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JOURNAL OF ADVANCED ENGINEERING

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5565	06-19	ART	Agustina, Teguh, Wijaya, Mermaliandi,...	STUDY OF SYNTHETIC DYE REMOVAL USING FENTON/TIO2,...	Awaiting assignment

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[AP] Submission Acknowledgement

1 message

Editorial Office <acta@cvut.cz> 19 June 2019 at 19:54
To: Tuty Emilia Agustina <tuty_agustina@unsri.ac.id>

Tuty Emilia Agustina:

Thank you for submitting the manuscript, "STUDY OF SYNTHETIC DYE REMOVAL USING FENTON/TiO2, FENTON/UV, AND FENTON/TiO2/UV METHODS AND THE APPLICATION FOR THE TREATMENT OF JUMPUTAN FABRIC WASTEWATER" to Acta Polytechnica. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL: https://ojs.cvut.cz/ojs/index.php/ap/author/submission/5565
Username: tuty_agustina

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

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[AP] Editor Decision

4 messages

Editorial Office <acta@cvut.cz> 15 October 2019 at 14:54
Reply-To: Ivana Vávrová <ivana.vavrova@cvut.cz>
To: Tuty Emilia Agustina <tuty_agustina@unsri.ac.id>

Dear Tuty Emilia Agustina,

We have reached a decision regarding your submission to Acta Polytechnica,
"STUDY OF SYNTHETIC DYE REMOVAL USING FENTON/TiO2, FENTON/UV, AND FENTON/TiO2/UV METHODS AND THE APPLICATION FOR THE TREATMENT OF JUMPUTAN FABRIC WASTEWATER".

Our decision is:

Revisions Required

Please upload a revised article according to the reviews bellow.

Also, please send us:
1) letters of response, one for each reviewer; each letter should contain detailed point-by-point answers responding to each question and/or comment of the reviewer,
2) corrected version of the article with highlighted changes.
Please upload these to the system or send them to me by email.

Best regards,

Ivana Vávrová

CTU Central Library, Czech Technical University in Prague, Czech Republic
ivana.vavrova@cvut.cz

Reviewer D:

Is the topic of this paper relevant to Acta Polytechnica?:
Yes

Does the manuscript contain original and significant information?:
Yes

Does the Abstract describe the content of the paper?:
Yes

Do the authors inform clearly about aim of the paper?:
Yes

Is the methodology described precisely and accurately?:
No

Is the approach and solution used by the authors appropriate, and is it described clearly?:
No

Are the Conclusions justified by the results?:
Yes

Can the paper be published in its present form, without major language revision?:

Yes

Comments to the Author(s)::

This manuscript described the degradation of Reactive Red 2 (RR2) by Fenton/TiO2, Fenton/UV and Fenton/TiO2/UV in model solutions. Comparisons have been made and the optimal conditions were applied to the wastewater from Jumputan fabric industry. The methods used in the manuscript are not novel, however, the results lend help to the treatment of real wastewater containing such synthetic dye as RR2.

Upon review of the submission, the reviewer finds it difficult to support the publication of this paper in the journal in its present form. Major editing is required to improve the quality of English style/grammar. The misuse of the English language is found throughout the manuscript.

Some specific comments are as follows.

1) Whole paper.

- Please add line numbers to the manuscript.

2) Page 170.

- Photocatalyst semiconductor [4] is not a technology, while photocatalysis is.

3) Page 171.

- Similarly, Fenton reagent is not a method, however Fenton oxidation is.
- The authors mentioned the Fenton process is able to produce hydroxyl radicals at a LOW COST. How was the conclusion drawn? What is the author's standard?
- The use of this reagent does not require…. What does "this reagent" refer to, Fe (iron) or Fenton reagents (Fe2+ and H2O2)?

4) Page 172.

