Ceiba Pentradenta wood waste activated carbon for waste water treatment

K. Geetha *, N. Velmani , S. Karthikeyan and P. S. Syed Shabudeen

Department of Chemistry, Kalaignar Karunanidhi Institute of Technology, Tamil Nadu, India

Adsorption is considered to be one of the most promising techniques for waste water treatment over the last decades. The low materials originated from various sources such as agricultural sources and by-products, agricultural residues and wastes, low-cost sources from which most complex adsorbents will be produced. The farming waste material has to be disposed either safely or must be reused for some valuable purpose. In this consent Ceiba Pentradenta Wood waste, an agricultural waste material which is being converted as Activated carbon in presence of Nitrogen atmosphere at 700°C is used as an adsorbent for dye removal. The portrayal studies such as bulk density, moisture content, ash content, fixed carbon content, soluble matter (water, acid), matter soluble in acid, pH, decolourising power, ion exchange capacity, percentage content and surface area have been carried out to assess the suitability of these carbons as absorbents in treatment of the water and wastewater. The present study reveals the recovery of valuable adsorbents from readily and cheaply available agriculture wastes.

Keywords: Agricultural waste, Ceiba Pentradenta barks waste, Chemical Characteristic.

1. INTRODUCTION:

In the early decades the dye industries used only natural dyes; but the later centuries the dominant development of industries made use of commercial dyes because of their increased demand of availability and inexpensive nature. Logwood is the only natural dye available in the market for the present use. The usage of synthetic dyes has been vast and the effluent water is let out without purification. Due to the toxic nature and adverse effect of synthetic dyes on all forms of life has been affected. One of the methods used for the effluent water treatment is by using Activated Carbon produced from sugar refining [1] was of first array Black ash was also an effective decolorizing liquids [2]. Agricultural by products and waste materials used for the production of activated carbons include olive stones [3], almond shells [4], apricot and peach stones [5], maize cob [6], linseed straw, saw dust [7], rice hulls [8], cashew nut hull, cashew nut sheath [9], coconut shells and husks [10], eucalyptus bark [11], linseed cake, tea waste ash [12]. Besides these, other sources of activated carbon are sulfonated coal [13], tyre coal dust [14], activated bauxite, cement kiln dust [15], Shale oil ash [16] and sunflower stalk [17] etc.
All these activated carbons have been successfully used for the adsorption processes. Therefore, carbons with excellent surface properties and specific functionalities should be developed to create a high affinity for adsorbate adsorption. It has been shown that total accessible surface area and pore volume for adsorption is inversely proportional to macromolecular size [18]. Ceiba Pentradenta wood waste was subjected to the following five different treatments CaCl$_2$, Na$_2$CO$_3$, H$_2$SO$_4$, H$_3$PO$_4$ and Na$_2$SO$_4$. These methods were adopted to produce wide range of activated carbon with different surface chemistry and porosity.

2. MATERIAL AND METHOD:

Ceiba Pentradenta wood waste was used as precursor for the preparation of activated carbon. The wood was cut into small pieces of 2 to 3 cm in size, dried in the sunlight for 10 to 20 days to remove moisture from the material. Then the dried material was used for preparation of activated carbons using physical and chemical activation methods.

2.1. CARBONIZATION PROCEDURES:

2.1.1 Carbonization with calcium chloride: Ceiba Pentradenta wood waste which was dried well was impregnated with the solution of 10 % calcium chloride for 24 h. At the end of 24 hours the excess chloride solution were decanted off and air-dried. The dried material was placed in the muffle furnace at 400 °C for 2 hours. The dried material was powdered well and placed in the tubular furnace in the presence of nitrogen atmosphere at a temperature of 600 °C for 1 hour. After activation, the carbon material obtained was washed with 4 N HCl to remove the cations in the material. The activated materials were washed with plenty of water to remove excess acid [19].

