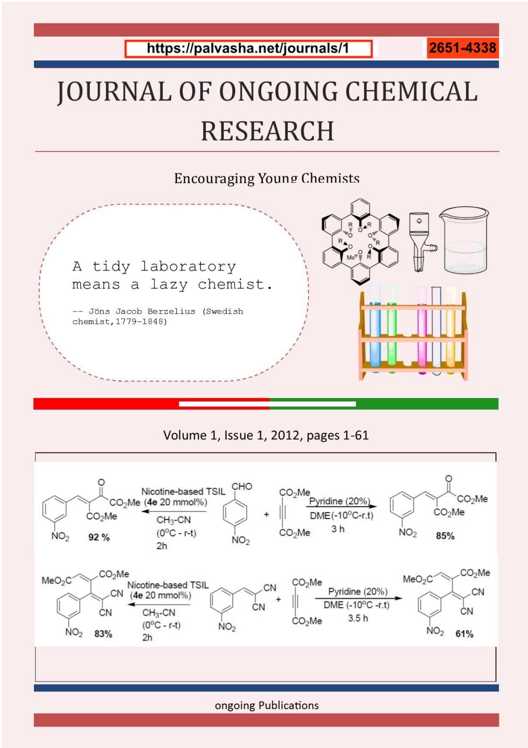
ADSORPTION OF ORGANIC DYES ON NON-CONVENTIONAL AND INEXPENSIVE ADSORBENT



JOURNAL OF ONGOING CHEMICAL RESEARCH

2019
Volume: 4
Issue: 1
Pages: 20-23
Document ID: 2019JOCR32
DOI: 10.5281/zenodo.3229034

J Ong Chem Res, 2019, **4**(1): 20-23, Document ID: 2019JOCR32, doi:10.5281/zenodo.3229034
Research Article

Adsorption Of Organic Dyes On Non-conventional And Inexpensive Adsorbent

Salman Zafar*, Inam Ur Rahman, Aziz Khan
For affiliations and correspondence, see the last page.

Abstract

Studies were conducted for the adsorption of textile organic dyes on sawdust of *Olea ferruginea*. The results revealed that sawdust of *Olea ferruginea* has fairly high adsorption capacity for textile dyes (VAT Black-4**,** VAT Blue-20, VAT Green-9**,** VAT Orange-3RT**,** VAT Pink-R**,** VAT Purple-3G, and VAT Red-F3B), collected from local market. Various parameters, such as the amount of adsorbent, reuse of the adsorbent and pH were studied to assess the adsorption capacity of the sawdust. The percent adsorption recorded on 1.0 g of adsorbent were 51% (Black-4)**,** 94% (Blue-20)**,** 75% (Green-9)**,** 85% (Orange-3RT)**,** 81% (Pink-R)**,** 94% (Purple-3G), and 93% (Red-F3B)**.** The results on 2.0 g of adsorbent were found to be 62% (Black-4)**,** 94% (Blue-20)**,** 34% (Green-9)**,** 70% (Orange-3RT)**,** 87% (Pink-R)**,** 74% (Purple-3G), and 82% (Red-F3B). The adsorbent was reused to check its efficacy after being used once and the percent adsorptions of 18.5% (Black), 3.3% (Blue), 40.9% (Green), 30% (Orange), 61.5% (Pink), 26.9% (Purple), and 66.6% (Red) were recorded. The effect of pH was also studied by varying the pH from 2 to 10. Results revealed that pH also has a profound effect on the adsorption capacity of various dyes.

Keywords: Adsorption, Dyes, Non-conventional Adsorbent, *Olea ferruginea*, Sawdust

INTRODUCTION

Adsorption is the chemical or physical retention of atoms or molecules on the surface of solid materials. Activated carbon is one of the most commonly used adsorbents mainly due to its efficacy in adsorbing a variety of organic molecules in general and dyes in particular [Dkabrowski, 2001]. Dyes are colored molecules having the affinity to bind to the surface of the material to which it is applied. Depending upon their origin, dyes may be synthetic or natural and are used in textile, tanneries, pulp, paints, and paper industries.