- The Titanium dioxide (TiO2) catalysts were purchased from Sigma Aldrich.
- Please provide more details of the experimental setup. The provision of experimental setup is best.
- It was written that after taking the sample immediately add 0.1 ml 1 N Na2S2O3…. Since the samples were taken every 5 minutes, the reviewer is wondering which sample refers to here on earth.
- COD0 is COD at t = 0, not t = o. Please revise the typo.
- In a previous study, Fenton reagent was used to treat RR2…. Where is the result of previous study? Please provide the citation if they have been published.

5) Page 173.

- 4.1 Effect of Fenton's reagent molar ratio
- The authors used the ratio of [Fe2+]/[H2O2] from 1:20, 1:40 to 1:80 in a decreasing order in Figure 1. Thus, it is not correct to say that the higher the Fenton molar reagent ratio used in this study, the higher the color and COD degradation obtained.
- It can be seen from figure 1 that the efficiency of color degradation and COD removal are still increasing when the ratio of [H2O2] / [Fe2+] was increased to 80:1. Further addition of H2O2 could possibly enhance the removal of COD.
- Please provide the unit of the catalyst concentration in figure 2.

6) Page 174.

- The results indicate that the rate of decolorization rises constantly with the increase in the amount of TiO2 catalyst… Are the results from your experiment or reference 22?
- Please provide more references than reference 23 as SEVERAL studies have also shown…..

7) Page 175

- Is the sunlight as efficient as UV light when it is used as light source? Please compare them and provide the results if possible.

8) References

- Provide DOI identifier for references when available (see the provided Manuscript Example on Author Guidelines webpage).
- Pay attention to the use of subscript.

Reviewer E:

Is the topic of this paper relevant to Acta Polytechnica?:
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Does the Abstract describe the content of the paper?:
Yes

Do the authors inform clearly about aim of the paper?:
Yes

Is the methodology described precisely and accurately?:
Yes

Is the approach and solution used by the authors appropriate, and is it described clearly?:
Yes

Are the Conclusions justified by the results?:
Yes

Can the paper be published in its present form, without major language revision?:
Yes

Comments to the Author(s)::
The authors studied the dye removal using Fenton/TiO2, Fenton/UV, and Fenton/TiO2/Uv methods and the application for the treatment of jumputan fabric wastewater. The results obtained are exciting and this manuscript merits publication in the journal “Acta Polytechnica Journal of Advanced Engineering.” However, the authors should address the following issues before acceptance for publication.

1. Authors should be rewritten the introduction due to research gaps are not clearly highlighted.
2. Fig 1-4 are challenging to read. The authors should be more rigorous on the quality of the figures provided.
3. Most of the references used are out of date. Please change with the newest one.
4. The author should provide the adsorption data of Ti oxide to see the contribution of dye removal because of the material.

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tuty_agustina unsri <tuty_agustina@unsri.ac.id> 9 November 2019 at 01:11
To: Ivana Vávrová <ivana.vavrova@cvut.cz>

Dear Ivana Vávrová,

Please find attached the file of the letters of response, one for each reviewer; and the revised article. All the reviewer requests have been addressed. The corrected version of the article is attached with the yellow highlighted changes. The revised article also.upload to the system.
Thank you very much for your editorial effort.

Best regards,
[Quoted text hidden]
--
Tuty Emilia Agustina, PhD
Chemical Engineering Department
Faculty of Engineering
Sriwijaya University
Jl Palembang Prabumulih Km 32 Indralaya 30662
South Sumatera-Indonesia

3 attachments

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Vavrova, Ivana <Ivana.Vavrova@cvut.cz> 12 November 2019 at 14:20
To: tuty_agustina unsri <tuty_agustina@unsri.ac.id>

Dear Tuty Emilia Agustina,

thank you for your responses etc. I sent your article for the second round.

I will let you know the results.

