Study on the Electrochemical Oxidation of Polycyclic Pollutants

Tingchun Yan¹, Yan Geng², Manning Wang³, Songhe Li, Yue Quan*

¹Department of Agricultural Resources and Environment, Yanbian University, Yanji, Jilin, 133002, P.R. China
*Corresponding author’s e-mail: quanyue@ybu.edu.cn

Abstract. In this study, electrochemical method was used to treat Rhodamine B (RB) wastewater. This paper discussed the influence of electrolysis time, voltage, electrolyte concentration and wastewater concentration on the decolorization rate of RB. The results showed that when the concentration of RB wastewater was 100.0 mg/L, 1.5 L, cathode was titanium mesh, anode was stainless steel mesh, electrode distance was 3.0 cm, 0.10 mol/L KCl was electrolyte, aeration volume was 1.20 L/min, voltage was 7.0 V, electrolysis time was 30.0 min, decolorization rate was 98.0%; the concentration wastewater was 150.0 mg/L, decolorization rate reached 95.49%.

1. Introduction
Rhodamine B (RB) is a synthetic organic compounds, that has a long chain and polycyclic structure and difficult to remove from the environment[1]. It causes serious environmental pollution and damages to the human health[2]. Currently, the removal methods for RB include photocatalysis[3], electrochemical oxidation[4-5], Fenton[6] and ultrasonic degradation[7-8]. Electrochemical technology has the advantages of sensitive, non-toxic and no secondary pollution etc. It was called "environment-friendly" technology. Compared with other methods, Electrochemical technology has great potential in green technology[9-10].

So, in this experiment, the effect of electrolysis time, voltage and electrolyte concentration on decolorization rate to RB wastewater were investigated. The results of this research could provide the theory foundation for the electrochemical treatment of polycyclic structure pollutant.

2. Materials and methods

2.1. Experimental materials
The electrolysis was performed in a reactor having 1.50 L of working volume. Stainless steel mesh and titanium mesh were used as anode and cathode, respectively. The effective area of positive and negative electrodes was 10.0 mm×8.0 mm, and the electrode distance was adjustable. The reactor was equipped with microporous aeration device with 1.20 L/min aeration rate.

2.2. Analysis methods
The concentration of RB wastewater was analyzed via a 723 spectrophotometer at the maximum wavelength of 550.0 nm.
2.3. Design of experiments
1.5 L RB wastewater was added to the reactor with KCL electrolyte, the electrode distance was adjusted, and a certain voltage was applied to the two electrodes. An oxygen-filled pump was placed at the bottom of the tank, and oxygen was supplied for the electrode reaction to achieve the purpose of uniform mixing. The aeration rate was 1.2 L/min. After a certain electrolysis time, two parallel samples were taken each time, diluted, and the absorbance was determined. The average absorbance of parallel samples was used to calculate the decolorization rate of wastewater. Each experiment was repeated 3 times and the average value was taken.

First the effects of electrolysis time, voltage and electrolyte concentration on electrolytic decolorization rate were discussed. Next the effect of RB wastewater concentrations on decolorization rate were also investigated.

3. Results and analysis

3.1. Effect of electrolysis time
As shown in Fig.1, the decolorization rate of RB wastewater increased with the decolorization time increased, and finally tended to stable. When the decolorization time less than 30.0 min, the decolorization rate of RB wastewater increased rapidly for 89.86%. Then, the decolorization rate increased slowly after 40.0 min. Lastly, the decolorization rate decreased after 70.0 min. With electrolysis time increased, the electric energy consumed greatly. So, 40.0 min electrolysis time was selected for the next step, and the decolorization rate was 90.08%.

![Fig.1 Effect of electrolysis time on decolorization rate](image)

3.2. Effect of voltage
As shown in Fig.2, when the electrolysis time was 40.0 min, the decolorization rate increased with the increased of voltage until 7.0 V. Once the voltage exceeded 7.0 V, decolorization rate becomes less notable. The more energy was consumed with voltage increased. Therefore, 7.0 V voltage was selected for the next step, and the decolorization rate was 99.11%.
3.3. **Effect of electrolyte concentration**

The change of decolorization rate under different electrolyte concentrations was shown in Fig. 3. Electrolyte concentration has a great influence on decolorization rate. High concentration electrolyte or low concentration electrolyte decreased decolorization rate. The highest decolorization rate was 99.11% when the electrolyte concentration was 0.10 mol/L at 40.0 min. For reasons, with the electrolyte concentration increased, more ·OH were generated under the electric field energy, oxidation efficiency were improved. When the electrolyte concentration increased to 0.15 mol/L and 0.20 mol/L, the decolorization rate decreased. For reasons: high concentration electrolyte generated much Cl⁻, it was adsorbed on the anode surface and decreased conductivity; in addition, the side reaction of hydrogen evolution on the cathode increased. In summary, the concentration of 0.10 mol/L KCL was selected for further experiments.

