ISSN 2229-5518

Research progress of the physical and chemical treatment of dye wastewater

Li Si, Yang Wei, Cao Chenglong, Wang Yanbo, Yang Shuangchun *
(Liaoning Shihua University. Fushun, Liaoning, China. 113001)

Abstract— With the development of the dye industry, in our country dye-wastewater has become main industrial wastewater. The wastewater increased year by year, which is causing increasingly serious environmental problems. In this paper research progress of the physical and chemical treatment technology of dye wastewater was reviewed such as ozone oxidation, microwave induced catalytic technology, electrochemical oxidation, photo-catalytic oxidation, membrane separation technology and adsorption, and technical advantages and disadvantages of various methods was pointed out.

Index Terms—industrial wastewater; dye wastewater; physical and chemical method; Research progress;

1 Preface

Dye industry with the characteristic of variety of kinds and processes complicated. Dying wastewater containing large amount of organic pollutants and belongs to wastewater difficult to degradation. During the “eleventh five years plan” period, the total output of dye in China is the first one all around the world, and it take proportion of 60% of the total output of the world. According to the environment statistics data from State Statistical Bureau, the daily quantity of wastewater effluent of printing and dyeing industry is $1.8\times10^7 m^3$, and dyeing wastewater is $6.0\times10^6 m^3$ occupies the 40%～50% of the whole industry. Now, the 《The Technical Specification of Printing and Dyeing Wastewater Treatment》 has been published. At present, the research of printing and dyeing wastewater treatment mainly focus on ozone oxidize method, microwave induced catalytic technology, electrochemical oxidation process, photo-catalytic oxidation, membrane separation technology and adsorption method. The research status and progress of physical chemical treatment of dye wastewater technology were introduced in this paper.

2 Research progress of the physical and chemical treatment of dye wastewater

2.1 Ozonation technology

Fenton reagent is the oxidation system constituted by hydrogen peroxide and Fe^{2+}, with the advantages of react quickly, reaction conditions mild, no secondary pollution etc. It is suitable for many industrial wastewater treatments which are difficult to deal with. Qiao Cong [2] treated the phenol refining waste water by Photo/Fenton/$C_2O_4^{2-}$ system. The results show that, when pH is 3, the amount of oxalic acid sodium, $FeSO_4.7H_2O$ and 30% H_2O_2 are appropriate, water bath temperature is 40℃, after 30 min seal light, the removal rate can reach 98.44%. The phenol refining wastewater oxidation reaction belongs to the first order reaction. Li Zhou [3] researched the Fenton reagent used in fluidized bed to oxidant simulated phenol wastewater. The results show that, when phenol mass concentration is 100 mg/L, temperature is 60℃, initial simulated wastewater pH is 4, $c(H_2O_2)$=12 mmol/L, $n(Fe^{2+})$=3 mmol/L, eaction time is 30 min, phenol removal efficiency can reach 92%. If use the gas liquid fluidized bed, the effect of can be improved, the removal rate can reach 96%. Dasong Zhang [4] used the UV/Fenton reagent to treat high concentration industrial phenolic wastewater. The results show that, when the initial concentration of phenol is 1000 mg/L, H_2O_2 concentration is 40-50 mmol/L, ultraviolet wavelength is 253.7 nm, pH is 6-7, Fe^{2+} concentration is 28-30 mg/L, reaction time is 30 min, the removal rate can reach 90%. Phenols are eventually degraded for CO_2 and H_2.

