THE EFFECTS OF pH AND TEMPERATURE OF ADSORPTION ON THE PURIFICATION OF COCA-COLA EFFLUENT

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Abstract

The carbonaceous materials (wood & bone) were sourced from Bida, Niger State while coca-cola effluent was obtained from Nigeria Bottling Company, Agidingbe Ikeja, Lagos. Carbonization was carried out in a burning chamber at 9()0°C for bone and 800°C for wood. The temperature and pH of the effluent solution were varied to watch their influence on the purification of the effluent. It was observed that the process was exothermic in nature and also is highly dependent on the pH value. As the temperature and pH were varied, wood gave a better result than bone. Under different temperature condition, 96.6% reduction in concentration of pollutant was achieved while 143.10% was obtained at various pH values. Wood is therefore, recommended for this liquid phase adsorption process.

Keywords: Carbonaceous material, carbonization, purification, absorbance, concentration, adsorbent, coca-cola effluent.

Introduction

It is no longer news that there is an alarming increase in the wave of environmental pollution on global basis as a result of man's activities such as sewage disposal in rivers, inadequately treated or untreated wastes from industries, hotels, homes, discharges from agricultural activities, just to mention but a few [Oyewusi et al., 1998]. It is therefore, necessary to develop a method or methods of removing these pollutants from both domestic and industrial effluents. The process of adsorption has been found to be simpler and inexpensive in reducing or eliminating this menace [Satish et ah, 2001],

However, liquid phase adsorption is tremendously influenced by temperature and the pH of the effluent. An increase in temperature of adsorption has a negative effect on the process of adsorption [Kirk-Other, 1964], while the process is highly favoured at very low pH values [Venkata el ah, 1997). It is equally an established fact that the effluent colour is primarily due to dissolved solutes, and as a result of degraded products, which are chemically stable, at times resistant to biological degradation (very high COD/BOD ratio), and are intractable to separate by conventional treatment method [EFA R2-73-I63, 1973],

Therefore, this work intends to study the influence of temperature and pH on the purification of coca- cola effluents using thermally activated carbonaceous materials.

Sourcing of Materials

Both the animal bone (cow) and wood were obtained form New Market and Timber shed (Ilorin Road) all in Bida town respectively. The coca-cola effluent was collected from Nigeria Bottling Company, Agidingbe Ikeja, Lagos.

Carbonization

Carbonization was carried out in a specially designed burning chamber (furnace), which allows limited air supply. The bone was first boiled in water to remove excess fat and then sun dried for two days. The carbon materials (bone and wood) were introduced separately into the furnace for ashing. The bone was carbonized at a temperature of 900°C while the wood was carbonized at a temperature of 800°C as recommended by Aneke ***et al,*** (2004). Carbonization lasted for two hours after which they were allowed to cool to room temperature. After cooling, the ashed materials were steamed under atmospheric conditions and later ground to a workable size of 75pm [Aneke, ***et al,*** 2004]. The adsorbents were purified by washing with 0.5m of hydrochloric acid solution and then rinsed with distilled water to remove the excess acid. They were then dried in an oven at 100°C for one hour and later stored in an air-tight bag ready for use.

Method

Effect of Temperature

30ml each of the effluent were measured and poured into different conical flasks. The conical flasks were then transferred into a water-bath (Gallenkamp Product, England) set at a required temperature. When the effluent reached the desired temperature, 8g of the adsorbent was measured and added to the effluent. The flasks and the contents were allowed to stand for 5, 10, 20, 40 and 60 minutes and at the end of each time interval, the contents of the flasks were filtered to remove the adsorbents. The temperatures were maintained at 29°C, 40°C, 50°C, 60°C, and 70°C. The absorbance and concentration readings were measured at the end of each time interval.

Effect of pH

The effect of pH on sorption was done at different solution pH values of 1.0, 3.0, 5.0, 7.0 and 9.0. The pH of the effluent solution was adjusted using cone. HCL and IM NaOH solution.

8g of adsorbent was measured and put into conical flasks. The flasks and contents were allowed to stand for 5, 10, 40 and 60 minutes with intermittent shaking. At the end of each time interval, the contents of the flasks were fdtered to remove the adsorbent while values of absorbance and concentration of filtrates were measured using UV spectrophotometer (No 204 - 0001 - 01).

Treatment of Data

The rate constant for reduction in concentration of the effluent by activated wood and bone were obtained by the use of equation I [Octave, 2003],

$$\log \frac{C}{Ce} \quad \frac{K}{2.303} \quad . t$$

where C is the initial concentration of effluent (ppm), Ce is equilibrium concentration (ppm), t is time in minutes and K is the rate constant (min^{-1}). A plot of log C/Ce versus t gave a straight line confirming a first-order kinetics of this sorption process. From equation (1), the energy of activation can be calculated by the use of Arrhenius law, expressed as [Vasanth et al., 2004].

$$K = K_{„}e^{K/RT} \qquad (2)$$

where E is the energy of sorption, K_0 is called the frequency factor, R is the universal gas constant. Therefore, a plot of Ink versus 1/T gives a straight line with the slope equal to E/R see Figs. 1.0 and 2.0.

Result and Discussion

Effect of Temperature

A straight line of log C/Ce versus t indicates the validity of first order reaction of sorption (Fig. 1 and 2). This enabled the calculation of the energy of adsorption by the use of equation (2). The result obtained is summarized on Table 1 below.

