Study on Treatment Methods of Phenol in industrial Wastewater

Li Si, Kong Ruixue, Sun Lin, Li Sifan, Yang Shuangchun*
(Liaoning Shihua University. Fushun, Liaoning, China. 113001)

Abstract—Industrial wastewater is a kind of wastewater that generate in the industrial production process. The wastewater from refining and coal carbonization contains high concentration of phenols pollutants. In this paper, study on phenol treatment methods in industrial wastewater were mainly reviewed and compared including advanced oxidation processes, biological fluid bed method, drop phenol bacteria method, light catalytic drop phenol method, peroxidase method, extraction method and biological tower method, and so on. In addition, suggestions were put forward for treatment methods of phenol in industrial wastewater.

Index Terms—blockage, Natural gas hydrate, Pipeline, Natural gas, stress corrosion, Vacuum drying method, desiccant drying method

1 PREFACE

PHenols in industrial effluent have teratogeny, carcinogenic, mutagenic effects. They are toxicity and difficult to biodegradation. They will do harm to environment [1] and have been listed in the 129 priority pollutants. The non-treated industrial effluents with phenols have threatened the living environment of humans and animals. Nowadays, the treatment of effluents with phenols have sparkled the concern of researchers. The methods for phenol wastewater treatment were reviewed, including apply conditions and removal rates.

2 THE RESEARCH OF THE TREATMENT OF PHENOL IN INDUSTRIAL WASTEWATER

2.1 ADVANCED OXIDATION PROCESSES

2.1.1 FENTON REAGENT TREATING PHENOL REFINERY WASTEWATER

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.

2.1.2 THREE DIMENSIONAL ELECTRODE OXIDATION DEGRADATION OF PHENOL WASTEWATER

Three dimensional electrodes method is a new type electrochemical treatment technology. Its reaction rate is speed. at present, this method has been widely used in sewage treatment field, and achieved a good test effect. Song Nie [5] studied the degradation of phenol in petrochemical refinery wastewater by three-dimensional electrode reactor which with self-made metal oxide particle electrode. The results show that, when the phenol concentration is 15-20mg/L, pH is 6.5, aeration flow is 0.5 L/min, quantity of particle electrode is 100 g, electrolytic voltage is 12 V, the reaction time is 60 min, the biggest phenols removal rate can reach 97.54%, the COD removal rate can reach 81.59%. Jie Yang [6] used the three dimensional electrodes method in simulated chemical phenolic wastewater. The results show that three dimensional electrodes method for phenol remove is feasible. When the water flow is 180 ml/min, the temperature is 25 ℃, pH is 6.0-7.0, current is 0.1 A, dose of sodium chloride is 1000 mg/L, cycle electrolytic 1.5 hours, the removal rate can reach 98%. The degradation effect of hydroxy free radical played a major role in the whole electrolytic process. Ning Xu [7]found that when the voltage is 1.5 V, ventilation is 0.2 L/min, XL1 bacteria was trained 40h, reaction time is 24 hours, the removal rate as high as 99%. Yi Xia [8] degradated the simulated phenolic waste water sample by three dimensional electrode oxidative degradation, and the phenol mass concentration is about 300 mg/L. The results showed that when the aeration intensity is 0.6 m^3/h, dose of activated carbon is 500 g, pH is 3, electrolytic voltage is 15 v, phenol removal efficiency can reach 91.2%.

