ChemSearch Journal 9(1): 13 – 18, June, 2018
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 12/12/2017 Accepted: 03/02/2018

Adsorptive De-Colouration of Textile Wastewater using an Acid-Modified Sawdust

Abdulsalam K. A.[1] and *Giwa A. A.[2]
[1]Department of Basic Sciences, Chemistry Unit, Faculty of Science, Adeleke University, P.M.B. 250, Ede, Nigeria.
[2]Department of Pure and Applied Chemistry, Faculty of Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
Email: giwa1010@gmail.com

ABSTRACT
Batch study of the decolourisation of wastewater from a local textile facility by concentrated Sulfuric acid-modified sawdust was conducted. The adsorbent was characterized using Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM) and Elemental Diffraction X - ray Spectroscopy (EDS) techniques. The effects of adsorbent dose, contact time and temperature were investigated. The characterization analysis indicates that the adsorbent has potential adsorption sites with several pores, and carbon content as high as 66.77%.The percentage color removal from the wastewater increased with adsorbent dose, contact time and temperature. The efficiency of the adsorbent is high, with a dose as low as 1 g removing as much as 88 % of the color from the wastewater.

Keywords: Adsorption, Batch studies, Modification, and Wastewater

INTRODUCTION
The complex aromatic structures of dyes make them more resistant to light, heat and oxidizing agents and they are also usually non-biodegradable. This is desirable in the industry as it attributes to color fastness, but it also makes it hard to treat wastewater effluents containing dye (Han *et al*., 2007). The presence of very small amounts of dyes in water even less than 1ppm for some dyes is highly visible and undesirable (Giwa et al., 2015). The removal of color from textile wastewater is a major environmental problem as some dyes and pigments are carcinogenic or mutagenic. They are the first contaminants to be visually recognized in polluted water (Banat et al., 1996). A number of technologies like coagulation, chemical oxidation, reverse osmosis, aerobic and anaerobic microbial degradation have been applied over the years for the treatment of dye-containing wastewaters (Mohammed et al., 2011; Giwa et al., 2015). Adsorption method has proven the best because of its efficiency and simplicity (Batzias et al., 2007**.** Sawdust of certain woods has been reported to be an efficient adsorbent (Shukla et al., 2002; Badu et al., 2014; Geetha and Palanisamy, 2015) Color removal has being the focus of significant attention in the last few years, compared to other pollutants in the textile industry, not only because of its toxicity, but also mainly due to its visibility problems and non-biodegradable characteristics (Hazrat et al., 2008). Therefore, many investigators have examined a wide variety of adsorbents to remove color from textile industry wastewater rather than removal of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in the textile industry wastewater ((Duraij and Duraij, 2012; Maya et al., 2014; and simion et al., 2015). Hence, this study is aimed at the removal of color, the most visible component of wastewater from textile industries using chemically treated sawdust of *Parkia biglobosa* .

MATERIALS AND METHOD
Preparation of Adsorbent
The adsorbent was prepared from *Parkia biglobosa* sawdust as described elsewhere (Abdulsalam et al., 2017).The sawdust was collected, sorted, sieved and treated with concentrated H_2SO_4 acid in ratio 1:1 (W/V). It was dried and activated in an oven at 160 ^oC for 15 hours. The dried black biomass was then washed with dilute $NaHCO_3$ solution, and distilled water respectively till the pH was stable. It was finally dried at 105 ^oC and stored.

Characterization of Adsorbent
The surface characteristics of the adsorbent was studied using scanning electron microscope (SEM), Fourier Transform Infrared Spectroscopy (FTIR), Elemental Diffraction X – ray Spectroscopy (EDS). These were to elucidate the surface morphology, surface functional groups and elemental composition of the adsorbent.

