Studies on Removal of Textile Dye from Wastewater Using Base Activated Pomelo Peel as a Sorbent

Htwe Htwe Mar[1], Khin Than Yee [2], Thinzar Nu[3]

Abstract

Base activated pomelo (*Citrus maxima*) peel was used as a sorbent for the removal of textile dye from wastewater. This research work concerns with the preparation of base activated pomelo peel (BPP) with NaOH.BPP was characterized by modern techniques. The sorption capacity of BPP was studied for the removal of Direct Fast Orange S (T) (orange dye) from aqueous solution with varying parameters. The removal percent of orange dye was found to be 98.108 % at 60 ppm of initial concentration, pH 6, 0.15 g of dosage and 3 h of contact time. Langmuir isotherm indicated that monolayer coverage value (Q_o) and separation factor (R_L) werefound to be 53.476 mg g^{-1} and 0.233. From Freundlich isotherm studies, the adsorption capacity (K_f) and adsorption intensity (n) were found to be 3.239 mg g^{-1} and 1.308. The experimental sorption data fitted both models and indicated that sorption conditions were favourable. BPP was effective and efficient sorbent for removal of orange dye from aqueous solution. BPP was applied for the removal of textile dye from wastewater. The removal percent of textile dye was observed to be 89.575 %. Base activated pomelo peel (BPP)could be applied in purifying the environmentally polluted wastewater.

Keywords: Adsorption, adsorption isotherms, pomelo peel, textile dyes, wastewater

Introduction

Dyes used in textile industry may be toxic to aquatic organisms and can be resistant to natural biological degradation. Hence, the removal of synthetic organic dyestuff from waste effluents becomes environmentally important (Prasad and Santhi 2012).

Many methods used to remove dyes from wastewaters such as coagulation and membrane separation process, electrochemical, chemical oxidation, reverse osmosis and aerobic and anaerobic microbial degradation, but these methods have many restrictions, and therefore not successful for removing the color completely from wastewater (Salleh*et al*., 2012).Among several methods, adsorption method has been found to be superior due to low cost, simplicity of design, flexibility, ease of operation and insensitivity to toxic pollutants**(**RaffieaBaseri*et al*., 2012).

Pomelo (*Citrus maxima*) peel is largely composed of cellulose, pectin, hemicellulose, lignin and other low molecular weight organic compounds. It can be used as an efficient and cost-effective bio adsorbent for removing dyes from aqueous solution(Tanzim&Abedin, 2015).

The objective of the present work was to explore the sorption capability of base activated pomelo peel as a sorbent for removal of Direct Fast Orange S (T) (orange dye) from aqueous solution and dyes from wastewater of textile mill.

[1]Lecturer, Department of Chemistry, Sagaing University of Education, Myanmar
[2]Lecturer, Department of Chemistry, West Yangon University, Myanmar
[3]Associate Professor,Department of Chemistry, University of Yangon, Myanmar

Materials and Methods

Sample Collection

The pomelo (*Citrus maxima*)peels were collected from Tarmwe Market, Tarmwe Township, Yangon Region, Myanmar.

Preparation of Base Activated Pomelo Peel (BPP)

The collected pomelo (*Citrus maxima*) peels were boiled with distilled water and the filtered. The peels werethen dried in oven at 80 ˚C for 24 hours. The dried peels were ground to a fine powder by using blender and sieved through 100 meshsieve(Tanzin and Abedin, 2015).The pomelo peel powder was soaked with 0.5 M sodium hydroxide for 2 h. Then, it was washed several times with distilled water until pH 7.0. The sample was dried in oven at 110 ˚C for 8 h. Then, it was ground to a fine powder by using blender and sieved through 100 mesh sieve. Finally, base activated pomelo peel (BPP) was obtained.

Characterization of BPP

BPP was examined by modern techniques such as TG-DTA, ED XRF, FT IR and SEM analyses(Stevulova*et al*., 2017, Silverstein *et al*., 2005and Zain *et al*., 2014).

Preparation of Stock Solution

Stock solution of Direct Fast Orange S (T) (orange dye) containing 100 ppm of sorbate wasaccurately prepared. In thepreparation of diluted dye solutions (concentration ranging from 1.5625 ppm to 50 ppm), distilled water was used as the diluent.