2.2 Microwave induced catalytic technology

Microwave induced catalytic technology absorbing microwave through sensitizer, and passing the power to organic pollution and make it change, finally purify the sewage. Guoyuan Wang [4] oxidized indigo carmine by microwave induced oxidization used granular activated carbon as catalyst. The results showed that removal rate of the acid indigo solution can reach 98.79% when the concentration of acid indigo solution is 100mg/L, microwave power is 100W, active carbon dosage is 1.5g, microwave radiation is 7min. Qijuan Sun [5] treated simulated mixed staining wastewater by microwave induced catalytic technology. The results showed under the perfect situation, which carbon dosage is 5g, microwave power is 700W, irradiation time is 6min and pH is 3.0, the decolorization rate over 73.6%. The optimal technique condition was used in piratical, and the decolorization rate is over 62.1%. What’s more, microwave induced oxidation was compared with microwave radiation and active carbon adsorption, the results showed that microwave induced catalytic technology has obvious advantages, and has no secondary pollution to the environment. Zongyu Liu [6] used microwave irradiation treating acid red dye wastewater and activated charcoal was used as catalyst. The results showed that the removal rate can reach 96%~98% when concentration of acid red dye wastewater is 400mg/L, carbon dosage is 2.0g, microwave power is 800W, irradiation time is 6min. Generally speaking, activated charcoal has been widely used as catalyst in the microwave induced oxidation process. Microwave irradiation can degraded the organic matter on the surface of activated charcoal and promote the regeneration of activated charcoal.

ISSN 2229-5518

However, mechanical strength of the activated charcoal is weak. Microwave destroyed its structure, and has an influence on its life and catalytic activity.

2.3 Electrochemical oxidation method

Hydroxyl radical produced by electrochemical method can destroy the molecular structure of dyes under the effect of electrode material, and then the concentration of pollution can be reduced. It doesn't have to add chemicals and have a good effect on organics and color difficult to degrade. Chaozheng Bian [7] studied the treatment of methythionine chloride simulated dye wastewater by electrochemistry method. the results showed that when Current Density was about 10mA/cm², the concentration of methylthionine chloride was about 5mg/L, the concentration of NaCl was about 0.2mol/L, the temperature was about 25℃, and the electrifying time was about 1 h, the decolorization rates can reach 91.8%. The decoloration rate of methylene blue will raise when the concentration of NaCl raise. When the concentration of NaCl is 0.1mol/L-0.2mol/L, the decolorization rate range from 72.1% to 91.8%. Jian Zhou [8] treated acid dye waster by eletrochemical method, titaniue plate was used as cathode, and IrO_2-SnO_2-TiO_2/Ti plate as anode. when reaction time was 2 hours, current density was 8.0A/dm², pH was 6.0, the removal rate of COD_{Cr} and ammonia nitrogen was 71.88% and 100%. Zhongtian Fu [9] used metal aluminum and iron as the poles, and used a novel electrochemical reactor to dispose dye wastewater imitated by reactive brilliant blue X- BR. The results showed that when the concentration of COD_{Cr} was 1232mg/L, the concentration of electrolyte was 0.06mol/L, the plate spacing was 1.0cm, pH was 8, voltage of electrolyzer was 10V, reaction time was 20min, switch time of power supply was 8s and the stiring speed was 1000r/min, chroma removal rate can reach 98.93% and COD_{Cr} removal rate can reach 85.26%, power consumption of processing waste water is 1.24 kW · h/m. Rajkumar D [10] used electrochemical methods to degrade the blue dye wastewater. The results showed that when the concentration of reactive blue was 400 mg/L, the concentration of NaCl was 1.5g/L, the wastewater removal rate of COD is 55.8% and the removal rate of TOC is 15.6%. Generally, the electrochemical method for the treatment of dye wastewater is a clean process. But the cost on power consumption and electrode materials is very large in actual operation and the development and wide application of this method was limited.