2.1.2 Carbonization with carbonate salts: Ceiba Pentradenta wood waste to be carbonized was soaked with 10 % sodium carbonate solution for a period of 24 hours. After impregnation, the liquid portion was decanted off and the material dried. The dried mass was subjected to carbonization process at 400 °C for 2 hours, powdered well and finally activated in presence of Nitrogen atmosphere at a temperature of 600 °C for 1 hour and further at a temperature of 800 °C for a period of 10 minutes [19].

2.1.3 Carbonization using Acid process: The dried material was treated with excess of sulphuric acid (1:1 ratio), charring occurred immediately, accompanied by evolution of heat and fumes. When the reaction subsided, the mixture was left in an air oven maintained at 140 - 160 °C for a period of 24 hours. At the end of this period, the product was washed with large volume of water to remove free acid, dried at 110 °C and finally activated at 800 °C [19].

2.1.4 Carbonization using Phosphoric acid: The material to be carbonized was soaked with phosphoric acid in the ratio of 1:1 at 80 °C for 48 hour. After 48 hour the material was crushed well using mortar and this crushed material was kept aside for 12 hour. Then the material was washed well with hot water until a neutral pH. The material was dried at 110 °C for 24 hour. The dried mass was subjected to carbonization process at 800 °C for about 10 minutes. The material was followed by thermal activation at 400 °C for about 10 minutes in the presence of nitrogen atmosphere. The final product was grounded well and used for analysis [20].

2.1.5 Carbonization with sulphate salts: Incorporation of sulphate salt on the source material is considered to enhance the carbonization process possibly due to the oxidation of carbon by the sulphate and the erosive action of the resulting sulphide on the carbon. To effect the process, the material to be carbonized was left soaked in 10 % solutions of sodium or ammonium sulphate for a period of 24 hours. After impregnation, the liquid portion was decanted off and then dried. The dried mass was subjected to
carbonized process at 400 °C powdered well and finally thermally activated at 800 °C for a period of 10 minutes. The material before use was washed well with water and dried [19].

3. CHARACTERIZATION OF ACTIVATED CARBON:

3.1 pH and Conductivity: 10 g of activated Carbon was suspended in 200 ml of distilled water and was equilibrated by agitating at 200 r.p.m. for 1 hour. The supernatant solution was analyzed for pH and conductivity using Elico pH meter (model L1-120) and conductivity meter (Model M-180), respectively [22].

3.2 Moisture: 5 g of activated carbon was placed in a petriplate and heated in an oven at 110 °C for 1 hour. After heating, the plate was cooled in a dessicator and then weighed. Heating, cooling and weighing was repeated at 30 minutes intervals until the difference between the consecutive weighing was less than 5 mg. The loss in weight gives the moisture content [22]:

\[
\text{Moisture content (%) by mass} = \frac{(M - X)}{M} \times 100
\]

Where,
\[M = \text{Mass of the material taken for test (g)}\]
\[X = \text{Mass of the material after drying (g)}\]

3.3 Ash Content: About 1 gm of activated carbon was weighed accurately in a tarred porcelain crucible and placed in a hot air oven 110 °C for 5 hours. The crucible was removed from the oven and the contents were ignited in an electric muffle furnace at a temperature of 800 °C for about 2 hours. The process of heating and cooling was repeated until the difference between two consecutive weighing was less than 5 mg [22].

\[
\text{Ash (on dry basis) % by mass} = \frac{M_1}{(M_2 - X)} \times 100
\]

where,
\[M_1 = \text{Mass of the ash (g)}\]
\[M_2 = \text{Mass of the material taken for test (g)}\]
\[X = \text{Percentage moisture content present in the material taken for test}\]

3.4 Bulk Density: 50 ml graduated pycnometer was weighed. For the determination of apparent density, a trip balance was used to fill the carbon in the cylinder. Sufficient amount of activated carbon was poured with constant tapping and filled to the 50 ml mark. The shaker attached to the balance should be adjusted so that the carbon filled the pycnometer at approximately 1 ml/sec. After filling the graduated cylinder with the carbon, it was weighed accurately. The apparent density was calculated by dividing the weight of the carbon by 50 [22].

