The study of a new type of micro-electrolysis technology on aniline wastewater treatment

Jing WANG[1,a], Xin Luo[1,b], Yinping Huang[1,c] , Yang Liu [1,d]

[1]Department of Environmental Engineering, North China Institute of Science and Technology, East Yanjiao, Beijing, China, 065201, P.R. China

[a]wangjing88583137@163.com (corresponding author), [b]luoxin@163.com, [c]cqkun@163.com

Keywords: Fly ash; Iron-carbon micro-electrolysis; Aniline wastewater; Single-factor experiment; Orthogonal experimental .

Abstract. In this work, a new type of micro-electrolysis technology using combined materials containing fly ash, iron scraps and lanthanon Gd on the treatment of toxic and harmful aniline wastewater was presented. Fly ash was applied instead of activated carbon in the combined materials and single-factor experiment was conducted to determine and optimize the relevant influence factors on the removal rate of aniline. Both the main and minor factors and the optimum levels influencing the aniline removing property were determined via the orthogonal experimental design. The results showed that the rank of each factor for removing ratio of aniline from better to less was respectively: pH, lanthanon Gd dose, reaction duration and mass ratio of fly ash and iron. The optimal combined conditions were 3.50, 16 mL, 1.50 h and 1:2, respectively. The experiment data of the removal rate of aniline was 86.7%. In addition, the removal efficiency was improved by 15.3% with the addition of lanthanon Gd.

Introduction

Aniline wastewater has the characteristics of high toxicity, high oxygen demand and difficult biodegradability, etc. Aniline is now recognized as one of the high toxic and carcinogenic substances in the world. It is also one kind of harmful wastewater needed to be focused on in China [1,2].

Iron-carbon micro-electrolysis technology is one of the methods to treat organic wastewater [3~5], which is based on electrochemical principle of metal corrosion and dissolution. Nowadays, the researches on micro-electrolysis are inclined to the consideration of iron carbon micro-electrolysis. However, few researches are focused on the problem of replacement of filler, especially on replacing original filler with solid waste. The rare earth has the special 4f electronic structure, unusually rich electronic energy levels and very lively chemical properties. Studies show that the unique catalytic effect and strong adorability of rare earth metals have been confirmed in the field of water treatment [2,6]. This paper proposes a new kind of micro-electrolysis method to treat the toxic and harmful aniline wastewater by a micro-electrolysis method, which replaces active carbon with coal ash, use waste iron scraps and a certain amount of catalytic rare earth Gd. This paper provides a new way for the recycling of solid waste coal ash and seek a new treatment method for aniline wastewater which containing toxic and harmful organic pollutants to realize treating wastes with wastes and reducing the emission of pollutants.

Experimental

Waste iron scraps after wash and soak iron scraps of particle size 3 ~ 8mm with washing powder and dilute sulfuric acid, rinse with distilled water, and set aside. Coal ash (Tangshan Datang International DouHe Power Plant): firstly, wash with water and dry it, then, immerse 48 h by analog aniline solution to make it saturated. The aniline solution with a concentration of 200mg/l was used as the analog aniline wastewater.

The treated waste iron scraps and coal ash were mixed in a certain proportion in the 250ml beaker, and then a certain amount of analog aniline wastewater was added. The mixture was stirred in the speed 150 r/min. The main influence factors on the treatment effect of analog aniline wastewater was investigated, including ratio of coal ash/iron scraps, pH, reaction time, and the dosage of rare earth Gd.

Aniline remove rate is calculated using the formula following:

$$\eta = (C_0 - C_t)/C_0 \times 100\%$$

where, η ——the aniline removal rate of wastewater in the reaction

C_0——the aniline concentration of initial wastewater

C_t——the aniline concentration of treated wastewater

Results and Discussion

Single-factor experiment

The influence of the mass ratio of coal ash/iron scraps on aniline removal rate. 100ml aniline wastewater with concentration of 200mg/L and 1g iron scraps were mixed. The mass ratio of coal ash/iron scraps were changed from 1:1 to 3.5:1 in order to investigate the influence of the mass ratio of coal ash/iron scraps on aniline removal rate. The experimental results were shown in Figure 1. With the increase of the mass ratio of coal ash/iron scraps, the aniline removal rate was on a downward trend.When the mass ratio of coal ash/iron scraps was 1:1~1.5:1, the aniline removal rate was larger, up to 65.2~63.1%.

