Decreasing concentration of textile dye congo red using Fenton reagent/TiO$_2$/UV

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Abstract. Industrial growth in Indonesia is increasing along with the development of science and technology, for example is the textile industry. Generally the wasted produced by the textile industry is in the form of colored liquid waste which contains various textile coloring agents. One of the substances that lead to pollution in wastewater is the congo red content in it. A method that can be used to treat textile wastewater is AOPS (Advanced Oxidation Processes) using Fenton reagent which are a mixture of hydrogen peroxide and ferro ions based on the formation of hydroxyl radicals ($\cdot$OH). The hydroxyl radical can be maximized by adding UV light to the H$_2$O$_2$/Fe$^{2+}$ system and adding TiO$_2$ photocatalysts. The results showed that TiO$_2$ in the Fenton/UV system could increase the decrease in concentration of congo red. The decrease in concentration of congo red with the fenton/TiO$_2$ system was 97.32% with the contribution of 100 ppm H$_2$O$_2$, FeSO$_4$.$7$H$_2$O 20 mg, and TiO$_2$ 0.2 gram.

Keywords: Congo red, fenton reagent, AOPs, TiO$_2$

1. Introduction

The material business in Indonesia will furthermore construct individuals’ necessity for clothing. The amount of material endeavors in Indonesia comes to 4,652 of each 2018. The amount of material organizations in Indonesia isn’t like the amount of real liquid waste dealing with. Material tone waste ought to be managed first before it discarded. Receptive tones are colors that by and large worn in concealing in the material business. Congo Red is either the responsive shadings which is routinely used by the material industry. Ecosystem imbalances can occur due to the existence of Congo Red in nature. These tones are particularly dissolvable in water and can't be corrupted naturally [1]. Designed shadings are one of the top poisons because of their personality, which interfaces light and lead to pollution and impact biological change [2]. Thusly, elective strategies have been made to oversee colors from batik wastewater.

The creative advances to debase Congo red is the Advanced Oxidation Processes(AOPs) technique, with an innocuous, eco-accommodating, and CO$_2$ and H$_2$O final product. AOPs are frameworks dependent on the exceptionally solid oxidative properties of hydroxyl reactives ($\cdot$OH). These reactives can be created from a mix of H$_2$O$_2$ with a ferrous particle (Fe$^{2+}$) normally alluded to as the Fenton reagent [3].

Also, different attributes of TiO$_2$ have stood out as climate cleansing catalyst, and the substance are as per the following. In any case, the decay response of polluted materials is for the most part an oxidative response, and is dependent upon the VB of the photocatalyst. Thusly, the oxidation response
Further creates when the VB holes have higher oxidative power and there is a more certain electrochemical potential concerning the conventional hydrogen terminal (NHE) potential. The band opening of TiO$_2$ is generally an extent of 3.0–3.2 eV, frequency is around 400 nm. This suggests that UV light brightening with a frequency lower than 400 nm begins a photograph response [4]. Therefore, when TiO$_2$ is enlightened with UV light under 400 nm, its surface is presumably going to achieve heat higher than 30,000 °C, and this extraordinarily high temperature oxidizes all materials. Along these lines, regular blends are rotated absolutely into CO$_2$ and H$_2$O [6].

The joined technique for H$_2$O$_2$, TiO$_2$, and UV light is the most focused on methodology and endeavored to cultivate various kinds of liquid waste. H$_2$O$_2$ is an expert that has strong oxidizing properties that talented to oxidizing mix of salt and not salt in liquid media. UV light is moreover prepared for setting off the breaking of bonds in regular blends. The mix of the two medicines, H$_2$O$_2$, TiO$_2$, and UV light can achieve a more capable and speedier cycle for dealing with the issues of toxins [7].

Fe$^{2+}$ in the fenton reagent goes probably as a force to accelerate the decay of H$_2$O$_2$ to outline a •OH. The system of the fenton response is shown in the circumstance under [8]:

Fe$^{3+}$ + H$_2$O$_2$ → Fe$^{2+}$ + •OH + OH$^-$ (1)

•OH + H$_2$O$_2$ → H$_2$O + HO$_2$$^*$ (2)

Fe$^{3+}$ + HO$_2$$^*$ → Fe$^{2+}$ + H$^+$ + O$_2$ (3)

Fe$^{3+}$ + HO$_2$$^*$ → Fe$^{2+}$ + HO$_2$ (4)

Fe$^{3+}$ + OH$^-$ → Fe$^{2+}$ + •OH (5)

RHX + •OH → X + oxidation product (CO$_2$ + H$_2$O) (6)

(RHX= organic compound)

The photo-Fenton association is a headway of the fenton cycle by adding splendid lights to accelerate and copy the •OH shaped. This cooperation (Fe$^{3+}$/H$_2$O$_2$/UV) captures •OH course of action by H$_2$O/UV and fenton (Fe$^{2+}$/H$_2$O$_2$) response. The presence of recognizable light causes the Fe$^{3+}$ shapedin the fenton response to being changed over indeed into Fe$^{2+}$ particles with the course of action of another hydoxyl reactive [9].

