Removal of Colour from Textile Effluent using Charcoal Material Derived from Bamboo

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Abstract:

Industrialization and human being activities have severe impact on the environment during discarding of dye effluent into natural watercourses. Colour is one of the factor by which one can recognize whether the water is normal water or it is a textile effluent. The occurrence of colour in the environment can be destructive in nature for a variety of living species and ground water. Adsorption method is one of the most important technologies for the handling of polluted water from colour, but in quest for the low-cost adsorbent is the target of this study. Bamboo charcoal has a lot of positive qualities. The highly porous structure of the bamboo charcoal absorbs colour present in the textile effluent. Bamboo charcoal has adsorption and filtration properties. In this study, Bamboo charcoal is created by: (a) Pyrolysing bamboo using aluminium foil, (b) in muffle furnace at temperature of 600 ℃. The obtained charcoal from pyrolysing bamboo in muffle furnace is further purified by solvent- extraction. The resulted charcoal obtained by these two methods is then characterized by XRD and FTIR. In order to figure out the optimal adsorption condition and the intrinsic change of the bamboo charcoal, effluents containing Reactive and Indigo dyes are used. Bamboo charcoal which contained potassium, calcium and other minerals, could have adsorption and filtration of dyes, extractives, oil, and other substances.

Keywords: *Bamboo, Charcoal, Dye, Textile effluent.*

1. Introduction

Dyes are usually present in trace quantities in treated effluents of many industries [1]. There are many methods for treatment of the textile effluent. These methods include chemical methods, physical methods and biological treatments. The treatments of effluent by chemical methods include oxidative processes [2], ozonation [3] photochemical treatment [4] and by use of sodium hypochlorite [5]. Physical methods for effluent treatment include adsorption by biosorbents like sawdust [6], waste orange peel [7], banana pith [8], rice husk [9] and sugarcane bagasse [10]. The other physical methods include ion exchange [11], Irradiation [12], coagulation and flocculation [13]. The biological treatment includes decolonization by white-rot fungi [14]. Activated carbon prepared from many substances can be used as an adsorbent. The substances that can be used to prepare activated carbon are sawdust and rice husk [15], coir pith [16] and bamboo [17]. Bamboo charcoal is considered as cheap and eco-friendly adsorbent which can be used as an alternative substitution of existing activated carbon substances for removal of dyes from wastewater.

Bamboo charcoal is the carbonaceous residue of bamboo left after heating organic matter (bamboo) in the absence of oxygen. Bamboo charcoal comes from pieces of bamboo plants, harvested after at least five years, and burned in ovens at temperatures ranging from 500 to 1000ºC. This fine and tasteless black powder is an adsorbent for many toxins, gases and drugs without any specific action [18]. Bamboo charcoal has an extra-ordinarily large surface area and pore volume that gives it a unique adsorption capacity [19]. It benefits environmental protection by reducing pollutant residue. It is an environmentally functional material featuring excellent absorption properties [20] .Commercial food grade charcoal products range between 300 and 2000 m^2/ g [21] . Charcoal has much higher adsorptivity than wood charcoal because bamboo charcoal has very high specific surface area, about 150-400 m^2/ g, which is 2-3 times bigger than wood charcoal and can be used for a wide range of different purification and absorption applications, such as purifying drinking water, in air filters, gas masks, mattresses and pillow and for certain industrial purification uses [22].

1.1 Structure of Bamboo charcoal

Bamboo charcoal has micro porous structure and countless small cavities. Bamboo charcoal has about four times more cavities than wood charcoal because it has surface area of 300m^2/g, which is 10 times more than wood charcoal. Cell wall mainly consists of cellulose, hemicellulose and lignin [23]. Bamboo charcoal being an outcome of pyrolyzing bamboo is a sort of porous material with excellent adsorption and electromagnetic shielding (Figure 1). The surface area to weight ratio of bamboo charcoal is 600:1. This is because of the presence of C60 carbon molecule that is like a ball shape [24].

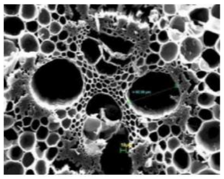

Figure 1: Micro-porous structure of Bamboo charcoal [23]

1.2 Adsorption capacity of Bamboo charcoal

Adsorption capacity of bamboo charcoal is an important characteristic because bamboo charcoal forms a lot of pores after pyrolysed under high temperature, which is similar to wood charcoal. It has adsorption capacity with big specific surface area (for example, its specific surface area reaches 385 m^2/g when it is carbonized at 700 ºC). Its physical and chemical properties are very stable. It is not soluble in water and other solvents. It demonstrates high stability in various working conditions except with strong oxidant in high temperature (for example, oxygen in high temperature, ozone, chlorine and salt of dichromate). So bamboo charcoal can be used both in a wide range of pH and in many solvents.