Collection of Textile Wastewater

Textile wastewater was collected from the student textile flow, in the Department of Fine and Applied Arts, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso. It was collected into an air tight bottle, placed in an ice pack, and transported to the laboratory, where it was refrigerated at 278 K (Duraij and Duraij, 2012). The wavelength of maximum absorbance (λ_{max}) of the wastewater was determined on UV spectrophotometer

Batch Adsorption Studies

Batch adsorption experiments were conducted at pH 7 to determine the effects of adsorbent dose, contact time and temperature (Duraij and Duraij, 2012). The initial and residual color intensities of the wastewater before and after adsorption were measured at its λ_{max}.

Color removal efficiency of the adsorbent was calculated using the following equations:

$$\% R = \frac{100(C_o - Ce)}{C_o} \quad (1)$$

Where, $C_o = \frac{Ao}{K}$ (2)

$C_e = \frac{Ae}{K}$ (3)

Thus, $\% R = \frac{\frac{1}{K}(Ao - Ae)X100}{\frac{1}{K}(Ao)}$ (4)

$$\% R = \frac{100(A_o - Ae)}{A_o} \quad (5)$$

Where, A_o is the absorbance of the wastewater before adsorption and A_e is the absorbance at equilibrium (after adsorption), K is the constant of proportionality (it is the product of molar absorptivity constant and the path length of the cell holder).

To determine the effects of dose of the adsorbent, different masses ranging from 0.1 - 1.0 g were weighed into several flasks. A 50 mL volume of the wastewater was added to each of the measured sawdust doses. The mixture was agitated at room temperature for 22 h for equilibrium to be attained. It was then filtered and the filtrate analyzed for residual color intensity. Similarly, a constant dose of the adsorbent with equal volumes of the wastewater were shaking for various predetermined contact times (5, 10, 15, 18, 20, 22, and 25 h) at room temperature; and at different temperatures (30, 40, 50 and 60 ^oC), to study the effects of contact time and temperature, respectively.

RESULTS AND DISCUSSION

Characterization of adsorbent

The surface textural structure of the adsorbent is presented at × 200 magnification (Figure 1).The scanning electron microscopy image as depicted in Figure 1 shows that the surface of the sawdust was highly porous this could be due to the fact that the sawdust has been modified (Abdulsalam et al., 2017).

The FTIR spectrum of the sawdust (Figure 2) shows some absorption peaks that indicate the complexity of the material. The spectrum indicates that the adsorbent has potential adsorption sites as represented by functional groups OH (3240 cm^{-1}), C = S (1104 cm^{-1}), and C = C (1574 cm^{-1}).

The elemental analysis of the modified sawdust as shown in Figure 3 shows a high percentage of carbon 66.77 % which makes the modified sawdust a very good adsorbent. The presence of sulphur in the acid-treated sawdust as suggested by the appearance of C = S bond in the FTIR spectrum was also confirmed by the results of the elemental analysis. This evidence further confirms the successful chemical modification of sawdust.