Sorption Studies for the Color Removal of BPP

The sorption capacities of BPP were studied for the removal of orange dyefrom aqueous solution with various parameters of initial concentration of dye solution, pH, dosage of sorbent and contact time.

Application of BPP for the Removal of Textile Dyes from Wastewater

Textile mill effluent was collected from textile dye workshop in South Okkalapa Township, Yangon Region, and Myanmar.BPP was used as a sorbent for the removal of textile dyes from wastewater.

Results and Discussion

Characterization of BPP

TG-DTA analysis

Thermal stability of BPP was determined by TG-DTA analysis under nitrogen atmosphere. The thermogram is divided into three stages. The thermal analysis results are shown in Figure 1 and Table 1.

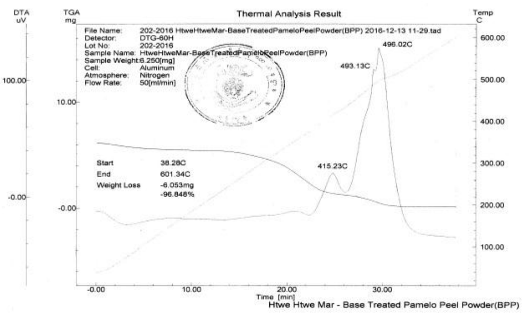

Figure1.TG-DTA thermogram of BPP

Table 1.Thermal Analysis Data of BPP

Temperature range (˚C)	Wt. loss (%)	Peak's temperature (˚C)	Nature of peak	TG remark
38 - 120	14.41	-	-	dehydration of moisture and absorbed water
120 - 435	65.38	415.23	exothermic	decomposition of pectin and hemicellulose, carbonization of organic compounds
435 - 600	17.05	493.13 496.02	exothermic exothermic	decomposition and combustion of cellulose and lignin

ED XRF analysis

The chemical constituents of BPP were detected by using ED XRF analysis. Figure 2 shows ED XRF spectrum of BPP. The resultant data were presented in Table 2. According to results, BPP sample contains carbon which was the main component.The facts that generally indicate BPP has the ability to remove dye.

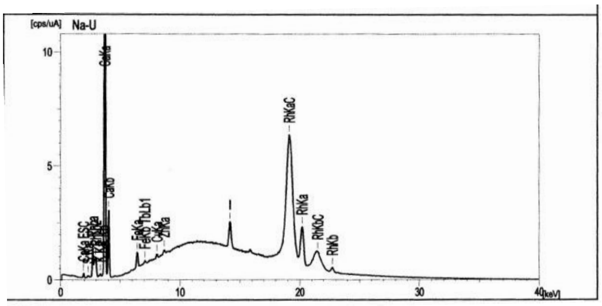

Figure2. ED XRF spectrum of BPP

Table 2.Relative Abundance of Elements in BPP by ED XRF Analysis

Elements	Cu	Zn	Fe	K	S	Ca	COH
Relative abundance ofelements (%)	0.001	0.001	0.009	0.026	0.081	1.886	97.995

FT IR analysis

The FT IR spectrum of BPP is shown in Figure 3. It can be observed that broad band at 3287 cm^{-1}attributed to O-H stretching. The peakappeared at 1019 cm^{-1}can be assigned to

C-O, C=C and C-C-O stretching. The peak located at 2923 cm^{-1} due to C-H stretching.The peak observed at 1603 cm^{-1}related to C=O stretching.The peak observed at 1420 cm^{-1}due to C-H in plane formation.The peak at 1318 cm^{-1}showed CH_2wagging. The peak at 897 cm^{-1} showed bending of C-C and C-H.

