ISSN: 2710-0588

Preparation of Ultrasound-enhanced Magnetic Materials and Degradation Studies of Dyes

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Abstract

As people's pursuit of spiritual life and material needs continues to increase, a large number of new products have been invented and manufactured, and the dyeing industry has developed at a high speed. With the rapid development of textile printing and dyeing industry has made the composition of printing and dyeing wastewater has become more and more complex, and the discharge volume has greatly increased, which not only increases the difficulty of the treatment of printing and dyeing wastewater, but also has a great impact on the environment, a very small amount of dyes can make the water produce a large chromaticity, which will cause discomfort to people, so printing and dyeing wastewater has become one of the major threats to China's water environment.

Keywords

Dyes; Magnetic; Wastewater.

1. Introduction

In recent years, printing and dyeing wastewater has the characteristics of large changes in water quality and quantity, high COD content, high salt content, high chromaticity, high toxicity, high pollutant concentration and poor biochemistry [1]. Conventional treatment methods are summarised as physicochemical and biochemical methods. Since the conventional treatment methods do not achieve the expected results, in recent years, the advanced oxidation method, mainly Fenton oxidation, has received widespread attention. The hydroxyl radical in the Fenton system has a strong oxygenation capacity, and the Fenton oxidation method is fast, easy to operate, and has a good treatment effect, so it is often used in the treatment of difficult degradation of organic wastewater. However, at the same time, this method also has many shortcomings, such as large dosage of chemicals, narrow pH range, low utilisation of H2O2 and catalyst, high treatment cost, and iron sludge in the effluent.

ISSN: 2710-0588

2. Domestic and International Research Progress

2.1. Research Status of Printing and Dyeing Wastewater Treatment Methods

Printing and dyeing effluents are highly coloured and have a complex organic content. Its organic pollutants are a combination of natural and synthetic organic substances. The high colour is due to the large number of chromogenic groups in the effluent, which increases the difficulty of decolourisation. In some companies, domestic wastewater is discharged in addition to production wastewater, resulting in unstable water quality. Nitrobenzene compounds in wastewater are toxic and difficult to degrade, which can seriously endanger people's lives and health. In order to achieve the sustainable development of the textile printing and dyeing industry, we must devote ourselves to solving the pollution problems in the printing and dyeing industry, effectively treat the printing and dyeing wastewater, and reduce the wastewater discharge as much as possible.

2.2. Status of Research on Fenton Oxidation for the Treatment of Printing and Dyeing Effluents

In recent years, with the rapid development of the textile printing and dyeing industry, industrial printing and dyeing wastewater is discharged in large quantities, which has a very bad impact on the environment and people's health, and it is imperative for us to treat the printing and dyeing wastewater economically and effectively. The Fenton oxidation method has a strong oxidising property, H_2O_2 produces hydroxyl radical (·OH) under the oxidising effect of Fe^{2+}, and the oxidation reduction potential (ORP) of hydroxyl radical (·OH) is 2.8V, which is slightly lower than that of fluorine. Therefore, Fenton oxidation has become a hot research topic among scientists for the treatment of difficult-to-degrade industrial wastewater. The research of Fenton oxidation has become a hot research point for many scholars.

2.3. Current Research on Fenton-like Oxidation for Treating Difficult-to-Digest Industrial Effluents

To overcome the shortcomings of the Fenton oxidation method, researchers have carried out further studies. On the basis of the traditional Fenton oxidation method, the Fenton oxidation methods of iron, iron oxides and doped with metals other than iron have been derived. This method not only solves the problem of high H_2O_2 dosage in the Fenton oxidation method, but also achieves catalyst reuse and avoids secondary contamination of iron sludge, which has a better treatment effect. The Fenton oxidation methods of iron, iron oxides and doped metals other than iron include: FeO/H_2O_2 Fenton system, Fe_3O_4/H_2O_2 Fenton system and Fe_3O_4-loaded Fenton system, etc. The Fenton oxidation methods of FeO/H_2O_2, Fe_3O_4/H_2O_2 and Fe_3O_4-loaded Fenton system were used in this research.

3. Research on the Treatment of Difficult-to-Degrade Industrial Wastewater by Intensive Fenton Oxidation Method

Although the Fenton-like oxidation method has improved the shortcomings of the traditional Fenton oxidation method to a certain extent, there are still some unsolved problems, such as the narrow pH range, high operation and treatment costs, and the phenomenon of iron ion leaching in many Fenton-like reaction systems, so further research is needed. Many researchers and scholars have adopted the electric Fenton oxidation method, ultraviolet light-assisted Fenton oxidation method, microwave-assisted Fenton oxidation method, ultrasound-assisted Fenton oxidation method to improve the shortcomings of Fenton oxidation method.

ISSN: 2710-0588

3.1. Electro-Fenton-like Oxidation

Li [2] used spectrally pure graphite and loaded FeOOH to form an electro-Fenton-type catalytic oxidation system for the treatment of petrochemical reverse osmosis (RO) concentrated water. The test showed that the H_2O_2 was added in two stages, 1.0 mL each time, the COD concentration of the RO concentrated water was 235 mg/L, the tank voltage was set at 4 V, and the catalyst was filled with 40% volume fraction for 2.5 h, and the COD removal rate could reach 82.1%.

Tang [3] and others used nickel foam (NF) and copper foam (CF) as the cathode of electro-Fenton-type catalytic oxidation to degrade nitrophenol by electro -Fenton-type catalytic oxidation, and the results were comparatively analysed. The experiments showed that NF and CF cathodes could extend the pH range of electro-Fenton-like catalytic oxidation, and the removal rates of nitrophenol were 72.9% and 80.7%, respectively after 180 min of reaction at a cathodic potential of -0.9 V. It was also shown that the degradation rate of nitrophenol was faster than that of the NF electrode when CF was used as the cathode, but the NF electrode had a better stability.

