time, pH, temperature, concentration and adsorbent dosage. The stability of glucose on PJGC was determined by desorption studies using water and ethanol.
Key Words- lignocellulosic wastes, Adsorption, *Prosopis Juliflora*

I .Introduction

Lignocellulosic wastes have been proposed as large renewable resources for chemicals and sugars. Lignocellulosic biomass has caused increasing interest in the bioconversion of this feedstock into liquid fuels and chemical products [1–5]. Cellulose and hemicellulose in agro wastes are hydrolyzed into sugar monomers that can be converted into liquid fuels [6–10]. Ionic liquids (ILs) are useful for dissolving biomass and separation of lignin from hemicellulose and cellulose [11–14]. The high solubility of glucose in these aqueous ionic liquids makes a challenging separation problem [15–18] likely to encounter formidable problems in practice..The ultimate goal of bio refineries is to develop processes which could convert biomass efficiently into fuels, power, heat, and value-added products. One of the most studied concepts is the so-called sugar platform where biopolymers (cellulose and hemicellulose) are hydrolyzed into monomers (sugars). Fermentable sugars may then be converted biochemically into various products. Hydrolysis is carried out enzymatically with cellulases and hemicellulases or using an acid, most often dilute sulfuric acid. Lignocellulosic biomass contains various sugar monomers such as xylose, mannose, glucose, fructose, and galactose but also arabinose and rhamnose, which are released under hydrolysis [19] Adsorption equilibrium data have been published for glucose, fructose, sucrose, arabinose, xylose, and some oligosaccharides on strong acid cation (SAC) exchange resins in K+, Na+, Ca^{2+}, or Fe^{2+} forms [20-23]. In this work, we consider adsorption of glucose as a possible method for separation.

II. MATERIALS AND METHODS

The glucose (Loba chemie pvt. Ltd.) is used to study the adsorption process. Anthrone (Loba chemie pvt. Ltd.) and concentrated sulphuric acid (Merck, 98%) are used for the colour reaction of sugars. The Prosopis Juliflora barks were collected from local areas, for the preparation of green carbon which is used as an adsorbent for the adsorption process. Hydrochloric acid (Merck) and sodium hydroxide (loba) were used to adjust the pH of the glucose solution.

Glucose solution preparation

A stock solution of 1000mg/L is prepared by dissolving 1g of glucose separately in distilled water in a 100ml standard measuring flask. The working solution of desired concentration is prepared by successive dilution of the stock solution. The concentration of glucose was analyzed by UV visible spectrometer (Perkin Elmer Lambda 25).

Green carbon preparation

The green carbon means that the carbon prepared from the cellulose based material by thermal method without using any chemicals. High temperature reactor used for the preparation of green carbon. *Prosopis Juliflora* barks were cut into chips and sun dried. The dried *P. Juliflora* chips were packed and supported either side by asbestos wool in a vertical type high temperature reactor. This reactor kept inside the tubular furnace. The furnace temperature is controlled by the digital temperature controller. The reactor temperature is increased up to 200°C and maintained the same temperature for 3 hours in the absences of air and reactor continuously evacuated during the carbonization reaction to remove volatile organics, hydrogen and moister. In further increase of temperature in the range of 250-350°C, the *P. Juliflora* chips becomes green carbon.

Determination of Glucose concentration by Anthrone method

Carbohydrates are dehydrated by conc.H_2SO_4 to form furfural and its derivatives which condense with anthrone to form blue-green complex with an absorption maximum at 578nm. Concentration of glucose was measured spectrophotometrically by Anthrone method briefly 2ml of chilled 75% H_2SO_4 and 4ml of chilled Anthrone solution were progressively added to 10ml of boiling tubes, and then add 1ml of Glucose solution to the tubes separately. Place the tubes in a boiling water bath for 15minutes, cool and measure the optical density at 578nm against a blank and converted to concentration from the calibration curve.