Dyes pose a great threat to the environment in general and animal life in particular. Presence of even a small quantity of dye is visible in the water and is, therefore, unwanted [Tao et al, 2003]. Dyeing industries release colored effluents which are highly toxic and are a source of major health and environmental hazards. Other industries, like dyestuff, tanneries, paper and pulp mills and distilleries are also expelling colored wastewater. A large number of dye effluents and aqueous wastes are discharged in the dying process with both high biological oxygen demand (BOD) and strong persistent color, both of which are aesthetically and environmentally unacceptable [Wang et al, 2007]. Decolorization of textile wastes employing the conventional technologies are not effective because of several shortcomings [Baseri et al, 2012], therefore focus has been shifted to the use of alternative, low cost, non-conventional adsorbents. Spent tea leaves (STL) have been used as a non-conventional and cost-effective adsorbent for methylene blue at 30 ^{o}C [Hameed, 2009]. The removal of various pollutants such as methyl blue (MB) and those which are not simply biodegradable needs more attention. Biological treatments and adsorption using activated carbon have become a common practice for elimination of dyes from wastewater. Although commercial activated carbon is a favored material for color adsorption, its general use is limited due to its high cost which led to the discovery and use of other non-conventional and less expensive adsorbents including industrial solid wastes, agricultural wastes, zeolites, clays minerals, and biomass. Agricultural waste materials can be used for MB removal, owing to its efficiency, low cost, and is a renewable source of biomass [Rafatullah et al, 2010]. Biological treatment with "activated sludge" was one of the most efficient effluent treatments that were used in large scale textile industries. The microorganisms which are contributing in biodegradation of organic molecules are bacteria

(*Aeromonas hydrophilia*, *Bacillus subtilis*, *Bacillus cetreus*, etc.) and fungi (white-rot fungi algae, *Chlorella* and *oscillotoria* species, etc.) [DosSantos et al, 2004]. Irradiation is another useful and effectual procedure for removing a great variety of organic dyes and also disinfecting harmful microorganisms using gamma rays or electron beams (e.g., monochromatic UV lamps working under 253.7 nm) [Borrely et al, 1998].

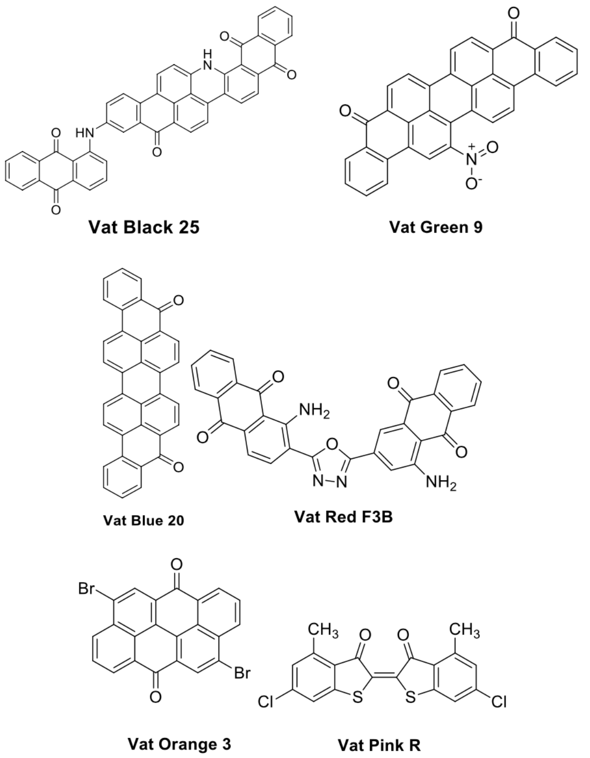


Figure 1. Chemical structures of the dyes

RESULTS AND DISCUSSION

Sawdust of *Olea ferruginea* was evaluated for its ability to be used as an adsorbent for dyes. The experiments were performed with different dyes (Figure 1). The amounts of adsorbent and pH of solutions were varied to check the effect of these parameters on the adsorption capacity of the adsorbent.

Effect of the Amount of Adsorbent

Adsorption efficiency of the sawdust was evaluated by using 1.0 g and 2.0 g of it in separate experiments. Percent adsorption increased by doubling the amount of adsorbent but the difference was not much pronounced (Table 1). This suggests that even a small amount of the *O. ferruginea* sawdust is effective enough for adsorption of dyes (Figure 2). The same amount of adsorbent could be used again to further quench the dye, thus avoiding the use of larger quantities. Percent adsorption and qt (adsorption/unit mass of adsorbent) are given in table 1.