Table 1: Heat of Reaction Using Thermally Activated Wood and Bone in Treating Coca-Cola Effluent

		Wood	**Bone**
S/N	**Temperature (K)**	**K ($rnin^{1}$)**	**K (min^{-1})**
1	302	0.036	0.015
2.	313	0.037	0.013
3.	323	0.029	0.010
4.	333	0.023	0.003
5.	343	0.025	0.017

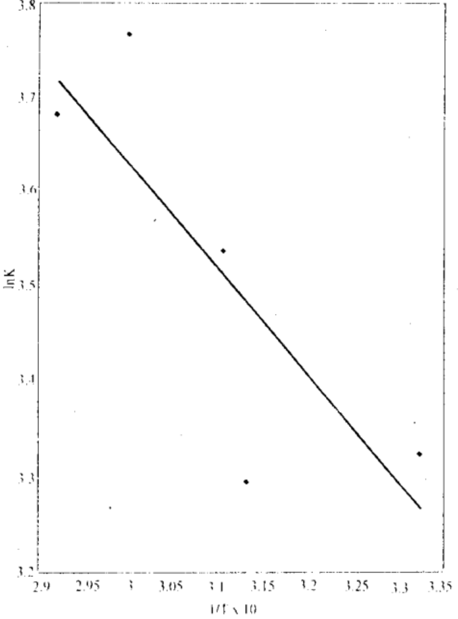

Fig 1.0 A plot of lnK vs 1/T for thermally activated wood on Coca-Cola Effluent.

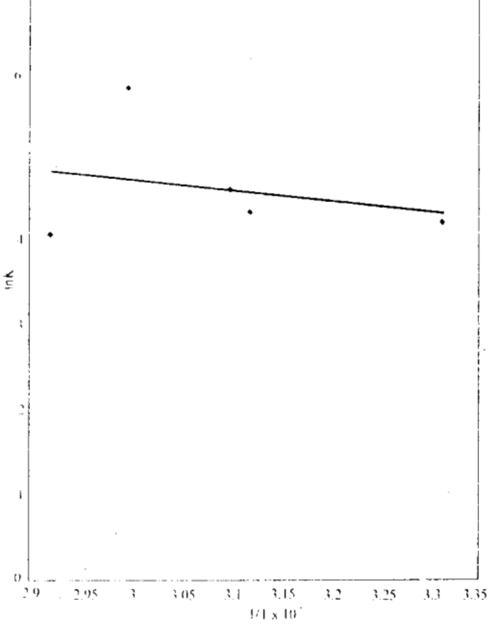

Fig 2.0 A plot of lnK vs 1/T for thermally activated bone on Coca-Cola Effluent.

From the plot of Ink against 1/T, Figures 1 and 2 (Table 1) the heat of adsorption were found to be -0.1615 and -0.1845 W/gmol for wood and bone based adsorbents respectively. The heat energy required when wood derived adsorbent was used is about two times greater than that when bone based adsorbent was used. From the energy point of view, wood is preferred to bone in the development of adsorbent for the purification of coca-cola effluent. The negative values of E indicate that the process is exothermic and therefore the sorption behaviour may be physical in nature and can be easily reversed by supplying the heat equal to calculated E value to the adsorption system [Vasanth, et al., 2004], Also negative E indicates the free diffusion of molecules through bulk solution and boundary layer is less than compensated by bulk groups and the stereo- tactic arrangements of adsorbates on the surface and in the pores of adsorbents (Vasanth et al., 2004],

It is equally of interest to note that the percentage purification is higher in using wood derived adsorbent ranging from 82.8 - 96.6%. Higher percentage purification were obtained between 29-40"C confirming the theory of adsorption processes i.e. adsorption is better conducted at lower temperature. However, the percentage purification using bone based adsorbent is seen to be quite smaller and decreases as the temperature of adsorption is increased. Therefore, it could be said that this process is better conducted at 29 to 40°C (Table 1). Adsorption is highly temperature dependent [Suzuki, 1990], The rate of fractional reduction in concentration of pollutant in the effluent was rapid initially and then slowed down gradually until it attained an equilibrium beyond which there was no significant increase in the rate of reduction. The initial rapid sorption process was perhaps due to participation of both macro and micro pores of the adsorbent. A large proportion of the process took place within a few minutes (10-20)minutes. Reduction in concentration using wood and bone based adsorbents attained maximum values of 96.6 and 75.9% respectively at the end of one hour contact time.

Effect of pH

Adsorption processes are also highly dependent on pH [Venkata et ah, 1997], The effect of pH on the purification of coca-cola effluent using activated wood and bone are also very prominent. The extent of adsorption decreases markedly as the pH of the sample solution is increased from 1.0 to 9.0. This behaviour is characteristic of anion sorption, and this also indicates that the adsorbent surface is of H^+ (cationic) type. At lower pH values, the surface of the activated adsorbent becomes positively charged and this facilitates the adsorption of dissolved anion substances in the test solution, probably by exchange sorption. In these instances, the pH values of 1.0 to 5.0 gave good results of 129.30 to 143.10% and 96.9 to 113.8% for wood and bone respectively. However, the negatively charged adsorbent surface at higher pH values may likely lead to competition between OH ions and anion ions for binding sites may have resulted in the reduction of adsorption capacity.

Conclusion

This process of purification of coca-cola using wood and bone based adsorbents is exothermic. The energies of adsorption for these adsorbents are -0.1615 and -0.1845 W/gmol for wood and bone respectively. At temperatures of 29°C and 40°C 96.6% purification was enhanced while at a pH of 3, as much as 143.10% purification was achieved. Therefore, the effluent pH is very important in treating coca-cola waste waters before discharge into the environment. This operation can be best conducted at 29°C (room temperature) and a pH value of (3-5). It is hereby suggested that lower temperatures and pH values should be investigated to determine the optimal processing condition for these process variables.

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