2.1.3 METHODBIOLOGICAL FLUIDIZED BED FOR PHENOL REMOVE

Biological fluidized bed allows gas, liquid and carrier to

circulation flow in the device and makes them touch each other completely. It can achieve favorable effects, so it has sparkled the wide concern of researchers in wastewater treatment filed. Yudong Song et al studied the method of Aerated biological fluid technology (ABFT) applied in phenol remove from FCC Gasoline Caustic Sludge. When phenol concentration is 4.9g/L and the hydraulic retention time is 60h, the removal rate of total phenol concentration can reach 99.3% and COD removal rate can reach 85%. The removal of phenol mainly take place in the first pool of ABFT, the removal rate can reach 90%. The main biomass of ABFT is biomembrane which filamentous bacterias attach growth on. Jing Dong et al studied the application of ABFT in coking wastewater and refinery wastewater. The results showed that the removal rate of phenol can stable at 100% when the influent phenol concentration range from 100mg/L to 500mg/L. Cheng Ding used the sodium alginate-chitosan-activated carbon microcapsule to immobilize the Photosynthetic bacteria, and then treated the simulation phenol wastewater. The removal rate can reach 91.7% when volume is 20L, temperature is 30℃, inoculation amount is 15thousands, pH is 7.0, and treatment time is 7d.

2.3 PHENOL-DEGRADING BACTERIUM TECHNOLOGY

Phenol-degrading bacterium technology belongs to the microbial degradation method and has been more and more widely used. It has the advantages of economy, safety and no secondary pollution. Yin Yane [12] studied the treatment of industrial phenolic wastewater by pseudomonas putida. The results show that the phenol degradation rate by immobilized pseudomonas putida is better than the free pseudomonas putida. Under the optimum conditions, temperature is 30-35℃, pH is 7-9, and the degradation efficiency of phenol by immobilized pseudomonas putida can reach 93%. He Zongjian [13] studied the degradation capacity of different bacterial strains for phenol in high concentration petrochemical refinery. Finally found a dominant strain: LJF-1. When the temperature is 30 ℃, the phenol degradation rate by LJF-1 can reach 98.77% after 15 hour. When the carbon source was 1g/L, the phenol degradation rate can reach 79.8% after 2 hours. When pH is 7.5, the phenol degradation rate can reach 92.55% after 12 hours. Chen Min [14] isolated 15 different bacterial strains from industrial wastewater containing phenol. The representative strains were studied on the growth and the phenol degradation efficiency. The results showed that the phenol degradation rate by six kinds of strains can reach 70%-100% when the concentrations of phenol range in the 0.4-1.4g/L.

2.4 DEGRADATION OF PHENOL BY PHOTOCATALYTIC TECHNOLOGY

Photocatalysis is a new type industrial wastewater treatment technology, owning the advantage of fast reaction speed, mild react conditions, good selectivity, nonhazardous. Niu Xianchun [15] researched the photocatalytic degradation of Oil refining wastewater containing phenol by nano Fe^{3+}/TiO_2 photocatalyst. The result showed that the nanometer Fe3+/TiO2 prepared under the optimum condition has the best degradation effect. When react time is 2.0 h, phenol degradation rate can reach 70%. After 2.0 h, phenol degradation rate increasing is gentle, up to 75%. Xiaoming Gao [16] study the photo catalytic degradation of phenolic wastewater by Cu - $BiVO_4$. In the neutral condition (the effect of catalyst on the target sewage treatment is best), the amount of catalyst is 1 mg/L, air quantity is 200 mL/min, react time is 180 min, and phenol degradation rate can reach 92.4%. Yuehui Wu [17] et al studied on the use of perovskite-type manganese oxides ($La0.9Ce0.1MnO_3$) photocatalyst in Photocatalytic degradation of simulate phenolic wastewater, the results show that, under the acid and alkali conditions, phenols were hardly degraded, the optimal pH was 6.5, when the photocatalyst amount less than 0.20mg/mL, the degradation rate increased with the photocatalyst amount increasing, but when the photocatalyst amount more than 0.20mg/mL, the degradation rate had no significant increasing trend.

2.5 PEROXIDASE FOR PHENOL REMOVAL

Peroxidase method for phenolic wastewater treatment with high efficiency, low energy requirements, less affected by the environment has been confirmed to be the most promising method for phenol removal. Lihua Zhang [18] found horse radish peroxidase can remove phenol effectively, and it has stable property and is available in abundance. Chui Wang [19] used nano-silica to immobilize radish peroxidase, and applied it in the treatment of phenolic wastewater. After 120min, the removal rate can reach to 73.1% when the phenol concentration is 2mmol/L, the temperature is 30℃, the pH is 6.0 and the dose of radish peroxidase is 100mg.

