Study on Adsorption Properties of Activated Brilliant Blue X-BR by Modified Carbon from Urban Greening Waste

Yonggang Zeng [1,2,*], Jin Huang [1,2], Wei Wang [2], Lili Ji [2], Rui Lan [1], Kaiyuan Xiao [1], Yang Gao [1], Wenting Lin [1], Lin Luo [3]

[1] School of Architecture and Civil Engineering, Chengdu University, Chengdu 610106, China
[2] Meat Processing Key Laboratory Foundation of Sichuan Province, Chengdu 610106, China
[3] Post Office in Chengdu, Sichuan province, Chengdu 610011, China
* Corresponding author: Yonggang Zeng

Abstract: In this experiment, the urban greening waste in Chengdu was used as raw material, and the carbonized urban greening waste was prepared by the innovative method in the laboratory, and its iodine adsorption value was determined. Then, the best adsorption conditions and adsorption effect for reactive brilliant blue X-BR were explored. Among them, the branch modified carbon modified by zinc chloride was the best modified carbon, and the adsorption time was 60min, the oscillation speed was 150r/min, the carbon dosage was 2.4g, and the mixed solution pH=1.8 was the best adsorption condition. The influence degree of each factor on the removal rate was in the order of mixed solution pH > adsorption time > oscillation speed > carbon dosage. The experimental results showed that the removal rate of reactive brilliant blue X-BR can reach 100% under the optimal conditions, and the adsorption effect was obvious.

Keywords: modified; reactive brilliant blue x-br; urban greening waste; carbonization

1 Introduction

With the promotion of eco-city construction and the increase of urban greening coverage, the total amount of urban greening waste is increasing. For urban greening waste, burning green waste will also cause certain air pollution, and the environmental problems brought by it are becoming more and more prominent [1]. Therefore, it is bound to become an inevitable trend of social development to reuse green waste as a kind of recycled resource [2].

Through the joint research and discussion of scholars at home and abroad [3-5], the results showed that the modified carbonized green plant waste was an excellent water treatment agent [6-9], which was of great practical significance for realizing the resource utilization of some solid wastes in cities [10-13].

2 Experimental Part

2.1 Materials, Reagents and Instruments

The selected branches and weeds came from Chengdu city. Zinc chloride, concentrated sulfuric acid, potassium hydroxide, iodine, potassium iodide, sodium thiosulfate and soluble starch, all of which were analytically pure.

Electric heating constant temperature blast drying oven: DHG-9140; Visible spectrophotometer: V-1200; Water bath oscillator: THZ-032; Electronic analytical balance: ESG220-4; pH meter: PHBJ-260; Mesh screen: 20 mesh, 50 mesh and 100 mesh; Universal electric furnace: DL-1.

2.2 Preparation of Modified Carbon from Urban Greening Waste

On the basis of the previous research [14-16], branches and weeds were used as raw materials to prepare activated carbon, and chemical activation method was adopted in this experiment. The activators were zinc chloride, potassium hydroxide and concentrated sulfuric acid respectively. Cleaning with distilled water, drying in an electric constant temperature air drying furnace at 100℃, and cutting 5cm strips. The dried raw materials were placed in a muffle furnace and heated to 800℃ at a heating rate of 10℃/min for 90 min. After cooling to normal temperature, they were taken out and sieved (40-60 mesh). The carbonized waste was mixed with 3mol/L $ZnCl_2$, 3mol/L KOH and 37% H_2SO_4 in a 100mL conical flask with a plug according to the mass ratio of 1:3. After oscillation, the solid modified carbonized waste was filtered, which was washed with 1:9 dilute hydrochloric acid solution (1mol/L), washed repeatedly with distilled water to neutrality, dried to constant weight, ground and screened out activated carbon below 200 mesh for later use [3,17-19].

2.3 Drawing of Reactive Brilliant Blue X-BR Standard Curve

Measure the absorbance of different concentrations, as shown in Table 1. Draw the standard curve of reactive brilliant blue X-BR, as shown in Figure 1.