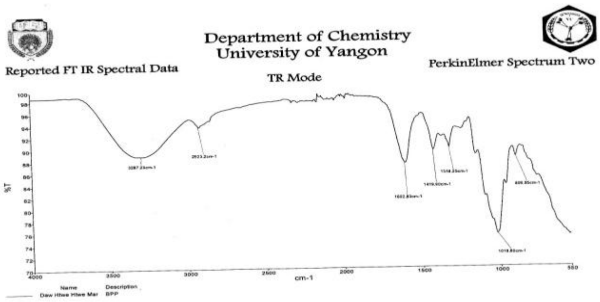

Figure3.FT IR spectrum of BPP

SEM analysis

The SEM photograph of BPP is presented in Figure 4. The surface morphology of BPP was heterogeneous due to the presence of pores with different shapes and sizes.It is demonstrated that BPP is an effective sorbent.

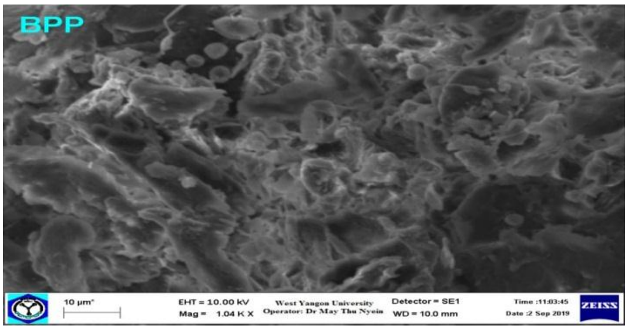

Figure4.Scanning electron micrograph of BPP

Sorption Studies for the ColourRemoval of OrangeDye by BPP

Effect of initial concentration

Removal of orangedye by BPPwas determinedby variousinitial concentrations from 20 ppm to 100 ppm of dye solution. Each sample (0.10 g) was added todye solutions (25 mL) individual andwasallowedto equilibrate for2h ina shaker. The equilibrium concentration was determined spectrophotometrically at its corresponding λ_{max}(490 nm). The results are shown in Table 3and Figure 5.It can be seen that as the removal percent decreases with increasing in initial concentration. This is due to the fact that with increase in dye concentration, there will be increased competition for the active adsorption sites and the adsorption process will increasingly slow down. After the equilibrium time, the removal percent was86.099 % with respect to initial concentration 60 ppm in 25 mL of dye solution.

Table 3. Effect of Initial Concentration on the Removal of OrangeDye byBPP

Initial concentration (ppm)	Final concentration (ppm)	Removal percent (%)
20	0.742	96.288
40	3.057	92.358
60	8.341	86.099
80	19.432	75.710
100	32.052	67.948

pH = 6.7

Dosage = 0.10 g/ 25 mL

Contact time = 2 h

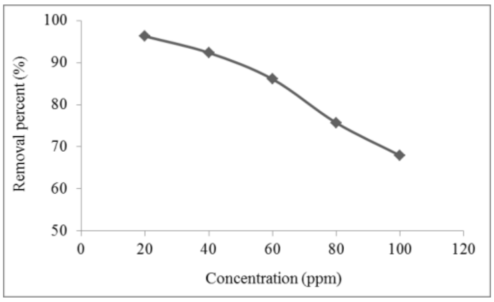

Figure5.Removal percent of orange dye byBPP as a function of initial concentration at 2h contact time

Effect of pH

The effect of pH was carried out over the pH range from 2 to 10. pHwas adjusted with HCl andNaOH. Each sample (0.10 g) was added to dye solutions (25 mL) individual and was allowed to equilibrate for 2h in a shaker. The results are shown in Table 4. Removal percent versus pH are shown in Figure6. From the results, increase in pH, the removal percent also increases up to pH 6. Beyond pH 6, the removal percent decreases with increasing in pH.Almost all the active sites of the sorbent might have been saturated at pH 6. Thus, the optimum pH 6 was chosen for further studies.