2.6 REMOVE PHENOL BY EXTRACTION TECHNOLOGY

Extraction is a physical method with good separation effect and low energy consumption. Chunyang Liu [20] taken off the phenol in oil refining waste by complexation extraction. The high concentration oil refining alkali dregs waste water with phenol is from Nanjing Yangzi petrochemical company, and it was treated by 30% TBP-system. The results showed, when pH is 9, normal temperature, the phenol removal rate can reach 99% after 15min 3 equilibrium stages. Zeguang Zhang [21] discussed the phenol removal capacity of membrane dispersion extraction. The results showed that the percent of extraction dephenol is higher than 80% under the condition of phenol concentration ranges from 1000 mg/L to 4000 mg/L, organic phase flow and inorganic phase flow are 1500mL/min. Chuan He [22] studied the treatment of phenol containing wastewater by extraction process with rosin amine. The results showed that the total percent of dephenol extraction is reached 99.9% under the conditions of the pH is 4, temperature is 25 ℃, the concentration of rosin amine is 30 %. The concentration of phenol can be reduced from 27000mg/L to 16.31mg/L.

2.7 THE TECHNIQUE OF DEPHENOLIZATION FOR BIOLOGICAL TOWER

Biological tower is a processing unit for wastewater; it is a simple flow, small volume and high effluent characteristics. It has higher treatment efficiency and it needs a further research. Feng Li has researched some treatment methods for wastewater contained phenol of a certain refinery, the concentration of phenol is under 200 mg/L, the research result indicates the removal rate of phenol can reach 99% when the concentration of phenol is under 0.5mg/L, the gas water ratio is 8.0, hydraulic retention time is 3.0h, pH value is between 6.8-8.0, the temperature is between 25-40℃, the period of the biological tower back wash is 2-3d.

3 CONCLUSION

Phenols can bring major damage for aquatic organism and people, it is hard to eliminate it in a short time, and the writer summarizes some treatment methods of phenol in the industrial wastewater and suggests people to do further research in mechanism of degradation, biological culture development and degradation rate of phenol.

REFERENCES

[1]. Li Xiaoyan, Cui Yuhong, Feng Yujie, et al. Reaction pathways and mechanisms of the electrochemical degradation of phenol on different electrodes [J]. Water Research, 2005, 39(10):1972-1981.

[2]. Cong Qiao, Qu Jiao. Degradation of refining wastewater containing phenol with super oxidation method [J]. Petroleum Processing and Petrochemicals, 2010, 42(6): 103-107.

[3]. Zhou Li, Zhong Hong, Li Xueping. Phenolic wastewater treatment by Fenton reagent in gas-liquid fluidized bed reactor [J]. Journal of Central South University(Science and Technology) . 2011, 42(11): 3284-3288.

[4]. Zhang Dasong, Gao Hongge, Shang Jie, et al. Experimental Study on Treatment of Wastewater Containing Highly Concentrated Phenol with UV/Fenton Reagent [J]. Journal of Shandong University of Science and Technology(Natural Science). 2011, 30(1): 92-95.

[5]. Nie Song, Zhou Zhaoxi. Experimental Study on the Oxidation Degradation of Phenolic Compound from Refinery Wastewater by Three-dimensional Electrode [J]. Advances in Fine Petrochemicals, 2011, 12(5): 28-31.

[6]. Yang Jie, You Xiangyu, Wang Yunyan, et al. Novel technology and mechanism of electrochemical degradation of phenol in wastewater with three-dimensional electrode reactor [J]. The Chinese Journal of Nonferrous Metals, 2012, 22(6): 1804-1811.