Best regards

Ivana Vavrova

Ivana Vávrová

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Od: tuty_agustina unsri <tuty_agustina@unsri.ac.id>
Odesláno: 8. listopadu 2019 19:11
Komu: Vavrova, Ivana
Předmět: Re: [AP] Editor Decision

[Quoted text hidden]

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tuty_agustina unsri <tuty_agustina@unsri.ac.id> 13 November 2019 at 07:08
To: "Vavrova, Ivana" <Ivana.Vavrova@cvut.cz>

Dear Ivana Vavrova,

Thank you very much.

Regards,
[Quoted text hidden]

[AP] Editor Decision

1 message

Editorial Office <acta@cvut.cz> 3 December 2019 at 15:34
Reply-To: Ivana Vávrová <ivana.vavrova@cvut.cz>
To: Tuty Emilia Agustina <tuty_agustina@unsri.ac.id>

Dear Tuty Emilia Agustina,

We have reached a decision regarding your submission to Acta Polytechnica,
"STUDY OF SYNTHETIC DYE REMOVAL USING FENTON/TiO2, FENTON/UV, AND FENTON/TiO2/UV METHODS AND THE APPLICATION FOR THE TREATMENT OF JUMPUTAN FABRIC WASTEWATER".

Our decision is:

Accept Submission

Please upload all the supplementary files to your article (.tex and .bib) and also please upload all the images separately (pdf, png, or jpg).

Best regards,

Ivana Vávrová

Central Library, CTU in Prague
ivana.vavrova@cvut.cz

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Hal : Penjelasan proses publikasi karya ilmiah.

Dengan ini menerangkan bahwa karya ilmiah kami,

Judul : Study of synthetic dye removal using Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods and the application to Jumputan fabric wastewater
Terbit di : Jurnal Acta Polytechnica, Vol.56, edisi Desember 2019

Proses submission jurnal di atas dimulai pada bulan Juni 2019, hasil review diterima pada bulan Oktober 2019, dan perbaikan hasil review disubmit kembali pada tgl 9 November 2019, serta dinyatakan diterima pada tgl 3 Desember 2019 (bukti komunikasi terlampir).

Sedangkan karya ilmiah kami,

Judul : The effect of Reactive Red 2 initial concentration on COD and colour degradation by using Fenton, Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods
Terbit di : IoP Conference Series: Materials Science and Engineering, Vol. 620, 2019

Paper pada IoP Conference Series di atas dinyatakan diterima pada 28 Agustus 2019, dan terbit secara on line pada **19 November 2019**. Namun paper ini belum termasuk dalam referensi paper di jurnal Acta Polytechnica, dikarenakan manuskrip yang dikirimkan ke jurnal Acta Polytechnica sudah submit sejak bulan Juni 2019, dan versi terakhir dari penulis yang disubmit ke jurnal Acta Polytechnica adalah pada tgl **9 November 2019**, dimana pada saat itu paper di IoP Conference Series **belum terbit.**

Dapat kami sampaikan bahwa jurnal di Acta Polytechnica dan Prosiding di IoP Conference Series ini menyajikan materi/data hasil penelitian yang berbeda, walaupun dalam satu tema penelitian yang hampir sama. Karya ilmiah yang diklaim adalah jurnal yang terbit di Acta Polytechnica.

Demikianlah penjelasan kami terkait proses publikasi kedua karya ilmiah di atas. Besar harapan kami, kiranya penjelasan mengenai proses publikasi ini dapat menjadi bahan pertimbangan. Atas perhatiannya diucapkan terima kasih.