Table 1. Effect of the quantity of adsorbent on adsorption of dyes.

Dye	Volume of dye (mL)	Adsorption time (min)	Quantity of adsorbent (g)	Initial conc. (ppm)	Final conc. (ppm)	Adsorption capacity OR (% ads)	dye adsorbed /unit mass of adsorbent (qt)
VAT balck-4	30	5	1	10	4.9	51	153
			2	10	3.8	62	93
VAT blue-20	30	5	1	10	0.6	94	282
			2	10	0.6	94	141
VAT green-9	30	5	1	10	2.5	75	225
			2	10	6.6	34	51
VAT orange-3RT	30	5	1	10	1.5	85	255
			2	10	3.0	70	105
VAT pink-R	30	5	1	10	1.9	81	243
			2	10	1.3	87	130.5
VAT purple-3G	30	5	1	10	0.6	94	282
			2	10	2.6	74	111
VAT red-F3B	30	5	1	10	0.7	93	279
			2	10	1.8	82	123

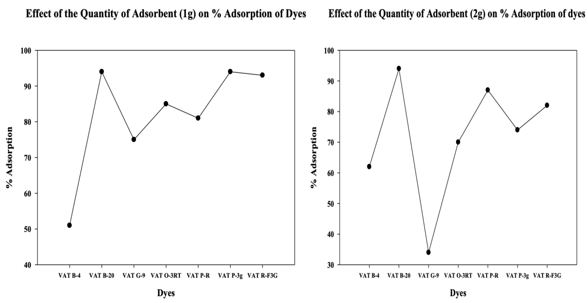


Figure 2. Effect of quantity of adsorbent on % adsorption of dyes

Table 2. Adsorption of dyes on 2.0 g of re-used adsorbent.

Dye	Volume of dye (mL)	Quantity of adsorbent (g)	Adsorption time (min)	Fresh/ Used	Initial conc. (ppm)	Final conc. (ppm)	Adsorption capacity OR (%ads)	Amount of dye adsorbed per unit mass of adsorbent (qt)
VAT black-4	30	2.0	5	Fresh	10	3.8	62	93
				Used	3.8	3.1	18.55	10.5
VAT blue-20	30	2.0	5	Fresh	10	0.6	94	141
				Used	0.6	0.4	33.3	3
VAT green-9	30	2.0	5	Fresh	10	6.6	34	51
				Used	6.6	3.9	40.9	40.5
VAT orange-3RT	30	2.0	5	Fresh	10	3.0	70	105
				Used	3.0	2.1	30	13.5
VAT pink-R	30	2.0	5	Fresh	10	1.3	87	130.5
				Used	1.3	0.5	61.5	12
VAT purple-3G	30	2.0	5	Fresh	10	2.6	74	111
				Used	2.6	1.9	26.9	10.5
VAT red-F3B	30	2.0	5	Fresh	10	1.8	82	123
				Used	1.8	0.6	66.6	18

Effect of Re-use of Adsorbent

The adsorbent was also re-used to study the effect of

J Ong Chem Res, 2019, **4**(1): 20-23, Document ID: 2019JOCR32, doi:10.5281/zenodo.3229034
Research Article

repetitive use of the same unwashed adsorbent for a fresh dye solution and the results showed that the adsorbent was still very much effective in adsorbing the dyes (Table 2, Figure 3). This is quite promising as it allows the use of a small quantity of the adsorbent and still be effective if used, again and again. Thus it can be used in water filters where the same material is re-used several times.