3.5 Specific Gravity: 5 g of oven dried carbon sample was placed in a small porcelain dish with about 50 ml of distilled water and the contents were heated to boil gently for 3 minutes to expel the air. After cooling in a water bath to10 °C the carbon suspension was transferred to a 100 ml pycnometer with the help of small funnel, a wire and a wash bottle. The pycnometer was filled with water and stopper was used to prevent the air bubble inside the container. The pycnometer was dried with a piece of cloth and weighed [23].
Specific gravity \((S)\) is given by:

\[
\text{Specific gravity } (S) = \frac{\text{Weight to adsorbent } (W_a)}{\text{Volume of water displaced } (V)} \quad \text{--- (3)}
\]

where

\[
V = \frac{W_b - W_c}{\text{Density of water } (1)} \quad \text{--- (4)}
\]

\(W_b = \) Weight of Pyconometer with water (g)

\(W_c = \) Weight of Pyconometer with adsorbent suspension

3.6 Porosity: Porosity was determined from the specific gravity \((s)\) and bulk density \((D)\) values of carbon by applying the following formula [22].

\[
\text{Porosity } (\%) = \frac{(s - D) \times 100}{s} \quad \text{--- (5)}
\]

3.7 Matter soluble in water: 5 g of the material of known moisture content was weighted accurately and transferred to a 1 litre beaker. About 300 ml of distilled water was added and heated to boiling with continuous stirring. Stirring was continued for 5 minutes after the flame was removed. The material was then allowed to settle. The supernatant was filtered through a gouch crucible fitted with an asesto mat. The procedure was repeated thrice with the residue in the beaker using 300 ml of water each time. The combined filtrate was concentrated to less than 100 ml over a water bath, cooled and made up to 100 ml mark in a volumetric flask. Exactly 50 ml of the concentrate was transferred to a china dish and evaporated to almost dryness on a boiling water bath and finally dried in an electric oven, maintained at 100°C 50°C cooled in a dessicator and weighed. The procedure of drying and weighing was repeated at 30 minutes interval, until the difference between the consecutive weighing was less than 5 mg [23].

\[
\text{Porosity } (\%) = \frac{(s - D) \times 100}{s} \quad \text{--- (5)}
\]

\(M_1 = \) Mass of the residue (g)

\(M_2 = \) Mass of the material taken for test (g)

\(X = \) Percentage of moisture present in the material

3.8 Matter soluble in Acid: 5 mg of the carbon materials of known moisture content was weighted accurately and transferred into a litre beaker. About 300 ml of 0.25 N HCl was added and heated to boiling with continues stirring. Stirring was continued for 5 minute after the flame was removed. The supernatant was filtered through a gouch crucible fitted with an asbestos mat. The procedure was repeated thrice with the residue in the beaker using 300 ml of water. Exactly 50 ml of the concentrate was transferred to a china dish and evaporated to almost dryness on a boiling water bath and finally dried in an electric oven, maintained at 100 ± 5°C, cooled in a dessicator and weighed. The procedure of drying and weighing was repeated at 30 minutes intervals, until the difference between the consecutive weighing was less than 5 mg [22].

\[
\text{Acid soluble in matter } (\%) = \frac{A}{(M-x)} \times 100 \quad \text{--- (7)}
\]
where A = Mass of the dried residue (g); M = Mass of the material taken for test (g); and X = Percentage of moisture present in the material

3.9 pH\text{zpc}: "Point of zero charge" for a given surface is the pH at which that surface has a net neutral charge. The point of zero charge, or PZC, can be said to be the first step in preparation of bulk solution of dye. It is a very important parameter used to determine the pH range at which the impregnation step should be carried out. The point of zero charge is defined as being the pH at which the surface charge of the carbon is neutral.

The PZC experiment was carried out by contacting the different carbons with, pH adjusted, deionized water. An eleven point PZC measurement is the most common experiment used to obtain the PZC. The eleven pH points used are 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13. The carbon was weighted out for each pH sample. The weight of the carbon depends on the surface area, surface loading, and volume of sample bottle. A sample calculation was given by equation (8). Finally, the carbon was added to each sample bottle, which contains the deionized water at different pHs, and shaken for an hour. The pH was measured and recorded as final pH.

\[ \Delta \text{pH} = \text{Final pH} - \text{Initial pH} \]

3.10 Decolorizing power: 0.1 gm of adsorbent was taken in a conical flask and titrated with 0.15 % of Methylene Blue from the burette. First 1 ml of it was added and shaken for 10 minutes and see the persistence of the blue colour. Then continue till the blue colour exists in the adsorbent [24].