[7]. Xu Ning, Tao Xiuxiang, Zhao Liang, et al. Preliminary Research on the Treatment of Phenolic Wastewater by Three-Dimensional Electrode-biofilm [J]. Journal of Suzhou College, 2010, 25(8): 18-21.

[8]. Xia Yi, Li Yafeng, Cheng Lin. Experimental study on the oxidation degradation of phenol wastewater by three-dimensional electrode [J]. Industrial Water Treatment, 2010, 30(5): 27-29.

[9]. Song Yudong, Yang Jian, Yang Jinghui, et al. Treatment of High-Concentration Phenolic Wastewater by Aerated Biological Fluidized Tank [J]. Research of Environmental Sciences, 2010, 23(7): 930-935.

[10]. Dong Jing, Song Yudong, Zhou Yuexi, et al. Analysis of the Structure of Filamentous Microbial Groups from Aerated Biological Fluidized Tank Treating Phenolic Wastewater [J]. Research of Environmental Sciences, 2010, 23(8): 1068-1075.

[11]. Ding Cheng. Disposal of Phenol Wastewater with the Immobilized Photosynthetic Bacteria in the Biological Fluidized Bed [J]. Journal of Sichuan Normal University (Natural Science), 2009, 32(4): 513-517.

[12]. Yin Yane, Xu Zhaoli, Xu Yayan, et al. Degradation of phenol by free and immobilized pseudomonas putida [J]. Technology of Water Treatment, 2012, 32(8): 34-36.

[13]. He Zongjian, Liu Min, Shen Yue, et al. The screening of strains to degrade high concentration of phenol-containing wastewater and studies on its characteristic [J]. Technology of Water Treatment, 2009, 35(12): 84-87.

[14]. Chen Min, Fang Xu. Isolation and diversity analysis of phenol-degrading bacteria in a wastewater treatment plant [J]. Acta Scientiae Circumstantiae, 2009, 29(5): 934-938.

[15]. Niu Xianchun, Zhou Jianmin, Wu Shanghuang. Photocatalytic Degradation of Refinery Wastewater Containing Phenol with Nano-Fe^{3+}/TiO_2 Catalyst [J]. Petrochemical Technology, 2009, 38(11): 1239-1244.

[16]. Gao Xiaoming, Fu Feng, Lv Lei, et al. Preparation of Cu-BiVO4 photocatalyst and its application in the treatment of phenol-containing wastewater [J]. Chemical Industry and Engineering Progress, 2012, 31(5): 1039-1043.

[17]. Wu Yuehui, Zhang Longfei, Yi Yong, et al. Study on the photodegradation of phenol containing wastewater by $La_{09}Ce_{01}MnO_3$ [J]. Environmental Pollution & Control, 2011, 33(6): 7-10.

[18]. Zhang Lihua. Applications of Horseradish Peroxidase in the Phenolic Wastewater [J]. Journal of Yanbei Normal University, 2012, 28(3): 35-39.

[19]. [Wang Cui, Jiang Yanjun, Zhou Liya, et al. Horseradish peroxidase encapsulated on nanosilica for phenol removal [J]. Horseradish peroxidase encapsulated on nanosilica for phenol removal, 2011, 62(7): 2026-2032.

[20]. Liu Chunyang, Liu Liu, Chen Tianan, et al. Study on Extraction by Chemical Complexation Used in FCC Caustic Sludge Acidification Liquid [J]. Pollution Control Technology, 2009, 22(5): 4-6.

[21]. Zhang Zeguang, Ma Yanlong, Ye Shichao. Research on treatment of phenol-containing wastewater by membrane dispersion extraction [J]. Modern Chemical Industry, 2011, 31(3): 37-39.

[22]. He Chuan. The study of dephenolization by solution extraction[J]. Henan Chemical Industry, 2010, 27(4): 40-41.

[23]. Li Feng. Discussion on Control Factors of Phenolic Wastewater Treatment by Biological Method [J]. Technology & Development of Chemical Industry, 2010, 39(8): 53-54.