Experimental Study on Photoelectric Cooperative Treatment of RDX Wastewater

H.X.Duan¹*, L.N.Bao², W.Z.Zhang³
¹,²,³Shenyang ligong University School,Shenyang, Liaoning,China
*Corresponding author,e-mail:duanhaixia@sylu.edu.cn

Abstract: RDX wastewater is a kind of wastewater containing energetic materials that is difficult to biochemically degrade.It is highly toxic and difficult to treat.In this paper, the synergetic treatment of RDX wastewater by ultraviolet light and three-dimensional electrode method is proposed. The optimum combination of 5mm carbon particles, 28W UV lamp and 3cm distance between electrodes was used in the experiment. The optimal experimental conditions were finally determined as follows: pH value is 6.6, carbon particle addition is 7.0g, NaSO₄ addition is 6.5g, electrolysis voltage is 7V, and reaction time is 70min. After 7 parallel experiments, the RDX removal effect is stable.

1. Introduction
Energetic materials refer to compounds or mixtures that contain explosive groups or contain oxidants and combustibles that can independently undergo chemical reactions and output energy. Roxygold wastewater belongs to nitrogen heterocyclic compounds. The Chinese name is cyclotrimethytriammonium nitrate, which is a very explosive cyclic nitro group. It belongs to waste water containing energetic materials that is difficult to biochemically degrade, and it is more harmful to the nervous system. Roxykin industrial water pollution discharge standard is 1.50mg/L. The treatment of Hexogen wastewater has always been an important research topic. At present, the main treatment methods are ozone oxidation method⁴,¹²,¹³, wet oxidation method⁶, biochemical method⁷,¹³, supercritical oxidation method and Fenton reagent method⁴,¹²,¹³. Each method has advantages and disadvantages. In this paper, the ultraviolet light-three-dimensional electrode method¹,⁸ is used to treat RDX wastewater, which has the characteristics of simple operation and high treatment efficiency.

2. Experimental water and main analysis methods
The test water uses self-prepared simulated RDX wastewater with a concentration of 30mg/L and pH=6.6. The determination of COD adopts fast airtight catalytic digestion method; pH value is measured with acidity meter. Dilute acid and dilute alkali are used for acidity adjustment.

3. Experimental results and discussion
3.1. Optimization of experimental conditions
Take 500ml of RDX simulated wastewater and put it in a self-made electrolytic cell. The cathode is a titanium plate, the anode is Ti/TiO₂-RuO₂-IrO₂, the spacing is 3cm, and the particle electrode is 5mm granular activated carbon. 2 UV tubes with a light intensity of 28mW/cm². On the basis of laboratory single factor experiments, the experimental conditions were optimized. This research choose five factors that have a greater impact in the experiment to optimize the experiment. The experimental
results are shown in Table 1 and Table 2.

**Table 1 Factors-Level Table**

| Level | pH value | The amount of carbon particles added/g | NaSO₄ addition amount/g | Electrolysis voltage /V | Processing time/min |
|-------|----------|----------------------------------------|------------------------|------------------------|---------------------|
| 1     | 3.5      | 5.5                                    | 1.5                    | 6                      | 70                  |
| 2     | 6.6      | 4.0                                    | 2.75                   | 6.5                    | 50                  |
| 3     | 8.0      | 6.5                                    | 2.0                    | 7                      | 85                  |
| 4     | 10.0     | 7.0                                    | 2.5                    | 5                      | 80                  |

According to Table 1, perform optimization experiments. The experimental results are shown in Table 2.

**Table 2 Orthogonal experiment results**

| Serial number | pH value | The amount of carbon particles added/g | NaSO₄ addition amount/g | Electrolysis voltage /V | Processing time/min | RDX removal rate(%) |
|---------------|----------|----------------------------------------|------------------------|------------------------|---------------------|---------------------|
| 1             | 3.5      | 5.5                                    | 1.5                    | 6                      | 70                  | 90.12               |
| 2             | 3.5      | 4.0                                    | 2.75                   | 6.5                    | 50                  | 88.58               |
| 3             | 3.5      | 6.5                                    | 2.0                    | 7                      | 85                  | 86.80               |
| 4             | 3.5      | 7.0                                    | 2.5                    | 5                      | 80                  | 82.35               |
| 5             | 6.6      | 5.5                                    | 2.75                   | 7                      | 85                  | 94.32               |
| 6             | 6.6      | 4.0                                    | 1.5                    | 5                      | 80                  | 91.18               |
| 7             | 6.6      | 6.5                                    | 2.5                    | 6                      | 50                  | 90.61               |
| 8             | 6.6      | 7.0                                    | 2.0                    | 6.5                    | 70                  | 92.15               |
| 9             | 8.0      | 5.5                                    | 2.0                    | 5                      | 50                  | 80.65               |
| 10            | 8.0      | 4.0                                    | 2.5                    | 7                      | 70                  | 84.5                |
| 11            | 8.0      | 6.5                                    | 1.5                    | 6.5                    | 85                  | 81.08               |
| 12            | 8.0      | 7.0                                    | 2.75                   | 6                      | 80                  | 88.65               |
| 13            | 10.0     | 5.5                                    | 2.5                    | 6.5                    | 85                  | 84.75               |
As shown in Table 2, among the five influencing factors, the influence of treatment time and electrolyte concentration dominates. The fifth group of RDX wastewater removal experiment conditions are: pH value is 6.6, the addition amount of carbon particles is 5.5 g, the addition amount of NaSO4 is 2.75 g, the electrolysis voltage is 7 V, and the reaction time is 85 min. Considering that the RDX removal rate of the eighth group of experiments is 92.15% and that of the fifth group of experiments, the reaction time is only 70 minutes, and the energy consumption is smaller than that of the fifth group of experiments. Finally, the eighth set of experimental conditions were adopted as the optimal experimental conditions: pH value was 6.6, carbon particle addition amount was 7.0 g, NaSO4 addition amount was 6.5 g, electrolysis voltage was 7 V, and reaction time was 70 min.