III. RESULTS AND DISCUSSION

Characterization of Glucose solution

The maximum absorption of Glucose solution is determined spectrophotometricaly by using anthrone reagent.The Blue green complex formed is characterized by UV-Visible spectrometer.The maximum absorption of Glucose-anthrone complex is 578nm is shown in fig:1

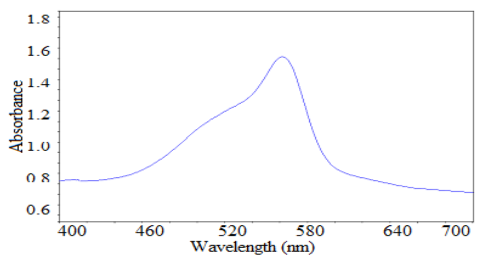

Figure 1: UV spectrum of Glucose-anthrone complex.

Characterization of the adsorbent

The adsorbent (Prosopis Juliflora Green Carbon) is characterized by FT-IR spectra and BET-surface area to find out the nature of the active site, structure, pore size and pore diameter.

FT-IR Spectrum of Green carbon

The FT-IR Spectrum of Green carbon is shown in fig. 3. The O-H stretching observed at 3430 cm^{-1} corresponds to the OH group present in the glucose unit of cellulose in Prosopis Juliflora chips. The peak at 1040 cm^{-1} corresponds to C-O-C stretching in cyclic form present in glucose unit. The peak at 1117 cm^{-1}corresponds to C-O-C stretching in between two glucose unit in the cellulose. The peak at 1014 and 1117 cm^{-1} are less intense in green carbon. This may be due to the cracking of glucose units in the cellulose polymers. Moreover, the peak at 1625 cm^{-1} in Green carbon is more intense, which may be due to the oxidation of alcoholic group to carbonyl group in the glucose unit of cellulose. Thus the characterization confirm the loss of OH group and have less number of ether linkage, which proved the formation of green carbon.

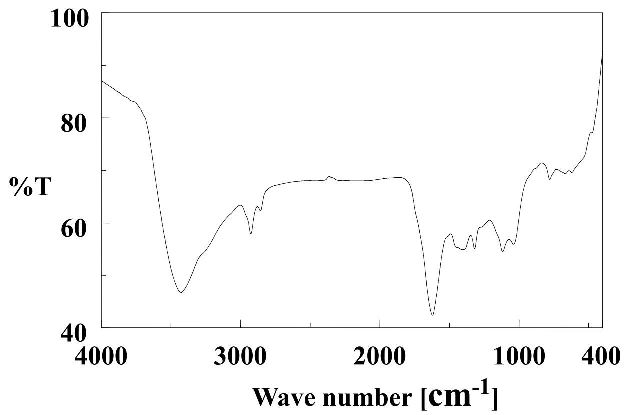

Figure 2: FT-IR Spectrum of Green carbon

BET-Surface area

The BET- Surface area of PJGC was measured by nitrogen adsorption isotherm method. The BET-Surface area was found to be 2.7219m^2/g. The pore size of green carbon is in the range of 12–15Å. Density of green carbon is 0.4857 and the particle size of green carbon is 0.667mm.

Adsorption isotherms

The adsorption isotherm of glucose on PJGC at different concentrations were studied and it was observed that both are well matched with the Langmuir and Freundlich adsorption isotherms (fig:3). The Langmuir equation is represented as

$$\frac{C_e}{Q_e} = \frac{1}{Q_{max} K_L} + \frac{C_e}{Q_{max}}$$

Where, Qe → equilibrium saccharide concentration on the adsorbent (mg/g), Ce → equilibrium saccharide concentration in solution (mg/L), Q_{max}→ monolayer capacity of the adsorbent (mg/g), K_L → Langmuir constant (L/g)

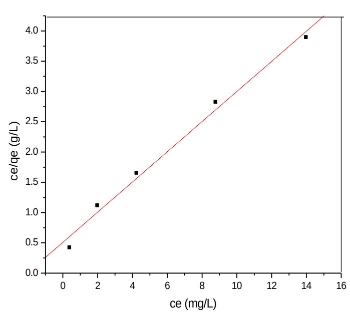

Figure 3: Langmuir Isotherm for adsorption of Glucose on PJGC

Table 1: Langmuir adsorption isotherm plot values for the adsorption of Glucose.