Table 1. Measurement of absorbance of reactive brilliant blue X-BR with different concentrations

Concentrations (mg/L)	0	4	8	12	16	20	24	28	32
Absorbance	0	0.02	0.036	0.054	0.072	0.09	0.107	0.124	0.145

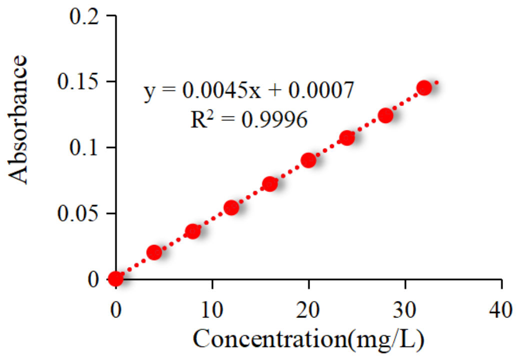


Figure 1. X-BR standard curve of reactive brilliant blue

Table 2. Experimental data of iodine adsorption value

Kind	**Active agent**	**Average consumption of sodium thiosulfate (mL)**
weeds	KOH	6.1
	$ZnCl_2$	6.8
	H_2SO_4	6.8
limb	KOH	7.3
	$ZnCl_2$	6.27
	H_2SO_4	7.1

3 Experimental Process

3.1 Determination of Iodine Value of Modified Carbon from Urban Greening Waste

In this experiment, the iodine value of carbonized branches was determined by the national standard GB/T12496.8-1999 "Test Methods for Wood Activated Carbon-Determination of Iodine Adsorption Value", as shown in Table 2. It can be clearly seen that the iodine value obtained by activating and modifying branches with zinc chloride ($ZnCl_2$) was relatively large and the adsorption efficiency was good [4]. Therefore, the branches activated and modified by zinc chloride were the main choice in the follow-up experiments.

3.2 Single Factor Experiment

3.2.1 Effect of dosage on decolorization rate

Results as shown in Figure 2, within a certain range, with the increase of carbon dosage, the decolorization rate increased, and when the carbon dosage was 2.8g, the decolorization rate reached the maximum. When the dosage reached a certain amount, the adsorption effect basically reached the limit, so the dosage should be determined according to the actual situation. Although the adsorption effect at 2.8g was the best, the adsorption effect basically reached the limit. Therefore, the effect was not obvious if the dosage was continuously increased.

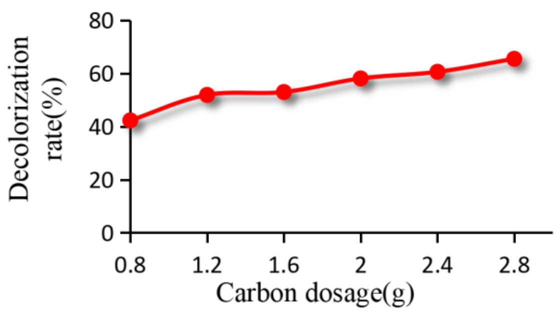


Figure 2. Effect of carbon dosage on decolorization rate

3.2.2 Effect of ph on decolorization rate

The experimental results were shown in Figure 3. When pH value was 2, the decolorization rate of modified carbon was the highest. Which can reach 80%, with the increase of pH value, the decolorization rate decreased obviously. Because it had better adsorption effect under acidic conditions. In strong alkaline solution, it was not conducive to the adsorption of pigment on the surface of activated carbon. Under alkaline conditions, substances carried by activated carbon will dissolve into the solution, resulting in poor adsorption effect.

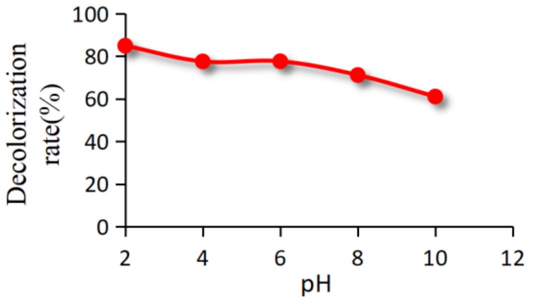


Figure 3. Effect of pH on decolorization rate

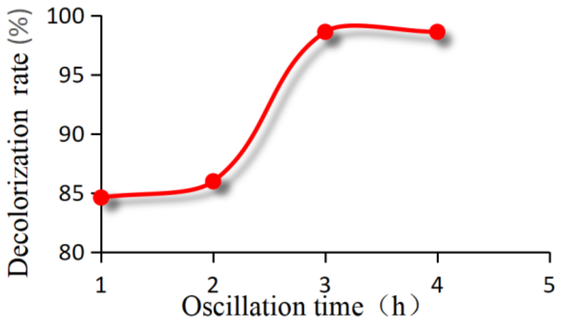


Figure 4. Effect of oscillation time on decolorization rate

3.2.3 Influence of oscillation time on decolorization rate

The experimental results were shown in Figure 4. With the increase of oscillation time, the decolorization rate increased significantly and tended to balance after 3h, so the highest decolorization rate reached 98.60% when the oscillation time was 3h. In the experiment, the mixture of activated carbon and adsorbed substances was oscillated to make them fully contact, and the effect of activated carbon was brought into full play.