Indralaya, 20 Januari 2020
Penulis utama/corresponding author,

Tuty Emilia Agustina, ST, MT, PhD
Jurusan Teknik Kimia Fakultas Teknik
Universitas Sriwijaya

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The effect of reactive red 2 initial concentration on COD and colour degradation by using Fenton, Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods

IOP Conf. Series: Materials Science and Engineering **620** (2019) 012017 doi:10.1088/1757-899X/620/1/012017

The effect of reactive red 2 initial concentration on COD and colour degradation by using Fenton, Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods

Tuty Agustina[1] , Dedi Teguh[1], Yourdan Wijaya[1], Febrian M[1] , Ahmad Bustomi[1] Jantan M[1] , Gita T[1] and Tessa Rebecca[1]

[1]Program Study of Chemical Engineering University of Sriwijaya

E-mail : tuty_agustina@unsri.ac.id

Abstract. One area that is developing in Indonesia is in the area of textile industry. These industries absorb a lot of labor and contribute to the country's foreign exchange but have a negative impact in the form of wastewater produced. The wastewater produced generally contains synthetic dyes such as Reactive Red 2 (RR2). This synthetic coloring material will pollute the environment if it is not well treated first before being discharged into the environment. In this study, RR2 will be used as a pollutant model. RR2 will be treated by several methods. Pollutant concentration is an important parameter in determining the most appropriate treatment method. The purpose of this research was to study the effect of RR2 initial concentration on reducing COD and color using Fenton, Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods. RR2 concentration was varied between 150-300 ppm. As the results, RR2 concentration from 150-300 ppm does not significantly affect the percentage of color degradation. However, at high concentration of 250 and 300 ppm, the percentage of COD degradation decrease by increasing concentration of RR2. When using 150 ppm of RR2, the highest COD and color degradation of 98.8 % and 89.5 %, respectively were achieved by using the Fenton/TiO_2/UV methods.

1. Introduction

One of industry that is growing rapidly in Indonesia is the textile industry. The textile sector is the main non-oil and gas export commodity from Indonesia. The existence of the textile industry has absorbed a lot of labor and generated foreign exchange for the country. No doubt this industry has made a positive contribution to the Indonesian economy. However, every industrial activity must have a side effect in the form of the production of waste, including wastewater from the textile industry. The main source of wastewater in the textile industries is on the use of dyes [1], it is because the textile dyes may be composed of various chemicals, toxins, heavy metals, pharmaceuticals, petroleum based oils, and greases, that are difficult to decompose [2]. The textile industries use a lot of synthetic dyes such as procion, erionyl and auramin [3] because of its relatively cheap price, long-lasting color, more various of color choices and easy to use compare to natural dyes [4]. Textile dyes may interfere the aesthetics, which is immediately visible from the wastewater generated. The colored wastewater will decrease the incoming sunlight into the water body and will inhibit the photosynthesis process. Moreover, it will disrupt the balance of the ecosystem. The synthetic dyes also have the character of carcinogenic and mutagenic material [4].

The Fenton reagents involve the application of ferrous ions (Fe^{2+}) to react with hydrogen peroxide (H_2O_2) producing hydroxyl radicals ($^{\bullet}OH$) with the powerful oxidizing ability to degrade organic

pollutants in wastewater [5] otherwise there is no energy needed in terms of activating hydrogen peroxide because the reaction takes place at room temperature and atmospheric pressure [6]. Fenton's reagent is a solution of hydrogen peroxide with dissolved ferrous iron as a catalyst. It is used to oxidize organic contaminant found in industrial wastewaters [7]. The oxidation method with Fenton reagent has been applied for processing various kinds of industrial wastewater containing toxic organic compounds such as olive oil processing industry [8], palm oil processing industry [9], and pesticides [10]. The mechanism of the reaction starts with Fe^{2+} initiating the reaction and catalyzing the decomposition reaction of H_2O_2 to produce hydroxyl radicals ($^{\bullet}OH$) according to the reaction equation:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + {}^{\bullet}OH \quad (1)$$