Fe$^{3+}$ + H$_2$O + $hv$ → Fe$^{2+}$ + •OH + H$^+$ (7)

Exactly as superficies of the TiO$_2$ impetuses settled in H$_2$O are enlightened with UV light, the light actuated electrons in the CB partake in the lessening processes, which routinely respond with crumbled O$_2$ in air to make superoxide reactive anions (O$_2$$^•$), the light actuated holes in the VB assimilate to the TiO$_2$ superficies and react with adsorbed H$_2$O, shaping •OH. Taking everything into account, the •OH is essential as a significant dynamic species categories types during the photocatalytic oxidation reaction[10].

2. Materials and Methods

2.1 Impact of H$_2$O$_2$ level

An amount of 100 mL of Congo red specimen entered into measuring utensil glass, trailed by H$_2$O$_2$ course of action with a focus varieties of 10 until 140 ppm. The specimen mixed during 1 hours in dim room, after that quantify the Congo red level at most extreme frequency. Do the H$_2$O$_2$ framework with enlightenment during 1 hours. Henceforth, the ideal level of H$_2$O$_2$ got.

2.2 Impact of FeSO$_4$.7H$_2$O Weight variation

An amount of 100 mL of Congo red specimen entered into measuring utensil glass, after that, entered with FeSO$_4$.7H$_2$O powder with a weight variety of 10; 20; 30; 40; and 60 mg and added with H$_2$O$_2$ optimum. The specimen mixed during 1 hours in dim room, after that quantify the Congo red level at most extreme frequency. Do the FeSO$_4$/H$_2$O$_2$ framework with illumination during 1 hours. Henceforth, the ideal load of FeSO$_4$.7H$_2$O got.
2.3 Impact of TiO$_2$ Weight Variation

An amount of 100 mL of Congo red specimen entered into measuring utensil glass, after that entered with TiO$_2$ powder with a weight variety of 0.1; 0.2; 0.3; and 0.4 gram and added with FeSO$_4$/H$_2$O$_2$ optimum. The specimen mixed during 1 hours in dim room, afterward centrifuged to isolate the congo red arrangement with TiO$_2$. Later quantify the Congo red level at most extreme frequency. Do the TiO$_2$/FeSO$_4$/H$_2$O$_2$ framework with light during 1 hours. Subsequently, the ideal load of TiO$_2$ got.

3. Results and Discussion

3.1. Variety of H$_2$O$_2$ Level

Decreased degrees of Congo red utilizing H$_2$O$_2$ framework and H$_2$O$_2$/UV framework respectively finished by fluctuating the level of H$_2$O$_2$. This framework is acted in dull spaces (without UV light illumination) and with UV illumination. The aftereffects of Congo red decolorization for H$_2$O$_2$ and H$_2$O$_2$/UV frameworks are displayed in Figure 1.

![Figure 1. Impact of H$_2$O$_2$ Level.](image)

In light of Figure 1, the results obtained that the more level of H$_2$O$_2$ is entered, the Congo red decolorization can increment the amount of OH is shaping. Nonetheless, the increase of a lot of H$_2$O$_2$ concentration makes Congo red decolorization be less effective, because it can reduce the amount of OH is shaping. HO$_2$• is formed from the reaction between exces H$_2$O$_2$ and •OH [12]. The mechanism of HO$_2$• shaping is displayed in the situation:

\[
\begin{align*}
\text{H}_2\text{O}_2 + \cdot\text{OH} & \rightarrow \text{HO}_2\cdot + \text{H}_2\text{O} \\
\text{HO}_2\cdot + \cdot\text{OH} & \rightarrow \text{H}_2\text{O} + \text{O}_2
\end{align*}
\]

3.2. Variety of FeSO$_4$ Weight

FeSO$_4$.7H$_2$O utilized as a wellspring of Fe$^{3+}$ to catalyze the photo-decolorization process.
In light of Fig. 2, the results obtained that the more FeSO$_4$ entered to the waste then the level of Congo red decolorization will be greater. The mechanism is happening in the FeSO$_4$ system is displayed in the situation [13]:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$  \hspace{1cm} (10)