2. MATERIALS AND METHODS

2.1 Materials

2.1.1 Bamboo fiber bundles: Fibre bundles were extracted from Raw Bamboo [Botanical Garden of GNDU, Amritsar].

2.1.2 Dye used: Brilliant Red 3BN anionic dye

2.2 Method used

2.2.1 Extraction of Fiber bundles

Raw culm of Bambusa vulgaris is harvested from Botanical Garden of Guru Nanak Dev University, Amritsar. The nodes of the raw bamboo (3 years old) are firstly separated. Then the remaining part is sliced in the longitudinal direction to the thin blocks with 10-15 cm in the length and 2-4 cm in the thickness by the slicer followed by the removal of its upper layer. Finally they are kept for drying at room temperature for four days. Nodes of bamboo (3 years old) are separated. Residual part is cleaved into longitudinal direction to thin blocks with 10-15 cm in length and 2-4 cm in thickness by slicer.

2.2.2 Preparation of Bamboo charcoal

2.2.2.1 Preparation of Bamboo charcoal using aluminium foil and spirit lamp

Bamboo bundles are wrapped with aluminium foil several times to protect it from air intact. A tiny hole is made at one side of the bamboo bundles wrapped with aluminium foil so as to prevent it from bursting. A wire-mesh is placed on the top of the spirit lamp and then position the aluminium wrapped bamboo on top of it. A spirit lamp is lighted up to dry the bamboo inside the foil. White smoke came out from this tiny hole and further turn in yellow colour with passage of time. When the colour of aluminium foil turns yellow, it indicates the completion of process. This yellow colour is caused by the bamboo tar .Precaution parameter is that do not open the aluminium foil until it is cooled as heat can break the charcoal easily.

2.2.2.2 Preparation of bamboo charcoal from bamboo using Muffle furnace

The dried bamboo culms are introduced into muffle furnace (SR NO: 096; MODEL NO: MF- 1450; TEMP MAX. 1450 °C) at constant temperature 650 °C for two hours, 90 min, 60 min, 45 min and 30 min. After that, it is kept for cooling at room temperature. The black mass so obtained after bamboo pyrolysis is then purified by solvent extraction using petroleum ether (non-polar solvent) and acetone (polar solvent) in the ratio of 1:1 for three number of runs in order to obtain pure form of bamboo charcoal. The solvent extraction is a method for separating a substance from a solution or mixture by dissolving it in another, immiscible solvents in which it is more soluble. The solvents used here are acetone (polar solvent) and petroleum ether (non-polar solvent) because they do not mix with the bamboo charcoal, so that when left undisturbed, they will form two separate layers.

(a) (b) (c)

Figure 2: Process sequence of bamboo charcoal obtained by bamboo pyrolysis in muffle furnace: (a) Dried bamboo culms ; (b) Bamboo charcoal obtained after pyrolysis done in muffle furnace at 650 °C for 30 minutes ; (c) Bamboo charcoal obtained after pyrolysis done in muffle furnace at 650 °C for two hours.

2.3 Adsorption Studies

Adsorption of dye on bamboo charcoal was performed in a batch technique. Two grams of bamboo charcoal was taken in a 50 mL solution of polar brilliant red 3BN dye in 250 mL Erlenmeyer flasks and kept at shaking condition (120 rpm) for 30 min. After shaking it was filtered through Whatman filter paper No. 42. The filtrate obtained was centrifuged at 3000 rpm for 25 min. The intensity of supernatant obtained was measured at maximum absorbance wavelength. The percent of adsorbed dye was calculated from the following equation 1.

$$\% \text{ Adsorption} = [(A_0 - A) / A_0] \times 100 \qquad \text{(Eq. 1)}$$

Where, A_0 is the absorbance of control sample and A is the absorbance of sample after adsorption on bamboo charcoal.

3. Results

3.1 XRD analysis

Figure 3 shows the XRD patterns for bamboo fibres and bamboo charcoal .