3.11 Ion Exchange Capacity: About 1 g of carbon was taken in a beaker and sufficient amount of distilled water was added to cover the carbon. The slurry was carefully transferred to a burette packed with glass wool at the bottom to about 1 cm. The column was never allowed to drain completely and the level of the liquid was maintained at about 1 cm above the carbon bed [24].

250 ml of a solution of 0.25 M sodium Sulphate was allowed to pass through the column at a rate of 2 ml/min and the effluent was collected in a 500 ml conical flask. When all the solution had passed through the column, the effluent was titrated with 0.1 NaOH.

4. RESULTS AND DISCUSSION:

The analysis of characterization of each type of chemically activated method are explained in detail and the suitable activated carbon out of the five chemically activated method used for the further study.

4.1 Bulk Density: The evolution characteristics of five types of activated carbon derived from Ceiba Pentradenta wood waste indicates that the carbon obtained by ACP2 has higher bulk density than the carbon prepared by other process. It was observed that carbon prepared by ACP5 has a low bulk density. As reported, the observed decrease in the bulk density may be due to increase in the pore size upon sodium sulphate impregnation [26].

4.2 Moisture Content: From Table (2), the moisture content was found to be higher in case of carbons obtained by ACP5 and ACP2 process. Even though moisture content of the carbon has no effect on its adsorptive power, it dilutes the carbon which necessitates the use of additional weight of carbon during treatment process. Among the carbons prepared by various methods, the carbon obtained by ACP1 process was found to contain less moisture compared to the carbon obtained by other process.
Table (1): List of various activation process and abbreviation of carbon

<table>
<thead>
<tr>
<th>No</th>
<th>Sample</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ACP1</td>
<td>Chloride Process using –CaCl₂</td>
</tr>
<tr>
<td>2</td>
<td>ACP2</td>
<td>Carbonate Process using – Na₂CO₃</td>
</tr>
<tr>
<td>3</td>
<td>ACP3</td>
<td>Acid process using Sulphuric Acid</td>
</tr>
<tr>
<td>4</td>
<td>ACP4</td>
<td>Acid process using Phosphoric Acid</td>
</tr>
<tr>
<td>5</td>
<td>ACP5</td>
<td>Sulphate Process using Sodium Sulphate</td>
</tr>
</tbody>
</table>

Table (2): Characterization analysis data of various activated Ceiba Pentradenta bark waste