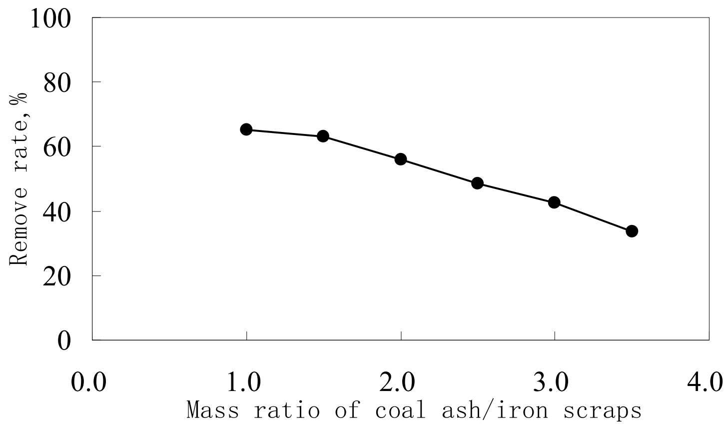

Fig.1 The influence of the mass ratio of coal ash/iron scraps on aniline removal rate

The influence of pH on aniline removal rate. The mass ratio of coal ash/iron scraps was1:1. To investigate the influence of pH on aniline removal rate. The pH values were adjusted to 2, 3, 4, 5 and 6, respectively. The experimental results were shown in Figure 2.

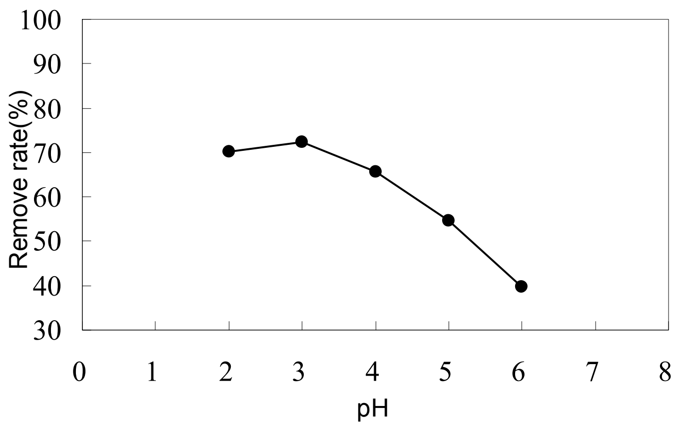

Fig.2 The influence of pH on aniline removal rate

The lower pH was conducive to the removal of aniline. The removal rate of aniline was higher when pH was 3, up to about72.4%. After that, with the increase of pH, the removal rate of aniline decreased rapidly. As can be seen, the pH was determined as 3.

The influence of reaction time on aniline removal rate. The effects of reaction time on aniline removal rate experimental results were shown in Figure 3. We can see that with the extension of reaction time, the aniline removal rate was continuously increasing. When the reaction time was 1.5h, the aniline removal rate reached 71.2%, and the increasing trend became gradually stable after 1.5h. So the reaction time was determined as 1.5h.

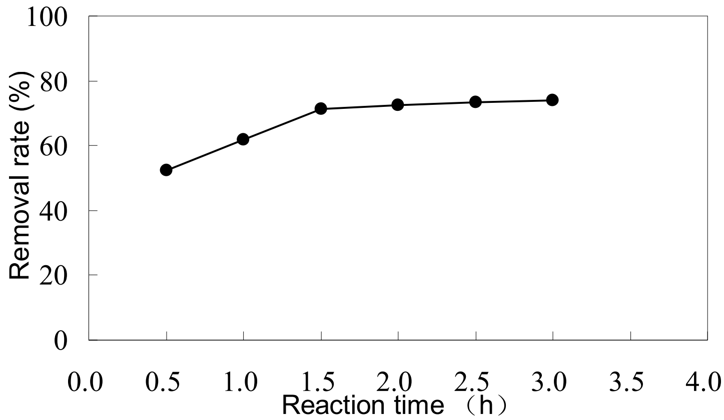

Fig. 3 The influence of reaction time on aniline removal rate.

The influence of rear earth Gd dosage on aniline removal rate. The experimental results were shown in Figure 4. The aniline removal rate increased with the increase of rare earth Gd dosage. The removal rate of aniline reached 84.5% when the dosage of rare earth Gd was 16ml. The removal rate of aniline was about 15.3% higher than that of without rare earth Gd. So the dosage of rare earth Gd was determined as 16 ml.