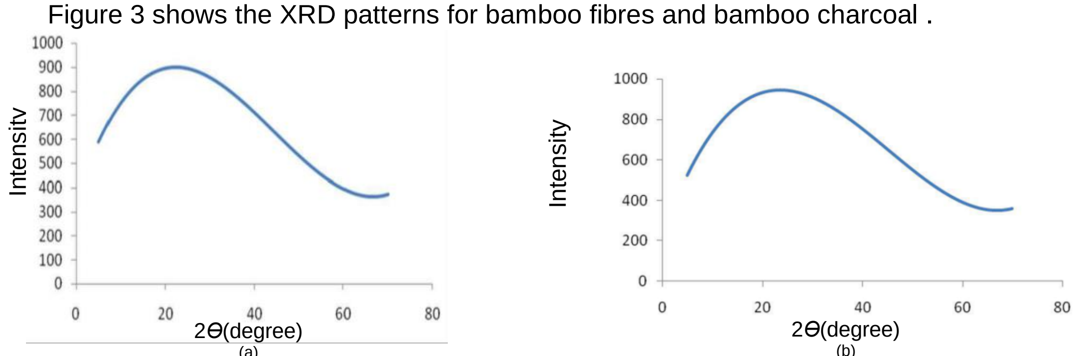

Figure 3: XRD pattern of (a) raw bamboo fibers and (b) bamboo charcoal

3.2 FTIR analysis

FTIR spectrum of bamboo: For bamboo the FTIR spectroscopy (Figure 4) provides information on the chemical structure of the material. Band assignments for the spectrum of bamboo indicate that bamboo contains a number of atomic groups and structures (OH, CH_2, C=O, C-O-C and so on)

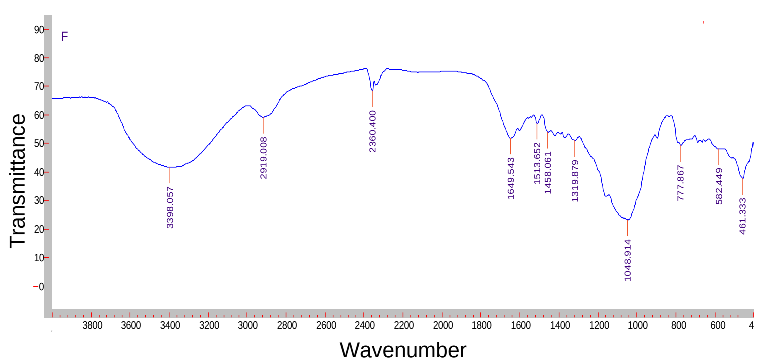

Figure 4. FTIR spectrum of bamboo charcoal, pyrolysed in muffle furnace at 600°C for 120 min.

3.3 Adsorptivity analysis

Based on the above test, the results of adsorption are obtained and listed in Table 1.

Table 1. Adsorption results of Bamboo.

S.No.	Concentration of dye in water (%)	Stir time (min)		
		20	60	80
1.	0.05	0%	50%	80%
2.	0.10	25%	40%	75%
3.	0.20	20%	38%	60%

Based on **Table 1,** when the concentration of dye in water is 0.05%, the adsorption of coloring components by bamboo does not occur for the stir time of 20 min but when the stir time approaches to 60 min, it shows 50 % adsorption. Excellent affect on adsorption rate occurs with increase in stir time of 80 min. This is because the adsorption gaps in the bamboo have been exhausted and equilibrium has been attained. For 0.10% concentration of dye, the adsorption increases with increase of the stir time but for 0.20% concentration of dye, and the adsorption is less in comparison of concentrations 0.05% and 0.10 % with increase in stir time. This is due to the attainment of saturation point by the pores available which causes decrease in adsorption with increase in stir time.

4. Conclusion:

Bamboo is known to be one of the most popular bioresources and its charcoal has an effective adsorbent properties. In this work, bamboo charcoal is used for removal of dye present in effluent and it is prepared using pyrolysing the bamboo pieces at 650 °C followed by purification by solvents. In this case, the dye's maximum adsorption is observed for the stir time of 80 min. Results showed that it can be successfully used for adsorption of dye from effluents. Finally, when these charcoal based samples were checked for their adsorption capability for dye present in the effluent, 80% adsorption was observed. Thus from the experimental observations it can be analysed that charcoal activated bamboo can act as adsorbents for removal of dye from industrial effluent.

5. References

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