Hydroxyl radical ($^{\bullet}OH$) is able to break down almost all organic compounds, typical application is the destruction of organic solvents that are resistant to biological oxidation such as phenols, formaldehyde, methylene chloride and chlorinated solvents [11]. It will react with dissolved components, and initiate successive reactions through a series of oxidation processes so that the component is degraded. Although involving complex reactions, generally the reactions that occur in Fenton reagents are as follows [12]:

$$^{\bullet}OH + H_2O_2 \rightarrow H_2O + HO_2^{\bullet} \quad (2)$$

$$Fe^{3+} + HO_2^{\bullet} \rightarrow Fe^{2+} + H^+ + O_2 \quad (3)$$

$$Fe^{2+} + HO_2^{\bullet} \rightarrow Fe^{3+} + HO_2^- \quad (4)$$

$$Fe_2^+ + {}^{\bullet}OH \rightarrow Fe^{3+} + OH^- \quad (5)$$

If illuminated with a light of an appropriate wavelength (180-400 nm), i.e. ultraviolet and some visible light, Fe^{3+} can catalyze the formation of hydroxyl radicals:

$$Fe_3^+ + H_2O + h\nu \rightarrow Fe^{2+} + H^+ + {}^{\bullet}OH \quad (6)$$

Photocatalyst is a catalyst that works when given a certain wavelength of light. Photocatalysts are generally a semiconductor that has a full valence band and an empty conduction band such as TiO_2. The TiO_2 is a catalyst that is often used in the photocatalysis process because of its superiority. If the semiconductor is subjected to a certain wavelength of light, the electrons will be excited from the valence band to the conduction band to produce a hole in the valence band [13]. This process occurs in the early stages of a photocatalyst reaction. Among the many types of semiconductors, until now TiO_2 has become a choice especially in the form of anatase crystals as photocatalysts.

$$TiO_2 + h\nu \rightarrow e^-_{cb} + h\nu^+_{vb} \quad (7)$$

$$h\nu^+_{vb} + H_2O \rightarrow {}^{\bullet}OH + H^+ \quad (8)$$

This reaction is one type of advanced oxidation processes and is the beginning of the next photocatalytic reaction [13]. If there are other oxidizing agents such as Hydrogen peroxide or ozone, additional hydroxyl radicals can be produced under UV irradiation. For example Hydrogen peroxide separated in the presence of UV light produces two hydroxyl radicals:

$$H_2O_2 + h\nu \rightarrow 2\ {}^{\bullet}OH \quad (9)$$

Hydroxyl radicals which become the character of AOPs have high oxidation potential, so they can reduce COD levels in wastewater. In this case the Fenton reagent serves as a degradator of pollutant or contaminant compounds that are difficult to degrade. The purpose of this study is to study the effect of RR2 initial concentration on degradation of COD and color by using Fenton, Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods. In addition, the results will be compared to determine the most effective method.

2. Materials and method

2.1. Materials

Reactive Red 2 (RR2) synthetic dye used in this research was obtained from dyes suppliers of Fajar Kimia in Jakarta. Titanium dioxide (TiO_2) catalysts was purchased from Sigma Aldrich. Sulfuric Acid (H_2SO_4), Sodium hydroxide (NaOH), Sodium Thiosulfate ($Na_2S_2O_3$), Hydrogen peroxide (H_2O_2 30% w/v), and Ferro sulfate ($FeSO_4.7H_2O$) were obtained from Merck. To adjust the pH 0.1 M H_2SO_4 and 0.1 M NaOH was used. The UV source is obtained from a 15 watt UV lamp with a wavelength of 253.7 nm (UV-C).

2.2. Procedure

The treatment of RR2 is carried out in a batch reactor equipped with mechanical stirrers and UV lamps. Synthetic dye wastewater is made by dissolving a certain amount of RR2 into distilled water. RR2 initial concentration was varied from 150 to 300 ppm. In this study, Fenton reagent was made with $FeSO_4.7H_2O$ and H_2O_2 molar ratio of 1: 80 by using 4 mM of $FeSO_4.7H_2O$.

