Adsorption of Brown Sugar Color-Causing Substance on Powdered Activated Carbon

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Introduction

Adsorption is a process where the energy associated with the surface of the solid attracts molecular or ionic species from the liquid to the solid. The nature of the surface, the degree of porosity, the concentration of adsorbates and adsorbents and the environmental conditions in which the reaction occurs affects the adsorption process.[1]

Activated carbon finds particular application in the clarification of effluents both in liquid and gas forms, removal of coloring matters from various types of solutions and the elimination of impurities causing color, taste and odor from potable water, chemical and food processing liquids and waste water. It is also used in metallurgical operations and in agricultural applications.

While many researchers [2],[3] have worked on adsorption isotherms of gases and liquids on activated carbon, very little attention is given on the nature and characteristics of adsorption reactions in viscous fluids. The present investigation is geared towards the understanding of adsorption of the color causing substances in brown sugars from the Philippines and Japan.

Procedure

A. Equilibrium Curve

The equilibrium curve was determined by adding equal amounts of brown sugar solutions to equal amounts of carbon in glass stoppered 50-ml Erlenmeyer flasks and kept in a shaker immersed in constant temperature

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water bath maintained at 30°C. At different time intervals, the samples were filtered and the filtrate was analyzed in a UV-Vis Spectrophotometer at 480 nm.

B. Adsorption Isotherm

Adsorption isotherm studies were carried out by adding 20 ml sugar solution with a known initial concentration to 50-ml glass stoppered Erlenmeyer flasks to which different weighed powder activated carbon quantities were added. The flasks were kept in a shaker at 30°C. At a predetermined time interval, the samples were filtered through a filter paper and the absorbance of the filtrate was determined at 480 nm in a Hitachi UV-Vis Spectrophotometer. Calibration curves were prepared in advance as the basis for the final concentrations of the sugar solution.

Results and Discussion

Although the values of the initial and final concentrations are expressed in gram per ml of sugar solution, it actually measures the amount of color-causing substance present in brown sugars.[4].

A. The Equilibrium Curve

Results of equilibrium studies are shown in Table I and graphically in Figure 1 at 30°C and a 1:100 carbon to sugar ratio.

Table 1. Adsorption Equilibrium Data of Brown Sugar on Activated Carbon.

Sample	Reaction Time [min.]	Absorbance
1	0	.339
2	5	.157
3	10	.151
4	20	.136
5	30	.140
6	40	.109
7	50	.109
8	75	.098

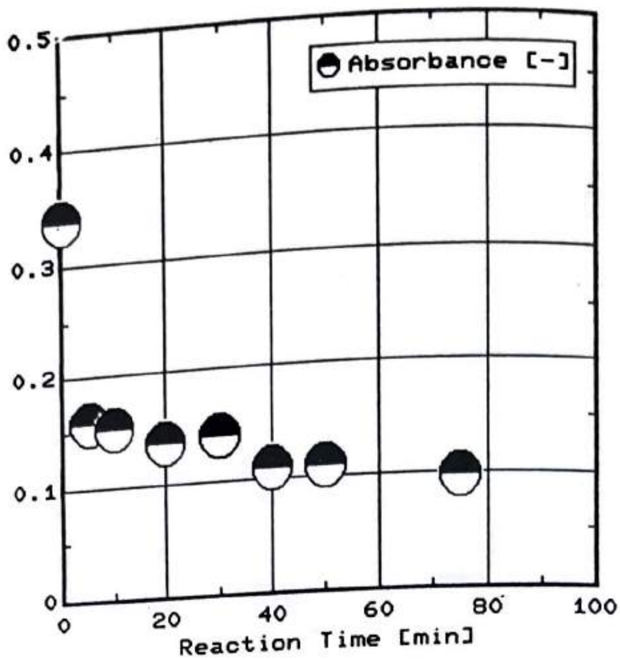

Figure 1. Adsorption Equilibrium of Activated Carbon and Philippine. Brown Sugar

There is a rapid decrease in absorbance during the first few minutes of the reaction. This implies that colored substances present were adsorb to the outer surfaces of the activated carbon particles. As the reaction proceeds, the outer surface become saturated and the adsorbates diffuses to the inner walls at a much slower rate due to the effects of viscosity and the size of the pores (inner tunnels in the carbon structure). As can be seen in the graph, the curve still has a negative slope. Equilibrium is reached when the value of the absorbance becomes a constant. This condition could be attained in a longer period of time.

B. Adsorption Isotherm

For this work, the Freundlich equation was used to describe the nature of adsorption. The equation in logarithmic form is; $\log X/M = \log K + \log C$

A plot of C against X/M on logarithmic paper gives a straight line at equilibrium conditions. This relationships are shown in Tables II and III and in Figures 2 and 3 for the Philippine brown sugar and the Japanese brown sugar respectively. Broken lines were obtained in both graphs of the Freundlich Equation which strongly indicates that equilibrium conditions

Table 2. Adsorption Isotherm Data of Activated Carbon and Philippine Brown Sugar at 30°C.