3.4. **Effect of wastewater concentration**

Fig. 4 showed effect of RB wastewater concentrations on decolorization rate. Decolorization rate achieved better results for low concentration RB wastewater. When RB wastewater concentration was 50.0 mg/L and 100.0 mg/L, the decolorization rate were 98.51% and 98.54% at 30.0 min. For 150.0 mg/L wastewater, the decolorization rate increased with the electrolysis time increased, and the maximum decolorization rate was 95.49% at 40.0 min. Therefore, for high concentration wastewater, good decolorization rate can also be achieve by prolonging the electrolysis time. In summary,
reasonable electrolysis time were chosen for different concentrations wastewater to meet the discharge standard and save electricity cost.

![Decolorization rate vs Electrolysis time](image)

**Fig.4** Effect of wastewater concentration on decolorization rate

### 4. Conclusion

The results showed that an effective decolorization effect on RB wastewater was obtained. It indicated that electrochemical treatment is an efficient method to polycyclic pollutants and dye wastewater. For 1.5 L RB wastewater with 100.0 mg/L, 30.0 min electrolysis time, stainless steel mesh as anode, titanium mesh as cathode, 0.10 mol/L potassium chloride, 7.0V voltage, the decolorization rate reached 98.0%; and for 150.0 mg/L RB wastewater, the decolorization rate reached 95.49% at 40.0 min.

### Acknowledgements

This work was supported by the National Natural Science Foundation of China (No. 51968073), the scientific and technological research project of Jilin Education Department (No. JJKH20191127KJ) and university student innovation and entrepreneurship training programs of Jilin (No. 202010184011, No. 202010184021).

### References

[1] Muhammad T., Mamriz M., Jehangeer K. (2020) Removal of rhodamine B dye from aqueous solutions using photo-Fenton processes and novel Ni-Cu@MWCNTs photocatalyst. J. J MOL LIQ., 312(10): 113399.

[2] Singh, S., Parveen, N., Gupta, H. (2018) Adsorptive decontamination of rhodamine-B from water using banana peel powder: a biosorbent. J. ENVIRON TECHNOL INNO., 12:189-195.

[3] Hegazy R.M., Ehab A., et al. Abdelrahman. (2020) Facile fabrication of hematite nanoparticles from Egyptian insecticide cans for efficient photocatalytic degradation of rhodamine B dye. J. J MATER RES TECHNOL., 9: 1652-1661.

[4] Dong W., Hui Q.L., Xiu L.Z., et al. (2020) The influence of pulse magnetic field intensity on the morphology and electrochemical properties of NiCoS alloys. J. SURF COAT TECH., 403(15): 126406.

[5] Lu P., Huang L., Shao C.L., et al. (2007) Study on Oxidative Degradation of Rhodamine RhB Water Solution by Potassium Ferrate. J. ENVIRON CHEM, 26(3):366-370.

[6] Li C. (2008) Study on Ultrasonic Degradation of Rhodamine B. and Liaoning. J. CHEM IND CHEM ENG Q., 37(7):478-480.
[7] Muhammad T., Mamriz M., et al. (2020) Removal of Rhodamine B dye from aqueous solutions using photo-Fenton processes and novel Ni-Cu@MWCNTs photocatalyst. J. J MOL LIQ., 312: 113399.

[8] Vinod K., Manjeet S., et al. (2020) Ionic liquid induced removal of Rhodamine B from water. J. J MOL LIQ., 319: 114195.

[9] Shi, C., Feng, J.W., Peng, S.C. (2013) Adsorption of activated carbon fiber to rhodamine B in water. J. ENVIRON CHEM., 32(3): 394-401.

[10] Flamur S., Manuel A. R., Nihal O., et al. (2015) Influence of the anode materials on the electrochemical oxidation efficiency. Application to oxidative degradation of the pharmaceutical amoxicillin. J. CHEM ENG J., 262(15): 286-294.