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TEXTILE AND DYEING WASTEWATER EFFECTIVELY TREATED BY FENTON IN MOVING BED ACTIVATED CARBON SYSTEM

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ABSTRACT

The complete treatment of colors and hazardous substances at a reasonable cost is of particular interest in the textile industry. In this batch form study, dye solution and textile dyeing wastewater were successfully treated by Fenton technology combining Moving Bed Reactor/Activated carbon (Fenton-MBR/AC) system. The optimum operating conditions including 3.5 of pH value, 0.5 of Fe/H_2O_2 ratio, 25mL of H_2O_2 (30%) solution, and 200mL of sample were found. After 60 min, the color removal and efficiency of COD treatment was 94% and 89%, respectively. Besides, the remaining COD after treatment was 97 mg/L. This value meets the requirements for effluent according to the national technical regulations on wastewater quality (QCVN 13:2015/BTNMT). Moreover, the optimal reaction time and the amount of physicochemical sludge generated from this technology were lower than that of traditional Fenton technology. So this technology can be seen as a highly promising technology in textile wastewater treatment in particular and industrial wastewater in general.

Keywords: *wastewater; textile dyeing; fenton; Moving Bed Reactor; advanced oxidation.*

1. INTRODUCTION

The danger of dyeing wastewater has been concerned for many years. The textile industry is impressive because of the huge demand for using water as well as high flow rate of wastewater. This production process is provided with many chemicals and dyes, so pollutants in textile wastewater contain natural impurities, impurities, oils, waxes, nitrogenous compounds, pectin, ... In the event that wastewater is not treated thoroughly and discharged directly to the receiving source, it will cause serious pollution, typically increasing the pH of the water, organic pollution, ... These pollutants will poison, deplete dissolved oxygen, damage aquatic life, cause corrosion and damage drainage structures. In addition, the high color temperature disrupts the aesthetics, causing negative impacts on residents' life. Therefore, many solutions to treat this type of wastewater are given to overcome the pollution. Along with the trend of industrial development and environmental protection, textile factories have been relocated to industrial zones and are required to comply with environmental protection legislation. Huge number of wastewater treatment facilities have been built and operated. However, the monitoring results still showed that many cases did not meet the national standards on the quality of treated wastewater. Furthermore, the thorough treatment of pollutants and low operating costs are of great interest by enterprises and researchers.

The Fenton process is commonly used in the removal of organic pollutants that are present in industrial wastewater [2]. The organic matter's removal of H_2O_2 will be greatly enhanced by the presence of Fe^{2+} ions in the Fenton's mechanism with the successive formation of highly oxidizing OH^0 radicals. Moreover, the Fenton method and its variants or Fenton based methods are of increasing particular interest in wastewater treatment. The combination of adsorption method and traditional Fenton system arranged in a fluidized bed reactor which has been conducted in bisphenol [3], dyes [4] containing wastewater treatment studies. This combination has the advantage of high efficiency of pollutant removal.

Activated carbon is known to be a typical adsorbent with high adsorption efficiency and a stable and durable structure for the adsorption process or carrier [5, 6]. This material has been widely used in combination of many different technologies. Until now, this adsorbent is still novel in the fabrication of variations of Fenton technology. Hence, this study aims to investigate the optimal conditions in the operation of textile wastewater treatment by the Fenton process in the presence of activated carbon.

2. MATERIALS AND METHODS

2.1 Materials

In this study, reactive dye was purchased from Tan Phu Cuong Company. Other chemicals were purchased from Hoa Nam Company. And, activated carbon is made in India.

2.2 Analytical method applied for the determination of dye concentration

The concentration of dye was determined using a Hitachi U5100 UV/visible spectrophotometer. The absorbance spectrum of dye over a broad wavelength was examined. The absorbance of dye solutions were recorded at the wavelength of 542 nm.Color and Chemical oxygen demand (COD) were monitored spectrophotometrically using an AQUALYTIC AL800 direct reading spectrophotometer.

2.3 Experiments

2.3.1 The optimum value of Fe^{2+}:H_2O_2 ratio

These experiments were performed based on the traditional Fenton process. The purpose of this work is to determine the optimal value of the ratio between Fe^{2+} and H_2O_2. Various chemical ratios (1:1, 1:2, 1:5, 1:10) were initially stirred (75 rpm) with a 1000 mg/L dye solution at pH 3.5. Subsequent experiments were conducted with increasing chemical quantities and predetermined chemical ratios. The optimum parameters were determined based on values of COD and color reduction efficiency.

2.3.2 Batch mode experiment of Fenton-MBR/AC

The process of variation of Fenton in the presence of activated carbon was carried out in a batch model lab-scale. The erlen-flask containing activated carbon, 200 mL of dye solution, and the optimum chemical quantity of the Fenton system found in experiment 2.2 was carried out according to the traditional Fenton process.. Experiments applied with textile dyeing wastewater were also conducted sequentially as dye solution.

3. RESULTS AND DISCUSSION

3.1 Dye concentration determination

The absorbance spectrum of dye solution showed that the reactive dye used in this experiment was absorbed maximum at the 542 nm of wavelength (Figure 1). The concentration of dye was determined via a 542 nm wavelength by a linear regression line, which is shown in Figure 2.