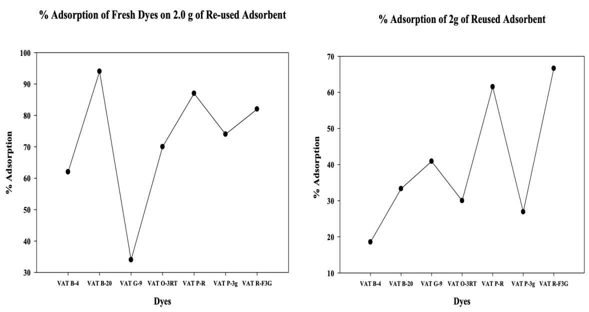


Figure 3. Effect of re-use of adsorbent on % adsorption of dyes

Effect of pH

Adsorption experiments were also performed at different pH values of the dye solutions. The results revealed the best adsorption values with their respective pHs as follows: VAT Black-4: 51 % at pH-4, VAT Blue-20: 94 % at pH-2, VAT Green-9: 75 % at pH-6, VAT Orange-3RT: 85 % at pH-6, VAT Pink-R: 81 % at pH-4, VAT Purple-3G: 94 % at pH-8, VAT Red-F3B: 93 % at pH-4. The data is represented in Table 3 and Figure 4.

Table 3. Effect of pH on adsorption of dyes.

S.No:	Dyes	Volume of dye sol. (mL)	Time (min)	%ads. at different pH (1.0 g of adsorbent)				
				2	4	6	8	10
1	VAT Black-4	30	5	36	51	42	47	50
2	VAT Blue-20	30	5	94	87	75	60	55
3	VAT Green-9	30	5	65	68	75	58	55
4	VAT Orange-3RT	30	5	75	70	85	63	66
5	VAT Pink-R	30	5	60	81	75	70	64
6	VAT Purple-3G	30	5	65	80	87	94	50
7	VAT Red-F3B	30	5	83	93	74	60	58

EXPERIMENTAL

General

Seven dyes, VAT Blue-20, VAT Black-4, VAT Orange-3RT, VAT Green-9, VAT Pink-R, VAT Purple-3G, and VAT Red-F3B (Figure 1) were purchased from the local market. The extent of adsorption was determined by spectrophotometric method, using UV/Vis spectrophotometer Model 721.

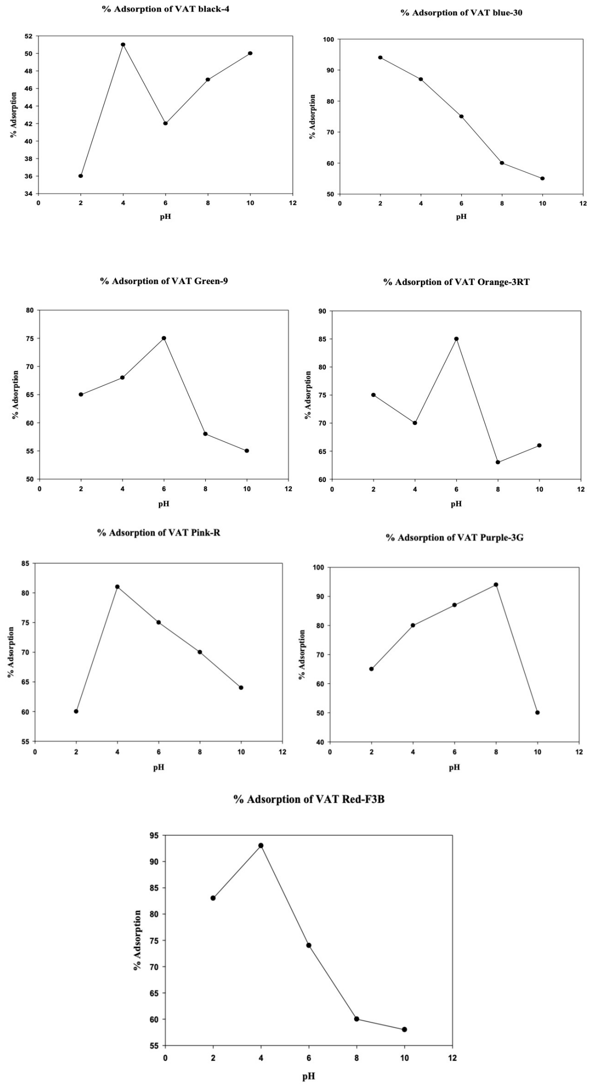


Figure 4. Effect of pH on % adsorption of dyes

Adsorbent

Sawdust of the *Olea ferruginea* stem was used as the adsorbent. The sawdust was meshed to remove large particles and washed with water thoroughly till a clear filtrate was obtained. The washed adsorbent was dried in an oven before use.

