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Degradation of Methyl Red Using a Mixture of Iron Oxide In Silica Mesoporous

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Abstract

Wasting color form textile industrial which is discharged to environment causing enviromental problems, it is because has a toxic and carcinogenic properties. Methyl red as an azo dye was being used as a textile dye. To ressolve this problem, the degradation of the dye was carried out with Fe_3O_4-Fe_2O_2@SiO_2 which was synthesized from natural material and H_2O_2 as oxidizers based on the Fenton method by forming of •OH to reduce methyl red. Degradation of methyl red by the Fenton method was carried out using Fe_3O_4-Fe_2O_2@SiO_2. Parameters of this study are the optimal conditions for degradation, time and the amount of catalyst effect. Optimal degradation conditions of methyl red at pH 3 using Fe_3O_4-Fe_2O_2@SiO_2 at 180 minutes and the amount of catalyst 100 mg. In this optimal condition the percentage of degradation is > 98%.

Keywords : *Fe_3O_4/Fe_2O_2@SiO_2, Degradation, Methyl Red*

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INTRODUCTION

Population growth makes the industrial sector as an important part in the country's development process, one of which is the textile industry. Along with the development of the textile industry, the production process produces dye wastewater that increases with time. During the production period at least 10-15% of the dye waste is produced. If that waste is not treated, it will causing the environmnet problems, It is because the dyes textile used have toxic and carcinogenic properties[1].

Coloring agent which is often used in the textiles industry is methyl red, because it produces good color and easy application. Methyl red is an azo dye (R-N = N-R ') which has the stable and mild characteristics of the azo group so that it is not easy to process this dye waste[2].

Various studies have been carried out to decipher dyes, one of which uses iron nanoparticles [4] which has the advantage that raw materials are abundant in nature. Small iron nanoparticles (Fe_3O_4) are easily oxidized to Fe_2 O_3.

$$Fe_3O_4 + 2H^+ \longrightarrow Fe_2O_3 + Fe^{2+} + H_2O \qquad (1)$$

Thus, The iron nanoparticles must be stabilized to maintain the state of the iron nanoparticles. The stabilization of the iron nanoparticles can be done with protection with mesoporous silica[5] It is because silica has a heat and acid-resistant properties. Protection of the iron oxides with silica does not reduce catalytic activity to degrade azo dyes[6].

The degradation of methyl red can be carried out by using the iron oxide nanoparticles in mesoporous silica with H_2O_2 as an oxidizer known as the Fenton method[7]. The oxidant reaction between the iron ions and H_2O_2 produces hydroxyl radicals (• OH), which in turn will attack the azo chromophore (N = N) and other bonds in the dye[8] [9].

$$Fe^{2+} + H_2O_2 \longrightarrow Fe^{3+} + \cdot OH + OH^- \qquad (2)$$

$$Fe^{3+} + H_2O_2 \longrightarrow FeOOH^+ + H^+ \qquad (3)$$

$$FeOOH^+ \longrightarrow HOO^+ + Fe^{2+} \qquad (4)$$

$Fe^{3+} + \cdot OH \longrightarrow Fe^{2+} + O_2 + H^+$ (5)

The offence of azo chromophore (N = N) by hydroxyl radicals (•OH) causing break down the dye into simpler molecules, like CO_2, NH_2, H_2O and other compound.

Solomon,R.V had been used photo-Fe_3O_4 to degradation the red dyes with the optimum time of degradation is only 70%[10]. While Aini, S. (2019) Fe_3O_4-Fe_2O_3@SiO_2 particles have been synthesized from natural materials, West Sumatra, Indonesia. Synthesized catalysts have different compositions as those used by Solomon. Therefore it is necessary to test the catalyst activity of Fe_3O_4-Fe_2O_3@SiO_2 which is synthesized in degrading methyl red In this study the degradation of methyl red dye using Fe_3O_4-Fe_2O_3@SiO_2 was synthesized using natural ingredients with H_2O_2 oxidizer under pH 3 conditions, this study was conducted with the aim of determining catalyst activity under optimal conditions, time and amount of catalyst.

MATERIALS & METHODS

Materials and Equipments

The material used to degrade the dye is a catalyst Fe_3O_4- Fe_2O_3@ SiO which is synthesized from natural materials, methyl red, 0.1M HCl and H2O2.

The equipment used in this study are, pH meter, magnet, Magnetic Stirrer and absorbance measured using UV-Vis Spectrophotometry.

Method

Determination of the optimum time

A total of 50 ml of 10 ppm methyl red is pipetted and put into a 100 mL beaker glass, then the pH adjustment solution becomes 3 with 0.1 M HCl. Add catalyst Fe_3O_4-Fe_2O_3@SiO_2 100 mg and 1 mL H□O□. Stirred with a magnetic stirrer at certain times 60, 120, 180, 240 and 300 minutes. The catalyst is drawn using a magnet. The concentration was determined using UV-Vis spectrophotometry.

