Evaluation of Adsorption Properties of Activated Carbon Prepared from Azadirachta Indica Leaves

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ABSTRACT

The large variety of chemicals and reagents used in the textile industry's many processes makes textile effluents a major contributor to global pollution concerns. It is not ideal to discharge effluents containing dyes into fresh water bodies due to the hue. This study used nine distinct carbonization procedures to produce activated carbon from *Azdirachta indica* leaves. Researchused activated carbon derived from Neem leaves impregnated with H_3PO_4 to examine the impact of pH on the adsorption of four different types of dyes: Methyl Violet, Methyl Green,Methylene Blue and Acid Yellow. Activated carbon's adsorption capabilities are assessed, and the impact of pH on the adsorption of four distinct dye classes is examined. Also treated with the chosen activated carbon were effluent samples from textile dyeing. Researches have shown that activated carbon made from Azadiarchta indica (Neem leaves) is just as effective as commercially available activated carbon, but costs much less.

Keywords: Effluents, BOD, COD, Dye, Activated Carbon

INTRODUCTION

In order for all forms of life on Earth to continue existing, water is an essential resource. The demand for textile goods is on the rise, which means that the textile industries and the wastewater they produce are also on the rise. One of the primary causes of serious environmental issues on a global scale is, hence, the textile industry [1]. Approximately 70% of all dyes manufactured each year end up in the textile industry[2]. In addition, the textile industry uses a wide variety of chemicals and reagents in their manufacturing processes. Polymers, inorganic compounds, and organic compounds are among the reagents [3]. It is not ideal to discharge effluents containing dyes into fresh water bodies due to the hue. Because they include carcinogens like benzidene, naphthalene, and other aromatic chemicals, breakdown products are very harmful to living things and may cause cancer or mutations [4]. Additionally, textile wastewaters include high concentrations of toxicants, colorants, chlorinated compounds, surfactants, and recalcitrant organics. Azo dyes, VAT dyes, and mordents are some of the synthetic dyes that are used. The vast majority of synthetic dyes are known to be carcinogenic, mutagenic, and poisonous [5]. The mordents that are used for color fixing include very poisonous heavy metals such as Cr, Fe, Cu, and Cd. High pH, temperature, oils, detergents, dissolved solids, suspended particles, hazardous metals, dispersants, leveling agents, color, alkalinity, and non-biodegradable materials are all characteristics of textile effluents that are generated and discharged throughout various manufacturing phases [6]. Discharges from textile industries are known for their highly variable pH, color, COD, and salt levels [7].

Because of their complicated polyaromatic structure and resistant character, most synthetic dye stuffs are ineffective when treated with conventional bio treatments. Anaerobic reductive azo bond breakage also produces aromatic amine metabolites, which are more poisonous than the dye molecules in their whole. On the other hand, complete mineralization occurs in aerobic environments, which are ideal [8]. The concentration, type, and quality of organic molecules substantially impact the efficiency of any biological or physicochemical treatment method. Effluent characterisation is critical for determining the safety of effluent reuse owing to extremely substantial water consumption. Therefore, recycling has been suggested as a solution to the problem of excessive pollution levels in textile wastewaters [9-10].

EXPERIMENTAL

Azadirachta indica (Neem) leaves, which are otherwise useless, were used to create activated carbon. On the grounds of Sun Rise University in Alwar, we gathered neem leaves. We rinsed, dried, and chopped the leaves into 2-3 cm pieces. Particles ranging in size from 300 to 850 micrometers were obtained by sieving the carbonized material into 20-50 ATM mesh size. From the carbonized material, nine distinct carbonization procedures were used to produce activated carbon, as shown in table 1. The carbonized material's characteristics were investigated using the same established methodologies as adsorption experiments. Neem Activated Carbons (ACTs) 1 through 9 are the nine kinds that are made. Aside from being inexpensive, the activated carbon that was produced was also kind to the environment.