Sample	Ac. Carbon Dosage [g/ml]	Initial Conc. [g/ml]	Final Conc. [g/ml]	Reduction [g/m]	X/M
1	0	.145	.145	0	-
2	.0005	.145	.073	.072	144
3	.0007	.145	.060	.085	121
4	.001	.145	.053	.092	92
5	.005	.145	.050	.095	19
6	.007	.145	.032	.113	16
7	.01	.145	.012	.133	13

Table 3. Adsorption Isotherm Data of Japanese Brown Sugar on Activated Carbon at 30°C.

Sample	Ac. Carbon Dosage [g/ml]	Initial Conc. [g/ml]	Final Conc. [g/ml]	Reduction [g/m]	X/M
1	0	.383	.383	0	-
2	.001	.383	.218	.165	165
3	.002	.383	.158	.225	112
4	.003	.383	.137	.246	82
5	.004	.383	.135	.248	62
6	.006	.383	.117	.266	44
7	.012	.383	.100	.283	24
8	.020	.383	.068	.315	16
9	.028	.383	.037	.346	12
10	.040	.383	.018	.365	9

were not attained in the experimental range. At lower carbon to sugar ratio (upper line) near-equilibrium conditions exists. At higher carbon to sugar ration (lower lines), the lines were almost horizontal and it seems that the activated carbons were no longer effective in adsorbing the color-causing substances. However, the slope of the lower lines could be explained by the

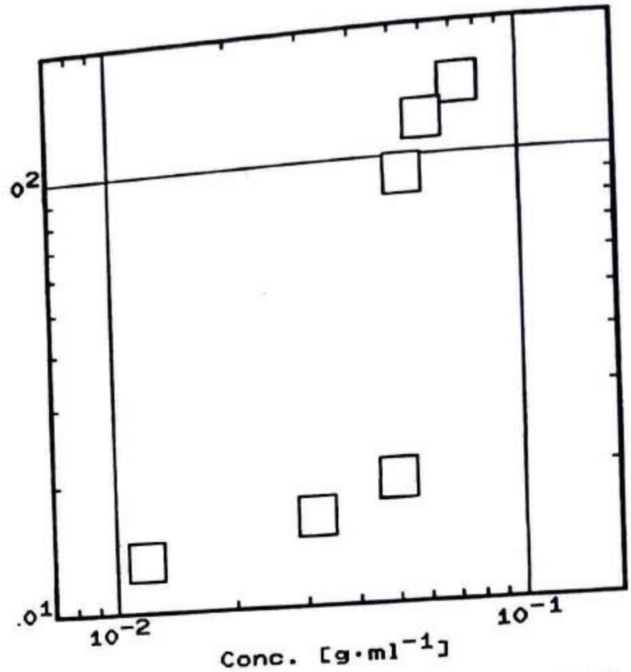

Figure 2. Isotherm of Activated Carbon and Phil. Brown Sugar at 30°C

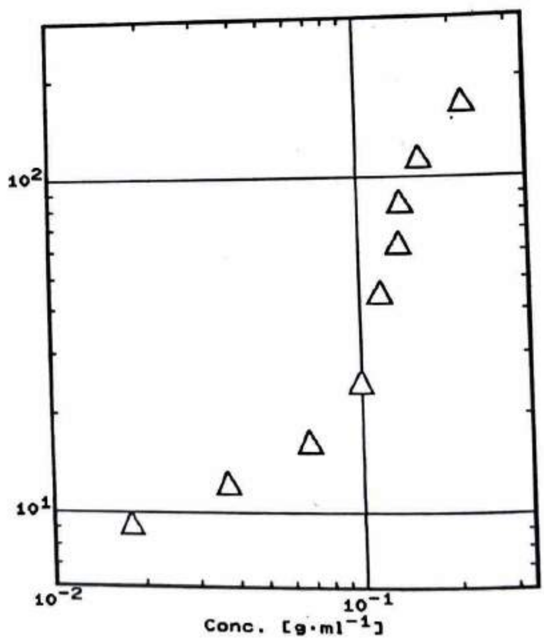

Figure 3. Isotherm of Activated Carbon and Japanese Brown Sugar at 30°C

combination of following statements:

1. There is not enough time for the adsorption process to compute.
2. Diffusion of adsorbates from the solution to the inner surfaces of the carbons are slowed down by viscosity related forces.
3. The amount of adsorbent present in the reaction vessel is more than the adsorbate. In a viscous medium and at high concentration, there is a possibility of forming clusters or layers of carbon particles thereby shielding other available surfaces for adsorption.
4. The presence of a reactant in excess must have changed the environmental conditions for the adsorption reaction.

Conclusion

Due to a very limited time of study equilibrium conditions for the adsorption isotherms of color-causing substances in brown sugars was not reached. There is also a need to study further the effects of temperature, viscosity and concentration of the reactants on the adsorption rates.

In future studies on sugar solutions involving longer periods of time, the reactants have to be sterilized to prevent the occurrence of fermentation so as not to affect the validity and reliability of results.

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