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$ \hspace{1cm} (11)

$$Fe^{3+} + Congo red \rightarrow complex \text{Fe}^{3+} - \text{Congo red}$$ \hspace{1cm} (12)

Fe$^{2+}$ and Fe$^{3+}$ particles fill in as coagulant that can bind to the Congo red design a complex. Regardless the proportion of FeSO$_4$ entered, UV illumination can likewise assist with expanding the rate decrease in Congo red levels because of photograph Fenton responses that produce •OH. With oxygen in the climate and the framework, Fe$^{2+}$ particles will oxidize to Fe$^{3+}$ while oxygen will be decreased to H$_2$O [9]. In light of Figure 2 the results obtained that the more FeSO$_4$ entered to the FeSO$_4$/UV framework, the more imperative the degree of Congo red decolorization. Be that as it may, assuming the expansion of FeSO$_4$ an excessive amount of will diminish Congo red decolorization ability. The more FeSO$_4$ entered after the ideal weight, Fe$^{3+}$ is produced from oxidized Fe$^{2+}$ residue, and Fe$^{3+}$ will form new compounds if it reacts with Congo red and lead decolorization cycles to less effective.

3.3. Variety of TiO$_2$ Weight
The decolorization of Congo red or diminished Congo red level in this framework is finished by varying TiO$_2$ weight.
In light of Figure 2, the results obtained that the more TiO$_2$ entered into the waste can increase the decolorization ability. The mechanism is happening in the TiO$_2$ framework is displayed in the situation [10]:

\[
\begin{align*}
\text{TiO}_2 + \text{UV} & \rightarrow e'_\text{(CB)} + h'_\text{(VB)} \\
h'_\text{(VB)} + H_2O & \rightarrow \text{TiO}_2 + H^+ + \cdot\text{OH} \\
h'_\text{(VB)} + OH^- & \rightarrow \text{TiO}_2 + \cdot\text{OH} \\
e'_\text{(CB)} + O_2 & \rightarrow \text{TiO}_2 + O_2^- \\
O_2^- + H^+ & \rightarrow \text{HO}_2\cdot \\
\text{HO}_2\cdot + \text{HO}_2\cdot & \rightarrow H_2O_2 + O_2 \\
e'_\text{(CB)} + H_2O_2 & \rightarrow \cdot\text{OH} + \text{OH}^- \\
H_2O_2 + O_2^- & \rightarrow \cdot\text{OH} + \text{OH}^- + O_2 \\
H_2O_2 + \text{UV} & \rightarrow 2 \cdot\text{OH} \\
\text{Organic Compound} + \cdot\text{OH} & \rightarrow \text{Intermediate} \\
\text{Intermediate} & \rightarrow \text{CO}_2 + \text{H}_2\text{O}
\end{align*}
\]

TiO$_2$ helped by the radiation of UV light brought about the excitation of electrons from the valence band to the conduction band. Electron excitation will cause holes in the valence band ($h^+\text{vb}$) to respond with hydroxyl particles (OH$^-$) to shape hydroxyl radicals which are solid and dynamic oxidizing specialists. In the interim, $e_c^-$ will bind to O$_2$ in the environment to create O$_2\cdot$ as diminishing specialists [10].

The addition of overabundance TiO$_2$ will bring about an abatement in the decolorization ability. This is on the grounds that the addition of abundance TiO$_2$ will make the TiO$_2$ contained in the arrangement block the entrance of UV light to the outer layer of the TiO$_2$ in it. Furthermore, it is evident that there is a recombination cycle on the catalyst so it can't form hydroxyl radicals. To make the decolorization activity decline [6].

### 4. Conclusion

In view of the research results, the decline of congo red substance utilizing fenton reagent/TiO$_2$ all the more successfully with the guide of UV light illumination analyzed about without illumination of light. The ideal level of H$_2$O$_2$ was 100 ppm, the ideal FeSO$_4$ was 20 mg, while the ideal TiO$_2$ was 0.2 gram with the decrease of congo red level for H$_2$O$_2$, H$_2$O$_2$/UV, H$_2$O$_2$/FeSO$_4$, H$_2$O$_2$/FeSO$_4$/UV, H$_2$O$_2$/FeSO$_4$/TiO$_2$, and H$_2$O$_2$/FeSO$_4$/TiO$_2$/UV independently by 2.08%; 6.64%; 47.90%; 65.85%; 78.05%; and 97.32%.
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