Table 1: The carbonization processes employed in the synthesis varieties of activated carbon from Azadirachta indica

Type of Activated Carbon	Method Used
ACT1	$ZnCl_2$ impregnation
ACT2	Acid process using H_2SO_4
ACT3	H_3PO_4 impregnation
ACT4	Na_2SO_4 impregnation
ACT5	Acid process using HCl
ACT6	Dolomite process
ACT7	Direct pyrolysis
ACT8	Acid process using H_2SO_4 & H_2O_2
ACT9	KOH impregnation

RESULTS AND DISCUSSIONS

Following established protocols, we conducted further analyses on all nine types of activated carbons for a wide range of physicochemical properties. Table 2 lists all of the physicochemical parameters that were considered. The pH of the activated carbons (ACT2, ACT3, ACT4, and ACT8) that were produced using acidic procedures was below [7]. The addition of acidic groups to activated carbon's surfaces is responsible for this. The rest of the activated carbons were all of a basic kind. Activated carbons sold in stores are typically of a simple type [12.]Activated carbons' conductivity is a result of the formation of exchangeable sites on their surface. Because activated carbons produce a greater number of exchangeable sites on their surfaces, ACT2 and ACT9 have moderate conductivities (1.52 µS/cm) and high conductivities (3.76 µS/cm), respectively. When compared to other activated carbons, those with a lower conductivity likely have fewer exchangeable sites on their surface. Carbons activated by pyrolysis have a moisture level of 12.50% while those activated by KOH have a moisture content of 11.02%, both of which are quite high. The adsorptive capacity of activated carbon is unaffected by moisture content; nevertheless, extra weight of activated carbon is needed during treatment owing to dilution. With the exception of commercial activated carbon, all of the other carbons were quite close in moisture content. Previous researchers have also found similar findings [14].

You can tell how much ash is in activated carbon by looking at how many inorganic components it contains. The presence of activating agents may explain the high ash content of ACT3, ACT5, and ACT7. The high ash concentration reduces the fixed carbon proportion. The strong charring tendency of H_2SO_4 and HCl leads to less ash production, which in turn increases the quantity of fixed carbon. The activated carbon (ACT3) that is made using the H_3PO_4 impregnation process has the greatest percentage of fixed carbon due to its low ash level. In order to determine the level of contaminants in activated carbon produced by various carbonization procedures, solubility investigations were conducted in acid and water. Research has shown that there is a very low concentration of acid- and water-soluble substances in all activated carbons. As a result, treated water quality may not be significantly impacted by the activated carbon preparation process, as there are less soluble contaminants. Greater adsorbate capacity per weight unit is achieved by adsorbents with higher bulk densities. There was very little variation in the bulk density of the activated carbons that were produced, suggesting that the activating agents have only a minor impact in this property. The largest surface area of 807.5 m^2/g in ACT3 produced by H_3PO_4 impregnation suggests that it is very porous in nature. Adsorption of molecules with

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low molecular weight is associated with the iodine number of activated carbon. Because iodine molecules are so tiny, their iodine number is a measure of their surface area or their ability to absorb microscopic adsorbates. Adsorbents' capacities to retain compounds with large molecular weights, such as dye molecules, are indicated by their phenol and methylene blue numbers; the iodine numbers for commercial carbons vary between 300 and 1,200 mg/g. As long as the methylene blue number (ACT3 and ACT5) is more than 200, the carbon is suitable for dye adsorption. If the wastewater has a high concentration of sodium or potassium, it will be easier to remove cations using the ion exchange procedure. Activated carbon was abundantly created using the dolomite procedure and subsequent impregnation with H_3PO_4. The adsorbent's surface charge, whether positive or negative, is indicated by the Point of Zero Charge (pHzpc). The surface becomes negatively charged and capable of adsorbing cations when the pH exceeds pHZpc. When the pH falls below pHZPC, however, anions are adsorbed onto the surface because the surface is positively charged. One of the nine types of activated carbons that were generated for further adsorption studies—ACT3—was chosen based on its physicochemical qualities; it was prepared by impregnating the carbon with H_3PO_4.