Dye Solutions and λ max calculation

100 ppm solution (stock solution) of each dye was prepared. λ_{max} for each dye was obtained by scanning the stock solutions from 380 nm to 700 nm. Calibration curves were obtained by preparing

solutions of different concentrations and scanning on the respective λ_{max} of each dye.

Adsorption Parameters

Percent adsorption of dyes was determined with different parameters, such as the amount of adsorbent (1g and 2g), re-use of the adsorbent and pH of the solution (2-8). Volume of the dye solution (30 mL) and time (5 minutes) were kept constant. PH was adjusted by using conc. HCl and NaOH solutions.

Adsorption Experiment

30 mL of the dye solution was added to 1.0 g and 2.0 g of the sawdust and shaken continuously for 5 minutes. The adsorbent was then filtered out with the help of filter paper and the filtrate solution was analyzed on UV-spectrophotometer for determination of the concentration of the dye solutions at their corresponding $\lambda_{max.}$ Percent adsorption and adsorption capacity were calculated.

CONCLUSION

Dyes, on one hand, make our world colorful through their colored products, but on the other hand they also pose threat to our health and environment. On the basis of the above studies, it is being concluded here that the saw dust of *Olea ferruginea* can be employed as an effective adsorbent for the adsorption of textile dyes from aqueous solution. Its efficiency was demonstrated with various parameters i.e pH and amount of adsorbent, which often affect the extent and capacity of adsorption. Studies also revealed that the same amount of *O. ferruginea* saw dust may be re-used again, still having greater adsorption capacity for different dyes.

Acknowledgements

The authors acknowledge the financial support obtained from the Higher Education Commission (HEC) of Pakistan for this project.

Bibliography

Baseri, J Raffiea; Palanisamy, PN; Sivakumar, P (2012). "Comparative studies of the adsorption of direct dye on activated carbon and conducting polymer composite", *Journal of Chemistry*, **9**, 1122-1134

Borrely, SI; Cruz, AC; Del Mastro, NL; Sampa, MHO; Somessari, ES (1998). "Radiation processing of sewage and sludge A review", *Progress in Nuclear Energy*, **33**, 3-21

Dkabrowski, A (2001). "Adsorption—from theory to practice", *Advances in colloid and interface science*, **93**, 135-224

Dos Santos, A Bezerra; Cervantes, FJ; Van Lier, JB (2004). "Azo dye reduction by thermophilic anaerobic granular sludge, and the impact of the redox mediator anthraquinone-2, 6-disulfonate (AQDS) on the reductive biochemical transformation", *Applied microbiology and biotechnology*, **64**, 62-69

Hameed, Bassim H (2009). "Spent tea leaves: A new non-conventional and low-cost adsorbent for removal of basic dye from aqueous solutions", *Journal of hazardous materials*, **161**, 753-759

Rafatullah, Mohd; Sulaiman, Othman; Hashim, Rokiah; Ahmad, Anees (2010). "Adsorption of methylene blue on low-cost adsorbents: a review", *Journal of hazardous materials*, **177**, 70-80

Tao, Andrea; Kim, Franklin; Hess, Christian; Goldberger, Joshua; He, Rongrui; Sun, Yugang; Xia, Younan; Yang, Peidong (2003). "Langmuir- Blodgett silver nanowire monolayers for molecular sensing using surface-enhanced Raman spectroscopy", *Nano letters*, **3**, 1229-1233

Wang, Shan-Li; Tzou, Yu-Min; Lu, Yi-Hsien; Sheng, Guangyao (2007). "Removal of 3-chlorophenol from water using rice-straw-based carbon", *Journal of hazardous materials*, **147**, 313-318

Affiliations and Corresponding Informations

Corresponding: Salman Zafar
Email: salmanzafar@uop.edu.pk
Phone: +923229011701

Salman Zafar: Institute of Chemical Sciences, University of Peshawar, Peshawar-25120, Pakistan

Inam ur Rahman: Department of Chemistry, Sarhad University of Science and Information Technology, Peshawar-25000, Pakistan

Aziz Khan: Department of Chemistry, abdul Wali Khan University, Mardan-23200, Pakistan