Zhang [4] investigated the effects of electro-Fenton and electro-Fenton-like methods on the removal of purslane red and disperse blue dyes, respectively. The experiments showed that the electro-Fenton-like method was significantly better than the electro-Fenton method for the decolourisation and mineralisation of the dye Purslane Red, with the mineralisation rate of the former reaching about 50% after 1 h of electrolysis and that of the latter reaching about 20% after 2 h of electrolysis. The results showed that the electro-Fenton method was better than the electro-Fenton method for the decolouration and mineralisation of the dye Purslane Red, with the mineralisation rate of the former reaching about 50% after 1 h of electrolysis and that of the latter reaching about 20% after 2 h of electrolysis. And dispersed blue has no possibility to use electrochemical oxidation for effective decolourisation and mineralisation.

3.2. Photo-assisted Fenton Oxidation

Ban [5] investigated the effectiveness of the light-assisted inhomogeneous Fenton method for the treatment of nitrophenol wastewater. It was shown that when 100 mL of nitrophenol wastewater with a concentration of 200 mg/L, the initial pH was adjusted to 4, and when the catalyst Fe/Al_2O_3 was added at 100 g/L and H_2O_2 at 50 mmol/L for 100 min, the removal rate of nitrophenol was 98.9%, and the removal rate of COD was 73.1%. The degradation of nitrophenol was accelerated by the generation of -OH using UV light.

Ma [6] investigated the decolourising effect of UV-H_2O_2. Fe^{3+}-citric acid system on methyl violet. It was shown that the concentration of citric acid as an activator in the reaction system could influence the decolourisation of methyl violet dye. The decolourisation rate of methyl violet could reach more than 80% when the initial pH was 3, the concentration of methyl violet was 40 mg/L, the concentration of citric acid was 90 mg/L, the concentration of H_2O_2 was 3% and the concentration of Fe^{3+} was 100 mg/L.

Lin [7] used light-assisted Fenton oxidation to degrade crystal violet dye effluent. It was shown that UV light promoted the decolouration and mineralisation of crystal violet dye wastewater. When pH=2.7, the dosage of H_2O_2 was 340 mg/L, and the concentration of Fe^{3+} was 28mg/L for 80 minutes, the decolourisation rate of crystal violet was almost 100%, and the removal rate of COD was up to 60.1%, and the removal effect of COD would be better if the dosage of H_2O_2 was done in sections. If H_2O_2 is added in sections, the removal effect of COD will be better.

3.3. Microwave-enhanced Fenton Oxidation

Yang [8] prepared a $CuO/\gamma\text{-}Al_2O_3$ catalyst for the degradation of phenol by inhomogeneous microwave-assisted Fenton-like oxidation. The experiment showed that the removal rate of phenol was 98% when the initial pH was 6, the amount of added H_2O_2 added was 4 mL/L, the

ISSN: 2710-0588

amount of added $CuO/\gamma\text{-}Al_2O_3$ added was 4g/L, and the power of the microwave oven was set at 500 W for 13 min. It was also found that the catalyst could be reused, and the phenol removal rate could reach 90.88% after nine reuses.

Wu [9] chose the activated bright red X-3B dye wastewater as the target object and treated it with microwave-assisted Fenton-like method. The experiment showed that the microwave-assisted degradation of activated bright red X-3B dye wastewater by Fenton-like method played a synergistic effect, and under the optimal reaction conditions, the colour could be removed by up to 99.08%, and the COD could be removed by up to 89.12%.

Li [10] prepared a Fenton-like system consisting of the loaded material CuO/petroleum coke and H_2O_2 for the microwave treatment of rhodamine B solution. The test showed that the removal rate of rhodamine B was 96% after 4 min of reaction with 200 mL of 100 mg/L of influent water, pH 3.0-3.5 , 20.4 mL of 30% H_2O, 180 g of CuO/petroleum coke, and 750 W. The microwave power was set at 750 W.

3.4. Ultrasound-enhanced Fenton Oxidation

Chen [11] investigated the coking wastewater using the ultrasonic Fenton-type oxidation method. The experimental results showed that under the optimum reaction conditions, the initial pH was adjusted to 3, the concentration of magnetic nano-Fe_3O_4 was 1.0 g/L, H_2O_2 was added at 1.0 mL/L, and the ultrasonic power was adjusted to 490 W. After 120 min of the reaction, 90% of COD could be removed. It was also found that with the continuous use of catalysts, the efficiency of the catalysts decreased and the COD removal effect became worse.

Xiao [12] chose the HCB-contaminated soil lysate as the research object, and investigated the degradation effect of the ultrasonic-assisted Fenton method and the influencing factors. The results showed that the ultrasonically enhanced Fenton-like method was significantly more effective than the Fenton-like method or ultrasonic treatment alone in treating HCB pollutants in soil lysate, and the treated water quality was better, and the removal rate of HCB and COD in soil lysate was more than 80% under the optimum reaction conditions.

4. Conclusion

The above studies show that ultrasonic technology can effectively degrade organic pollutants in wastewater, and is widely used in the treatment of printing and dyeing wastewater. Under the cavitation effect of ultrasound, a high-temperature, high-pressure environment is generated locally, in which the organic matter will undergoes pyrolysis reaction to be effectively removed and the catalytic degradation rate is accelerated. At present, the ultrasound-assisted advanced oxidation method is the focus and hotspot of research for the treatment of printing and dyeing effluents.

Acknowledgments

This work was supported by Shaanxi Province Innovative Talent Promotion Program Young Science and Technology Rising Star Project (2023KJXX-123), Shaanxi Postdoctoral Programme (2023BSHGZZHQYXMZZ36).

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