Table 4.Effect of pH on the Removal of OrangeDye by BPP

pH	Final concentration (ppm)	Removal percent (%)
2	10.568	82.387
3	10.044	83.260
4	9.476	84.207
5	7.729	87.118
6	6.594	89.010
7	8.166	86.390
8	8.821	85.298
9	9.869	83.552
10	11.616	80.640

Initial concentration = 60 ppm

Dosage = 0.10 g/ 25 mLContact time = 2 h

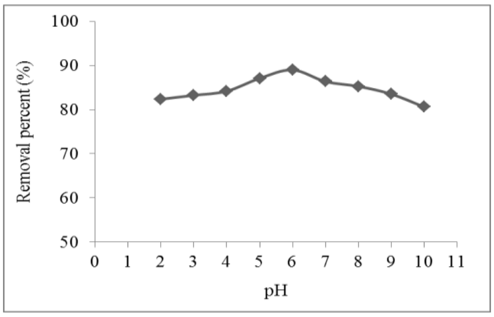

Figure6.Figure 6.Removal percent of orangedyeby BPP as a function of pH at 2h contact time

Effect of dosage

Thecolour removal of dye solution was determined by various dosage of BPP from 0.05 g to 0.30 g under the optimum conditions. The results are shown in Table5.The removal percent with respect to sorbent dosage are shown in Figure 7.It can be seen that the removal percent increases with increasing in sorbent dose. This isdue to increase the amount of sorption sites available.According to results, 0.15 g was taken as the suitable sorbent dosage. The removal percent of dye being adsorbed was93.887 %.

Table 5.Effect of Dosage of BPP on theRemoval of Orange Dye

Dosage (g)	Final concentration (ppm)	Removal percent (%)
0.05	13.493	77.512
0.10	6.550	89.083
0.15	3.668	93.887
0.20	2.751	95.415
0.25	2.183	96.362
0.30	1.790	97.017

Initial concentration = 60 ppm

pH = 6

Contact time = 2 h

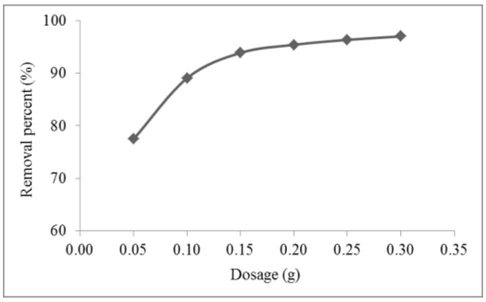

Figure7.Removal percent of orange dye by BPP as a function of dosage at 2 h contact time

Effect of contact time

The effect of contact time was investigated for different periods of time from 1 to 6 h by keeping optimum conditions. The results are shown in Table 6 and Figure 8. Sorption percent increases significantly around 3 h due to the large number of vacant sites available at the initial stage and then increased slowly.Thus, 3 h was chosen for optimum contact time. The removal percent of dye being adsorbed was 83.115 % at 3 h.

Table 6.Effect of Contact Time on the Removal ofOrangeDye by BPP

Contact time (h)	Final concentration (ppm)	Removal percent (%)
1	5.983	90.028
2	3.886	93.523
3	1.135	98.108
4	0.873	98.544
5	0.568	99.054
6	0.262	99.563

Initial concentration = 60 ppm

pH = 6

Dosage = 0.15 g/ 25 mL

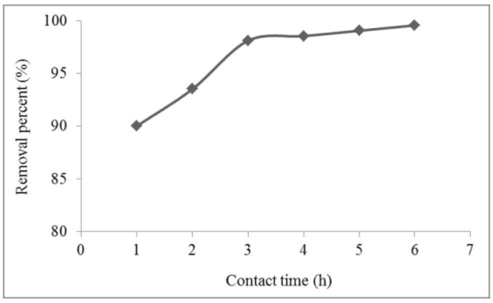

Figure 8.Removal percent of orange dye by BPP as a function of contact time

Adsorption Isotherms

Langmuir isotherm

The linearized Langmuir equation is given as:

$$C_e / x/m = (1 / Q_o b) + (C_e / Q_o)$$

where x/m is the amount of sorbate adsorbed per unit mass of sorbent (mg g^{-1}), C_e is the equilibrium concentration of adsorbate (mg L^{-1}), Q_o is the maximum monolayer coveragecapacity (mg g^{-1}) and b is Langmuir constant (L mg^{-1})(Abou-Gamra and Medien,2013).

Table 7 represents Langmuir data for sorption of orange dye by BPP and Langmuir isotherm is shown in Figure 9. From the slope and intercept of the linear plot of the Langmuir isotherm, Langmuir constant and separation factor were obtained. The values of Q_o and b with the correlation coefficient (R^2) are listed in Table 8.

