

Advanced Non-Conventional Activated Carbon and Sawdust Coated with Polymers for the remediation of Dye House Effluent

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ABSTRACT: Activated carbon and Sawdust coated with polymers prepared from the fruit of the gardening plant material Cordia Sebestena were used to treat the synthetic dye solutions and dye house effluents. In this study, H₃PO₄ impregnated activated carbon, polyaniline coated sawdust and polypyrrole coated sawdust adsorbents were used for the removal of colouring matter present in the dye house effluents as well as for the various categories of synthetic dye solutions namely acid orange 7, basic red 29, direct green 6 and reactive orange 16. A comparative study was also made in order to check the efficiency of the prepared adsorbents. The batch mode adsorption study was conducted by keeping the parameters namely dye concentration, contact time, pH, dosage and temperature as constant for the prepared adsorbents with the selected synthetic dye solutions and for dye house effluent. The experimental results indicated that the prepared three adsorbents are suitable for the removal of various categories of synthetic dyes as well as dye house effluents. It also suggested that among the three adsorbents, the polypyrrole coated sawdust proves to be an excellent adsorbent for removing the colour.

KEYWORDS: Activated carbon, Sawdust coated with polymers, Adsorption, Cordia Sebestena fruit, Synthetic dye solution, Dye house effluent.

I. INTRODUCTION

Environmental pollution becomes one of the most critical issues today because of technological advancement. The controlling pollution is the main concern nowadays which rises the environmental awareness worldwide. Among all industrial effluents, wastewater generated by the textile industry is rated as one of the most polluting agents considering both the volumes discharged and the effluents composition. Overall at present there are more than 100,000 commercial dyes with a rough estimated production of 7×10^5 to 1×10^6 tons per year [1]. Of such a huge production, the exact data on the quantity of dyes discharged in environment is not available. However, it is reported that 10 to 15% of the used dyes enter the environment through wastes [2]. Color removal from industrial waste water by adsorption techniques has been of growing importance due to the chemical and biological stability of dyestuffs to conventional water treatment methods and the growing need for high quality treatment[3].

Currently, activated carbon is the most popular and extensively used commercial material due to its high adsorption capacity, surface area and degree of surface reactivity as well as microporous structures. But it shows some disadvantages such as high operating costs and regeneration problems[4]. The use of renewable sources as raw material for manufacturing activated carbon is advantageous as these are less expensive to manufacture[5]

Many researchers have proved several low cost materials such as pear millet husk carbon[6], aspergillus niger[7], rice husk, banana pith, cotton waste, kaoline[8], coir pith[9], guava seeds[10], neem saw dust[11], clay[12] and mango seed kernel[13] as suitable adsorbents for the removal of dyes. Conducting polymers such as Poly pyrrole and polyaniline coated on saw dust are recently used as novel adsorbents due to their electrical conductivity and electro negativity[14]. Also Polymers have an advantages of less sludge generation and effective in both batch and column mode systems.

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In this investigation, the fruit of the plant material *Cordia Sebestena* is used as the source material. *Cordia Sebestena* is widely planted throughout the tropics and subtropics as an ornamental plant in gardens because of its flowers. It has dark green, oval shaped leaves, and grows oval shaped fruits. The fruit of this plant does not have any economical importance and usually it is not used for edible purpose. In this study, polyaniline polymer composite, polypyrrole polymer composite were chemically synthesized on the saw dust and also the activated carbon prepared by carbonization followed by chemical impregnation with H_3PO_4 of the fruit of the plant material *Cordia Sebestena*. The comparative study of the polymers coated sawdust and activated carbon for the adsorption of various categories of synthetic dye solutions namely acid orange 7, basic red 29, direct green 6, and reactive orange 16 as well as for the dye house effluents is carried out by batch mode adsorption tests.