3.3 Orthogonal Experimental Design of Adsorption of Reactive Brilliant Blue X-BR by Modified Carbon FROM Urban Greening Waste

In the experimental design of this paper, the combination of key factors and levels were arranged according to the orthogonal test method [20-21]. For example, the decolorization rate of reactive brilliant blue X-BR was selected as an index to optimize the conditions of adsorption of reactive brilliant blue X-BR by modified carbonized branches. The optimal conditions for decolorization rate test of modified carbon adsorption active brilliant blue X-BR were shown in Table 3.

Table 3. Optimum conditions of modified carbon adsorption reactive brilliant blue X-BR test

Group	Adsorption time (min)	Oscillation speed (r/min)	Carbon dosage (g/L)	pH
1	60	100	2	1.8
2	60	150	2.4	2.8
3	60	200	2.8	3.8
4	120	100	2.4	3.8
5	120	150	2.8	1.8
6	120	200	2	2.8
7	180	100	2.8	2.8
8	180	150	2	3.8
9	180	200	2.4	1.8

3.4 Analysis of Orthogonal Experimental Results

In this paper, the main index of orthogonal experiment was the decolorization rate of reactive brilliant blue X-BR. When analyzing the results, the decolorization rate was analyzed by the range analysis method of orthogonal experiment, and the influence of each factor on the experimental index was discussed. Finally, on the basis of the above analysis of decolorization rate, the influence of various factors and levels on experimental indexes were comprehensively analyzed, and the most combination of factors and levels were given.

According to the range analysis method of orthogonal experiment, the decolorization rate of reactive brilliant blue X-BR was visually analyzed, and the calculated results were shown in Table 4 .

Table 4. Visual analysis table of decolorization rate by orthogonal test

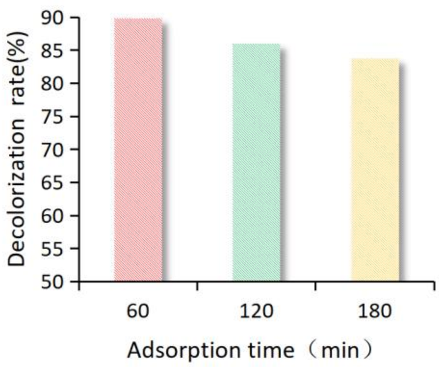
Serial number	Adsorption time (min)	Oscillation speed (r/min)	Carbon dosage (g/L)	pH	Decolorization rate
1	60	100	2	1.8	98.20%
2	60	150	2.4	2.8	98.81%
3	60	200	2.8	3.8	72.60%
4	120	100	2.4	3.8	59.90%
5	120	150	2.8	1.8	100.00%

6	120	200	2	2.8	98.00%
7	180	100	2.8	2.8	94.43%
8	180	150	2	3.8	56.80%
9	180	200	2.4	1.8	100.00%
k1	0.8987	0.841766667	0.843333333	0.994	
k2	0.859666667	0.852033333	0.862366667	0.9708	
k3	0.837433333	0.902	0.8901	0.631	
R	0.061266667	0.060233333	0.046766667	0.363	

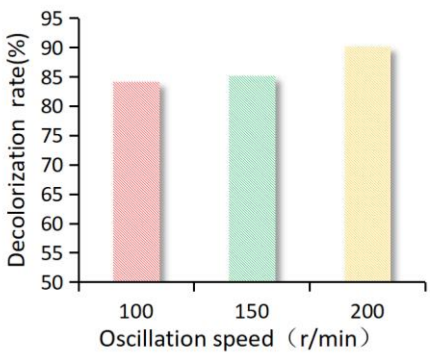
K1, k2 and k3 in the above table represented the decolorization rate of each factor at level 1, level 2 and level 3, respectively, welcoming the influence of different levels of each factor on the decolorization rate, and getting the best level of this factor. The range R of decolorization rate under different levels of a certain factor was used to reflect the influence of the level change of the factor on decolorization rate. The larger the range, the more important the factor was, and vice versa.