2.4 Photocatalytic oxidation

Photocatalytic technology, an environmentally friendly technology skill, has an important application in the energy and environment science. Currently, it mainly uses TiO_2 as the photocatalyst. Scholars have done a large amount of researches on TiO_2 photocatalytic degradation of dye wastewater. Pinji Chai [11] et al investigated the photocatalytic activity of TiO_2 on the dye wastewater. The results indicated that the conversion of brilliant blue could reach 75.6%. The fractional conversion of brilliant blue decreased as the brilliant blue initial concentration raze but increased with the ultraviolet light irradiation time last, and the suitable time of the experiment was 60min. pH had significant influence on the catalytic effect, the appropriate pH of the study was 3-4. Hua Lv [12] et al investigated photocatalytic degradation of simulated wastewater of Reactive Brilliant Blue KN -R by using nano-TiO_2 as photocatalyst. Effects of operation parameters such as catalyst loading and initial pH value on decolorization were studied under the condition of light irradiation time is 1.5h, Reactive Brilliant Blue KN-R initial concentration is 50mg/L. Results showed that the decolorization of the dye increased from 63.2% to 79.5% with the increase of pH value (2.0-12.0); When the initial pH value is 6, the decolorization of dye increased from 19.6% to 69.5% with the dose of TiO_2 increasing from 0g/L to 0.7g/L. A mount of studies indicated that TiO_2 photocatalytic is an efficient method for the degradation of dye wastewater, but there are also some problems. TiO_2 is difficult to separate after reaction and this will influence the effluent quality. The absorption threshold value of TiO_2 is less than 400 nm and the utilization rate of light is low. The widely application of TiO_2 is still limited by the wavelength.

2.5 Membrane separation technology

Membrane separation technology is a separation technology, that liquid waste mixture can be separated by selective film because of different particle size. It has small footprint, wide adaptation range and processing efficiency. Feng Wu [13] et al. studied the treatment of simulate dyeing wastewater with high salinity by nanofiltration membrane. The results showed that the retention rate of dye is reducing with the increase of pressure, when pressure ranges from 0.10MPa to 0.50MPa, the dye retention rate ranges 99% to 90.6%, and salinity retention rate increases from 5.2% to 8.5%, and then go to steady to 4.8%. Whit the rise of pH, the dye retention rate increased first and then decreased. When pH is 5-7, dye retention rate reached the biggest. However, the salinity retention rate is reducing with the increase of pH. Wei Cong [14] et al. used ultrafiltration/ nanofiltration double membrane to treatment the printing and dyeing wastewater has been through the second level treatment. The results showed that ultrafiltration as the pretreatment of nanofiltration, can remove more than 90% turbidness and more than 50% COD. After nanofiltration, the concentration of Cl^-can reduce to 461mg·L^{-1} , SO_4^{2+} reduce to 18mg·L^{-1}, turbidness reduce to 1.8 NTU and COD reduce to 49mg·L^{-1}, the effluent conformed to the senior grade. Though membrane separation technology has many advantages, there are also several disadvantages such as membrane fouling, membrane cleaning and the acid-base resistance and the corrosion resistance of membrane.

- *Li Si is currently pursuing masters degree program in Liaoning Shihua University, China, PH-86-15041390373. E-mail: 510094522@qq.com*
- *Yang Shuangchun is currently a lecturer in electric power engineering in Liaoning Shihua University, China, PH-86-15242346207. E-mail: yangchun_bj@126.com*

2.6 Conclusion

The dye wastewater treatment has been an important tasks in environmental protection, and the economic and effective has been become a key topic in current research. In this paper, the domestic technology of dye wastewater treatment is summarized in recent years. The main research directions in the treatment of dye wastewater in the future are: interdisciplinary research on the base of traditional foundation methods, developing advancing technology for printing and dyeing wastewater; Improving the electric source and developing new electrodes materials and structures to reduce the cost; Decorating the surface of TiO2 photocatalyst to increase the activity and selectivity; developing the technology for membrane pollution prevention to lengthen the service life of membrane.