Effect Amount of Catalyst

A total of 50 ml of 10 ppm methyl red is pipetted and put into a 100 mL beaker glass, then the pH adjustment solution becomes 3 with a 0.1 M HCl solution. Add Fe_3O_4-Fe_2O_3@SiO_2. with catalyst amounts 50, 100, 150 and 200mg plus 1 mL H□O□. Stirred with magnetic strirer at the optimal time obtained in the previous procedure. The catalyst is drawn using a magnet. The concentration was determined using UV-Vis spectrophotometry.

The results of the analysis are absorbance values at the measurement wavelength, converted to concentration and then calculated efficiency in percent using the following equation:

Degradation (%) $= \frac{Co - Ct}{Co}$ x 100%

RESULT AND DISCUSSION

Analysis determination of the optimum time

Determination of the optimum time in the process of methyl red degradation using Fe_3O_4-Fe_2O_3@SiO_2 has been done and can be seen in Fig.2 and Fig.3.

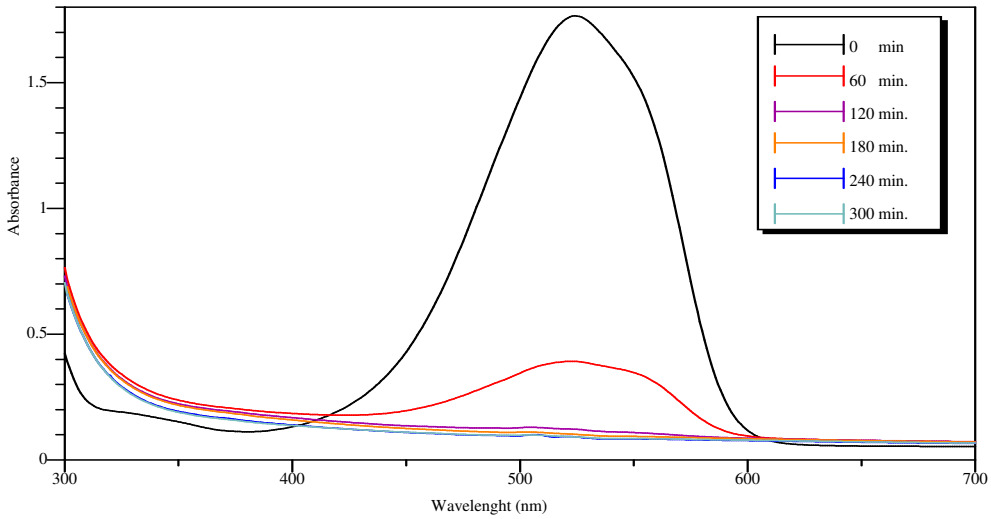

Fig. 1 Absorbance curve of methyl red degradation at optimal time conditions

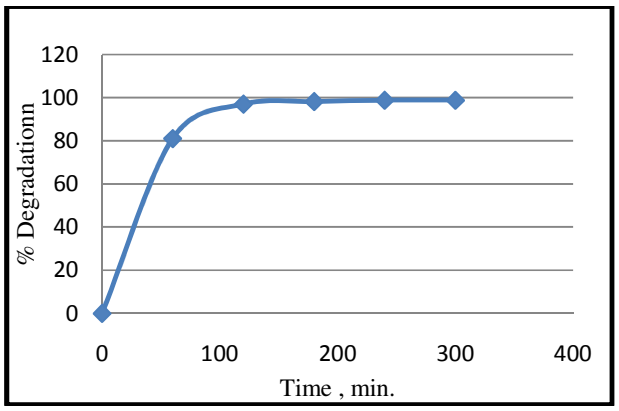

Fig 2.Effect of time on the percentage of methyl red degradation.

Experiments to determine the optimal time for methyl red degradation using 100 mg Fe_3O_4-Fe_2O_3 @ SiO_2; 1 mL H_2O_2 in 50 mL of 100 ppm methyl red according to Figure 3 shows the amount of methyl red decomposed from 0-300 minutes, and the 180 minute decomposition time can be used as the optimum condition of degradation time with the reduction of 98.22. % This is because the contact time between the dyes described with the catalyst will produce longer hydroxyl radicals and cause a large percentage of degradation, and this study was shown at 300 minutes. However, the change in the percentage of degradation between the 180th minute and the 300th minute was not very significant, where there was a 98.83% reduction. So the decomposition treatment at the 300th minute is not efficient to be used as the optimal time.

Compared with degradation using photo-Fe_3O_4 which degradation methyl red as much as <70% in 60 minutes, degradation using Fe_3O_4-Fe_2O_3@ SiO_2 synthesized using raw materials from nature gives better results, with 81% degradation in 60 minutes and capable of decomposition of methyl red >98% at an optimal time of 180 minutes.