First, measure COD and absorbance of RR2 solution with a concentration of 150 ppm. Add the solution to the UV reactor. Set the stirring speed to 500 ppm. Add $FeSO_4.7H_2O$ and set the pH to 3 by adding a solution of 0.1 M H_2SO_4 or 0.1 M NaOH. Next add H_2O_2 to make a comparison of $[Fe^{2+}]/[H_2O_2]$ 1: 80. In the Fenton/TiO_2 process, the addition of 0.4% (w/v) TiO_2 was carried out after adding the Fenton reagent to the reactor. Then repeat the experiment by varying RR2 concentration.

In the Fenton process the reaction time starts when H_2O_2 is added. In the Fenton/TiO_2 process, the reaction time starts when TiO_2 is added. In the Fenton/UV process the reaction time starts when H_2O_2 is added and the UV lamp is turned on. Whereas in the Fenton/UV/TiO_2 process, the reaction time starts when TiO_2 is added and the UV lamp is turned on. The solution sample was taken every 5 minutes to analyze the COD value and its absorbance. After taking the sample immediately add 0.1 ml 1 N $Na_2S_2O_3$ into the sample solution to stop the reaction [14].

2.3. Analysis

The UV-Visible GenesysTM 20 Spectrophotometer was used to analyze the color through absorbance measurements, while the COD value was determined by titrimetric method. pH measurement is done by using pH meter (Hanna instrument). The percentage of RR2 color degradation is determined by following equation:

$$\%\ color\ degradation = \frac{(A_0 - A_t)}{A_0}\ x\ 100\% \quad (10)$$

With A_0 is color absorbance at t = 0, A_t is color absorbance at t = t, and t = time. While the percentage of COD degradation is calculated by following equation:

$$\%\ COD\ degradation = \frac{(COD_0 - COD_t)}{COD_0}\ x\ 100\% \quad (11)$$

With COD_0 is COD at t = 0, COD_t is COD at t = t, and t = time.

3. Results and discussion

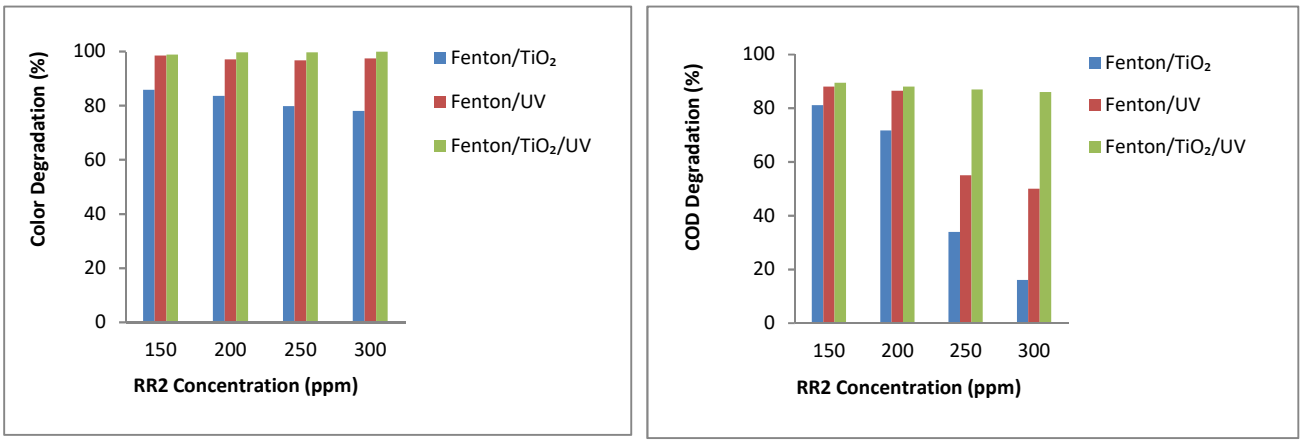
The parameters analyzed in this study are color and COD. The COD value represents the amount of total oxygen needed to decompose organic and chemical compounds that are chemically dissolved in a wastewater. The proposed mechanism of the reaction for RR2 degradation by using Fenton reagent is as follows:

$$C_9H_{10}C_{12}N_6Na_2O_7S_2 + {}^{\bullet}OH \rightarrow C_9H_{10}C_{12}N_6Na_2O_7S_2(\text{-}OH) + \text{oxidized intermediates} + CO_2 \quad (12)$$