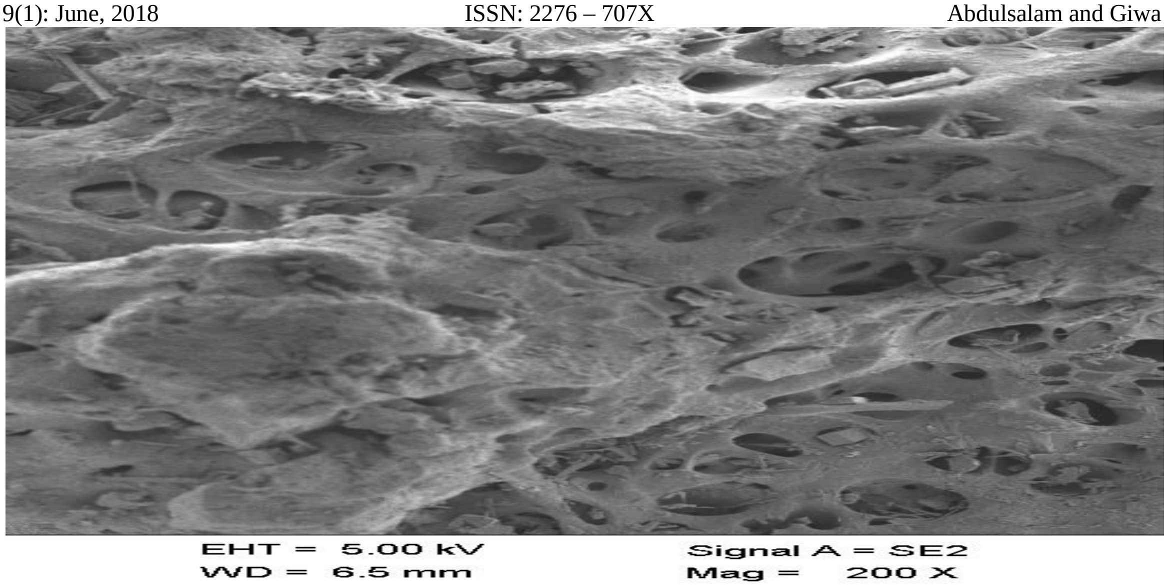

Figure 1: Scanning Electron Microscopy (SEM) image of the acid modified sawdust

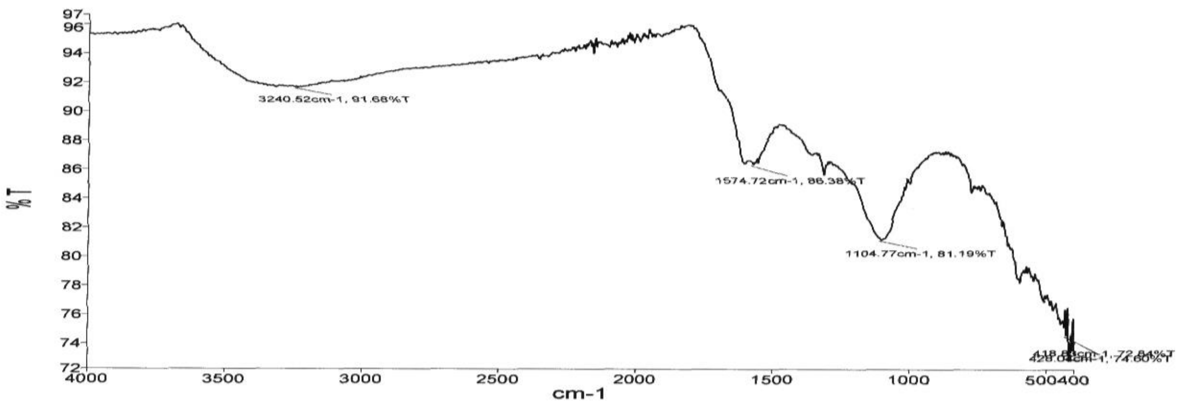

Figure 2: Fourier Transform Infrared (FTIR) Spectroscopy Micrograph of the acid modified sawdust

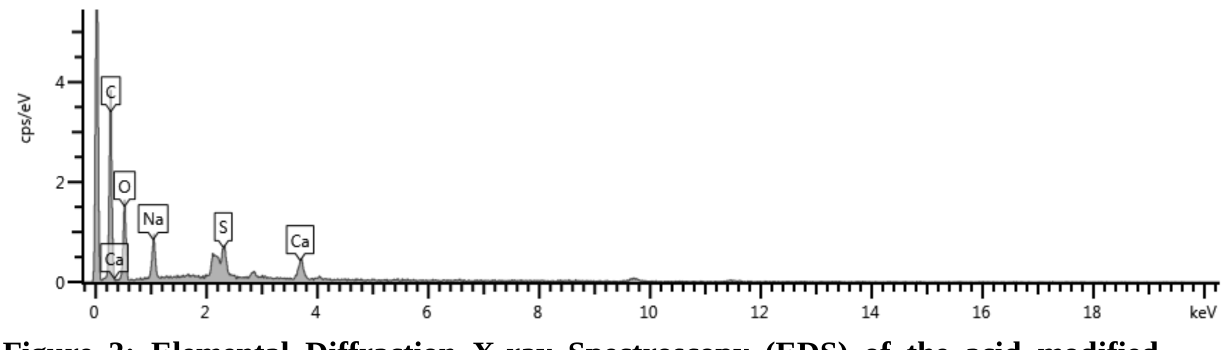

Figure 3: Elemental Diffraction X-ray Spectroscopy (EDS) of the acid modified sawdust