<table>
<thead>
<tr>
<th>No</th>
<th>PROPERTY</th>
<th>ACP1</th>
<th>ACP2</th>
<th>ACP3</th>
<th>ACP4</th>
<th>ACP5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>7.6</td>
<td>9.8</td>
<td>4.8</td>
<td>6</td>
<td>9.1</td>
</tr>
<tr>
<td>2</td>
<td>Moisture Content (%)</td>
<td>4.4</td>
<td>6.8</td>
<td>5</td>
<td>6</td>
<td>9.6</td>
</tr>
<tr>
<td>3</td>
<td>Ash Content (%)</td>
<td>12</td>
<td>14</td>
<td>10.5</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Conductivity ms/cm</td>
<td>0.88</td>
<td>1.05</td>
<td>0.33</td>
<td>0.27</td>
<td>0.70</td>
</tr>
<tr>
<td>5</td>
<td>Specific Gravity (S)</td>
<td>1.29</td>
<td>1.33</td>
<td>1.25</td>
<td>1.39</td>
<td>1.49</td>
</tr>
<tr>
<td>6</td>
<td>Bulk Density (D)</td>
<td>0.3248</td>
<td>0.3951</td>
<td>0.333</td>
<td>0.3633</td>
<td>0.3063</td>
</tr>
<tr>
<td>7</td>
<td>Porosity (%)</td>
<td>74.8</td>
<td>70.29</td>
<td>73.36</td>
<td>79.4</td>
<td>73.86</td>
</tr>
<tr>
<td>8</td>
<td>Matter soluble in Water (%)</td>
<td>1.04</td>
<td>1.31</td>
<td>1.35</td>
<td>1.45</td>
<td>1.65</td>
</tr>
<tr>
<td>9</td>
<td>Matter soluble in acid (%)</td>
<td>2.21</td>
<td>2.17</td>
<td>1.87</td>
<td>2.81</td>
<td>3.14</td>
</tr>
<tr>
<td>10</td>
<td>Carbon (%)</td>
<td>68.09</td>
<td>71.60</td>
<td>51.72</td>
<td>72.95</td>
<td>67.10</td>
</tr>
<tr>
<td>11</td>
<td>Hydrogen (%)</td>
<td>0.69</td>
<td>0.67</td>
<td>0.54</td>
<td>0.41</td>
<td>0.32</td>
</tr>
<tr>
<td>12</td>
<td>Nitrogen (%)</td>
<td>0.04</td>
<td>ND</td>
<td>ND</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>13</td>
<td>Sulphur (%)</td>
<td>ND</td>
<td>ND</td>
<td>3.72</td>
<td>ND</td>
<td>3.02</td>
</tr>
<tr>
<td>14</td>
<td>Oxygen (%)</td>
<td>30.97</td>
<td>27.73</td>
<td>44.02</td>
<td>26.53</td>
<td>29.46</td>
</tr>
<tr>
<td>15</td>
<td>Ion exchange capacity mg/l</td>
<td>0.04</td>
<td>-----</td>
<td>0.36</td>
<td>0.52</td>
<td>0.06</td>
</tr>
<tr>
<td>16</td>
<td>Decolorizing Power mg/l</td>
<td>41</td>
<td>38</td>
<td>30</td>
<td>39</td>
<td>45</td>
</tr>
<tr>
<td>17</td>
<td>BET Surface Area (m²/g)</td>
<td>109.81</td>
<td>229.71</td>
<td>233.71</td>
<td>377.65</td>
<td>111.76</td>
</tr>
</tbody>
</table>

4.3 Ash Content: Ash content of an activated carbon gives an indication about the amount of inorganic constituents present in a carbon. ACP2 and ACP5 have more ash content, which may be incorporated by the activating agents. Carbon prepared by Phosphoric acid method (ACP4) shows least ash content, which supports the above said assumption. High ash content ultimately reduces the fixed carbon percentage.

4.4 Matter soluble in Acid and water: Solubility studies of carbon in acid and water were performed to evaluate the amount of impurities present in the carbon prepared by different carbonization process. The solubility studies were preformed since the presence of impurities in the carbon may affect the expected quality of the treated water during treatment. From Table 1, the data pertaining to the matter soluble in water and in acid indicates that, except carbon obtained by ACP3 process, the carbon prepared by all other processes exhibits moderate level of impurities. The high value of water soluble matter is prepared by ACP5 process which indicates that a large amount of sulphate salts would have been incorporated into the carbon structure. The acid leachable matter was also found to be higher in the carbon prepared by the process.

4.5 Conductivity: The carbon derived from phosphoric acid process was acidic in nature with moderate conductivity compared with the carbon prepared by other carbonization process. As reported by Srinivasan etal \(^8\), this may be due to the incorporation of acid in the carbon structure. Due to the
presence of both +ve and -ve ions in the porous areas results in an increased conductivity. Sulphate impregnated carbon is also found with moderate conductivity. This may be due to the development of exchangeable sites on the surface of the activated carbon.

4.6 Ion Exchange Capacity: The ion content was considerably lower in all the varieties of carbon prepared by different methods. This implies that the carbon prepared by different carbonization process can be utilized in the treatment of effluent water without the problem of iron leaching into the treated water. The level of sodium and potassium was found to be moderate and slightly high in the carbons prepared by ACP4 process. This can be taken as an advantage for ion exchange process, the surface area of carbons prepared in all other methods were found to be in the following order.