In the previous study, the use of Fenton reagent alone (molar ratio of 1:80) in processing RR2 with a concentration of 150 ppm resulted in 69 % of color degradation. While the use of UV lamps and Fenton reagent with the same molar ratio is able to achieve a higher color degradation of 97.5 % even though it is used at higher RR2 concentrations (300 ppm). Thus the Fenton/UV method provides better color degradation than using Fenton method alone. This is due to the Fenton/UV method, more hydroxyl radicals are produced, which are initiated by the presence of UV light according to equation (9).

The effect of initial concentration of RR2 dye solution needs to be investigated because the pollutant concentration is an important parameter in wastewater treatment [15]. By knowing how much concentration can be charged to a processing method, it can be known the efficiency of the method. Because the purpose of any wastewater treatment is the fulfilment of environmental quality standards at the end of processing, before wastewater is discharged into the environment. In this study, the initial concentration of RR2 varied from 150-300 ppm with a molar ratio of 1:80.

In Figure 1 (a), it can be seen that the Fenton/TiO_2/UV method gives the highest percentage of color degradation compared to the Fenton/UV or Fenton/TiO_2 methods. In the use of RR2 with an initial concentration of 150 ppm, the color degradation were 85.8 %, 98.5 %, and 98.8 % by using the Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods respectively. However, in general, variations in RR2 concentration from 150-300 ppm do not significantly affect the percentage of color degradation in each processing method. The formed hydroxyl radicals will break the double bond on the procion red into a simpler compound and so the color will degrade in the wastewater, which was originally red to became clear [16].



(a) (b)

Figure 1. Effect of initial RR2 concentration on (a) Color degradation and (b) COD degradation by using Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods (Fenton reagent molar ratio of 1:80, pH 3, 0.4% TiO_2 catalyst concentration, and reaction time of 5 min)

As can be seen in Figure 1 (b), the COD degradation were 81.2%, 88%, and 89.5 % by using the Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods respectively were obtained when using RR2

initial concentration of 150 ppm. Obviously, the Fenton/TiO_2/UV method also gave the highest percentage of COD degradation compared to the Fenton/UV and Fenton/TiO_2 methods as shown in Figure 1 (b). This is caused, in the Fenton/TiO_2/UV method, the hydroxyl radical produced is more than in the Fenton/UV or Fenton/TiO_2 method. The use of Fenton/TiO_2/UV can produce hydroxyl radicals according to equation (1), (6), and (8). In the use of concentrations of RR2 of 250 and 300 ppm, a significant difference in COD degradation was obtained from each method. The COD degradation of 86%, 50%, and 16%, respectively, were achieved by the Fenton/TiO_2/UV, Fenton/TiO_2, and Fenton/UV methods, when using a concentration of RR2 of 300 ppm. In this case, the Fenton/UV and Fenton/TiO_2 method looks less effective than Fenton/TiO_2/UV, probably because of the concentration of RR2 and TiO_2 catalyst which is high enough to block UV light from initiating the oxidation reaction according to equations (6), (8), and (9), thus inhibiting the formation of hydroxyl radicals.