Based on the effect of separation factor on isotherm shape, the R_L value is in the range of $0 < R_L < 1$, which indicates that the sorption of dye solution on BPP was favourable.

Langmuir parameters			R^2
Q_0 (mg g^{-1})	b (L mg^{-1})	R_L	
53.476	0.055	0.233	0.9653

Table 8.LangmuirParameters for the Sorption of OrangeDye by BPP

Table 7.Langmuir Data for the Sorption of OrangeDye by BPP

Weight of sample, m(g)	Final concentration, C_e(mg L^{-1})	Amount of adsorbed, x(mg)	x/m(mg g^{-1})	C_e/ x/m(g L^{-1})
0.05	13.493	1.163	23.260	0.580
0.10	6.550	1.336	13.360	0.490
0.15	3.668	1.408	9.387	0.391
0.20	2.751	1.431	7.155	0.384
0.25	2.183	1.445	5.780	0.378
0.30	1.790	1.455	4.850	0.369

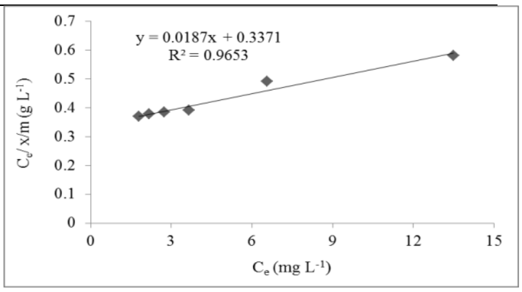

Figure9.Langmuir isotherm: Sorption of orange dye by BPP

Freundlich isotherm

The linearized Freundlich equation is given as:

$$\log x/m = \log K_f + 1/n \log C_e$$

where x/m is the amount of sorbate adsorbed per unit mass of sorbent (mg g^{-1}), C_e is the equilibrium concentration of adsorbate (mg L^{-1}), K_f is Freundlich constant (mg g^{-1}) and n is adsorption intensity (L mg^{-1}) (Abou-Gamra and Medien, 2013).

Table 9 represents Freundlich data for sorption of orange dye by BPP and Freundlich isotherm is shown in Figure 10. Figure showed the straight line. The values of K_f andn with the correlation coefficient (R^2) are listed in Table 10. The adsorption intensity (n) value of dye sorption for BPP lies between 1 and 10, thus indicating a favourable.

Table 9.FreundlichData for the Sorption of OrangeDye by BPP

Weight of sample, m(g)	Final concentration, C_e(mg L^{-1})	Amount of adsorbed, x(mg)	x/m(mg g^{-1})	Log C_e	Log x/m
0.05	13.493	1.163	23.260	1.130	1.367
0.10	6.550	1.336	13.360	0.816	1.126
0.15	3.668	1.408	9.387	0.564	0.973
0.20	2.751	1.431	7.155	0.439	0.855
0.25	2.183	1.445	5.780	0.339	0.762
0.30	1.790	1.455	4.850	0.253	0.686

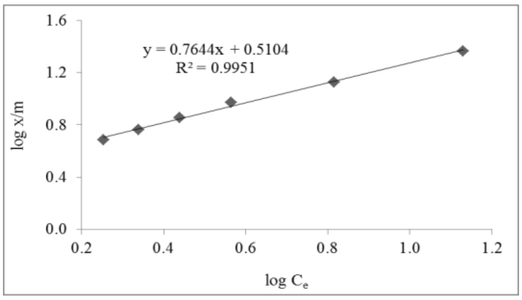

Figure 10.Freundlich isotherm: Sorption of orangedye by BPP

Table 10. FreundlichParameters for the Sorption of OrangeDye by BPP

Freundlich parameters		
K_f (mg g^{-1})	n	R^2
3.239	1.308	0.9951

Application of BPP for the Removal of Dye from Wastewater of Textile Mill

Textile mill effluent was collected from textile dye workshop in South Okkalapa Township, Yangon Region, Myanmar. Its maximum wavelength was found to be 560 nm.0.15 gof BPP was added to the textile mill effluent (25 mL). The mixture was allowed to equilibrate for 3h in a shaker. The removal percent of textile dye from wastewater using BPP was found to be 89.575 %. It is concluded that BPP can be used as an effective and efficient sorbent for removal of textile dye from wastewater because of its high adsorptive capacity.