According to the analysis, the factors affecting the decolorization rate of reactive brilliant blue X-BR in this orthogonal experiment were mixed solution pH, adsorption time, oscillation speed and carbon dosage. That was to say, the combination of factors to obtain higher decolorization rate was five groups with adsorption time of 120min, oscillation speed of 150r/min, carbon dosage of 2.8g and pH=1.8, and nine groups with adsorption time of 180min, oscillation speed of 200r/min, carbon dosage of 2.4g and pH=1.8 .

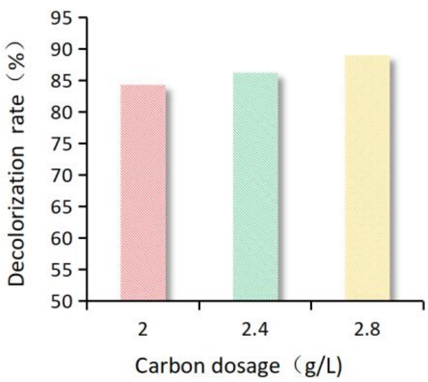
The effect graph was an image description of the intuitive analysis table of orthogonal experiment, and the average value of each level result of each factor in Table 4 was expressed by the effect graph, as shown in Figure 5 .



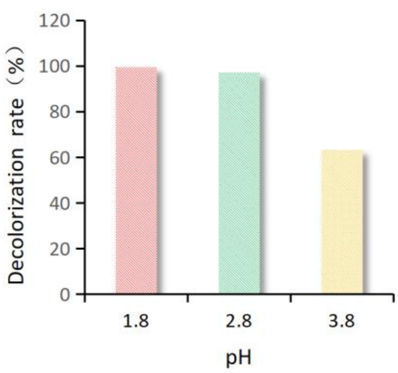
(a) adsorption time



(b) oscillation speed



(c) carbon dosage



(d) pH

Figure 5. Visual analysis effect curve of decolorization rate

4 Conclusion

In this experiment, orthogonal experiment and single factor method were used to explore the best adsorption conditions of active brilliant blue X-BR by carbonized active branches and the influence of various factors on adsorption. After analysis, in the process of exploring the adsorption time, when the adsorption time was more than 3h, the decolorization rate tended to be balanced. Therefore, in order to fully mix the activated carbon with the adsorbed substance, the adsorption time was 4h instead of 3h as the best adsorption time. Therefore, the final optimal adsorption conditions were as follows: adsorption time was 4h, concentration of reactive brilliant blue X-BR was 100mg/L, oscillation speed was 200r/min, dosage was 2.4g/L, and pH value of mixed solution was 1.8. The order of influence of various factors on decolorization rate was: pH of mixed solution > adsorption time > oscillation speed > dosage.

Acknowledgements

This research was financed by the Meat Processing Key Laboratory Foundation of Sichuan Province (No.18-R-17, No.20-R-07), the National Natural Science Foundation of China (No.31600253) and the Education Department Foundation of Sichuan Province (No.18ZA0119).

References

[1] Wang, F.; Li, H.Y. Resource utilization and prospect for the greening waste. *China Development* **2014**, 14(1), 5-11.

[2] Fan, S.Y. Study on degradation of reactive brilliant blue X-BR simulated dye wastewater by TiO_2 expanded perlite. *Liaoning University of Science and Technology* **2014**.

[3] Wen, G.F.; Yin, C.L.; Lan, Q.; Wang, X.F.; Huang, Q.Z.; Yang, X.; Meng, J.L.; Meng, X.Y. Effects of activator types on properties and structure of peanut shell activated carbon. *Journal of Guangxi University (Natural Science Edition)* **2013**, (5), 1245-1250.

[4] Qin, C.; Gao, J.M.; Chen, Y. Manufacture and characterization of activated carbon made from abandoned marigold straw. *China Forest Products Industry* **2014**, 41(3), 28-31.

[5] Georgiou, D.; Aivazidis, A.; Hatiras, J. Treatment of cotton textile wastewater using lime and ferrous sulfate. *Water Rescarch* **2003**, 37(9), 2248-2250.

[6] Teng, R. Preparation of Ce/chitosan/fly Ash composite adsorbent and its adsorption on direct dye. *Inner Mongolia Norm. Univ.* **2017**.