Analysis Effect Amount of Catalyst

The amount of catalyst has an influence in the process of decomposition of dyes, this is evidenced in the results of methyl red degradation experiments with variations in the amount of catalyst shown in Figure 3 and Figure 4.

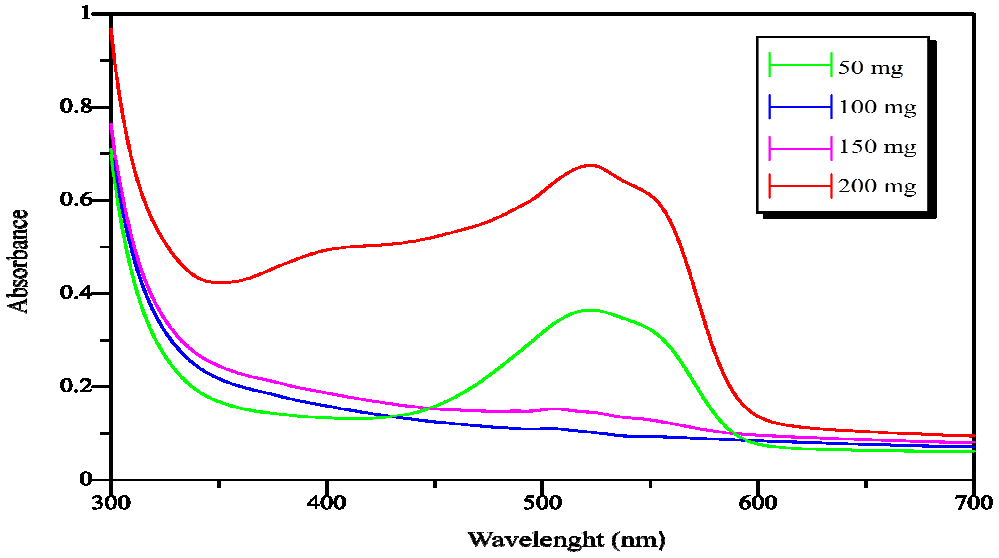

Fig 3. The absorbance curve of methyl red degradation under determination of the optimum conditions for the amount of catalyst.

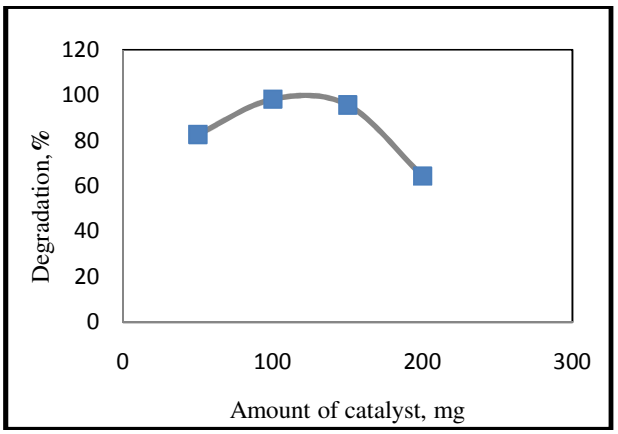

Fig.4. Effect of the amount of catalyst on the percentage degradation of methyl red.

The optimization results of the amount of catalyst Fe_3O_4-Fe_2O_3@SiO_2 in the degradation of methyl red dye is 50; 100; 150 and 200 mg, and the use of a 100 mg catalyst is an optimal condition that results in a reduction of 98.20% can be seen in the figure. This is because the more catalyst used, the more hydroxyl (•OH) radicals are produced so that the breakdown of methyl red is optimal. on the use of 50 mg catalyst to produce hydroxyl radicals (• OH), the result of methyl red degradation occurred as much as 82.72%. However, the use of catalyst more than 100 mg decreased the percentage of degradation, where the use of catalysts 150 and 200 mg with the percentage of degradation were 95.66% and 64.4%, respectively. The decrease in the percentage of degradation is caused by excessive use of catalyst, Fe_3O_4-Fe_2O_3@SiO_2 when added to excessive methyl red and H_2O_2 solution causes the formation of Iron Oxides-Hydroxides which are scattered in solution.

$$Fe^{3+} + H_2O_2 \longrightarrow FeOOH^+ + H^+ \qquad (9)$$

Excessive formation of iron oxide-hydroxide prevents the formation of hydroxyl radicals (•OH) thereby reducing catalyst activity in reducing dyes[11].

CONCLUSION

Based on the research, it can be concluded that the optimum time for degradation of methyl red using Fe_3O_4-Fe_2O_3 @ SiO_2 at pH = 3 is 180 minutes and the optimal amount of catalyst is 100 mg. In this condition the percentage of degradation reaches> 98%.

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