Conclusion

Base activated pomelo peel (BPP) as a sorbent was used for the removal of dye from wastewaterof textile mill. According to characterization techniques, BPP was a suitable sorbent for removal of dye from aqueous solution. The effects of various parameters on BPP were investigated in sorption process. From the results, 60 ppmof initial concentration, pH 6, 0.15 g in 25 mL of dosage and3 h of contact time were selected for the optimum conditions. The maximum removal percent of Direct Fast Orange S (T)(orange dye) fromaqueous solutionby BPP was observed 98.108 %. From Langmuir isotherm studies, monolayer coverage value (Q_o) was found to be 53.476 mg g^{-1}. From Freundlich isotherm studies, adsorption capacity (K_f) was found to be 3.239 mg g^{-1}. According to equilibrium data, dye sorbent system fitted both models and indicated that the sorption conditions were favourable.BPP was applied for the removal of textile dye from wastewater. The removal percent of textile dye was observed to be 89.575 %. The result showed that base activatedpomelo peel (BPP) could be used as a sorbent for purifying the environmentally polluted wastewater.

Acknowledgements

The authors would like to express their profound gratitude to Rector Dr Saw PyoneNaingand Pro Rectors DrMyatMyat Thaw from Sagaing University of Education, for giving permission to submit this paper. We also thank to Professor DrKathy Myint Thu, Head of Department of Chemistry, Sagaing University of Education, for her kind encouragement.

References

Abou-Gamra, Z. M. and Medien, H. A. A. (2013). “Kinetic, Thermodynamic and equilibrium Studies of Rhodamine B Adsorption by Low Cost Biosorbent Sugar Cane Bagasse”. *Eur. Chem. Bull.* vol. 2 (7), pp. 417 - 422

Prasad, A. L. and Santhi, T. (2012). “Adsorption of Hazardous Cationic Dyes from Aqueous Solution onto *Acacia nilotica* Leaves as an Ecofriendly Adsorbent”. J. *Sustain. Environ. Res.*, vol. 22 (2), pp. 113-122

RaffieaBaseri, J., Palanisamy, P. N. and Sivakumar, P. (2012). “Adsorption of Reactive Dye by a Novel Activated Carbon Prepared from *Thevetiaperuviana*”. *Int. J. of Chem. Res.*vol. 3 (2), pp. 36-41

Salleh, M. A. M., Mahmoud, D. K., Abu, N. A. B. A., Karim, W. A. W. A. and Idris, A. B. (2012). “Methylene Blue Adsorption from Aqueous Solution by Langsat (*Lansiumdomesticum*) peel”. *J. of Purity, Utility Reaction and Environ.* vol.1 (10), pp. 472-495

Silverstein, R. M., Webster, F. X. and Kiemle, D. J. (2005). Spectrometric Identification of Organic Compounds. New York: 7th Edn., John Willey & Sons, Inc. pp. 1-550

Stevulova, N., Estokova, A., Cigasova, J., Schwarzova, I., Kacik, F. and Geffert, A. (2017). "Thermal Degradation of Natural and Treated Hemp Hurds Under Air and Nitrogen Atmosphere". vol. 128 (3), pp. 1649 -1660

Tanzim, K. and Abedin, M. Z. (2015)."A Novel Bioadsorbentfor the Removal of Methylene Red from Aqueous Solutions". *IOSR J. Environ. Sci., Toxicol. and Food Technol.* vol. 9 (12), pp. 87-91

Tanzim, K. and Abedin, M. Z. (2015)."Adsorption of Methylene Blue from Aqueous Solution by Pomelo (*Citrus maxima*) Peel". *Intl. J. Sci. and Technol. Res.* vol. 4 (12), pp. 230-232

Zain, N. F. M., Yusop, S.M. and Ahmad,I. (2014)."Preparation and Characterization of Cellulose and Nanocellulose from Pomelo (*Citrus grandis*) Albedo". *J. Nutr. Food Sci.* vol. 5 (1), pp.1-4