Effects of adsorbent dose

The effect of the amount of CMS used on color removal from the wastewater was investigated by varying the dose in the range 0.1 – 1.0 g in 50 mL of the wastewater while keeping other parameters (contact time and temperature) constant. Figure 4 shows the dependence of the percentage color removal on the amount of CMS. It was observed that the color removal efficiency increased with an increase in adsorbent mass For instance, the percentage color removal increased from 30.99 to 36.39 % with an increase in CMS dosage from 0.1 g to 0.2 g. This trend may be attributed to the availability of more adsorption sites with increasing adsorbent dose which make penetration of the dye molecules onto the adsorption sites easier (Giwa et al., 2013).

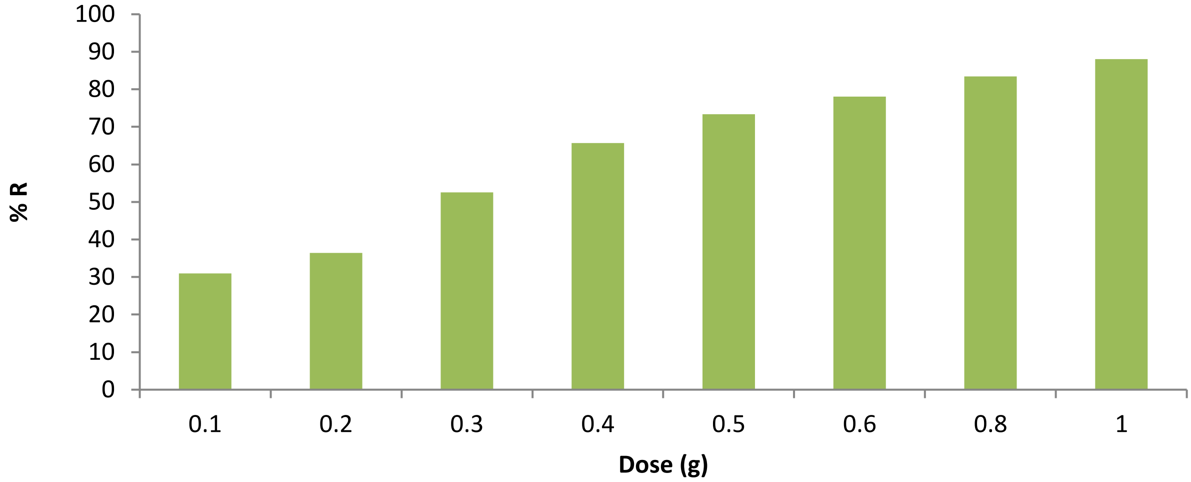

Figure 4: Effects of Adsorbent Dose on Percentage color Removal

Effects of contact time

The effect of contact time on the color removal from the wastewater by CMS was investigated by varying the contact time between 5 - 25 h while keeping adsorbent dosage and temperature constant. Figure 5 shows the dependence of the percentage color removal on the contact time. The percentage color removal increased from 15.19 to 83.58 % with an increase in contact time from 5 to 22^{nd} h.

Generally, the rate of percentage color removal increases with an increase in contact time till 22^{nd} hr. Further increase in contact time does not give a significant increase in the adsorbate uptake after equilibrium is attained, this may be due to deposition of dyes on the available adsorption site on adsorbent material (Ansari et al., 2010).

Effects of temperature

The percentage removal increases infinitesimally with increasing temperature as depicted in Figure 6. The increase with temperature may be due to increasing the mobility of the dye molecules and an increase in the pore volume of the adsorbent with increase in temperature (Giwa et al., 2015).