References

[1]. Wang Lu. Degradation of disperse dyestuff wastewater by homogeneous catalytic ozonation [D]. ShangHai: Donghua University. 2012:112-119.
[2]. Gong Yi, Luo Hanjin, Wei Chaohai. Mechanism of degradation of reactive light yellow X-7G by ozonation [J]. Environmental Science & Technology. 2009, 32(3): 126-129.
[3]. Khadhraoui M,Trabelsi H,Ksibi M,et al.Discoloration and detoxicification of a Congo red dye solution by means of ozone treatment for a Possible water reuse [J]. Journal of Hazardous Materials. 2008,165: 1130-1136.
[4]. Wang Guoyuan, Mai Wenning, Xiao Shan. Treatment of Acid Indigo Wastewater by Microwave Induced Activated Carbon Catalytic Process [J]. Journal of Anhui Agricultural Sciences. 2012, 40(6): 3518-3520.
[5]. Sun Qijuan, Chang Xiangdong, Yun Shangwei. Study on the Decolorization Treatment of Dye Wastewater by Microwave Combined with Active Carbon [J]. Guangzhou Chemical Industry. 2012, 40(6): 90-92.
[6]. Liu Zongyu, Sun Baoping. Study on the treatment of dyestuff-bearing wastewater by microwave radiation [J]. Industrial Water Treatment. 2010, 30(2): 44-46.
[7]. Bian Chaozheng. Study of Chemical Regulatory Factors of Electrochemical Degradation of Complex-component Dyes [D]. Da Lian: Dalian University of Technology. 2009: 1563-1570.
[8]. Zhou Jian, Ding Yanyan. Experimental study on acid dye wastewater treatment by electrochemical oxidation [J]. Industrial Water & Wastewater. 2011(6): 37-39.
[9]. Fu Zhongtian, Zheng Linzi, Zhao Feifei, et al. Study on the Treatment of Reactive Brilliant Blue X-BR Simulated Wastewater by Electrochemistry Method [J]. Environmental Protection Science. 2010, 36(5): 14-17.
[10]. Rajkumar D, Byung Joo song, Jong Guk Kim. Electrochemical degradation of Reactive Blue 19 in chloride medium for the treatment of textile dyeing Wastewater with identification of intermediate compounds [J]. Dyes and Pigments. 2007(72): 1-7.
[11]. Cai Binji, He Yu, Zhang Bo, et al. Study on Photocatalytic Oxidation of Brilliant Blue Dye Wastewater over TiO_2 [J]. Hebei Chemical Engineering and Industry. 2009, 32(5): 30-32.
[12]. Lv Hua, Jiang Juhui, Liu Yumin, et al. Photocatalytic Degradation of Reactive Brilliant Blue KN-R by Titanium Dioxide [J]. Environmental Science & Technology. 2010, 33(5): 47-50.
[13]. Wu Feng, Wu Huifang, Lu Jilai, et al. Influence factors of nanofiltration membrane treatment on acid dye wastewater [J]. Textile Auxiliaries. 2012, 29(3): 35-38.
[14]. Cong Wei, Xiang Hai, Zhang Guoliang. Dyeing wastwater treatment and reutilization through ultrafiltration and nanofiltration integrated membrane processes [J]. Technology of Water Treatment. 2008, 34(10): 75-78.
[15]. Su Hui, Song Ben, Zhang Ying, et al. Study on the Adsorption Dynamics of Powder Activated Carbon for Reactive Ryes [J]. Guangzhou Chemical Industry. 2009, 37(9): 116-118.
[16]. Zhang Runpu, Hao Weihui, Zhang Chunyang. Activated Carbon Decolorization of Dye Wastewater [J]. Environmental Science and Management. 2010, 35(7): 89-91.
[17]. Wang Yu, Liu Miao, Chen Like, et al. Study on treatment of dyeing wastwater by electrochemical oxidation process combined with macroporous resin adsorption [J]. Journal of Northeast Normal University(Natural Science Edition). 2012, 42(4): 101-105.
[18]. Gu Zhipan, He Shaohua. Study on the adsorption of dye wastewater by Diatomite [J]. Popular Science & Technology. 2011. (5): 91-92.
[19]. Zhang Geshan. Study on Adsorption of Organic Dye onto Diatomite［D］. Ji Lin: Jilin University. 2009: 1113-1123.