Adsorption studies of activated carbon prepared by H_3PO_4impregnation

Four classes of dyes— Acid Violet, Methyl Green, Methylene Blue and Acid Yellow—were utilized in batch adsorption experiments to investigate the adsorption properties of activated carbon prepared by water (H_3PO_4) impregnation. The current investigations assess the adsorption properties of activated carbon and examine the impact of pH on the adsorption of four distinct classes of dyes. The activated carbon that was chosen was also applied to effluent samples derived from textile dyeing plants. Activated carbon derived from Azadiarchta indica leaveshas been determined to be a more cost-effective and effective adsorbent than commercial activated carbon, according to the findings of the present study. As stock solutions, 1000 mg/L concentrations of each adsorbate were produced by dissolving the used pigments in 1000 mL of distilled water each. Compounds of the stock solution that are suitable

Effect of pH on the adsorption of dyes by activated carbon

Significant determinants of solution chemistry, including precipitation, hydrolysis, redox reactions, and complexation with organic or inorganic ligands, are pH levels. Dye availability and speciation for adsorption are both impacted by pH (18). Fig. 1 illustrates the impact of pH on the adsorption of the four dyes that were selected, while Table 3 provides the data for the adsorption of these dyes on ACT3 over the pH range of 2 to 12. The electrostatic interaction between the adsorbent surface and the adsorbate is what induces dye adsorption by activated carbon. The adsorption of cationic and anionic dyes is significantly influenced by pH scale. In the pH range of 2 to 12, the data indicate that cationic dye uptake increases while anionic dye uptake decreases. Adsorption characteristics of activated carbon derived from Euphorbia antiquorum wood yielded comparable outcomes [19].

Effect of pH on the adsorption of Acid Violet :

A decrease in AV uptake from 89.20 to 68.02 mg/g was observed as the pH increased from 2 to 12. Adsorption of the dye was greatest at a pH of 2. Repulsion between the surfaces of the adsorbent and adsorbate causes a decrease in the quantity of dye adsorbed when the pH of the solution exceeds 3.3. The dye is present in ionic form at and above a pH of 3.3. Prior studies have established that the molecular form of a solute molecule has a greater adsorption capacity than its ionic counterpart [20].

Effect of pH on the adsorption of Methyl Green (MG)

Following a phase transition from 2 to 12, the uptake of in solution increased from 47.51 to 96.63 mg/g before remaining constant. A cationic dye is MG An increase in pH resulted in a concomitant augmentation of the negatively charged sites on activated carbon [21]. As the pH increased, the attraction of electrostatic charge between the cationic dye molecules and the

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negative surface of carbon intensified until it became saturated at pH 9. Consistent outcomes were derived when silkworm pupa [22] was utilized to adsorb BR41.

Effect of pH on the adsorption of Methylene Green (MeG):

The uptake of MeG increased from 93.20 to 38.31 mg/g as the pH of the solution rose from 2 to 12. By virtue of the sulphonate groups that are present in them, reactive dyes exist in aqueous solution as ionized anions. At low pH, negatively charged MeG dyes and positively charged adsorbents are attracted electrostatically, resulting in a high absorption of the dye. Positively charged sites become fewer in number as the pH rises, while the quantity of negatively charged sites increases. The absence of anionic dye adsorption on adsorbent surfaces is attributed to electrostatic repulsion attributable to negatively charged sites [23].