II. EXPERIMENTAL

Preparation of H_3PO_4 impregnated activated carbon

The *Cordia Sebestena* plant fruit was used as precursor for the preparation of activated carbon. The fruits were collected, dried in sunlight for 10 days. The dried material was impregnated with 35% boiling solution of H_3PO_4 for 2 hours and left for 24 hours, then excess solution was decanted off and air dried. The dried material was carbonized at $550^\circ C$ for 1½ hrs in muffle furnace, powdered and activated at $800^\circ C$ for 10 min. The resulting carbon was washed with plenty of water to remove the acid, dried and powdered.[15] The activated carbon was powdered, characterized using physicochemical methods and used for adsorption studies (Table.1) [16] .

Preparation of Polymer Coated sawdust

a) Polyaniline Coated Sawdust (PAn/SD)

In order to prepare polyaniline coated onto sawdust (termed as PAn/SD), 5.0g sawdust of *Cordia Sebestena* (180 to 300μ size) immersed in 100 mL of 0.20 M freshly distilled aniline solution for 12 hrs before polymerization. The excess of the monomer solution was removed by simple decantation. About 50 mL of oxidant solution (5g ammonium persulphate ($(NH_4)_2S_2O_8$) was gradually added into the mixture, and the reaction was allowed to continue for 5 hrs at room temperature. Polymer coated sawdust (PAn/SD) was filtered, washed with distilled water, then dried at temperature about $60^\circ C$ (in an oven) and sieved before use. The coating percentage of each polymer onto sawdust was determined by weight difference of the dried sawdust before and after coating and it was nearly about 5%.

b) Polypyrrole Coated sawdust (PPy/SD)

The *Cordia Sebestena* plant fruit is used for the preparation of polymer composite. The sawdust was first washed with distilled water in order to remove any dust or impurities and finally dried at $60^\circ C$ for 2 hrs in an air oven. In order to achieve uniform coating the saw dust sieved into a particle size of 180 to 300μ before coating. The polypyrrole was synthesized on sawdust surface which was previously soaked in monomer pyrrole solution (0.2M) for 12 hrs at room temperature followed by slow addition of chemical oxidant 0.5M $FeCl_3$ at room temperature for 4 hrs. Polymerisation was carried out on the surface of sawdust immediately after the addition of oxidant solution. The polymer coated sawdust designated as PPy/SD was filtered, washed with distilled water and dried at $60^\circ C$ (in an oven) and sieved before use. The coating percentage of each polymer onto saw dust determined by weight difference of the dried saw dust before and after coating and it was nearly about 5% [14]. The characteristics of the PPy/SD and PAn/SD were studied (Table.1) as per the standard procedures [14].

Table.1 Physico-chemical Characteristics of CSAC, PAn/SD & PPy/SD

S.No	Properties	CSAC	PAn/SD	PPy/SD
1	pH	7.2	7.56	7.81
2	Conductivity, $mS\ cm^{-2}$	0.586	6.143	6.599
3	Moisture content, %	5.4	7.1	8.3
4	Ash, %	17.82	15.98	16.67
5	Volatile matter, %	18.90	54.32	57.63
6	Matter soluble in water, %	0.51	0.58	0.64

7	Matter soluble in 0.25 M HCl, %	5	5.6	5.2
8	Bulk density, g mL ⁻¹	0.53	0.27	0.29
9	Specific Gravity	1.46	0.56	0.58
10	Porosity, %	63.69	51.78	50.0
11	Methylene Blue Value, mg g ⁻¹	202	33	39
12	Iodine Number, mg g ⁻¹	418.77	60	67
13	Fixed Carbon, %	57.88	22.6	17.4
14	Yield, %	53.5	92	87

III. RESULTS AND DISCUSSION

Characterization study

SEM Analysis

Scanning electron microscopy (SEM) was used to envisage the morphological type and surface features of the activated carbon and polymers coated sawdust materials. The SEM photographs of activated carbon and polymers coated sawdust are given in Figure.1,2,3. The surface of CSAC has more splintered and splitted structure with long ridges which increase the surface area of the adsorbent. The SEM image of PAN/SD has small cavities and rough surfaces indicate the presence of interconnected porous network. The SEM image of PPy/SD reveals that the surface consists of well developed, smooth spherical tight particles.