[7] Zhang, W.W.; Yao, R.; Chen, L. Research progress in the treatment of dye wastewater by advanced oxidation technology. *Water Pol. Treat.* **2018**, 6(04), 159-164.

[8] Gong, Z.Y. Water quality characteristics and treatment technologies of dyeing wastewater. *Jiangxi Chem. Ind.* **2017**,(04), 24-27.

[9] Hunag, Y.Y. Research progress of agricultural waste as biomass adsorbent for wastewater treatment. *Appl. Chem. Ind.* **2017**, 46(2), 368-372.

[10] Yan, Y. Adsorption of phenol from carbonized pomelo peel. *Jiangsu Agric. Sci.* **2016**, 44(08), 481-483.

[11] Li, H.Z.; Sun, Z.B.; Zhang, L.; Tian, Y.X. A cost-effective porous carbon derived from pomelo peel for the removal of methyl orange from aqueous solution. *Colloid Surface A* **2016**, 489.

[12] Hao, Y.G.; Wang, Z.; Wang, Z.G.; He, J.J. Preparation of hierarchically porous carbon from cellulose as highly efficient adsorbent for the removal of organic dyes from aqueous solutions. *Ecotox. Environ. Safe.* **2019**, 168, 1.

[13] Meng, F.Q.; Lu, D.F. Research progress of dyeing wastewater treatment technology. *Environ. Dev* **2018**, 30(2), 103-103.

[14] Zeng, Y.G.; Li, W.Y.; Huang, J.; Huang, Z.W.; Wang, J.; Qian, J.; Yuan, A.; Du, T.T.; Hu, Y.Q.; Li, D.G. Study on new rural domestic sewage treatment technology based on CASS and VBF. *Bulgarian Chemical Communications* **2017**, 49(1), 176-182.

[15] Zeng, Y.G.; Li, W.Y.; Wang, L.L.; Du, T.T.; Huang, J.; Huang, Z.W.; Wang, J.; Tang, J.L.; Wang, M.K.; Wang, J.M.; Jiang, C.Y.; Yang, P. Study on the Kinetics of the adsorption of reactive brilliant red K-2BP onto modified soybean straw activated carbon. *Desalination and Water Treatment* **2018**, (125), 302-309.

[16] Zeng, Y.G.; Li, W.Y.; Luo, L.; Du, T.T.; Yang, P.; Xu, Q.; Liu, J.J.; Shen, J.W.; Zeng, Y.; Li, X.; Chen, X.X.; Jia, R.X. Research on adsorption and mechanism of modified carbonized straw on wastewater containing Cr^{6+} by response surface methodology. *Applied Ecology and Environmental Research* **2019**, 17(6), 12985-12999.

[17] Zeng, Y.G.; Huang, J.; Zheng, X.Y.; Luo, L.; Lan, R.; Li, K.; Li, Y.Y.; Ni, Z.H.; Chen, Y.J.; Lin, W.T. Adsorption kinetics study on modified carbonized straw to high concentration nitrogenous waste water. *Journal of Simulation* **2020**, 8(6), 61-67.

[18] Zeng, Y.G.; Huang, J.; Zheng, X.Y.; Zeng, Y.; Lan, R.; Li, K.; Li, Y.Y.; Chen, Y.J.; Lin, W.T. Experimental study on response surface analysis of modified carbonized straw to nitrogenous waste water based on ultrasonic. *International Journal of Computational and Engineering* **2021**, 6(1), 277-283.

[19] Zeng, Y.G.; Zeng, Y.; Huang, J.; Zheng, X.Y.; Luo, L.; Lan, R.; Luo, X.; Chen, Y.J.; Lin, W.T. Adsorption kinetics study on reactive brilliant red K-2BP by modified carbonized pomelo peel. *International Journal of Education and Teaching Research* **2021**, 2(1), 160-166.

[20] Mostafa, K. Response surface modeling of essential oil components from mentha piperita by supercritical fluid extraction:box-behnken experimental design. *Journal of Essential Oil Bearing Plants* **2012**, 15(5), 731-738.

[21] He, B.; Zhang, L.L.; Yue, X.Y.; Liang, J.; Jiang, J.; Gao, X.L.; Yue, P.X. Optimization of ultrasound-assisted extraction of phenolic compounds and anthocyanins from blueberry (vaccinium ashei) wine pomace. *Food Chemistry* **2016**, 204, 70-76.