3.2. Verification of optimal experimental conditions
Under the best experimental conditions, conduct parallel experiments to verify the stability of the treatment effect. The experimental results are shown in Figure 1.
4 Conclusion
The experimental research on the treatment of RDX wastewater by ultraviolet light-three-dimensional electrode has led to the following conclusions:

1) The experiment was carried out with a UV lamp with a titanium plate as the cathode, Ti/TiO2-RuO2-IrO2 as the anode, 3cm spacing, 5mm granular activated carbon as the particle electrode, and 28mW/cm² light intensity. The optimized experimental conditions were obtained through experimental optimization. The pH value is 6.6, the amount of carbon particles added is 7.0g, the amount of NaSO4 added is 6.5g, the electrolysis voltage is 7V, and the reaction time is 70min.

2) Under the best experimental conditions, the RDX removal rate of seven parallel experiments is relatively stable, with an average of about 92%.

3) The fundamental reason for the treatment of RDX wastewater by the ultraviolet light-three-dimensional electrode method is mainly the result of the direct oxidation process of the electrode and the hydroxyl radical process.

Acknowledgements
This research is grateful to Professor Wang and Professor Cheng of Shenyang Ligong University for their help during the experiment. In addition, I would like to thank the professor Ban of Shenyang Jianzhu University for supporting this research.

References
[1] Wang C T,Hu J L,Chou W L,et al.Removal of color from real dyeing wastewater by electro-Fenton technology using a three-dimensional graphite cathode(2008).J.Journal of Hazardous Materials,152(2):601-606.
[2] Wang Liang.Research on degradation of RDX wastewater by UV/Fenton reagent(2010).J.Shanxi Chemical Industry,30(2):55-58.
[3] Yuan Fengying Qin Qingfeng.Research on UV-assisted Fenton Advanced Oxidation Technology for Treatment of Raspberry Wastewater .J.Journal of North University of China,27(6):511-514.
[4] Ai Cuiling.Experimental study on O3 oxidation treatment of explosive wastewater containing RDX(2007).J.Energetic materials,15(2):178-180.
[5] Chai Jia.Research on the treatment technology of waste water from the demolition of the simulated RDX(2015).D. North University of China.
[6] Fang Qi.Research on wet catalytic oxidation method for treating Raspberry Wastewater(2005).D. Nanjing University of Science and Technology.
[7] Liao Zhengjun.Treatment of TNT-RDX mixed wastewater by anaerobic biochemical tower(2006) J.Sichuan Environment,25 (5):53-55.
[8] Shen Yong.Study on the composition of wastewater and analysis of nitrification mechanism in the process of direct preparation of Roxygen(2014).J.Chemical Industry Progress,33(4):1041-1044.
[9] Zhou Yali.Study on the treatment of explosive wastewater by ultraviolet light combined with Fenton method(2006).D.North University of China.
[10] Zhang Dongxiang.Fenton oxidation and photo-assisted Fenton oxidation for the treatment of wastewater from the RDX recovery process(2007).J.Acta Armamentarii,28(7):867-871.
[11] Wu Kun.Fenton and Fenton-like oxidation process technology progress in the treatment of energetic compound wastewater(2014).J.Chemical Propellants and Polymer Materials,13(2):56-60.
[12] Ai Cuiling.Experimental study on degradation of RDX in explosive industrial wastewater by O3, O2/H2O2/O3/H2O2/UV process(2013).J.Safety and Environmental Engineering,20(1):56-59.
[13] Liang Xiaoxian.Experimental study on RPB-O3/H2O2 method for the treatment of riparian wastewater(2012).J.Modern Engineering,32(9):89-92.