Effect of pH on the adsorption of Acid Yellow (AY):

By elevating the pH from 2 to 12, the adsorption capacity of AY decreased from 55.03 to 12.82 mg/g. The surface of carbon acquires a positive charge as a result of the H+ ion being adsorbed due to its hydrophobic characteristics. Activated carbon is positively charged due to the elevated concentration of hydrogen ions at low pH. Enhanced adsorption occurs due to the electrostatic attraction between negatively charged AY dye and positively charged carbon. The repulsion between negatively charged activated carbon and anionic AY molecules is enhanced as the pH of the solution rises and the quantity of negatively charged sites on the carbon increases. The degree of adsorption was found to be greatest at a pH of 2, and the least at a pH of 9. Increased negativity sites on the surface of the activated carbon result from the excessive OH- ions present under alkaline conditions, which also inhibits the adsorption of AY molecules.

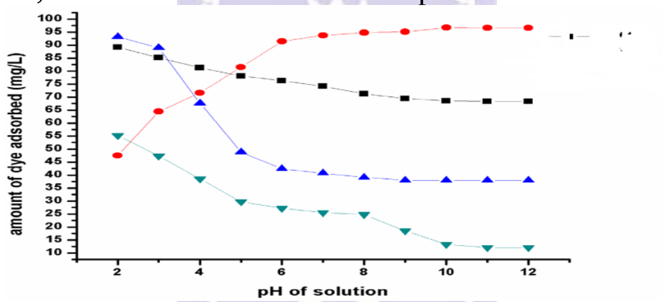

Fig 1: Effect of pH on the adsorption of the four selected dyes by ACT3
RED Curve: MeG, Black Curve: AV, Blue Curve: AY, Green Curve: MG

Adsorption studies of Dyed Effluents of Alwar

From the outflows of dyed effluent samples were obtained. ACT3 was utilized to remediate the effluent samples. Table 4 provides a comparison of the characteristics of treated and untreated effluents from the textile industry. Illustration 2 illustrates the treated effluents graphically. Every specimen of effluent was turbid and colored. A substantial reduction in the color of the effluent samples was observed following treatment with Neem activated carbon (ACT3), which was prepared using the H_3PO_4 impregnation method. The reduction in the total dye concentration and the quantification of total organic content were denoted by the percentage decrease in optical density and COD, respectively; these values were [24] . In the majority of samples, ACT3 detected complete pigment removal. Multiple factors, including TDS, influence the adsorption of dyes by activated carbon. Due to the dissolved salts, a high TDS value signifies an increase in ionic strength. Due to increased competition between analogous ions, an increase in ionic strength 25 has an effect on the adsorption capacity of activated carbon. An indicator of the percentage of pigment removal is the decline in BOD and COD. Adsorption-mediated color removal is also significantly influenced by the structure of the dye. As a rule, activated carbon adsorbs direct and reactive dyes with minimal resistance. Color-wise, the resistance of most dyes to adsorption is greater for those that are violet, pink, or black. Significantly lower in pH than the ground water, the textile effluents were discovered to be. In the same manner, the activated carbon efficiently eliminated chlorides and sulphates. ACT3 could potentially function as a cost-effective adsorbent and replace commercial activated carbon with a more favorable alternative, as the amount of ACT3 required for the majority of the samples was nearly equivalent to that of the commercial activated carbon.

CONCLUSION

As a consequence of the profound contamination levels present in the effluents generated by the textile industry during diverse stages of dying and finishing, it has been advised that dyed textile effluents be recycled prior to their release into freshwater ecosystems. Textile effluents exhibit remarkable variability in a range of parameters, such as pH, BOD, and COD. Additionally, the effluents from dyed textiles must be treated for carcinogenic recalcitrant organic pollutants and azo dyes. Activated carbon adsorption of dyes is one of the most practical and essential methods currently in use for removing dyes and other toxic compounds from effluents from dyed textiles. The effluent samples of dyed textiles obtained from the discharge points of textile industries were subjected to treatment using activated carbon (ACT3) derived from the leaves of Azadirachta indica (commonly known as neem) via the H3PO4 impregnation method. Complete color removal was observed in effluent samples with the following hues: pale purple, bluish black, green, and pink. Nevertheless, violet samples exhibited a minor resistance to pigment removal. An investigation was conducted to assess the adsorption characteristics of activated carbon (ACT3) through an examination of the impact of pH on the adsorption of four distinct pigment classes (Acid Violet, Methyl Green, Methylene Blue and Acid Yellow) onto ACT3. Additionally, an assessment has been conducted to determine whether activated carbon (ACT3) derived from Neem leaves could serve as a viable, cost-effective substitute for commercially available activated carbon.