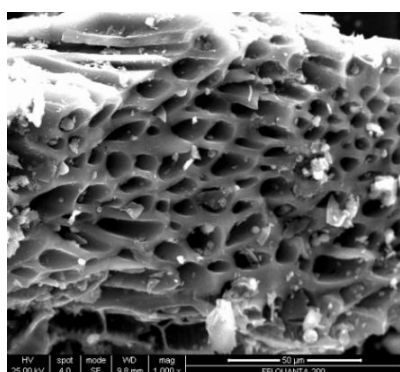


Figure.1 SEM image of CSAC

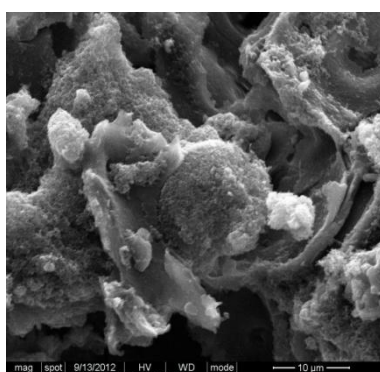


Figure.2 SEM image of PAN/SD

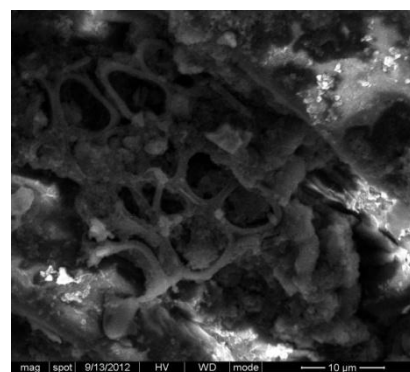


Figure.3 SEM image of PPy/SD

Batch experiments

Batch adsorption experiments were conducted by shaking 0.1 g of CSAC, PPy/SD and PAN/SD with 100 ml aqueous solution of various categories of dyes at a concentration of 50 ppm for 3 hrs time duration at 30^oC of temperature with natural pH conditions. The adsorbent was removed by centrifugation and the concentration of dye in the supernatant liquid was determined spectrophotometrically (Elico make BL-198).The same procedure was followed for the dye house effluent with the prepared three adsorbents. The result of the percentage of adsorption for the selected synthetic dyes and for the effluent is given in the Table 3.

Table.3 The percentage of adsorption of selected synthetic dyes and effluent

S.No	Name of the dye	% of Adsorption		
		CSAC	PAN/SD	PPy/SD
1	Acid Orange 7	66.19	83.90	89.23
2	Basic Red 29	68.53	81.80	84.33
3	Direct Green 6	60.85	76.83	80.73
4	Reactive Orange16	63.17	79.50	82.17
5	Effluent	68.62	82.35	88.23

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It was found that the percentage of adsorption for the selected synthetic dyes and for the effluent is increased in the following order for the prepared three adsorbents.

CSAC<PAn/SD<PPy/SD

Thus the percentage removal is high for PPy/SD adsorbent.

The detailed kinetic and thermodynamic studies of the selected synthetic dyes for the prepared adsorbents have carried out [17,18].

IV.CONCLUSION

In this investigation, activated carbon (CSAC) and polymers coated sawdust (PAn/SD & PPy/SD) were prepared from the fruit of the plant material Cordia Sebestena. The synthetic dyes namely acid orange 7, basic red 29, direct green 6, and reactive orange 16 were selected for the analysis of adsorption characteristics of CSAC, PAn/SD & PPy/SD at room temperature. An extensive study was made with CSAC, PAn/SD & PPy/SD which reveals that PPy/SD is assumed as a better adsorbent. It was also proved by the characterisation studies from SEM analysis. The percentage of adsorption of dyes by PPy/SD is high when compared with other adsorbents. Moreover it could be suggested that the prepared PPy/SD adsorbent may be effectively used to treat the dye house effluents.

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