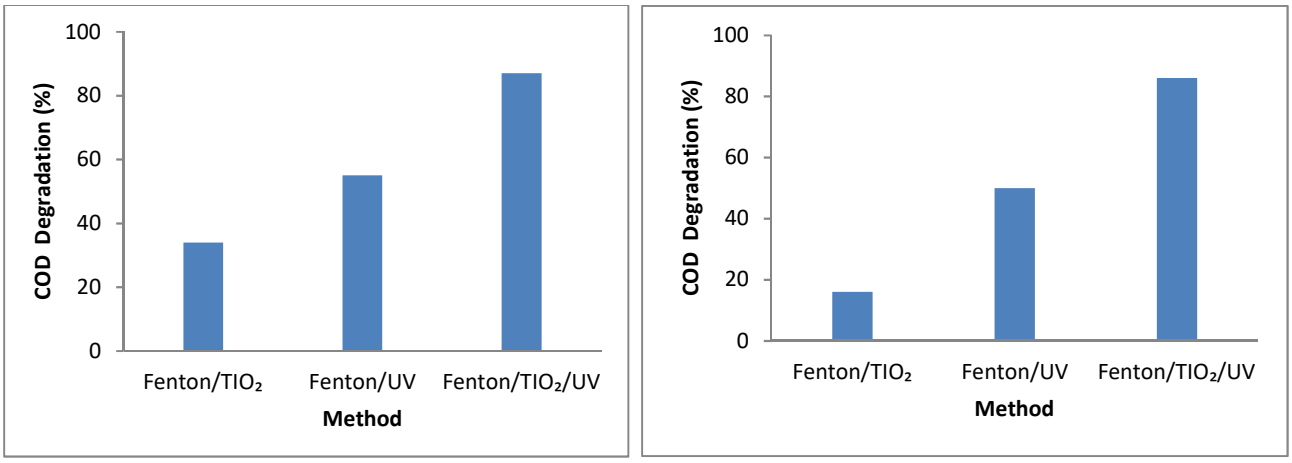


Figure 2. COD degradation by using Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods when using initial RR2 concentration of (a) 250 ppm and (b) 300 ppm (Fenton reagent molar ratio of 1:80, pH 3, 0.4% TiO_2 catalyst concentration, and reaction time of 5 min)

Figure 2 (a) and (b) compare the COD degradation by using Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV methods. From both figures, it is clear that the highest COD degradation was achieved when applying Fenton/TiO_2/UV method. This is because this method produces the most hydroxyl radical according to equation (1), (6), and (8). The percentage of COD degradation decrease by increasing initial RR2 concentration from 250 to 300 ppm, as can be seen in both figures. For example, in Fenton/TiO_2 method, the COD degradation percentage of 34% was obtained by using initial concentration RR2 of 250 ppm as demonstrated in Figure 2 (a), while the COD degradation percentage of 14% was obtained by using initial concentration RR2 of 300 ppm as shown in Figure 2 (b). This result is in agreement with other research conducted by Agustina and Ang (2012). In their study, increasing the initial concentration of Reactive Blue 4 from 20 to 200 ppm decreases the decolorization from 94.5% to 81%, and similarly for Reactive Red 2, increasing the initial concentration from 20 to 200 ppm decreases the decolorization from 100% to 91.5%, within 60 minutes of reaction [17]. The increase in dye concentration increases the number of dye molecules but not the number of hydroxyl radical. That is why the percentage of degradation decrease with increasing the initial dye concentration.

4. Conclusion

In this study Reactive red 2 (RR2) synthetic dye was treated by using Fenton-based of Advanced Oxidation Processes, namely, Fenton, Fenton/TiO_2, Fenton/UV, and Fenton/TiO_2/UV. The effect of RR2 initial concentration on COD and color degradation were studied. From the study, it was found that RR2 concentration from 150-300 ppm do not significantly affect the percentage of color degradation. However, at high concentration RR2 of 250 and 300 ppm, the percentage of COD degradation decrease by increasing concentration of RR2. The Fenton/TiO_2/UV method is superior to other methods with the highest COD and color degradation, using Fenton reagent molar ratio of 1:80, pH of 3, and TiO_2 catalyst concentration of 0.4% (w/v), in a reaction time of 5 minutes. When using 150 ppm of RR2, the highest COD and color degradation of 98.8 % and 89.5 %, respectively were achieved by using the Fenton/TiO_2/UV methods.

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