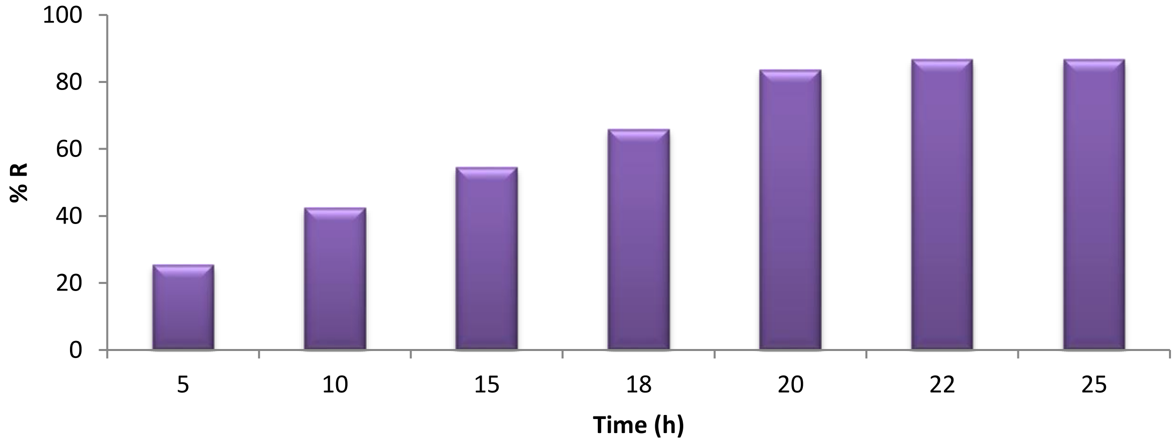

Figure 5: Effects of Contact time on Percentage Color Removal

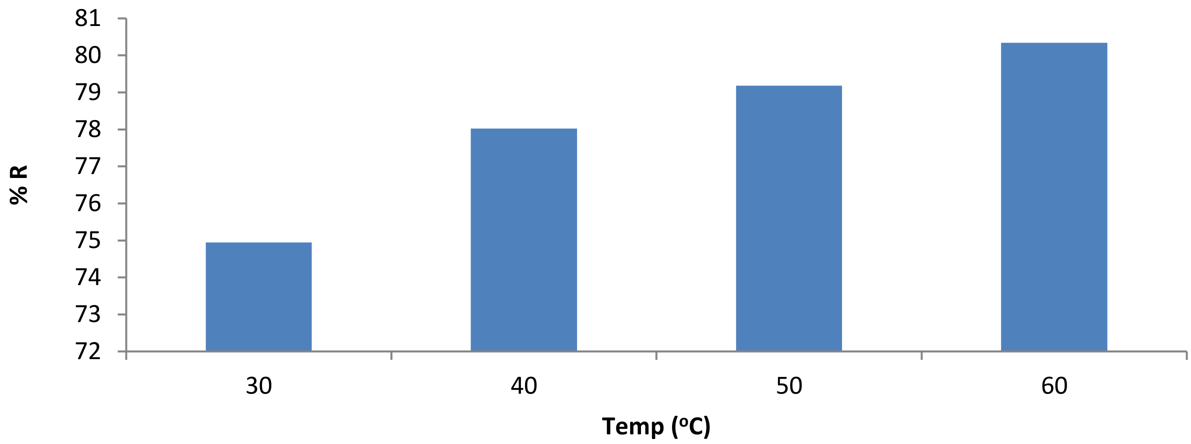

Figure 6: Effects of Temperature on Percentage Color Removal

CONCLUSION

The adsorbent prepared by treating the sawdust of *Parkia biglobosa* with concentrated sulphuric acid in this study was able to remove dye mixture from wastewater from a university 'Tie and dye' textile facility. The percentage of color removed from the wastewater increased with adsorbent dose, contact time and temperature

ACKNOWLEDGEMENT

I acknowledge the students of the department of Fine and Applied Arts, Ladoke Akintola University of Technology (LAUTECH) for allowing the use of this wastewater. So also, are members of staff and all technologists of the Department of Chemistry and the University Central Research Laboratory of LAUTECH. I also acknowledge the support of Prof. I. A. Bello and Dr. Wewers Francois on this research.

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