Saccharide	**Q_{max}**	**K_L**	**R^2**
Glucose	4.0159	0.4874	0.9947

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The Freundlich equation is represented as

$$\ln Q_e = \ln K_F + \frac{1}{\ln C_e}$$

Where, Q_e → equilibrium saccharide concentration on the adsorbent (mg/g), C_e → equilibrium saccharide concentration in solution (mg/L), K_f → Freundlich constant (L/g), n → (dimensionless) is the heterogeneity factor.

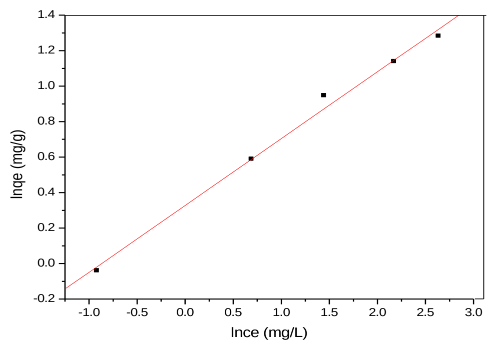

Figure 4: Freundlich isotherm for adsorption of Glucose on PJGC

Table 2: Freundlich adsorption isotherm plot values for the adsorption of Glucose

Saccharide	**n**	**K_F**	**R^2**
Glucose	2.6543	1.3873	0.99657

The various parameters obtained from Langmuir and Freundlich adsorption isotherm are given in Table 1&2. The R^2 values for both the adsorption models of glucose on PJGC are close to 1 indicated that the adsorption of glucose followed the Langmuir and Freundlich adsorption isotherms. The value of n more than one corresponds to multilayer adsorption of glucose.

Desorption studies

Desorption studies of glucose is shown in the figure 5. Desorption studies of glucose have been carried out in the presence of water and ethanol at room temperature. Mild conditions are satisfactory for reaching complete glucose recovery after adsorption. The high desorption of sugars from PJGC indicated that the sugars were weakly adsorbed (physisorption) on PJGC. The high desorption is promising for separation of sugars by adsorption. The PJGC is the best adsorbent for the recovery of sugars from the aqueous solutions.

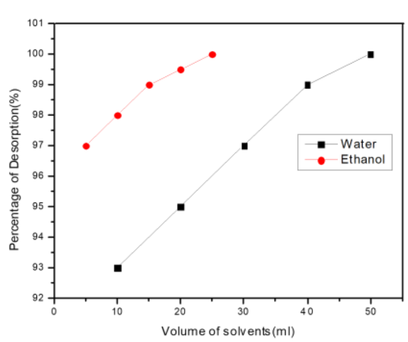

Figure 5: Desorption of Glucose (Time: 10minutes, Temperature: 30°C)

V. CONCLUSION

Prosopis Juliflora Green Carbon is used as an adsorbent for the adsorption of glucose. It is characterized by FT-IR spectra and BET surface area. The percentage of adsorption decreased with an increase in the concentration of glucose. This is attributed to the saturation of active sites and surface area of the adsorbent. From the adsorption studies, adsorption isotherms were calculated. The adsorption isotherm data are well matched with Langmuir and Freundlich adsorption isotherm model. Adsorption isotherm studies used to find out the maximum adsorption, the number of maximum layers and the adsorption capacity of each layer. Desorption study is carried out by using the solvents like water and ethanol to find out the binding stability of glucose on adsorbent. Glucose was completely desorbed in both water and ethanol. This high desorption of sugars from PJGC indicated that the sugars were physisorbed on PJGC. The experimental methods carried out in the present study can be suggested to fractionate the glucose from the lignocellulosic wastes in food industries.

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