ACP4 > ACP3 > ACP5 > ACP1 > ACP2

4.7 Porosity: The precursor was prepared with 5 different techniques. Ceiba Pentradenta bark waste prepared by ACP4 if found to be highly porous compared to that of other methods. ACP1 was found to have less porosity compared to those remaining techniques. ACP2 was found to have least porosity.

ACP4 > ACP5 > ACP1 > ACP3 > ACP2

4.8 Carbon, Hydrogen, Nitrogen, Oxygen and Sulphur: Carbon content was found to be high in ACP4 treatment when correlated with other precursor method. The Hydrogen and Nitrogen content percentage prepared by this method was also comparatively to have less value and their Oxygen content was compared lesser than that prepared by other methods. The percentage value for other precursor methods was comparative less prepared by ACP4 method. The high carbon content in ACP4 method shows that they are more preferable for effluent treatment.

4.9 Decolorizing Power: The carbon with high decolorizing power shows greater tendency for the removal of organic than inorganic. The trends shown by the above carbon are in the following order,

ACP5 > ACP1 > ACP4 > ACP2 > ACP3

4.10 pH \textit{ZPC}: From the above 5 activated carbon process, the point of zero charge of phosphoric acid activated carbon has alone be calculated. Carbon activated using ACP4 was found to be better. The Point of zero charge for ACP4 has alone be calculated and a graph has been plotted between ΔpH and Final pH. The value of ΔpH decreases gradually from 3.3 to -3.7 and the final pH value vary from 5.3 to 6.3, but a final pH value of 5.8 is observed between the pH of 4 to 9. The graphical representation for ZPC is given below for ACP4 method.
4.11 BET Surface Area: The order of surface area of carbons prepared with different process given as follows.

\[
\text{ACP4} > \text{ACP3} > \text{ACP5} > \text{ACP2} > \text{ACP1}
\]

Carbon prepared using \( \text{H}_3\text{PO}_4 \) impregnation process has high surface area. This might have been attributed to active phosphate sites in the porous area of carbon. Except Calcium chloride and Sodium sulphate all other carbons were found marginally higher.

4.12 SEM Image for ACX4 treated material: The SEM image of activated carbon prepared by ACX4 method was found to have high porosity and their images are shown in Figure (1). Examination of the SEM micrographs (Figure 1) of the clean activated carbon particles showed smooth areas with large number of holes and rough areas with micropores and more number of minute openings. An electron microscope study reveals highly porous and branched particles particularly in ACP4. Small cavities, pores and more rough surfaces on the carbon sample indicate the presence interconnected porous network. Spherical pores and void will increase the surface area of the adsorbent by many folds. ACP4 with 5000x magnification clearly shows the morphology of highly porous activated carbon sample. Most of the particles are having very fine pores of 5\( \mu \)m size in the cavity walls. SEM of other activated carbon is shown in Figure (2 - 6).

![Figure (1) SEM image of ACP4](image1)

![Figure (2) SEM image of ACP4](image2)

4.12.1 SEM images of other activated carbon:

![Figure (3) SEM image of ACP1](image3)

![Figure (4) SEM image of ACP2](image4)
4.13 Dye adsorption Characteristics: Acid, reactive and direct dyes have anionic character, where as basic dyes are cationic in nature. In this study Acid Red RS, Malachite Green, Direct Green-6 and Reactive Blue-4 are selected for the analysis of adsorption characteristics of the activated carbon prepared by Phosphoric acid methods. Figure (7) shows the structure of selected dyes activated carbon prepared from Ceiba Pentradenta wood waste.

A close relationship between surface area and surface groups of the modified activated carbons and the percentage of dye removal by adsorption can be observed. For the 5 types of activated carbons prepared from Ceiba Pentradenta wood waste carbon, a similar behavior was observed for anionic dyes (i.e. acid, direct and reactive dyes) following an increase in the adsorption capacity with increase in the surface area. Different performances are obtained for the materials tested; varying from 10 % to 98 % of anionic dye removal for the Ceiba Pentradenta sample ACP4 is the most efficient material for the adsorption of all the anionic dyes tested (refer structure).