BIBILOGRAPHY

1. Andre, B. S.; Francisco, J. C.; Jules, B. L. *Bioresource Technol*. **2007**, *98*, 2369.
2. Correia, V.M.; Stephenson T and Judd SJ, *Environ Technol.* **1994,** *15*, 917.
3. APHA.; Standard methods for the examination of water and wastewater, 20th edn. DC, New York. **1998**.
4. Mishra, G.; Tripathy, M.; *Colourage*. **1993,** *40*, 35.
5. Kumar, P.; Prasad, B.; Mishra, IM.; Chand, S. *J. Hazard. Mater*. **2007**,*149*, 26.
6. Robinson.; Mcmullan, G.; Marchant, R.; Ningam, P. Biores. T*echnol*. **2011**, *77*, 247.
7. Talarposhti, AM.; Donnelly, T.; Anderson, GK. *Water Res*. **2001,** *35*, 425.
8. Bannat, IM.; Nigam, P.; Singh, D.; Marchant. *Bioresource Technol*. **1996**, *58*, 217.
9. Suteu, D.; Zaharia, C.; Bibla, D.; Muresan, A.; Muresan, R.; Popescu, A.; *IndustriaTextila*. **2009,** *5*, 254.
10. Varunprasath, K.; Daniel, AN.; *Iranica J. Energy Environ*. **2010,** *1*, 315.
11. ISI., "Methods of sampling and tests for activated carbon used for decolourizing vegetable oils andsugar solutions'', Indian Standards Institute. **1977**, *IS*-877.
12. Regnaraj, S.; Banumathi, Arabindo.; Murugesan, V. *Int. J. Chem. Technol*. **1999,** *6*, 1.
13. Karthikeyan, S.; Sivakumar, P.; Palanisamy, P.N. *E.J. Chem*. **2008**, *5*, 409.
14. Banat, I M.; Nigam P.; Singh, D.; Marchant, R. *Bioresource Technol*. **1996**, *58*, 217.
15. Malik, P.K. *Dyes Pigments*. **2003**, *56*, 239.
16. Chandrashekhar, S.; Parmada, P.N.; Adsorption. **2006**, *12*, 27.
17. Ekpete, O.A.; Horsfall, R. *Res. J. Chem. Sci*. **2011**, *1*, 10.
18. Ozacar, M.; Sengil, A.I.; *J. Hazard. Mater*. **2003,** *B98*, 211.
19. Palanisamy, P.N.; Sivakumar, P. *Rasayan J. Chem. **2008***, *1*, 901.
20. Nouri, S.; Hagsheresht, F.; Max, GQ. *Adsorption.* **2002**, *8*, 215.
21. Rao, M.; Bhole, A.G. *Indian Chem. Eng*. **2002**, *44*, 25.
22. Noroozi, B.; Sorial, G. A.; Bahrami H.; Arami M. *J. Hazard Mater*. **2007**, *B139*, 167.
23. Won, S. W.; Wu, G.; Ma, H.; Liu, Q.; Yan, Y.; Cui, L. *J. Hazard. Mater*. **2006,** *138*, 370.
24. Prakash, A.; Solanki, A.; Prasada Rao. *Indian J. Chem. Technol*. **2008,** *15*, 146.
25. Weber, W. J.; Morris, J.C. *Proc. Int. Conf. Advances in Water Poll. Res.* **1963**, *2*, 231.