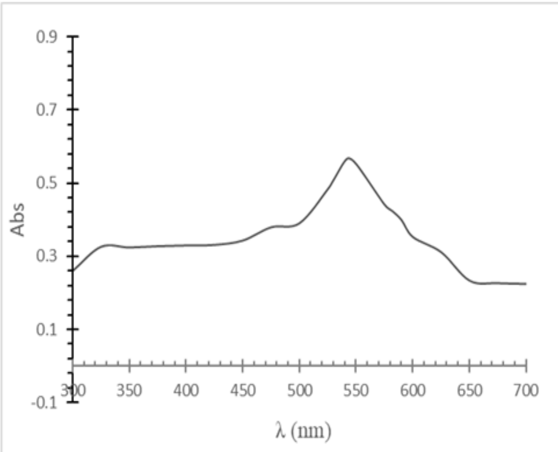


Figure 1. *Absorbance spectrum survey*

3.2 The optimum value of Fe^{2+}: H_2O_2 ratio

Table 1 shows that as 25mL H_2O_2 combined with 50mL $FeSO_4.7H_2O$, the reactive dye was treated with the highest efficiency (87%). In addition, the efficiency obtained at the 1:5 and 1:10 ratios is slightly higher than the 1:2 ratio. Therefore, when the amount of chemicals is less consumed and high efficiency is obtained, the 1:2 ratio is chosen as the optimal value.

3.3 Batch mode experiment of Fenton-MBR/AC

Fig. 3 shows a comparison of the variation of color removal and COD removal of dye solution and textile dyeing wastewater with Fe^{2+}/H_2O_2 and $Fe^{2+}/H_2O_2/AC$ at 30^0C from which it is apparent that both Fenton and Fenton-MBR-AC oxidation were effective in dye decolourisation and COD removal. The extent of dye decolourisation and COD removal was 94% and 89% after 60 min, respectively.

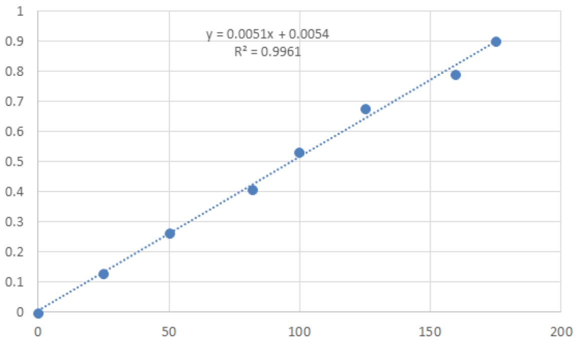
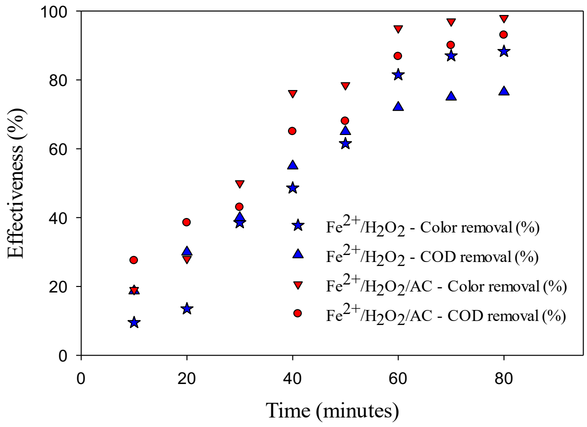


Figure 2. *Linear curve for the reactive dye against its concentration.*

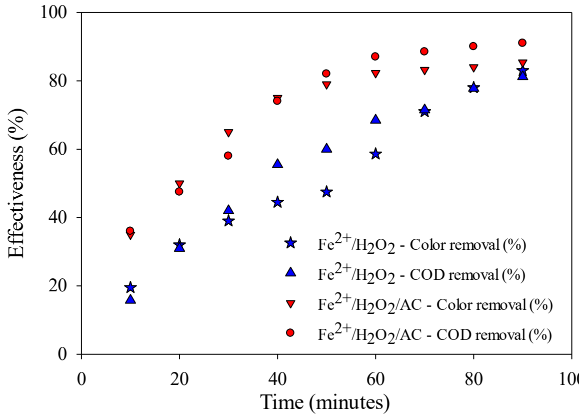
Table 1. *The COD treatment efficiency of the reactive dye obtained corresponds to the ratio between $FeSO_4$ (10g/L) and H_2O_2 (30%).*

H_2O_2 (mL)	Ratio			
	1:1	**1:2**	**1:5**	**1:10**
5	26.09	28.6	20.14	22.12
10	31.2	33.33	33.48	37.4
15	46.46	47.83	52.14	50.08
20	60.87	77.92	70.5	71.7
25	74.41	**86.96**	88.91	80.7
50	73.91	82.09	85.2	82.13

On the other hand, decolourisation exhibited different rates for the two systems. The decolourisation rate in $Fe^{2+}/H_2O_2/AC$ oxidation was much faster than that of the Fe^{2+}/H_2O_2 reaction in the early 60 minutes and the degree of degradation was similar for both systems after 90 min. During the Fenton or Fenton-MBR/AC reaction, dye decomposition is caused by both hydroxyl and hydroperoxyl radicals. It is known that the hydroperoxyl radical has lower oxidation capability than OH^0 [7].



(a)



(b)

Figure 3. *The color and COD removal in the Fenton system with and without AC, in case of dye solution (a) and textile dyeing wastewater (b)*

The increased treatment efficiency in the presence of activated carbon has also been highlighted in previous studies. Several investigations into the degradation of organic compounds or dyes have shown that the initial rate of mineralisation was faster with MBR/AC system than with the same reaction system without AC, due to the higher surface area or more contact between the oxidation elements and pollutants in the case of MBR/AC system [8].

4. CONCLUSIONS

The Fenton process with the presence of activated carbon which is operated according to the moving bed principle exhibited greater efficiency than that of a traditional Fenton system. Furthermore, the chemical savings are evident under the systematic operating conditions of the decolorization of textile wastewater. These advantages will contribute greatly in the elimination of harmful pollutants, and more convincing with the investment needs of wastewater treatment systems.

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