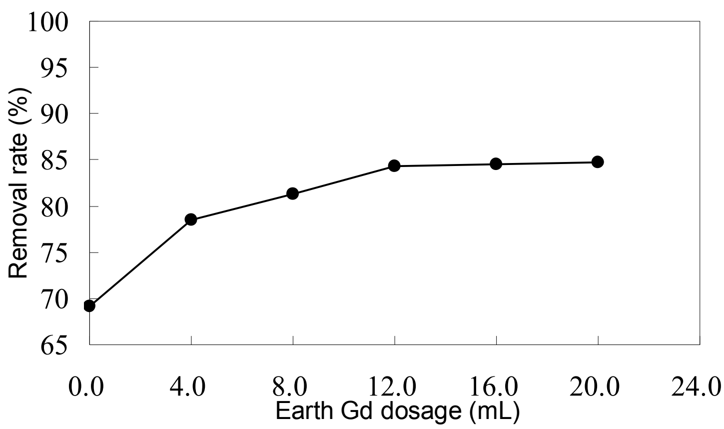

Fig. 4 The influence of rear earth Gd dosage on aniline removal rate

The orthogonal experiment

According to the single factor experiment results, the main factors and the level range of each factor in orthogonal experiments of aniline wastewater was confirmed, which treated by micro-electrolysis method that replace active carbon with coal ash. These factors are expressed by A, B, C and D, respectively. The main influence factors include mass ratio of coal ash/iron scraps ,pH, reaction time and the dosage of rare earth Gd. Choose three levels of each factor. Design the Orthogonal table as $L_9(3^4)$. As shown in Table 1 and the results were shown in Table 2.

Table 1 Orthogonal table

Factors / levels	A （Mass ratio of coal ash/iron scraps）	B （pH）	C （Reaction time/h）	D （Dosage of rare earth Gd /ml）
1	1：2	2.5	1	8
2	1：1	3.0	1.5	12
3	2：1	3.5	2	16

Table 2 Orthogonal experiment results table

Factors / NO.	A （Mass ratio of coal ash/iron scraps）	B （pH）	C （Reaction time/h）	D （Dosage of rare earth Gd /ml）	Removal rate of aniline /%
1	1：2	2.5	1	8	63.7
2	1：1	2.5	1.5	12	70.1
3	2：1	2.5	2	16	76.5
4	1：1	3.0	1	16	75.7
5	2：1	3.0	1.5	8	71.2
6	1：2	3.0	2	12	76.8
7	2：1	3.5	1	12	80.2
8	1：2	3.5	1.5	16	86.7
9	1：1	3.5	2	8	83.4
K1	227.2	210.3	219.6	218.3	
K2	229.2	223.7	228.0	227.1	
K3	227.9	250.3	236.7	238.9	
R	2.0	40.0	17.1	20.6	

The experimental results showed that: the order of influence factors of aniline wastewater treatment by micro-electrolysis was pH > dosage of rare earth Gd > reaction time > mass ratio of coal ash/iron scraps. The optimal combination was $A_1B_3C_2D_3$. Namely, the mass ratio of coal ash/iron scraps 1:2, pH 3.5, reaction time 1.5h, the dosage of rare earth Gd solution 16ml. Under the optimal experimental conditions, the removal rate of aniline was86.7%.

Conclusions

In this work, the micro-electrolysis method could replace active carbon with coal ash and use waste iron scraps and catalytic rare earth Gd to treat the toxic and harmful aniline wastewater. The experimental results showed that the order of influence factors of aniline wastewater treatment by micro-electrolysis was pH > dosage of rare earth Gd > reaction time > mass ratio of coal ash/iron scraps. The optimal combination was $A_1B_3C_2D_3$. Namely, the mass ratio of coal ash/iron scraps 1:2, pH 3.5, reaction time 1.5h, the dosage of rare earth Gd solution 16ml. Under the optimal experimental conditions, the removal rate of aniline was86.7%. The rare earth Gd on aniline wastewater treatment had a better catalytic effect, which was an important factor affecting the removal rate of aniline. The aniline removal rate increased about 15.3%.

Acknowledgements

This work was supported by the construction of Key Laboratory fund project of North China Institute of Science and Technology (Basic scientific research business of the Central University, Grant No. 3142014017)

References

[1] ］Li W． , Barrington S． , Kim J． W． Biodegradation of pentyl-amine and aniline from petrochemical wastewater． Environ．Manage． , 2007， 83(2) : 191-197

[2] Xu Jiaqing, Dong Xiaoyi. Study on anaerobic-aerobic biodegradable treatment of aniline wastewater [J]. Chinese Journal of Environmental Engineering 2011, 5(9):2075~2081

[3] T an Ming , Zou Donglei, Zhao Xiaobo. A Study of Ironscurf and Ash Micro- Electrolysis Used in Pretreating Dye- Stuf f Waste Water [J]. Journal of Jilin University (Earth Science Edition) 2004,34:122~125

[4] Pan Quan,，Wang Hui，Yang Yujiao，Song Gongwu. Study on Dyeing Waste Water by Micro-electrolysis [J]. Journal of Hubei University (Nature Science) , 2011, 33(2): 165 ～167

[5] Zou Dong-lei, LI Meng, Zou Hao-chen, Fan Dong- yan, Sun Ming-zheng. Treatment of Benzene in Simulated Polluted Groundwater by New Iron-Carbon Micro-Electrolysis Packing[J]. Journal of Jilin University (Earth Science Edition) 2010,40(6):1441~1445

[6] Guo Yun, Lu Guanzhong. Current Status and Some Perspectives of Rare Earth Catalytic Materials [J]. Journal of the Chinese Rare Earth Socciety,2007,25(1):1~15