This difference in the uptake of anionic dyes cannot be explained on the basis of surface area alone, as ACP4 which has larger surface area adsorbs larger amount anionic dyes. As the carbons prepared using different preparation procedures, these carbons are expected to have different chemical structures and textural properties on their surface.

Table (3): Selected dyes and their characteristics taken from colour index, Structure, $\lambda_{\text{max}}$ and formula waste.

<table>
<thead>
<tr>
<th>No</th>
<th>Class</th>
<th>Commercial Name</th>
<th>C.I. No</th>
<th>Structure/Class</th>
<th>$\lambda_{\text{max}}$ (nm)</th>
<th>Formula Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acidic</td>
<td>Acid Red RS</td>
<td>23635</td>
<td>Anionic Dye</td>
<td>520</td>
<td>830.82</td>
</tr>
<tr>
<td>2.</td>
<td>Basic</td>
<td>Malachite Green</td>
<td>42000</td>
<td>Cationic Dye</td>
<td>680</td>
<td>463.50</td>
</tr>
<tr>
<td>3.</td>
<td>Direct</td>
<td>Direct Green-6</td>
<td>30295</td>
<td>Anionic Dye</td>
<td>520</td>
<td>812.70</td>
</tr>
<tr>
<td>4.</td>
<td>Reactive</td>
<td>Reactive Blue-4</td>
<td>61205</td>
<td>Anionic Dye</td>
<td>620</td>
<td>681.39</td>
</tr>
</tbody>
</table>
Acid Red RS (Acid Red 114)

Malachite Green

Direct Green-6

Reactive Blue-4

Figure (7): Selected dyes for analysis

All the anionic dyes show comparatively lesser adsorption than Malachite Green. Amount of Reactive Blue 4 adsorption is slightly higher than Acid Red RS and Direct Green 6. This may be due to its smaller molecular size. Acid Red RS and Direct Green 6 are high molecular weight dyes; hence, they occupy more area in the activated carbon. This leads to the lower amount of adsorption on the carbon surface. While analyzing the pH of phosphoric acid variety of carbon (nearly neutral), role of surface groups on the adsorbent adsorption anionic dyes are also not a prominent factor.

This indicates that as shown by several earlier workers [27] the surface chemical structure of the carbon also influences the dye adsorption. Basic dyes have a cationic character and different behavior was expected for their adsorption on modified activated carbons prepared from Ceiba Pentradenta wood waste in comparison to that of the anionic dyes. The major difference observed for basic dyes in comparison to anionic dyes is the good performance observed the acid treated samples ACP3 and ACP4. This was expected since the large amount of surface acid groups presented in the sample (mainly carboxylic, anhydride, lactones and phenols etc.) are good anchoring sites for basic dyes as a result of electronic interactions. The existence of this type of adsorption mechanism has been reported by Perira.R et al. [28], who observed the existence of this type of adsorption mechanism in the adsorption of basic dyes on the activated carbons.

5. Conclusion: From the results of the present investigation, it can be concluded that:

- Ceiba Pentandra Bark waste can be used as the adsorbent for the dye removal which is found to be more economical and it is a soft waste wood.
- The wide-ranging characterization studies of the different process activated carbon reveal that the carbons obtained from all the treated methods are assessed as superior grade carbons.
Surface chemical groups of activated carbon play a key role in dye adsorption along with surface area. Starting from same material and using appropriate chemical treatments to modify their surface chemistry without changing significantly their textural properties, a substantial variation in the dye removal capacity was observed.

Acid processes were the most efficient among the chemical treatments performed to modify the surface chemistry.

For anionic dyes (reactive, direct and acid) a close relationship between the surface area and surface chemical groups of the modified activated carbon and the percentage of dye removal by adsorption can be observed.

Cationic dyes large amount of acid groups present in the sample (mainly carboxylic anhydrides, lactones and phenols etc.) are good anchoring sites for the adsorption.

Hence, the activated carbons obtained from all the five methods can be used for the removal of wide variety of impurities from the waste water.

References:


