Effect of Uv Light Variation and $CaCO_3$ (Scavenger) Concentration in Reducing Humic Acid Using TiO_2/Fe_3O_4

Salsabila Juwita Lestari, Fahrizal Adnan(✉), Muhammad Busyairi, and Searphin Nugroho

Department of Environmental Engineering, Mulawarman University, Samarinda, Indonesia
fahrizaladnan@ft.unmul.ac.id

Abstract. Photocatalyst using TiO_2/Fe_3O_4 aims to degrade humic acid with the help of UVA and UVC. This study also studied the effect of scavengers using calcium carbonate ($CaCO_3$). This study used the sol-gel method for the synthesis of TiO_2/Fe_3O_4. The percentage of degradation using TiO_2/Fe_3O_4 with the help of UVA light is higher, namely 87.032% compared to the percentage of UVC degradation which is 85.495%. This is because the use of UVC rays causes other carcinogenic chemical compounds to be degraded. The percentage of degradation using TiO_2/Fe_3O_4 with the help of UVA light and the addition of 10 mg of $CaCO_3$ got the highest percentage of degradation of 88.761% compared to the addition of 20 mg of $CaCO_3$ getting the percentage of degradation of 85.110%. This is because $CaCO_3$ helps precipitate the catalyst material if added in the right dose. This study used a standard solution of humic acid pH 3 with a humic acid concentration of 15 ppm, this study was conducted for 5 h with sampling every 30 min and repeated 3 times.

Keywords: $CaCO_3$ · Photocatalyst · TiO_2/Fe_3O_4 · UVA · UVC

1 Introduction

Humic acid is an organic substance that is often found in the environment with a complex molecular structure with a high molecular weight (macromolecules or organic polymers) and contains active groups. Humic acids found in nature are formed through physical, chemical and biological processes derived from materials that have gone through the humanification process in the form of plants and animals (Zainul et al., 2020). Humic acid has the ability to bind organic compounds and metal ions (Firda et al., 2016). The increase in pH in the soil is caused by the presence of humic substances or humic acids which have a very significant effect on changes in soil pH. in the soil[1].

One way to degrade humic acid is to use a photocatalyst. Photocatalyst is a combination of photochemical process and catalyst. The photochemical process is a chemical transformation process using light as a trigger, while a catalyst is a substance that can speed up the rate of a reaction. Chemical reactions involving photocatalysts are called

T. D. Larasati et al. (Eds.): ICTROPS 2022, ABSR 31, pp. 114–119, 2023.
https://doi.org/10.2991/978-94-6463-180-7_14

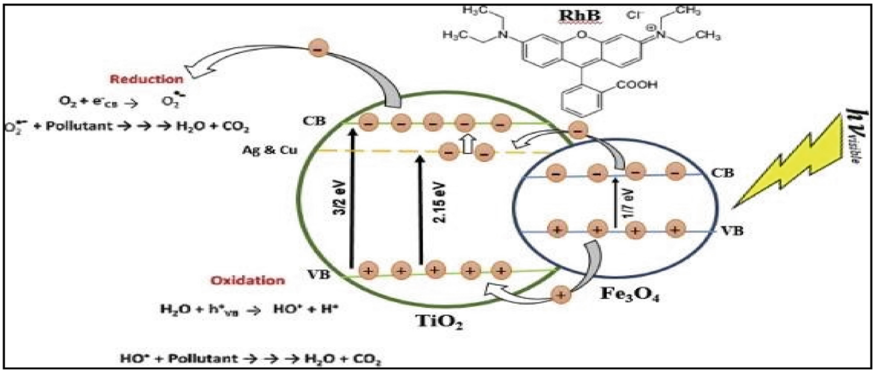

Fig. 1. TiO_2/Fe_3O_4 Photocatalyst Mechanism

photocatalytic reactions. Photocatalyst itself is a material that can accelerate the rate of reaction by oxidation or reduction through photochemical reactions that are semiconductors. UV light or sunlight can cause semiconductors to produce electrons in the conduction band and cause holes in the valence band to form which can cause radicals and can degrade organic waste with the help of UV light or sunlight which has more photons than the electron excitation energy. The advantage of using semiconductors from photocatalysts is that they can mineralize the total organic pollutant content. Another advantage of photocatalysts is that as long as there is light and a catalyst, they will continue to produce radicals that will attack other substances non-selectively.

The form of TiO_2 that is often used because it is easier and has a large surface area is powder, but this powder form can form a suspension in solution and make it difficult to separate photocatalyst solids from solution. The process of separating photocatalyst solids from solution using an external magnetic field. Photocatalyst using magnetic elements is done by coating TiO_2 on the magnetic elements used. One of the magnetic materials that can be used because it has ferromagnetic properties that are relatively inexpensive, does not have toxic properties, is biocompatible, and has a broad sensor, has catalytic properties, namely Fe3O4[2]. There are several things that can affect the photocatalyst process, one of which is the addition of scavengers or interfering substances. Scavenger is also an important factor in the catalytic process because it can increase the reactivity of TiO2[3] (Fig. 1).

2 Methods

In this research, two types of UV light were used to determine the best light for degradation through the photocatalyst process, namely UVA and UVC rays. The method used to determine the best type of lamp is to use 4 reactors, each containing 2 pairs of UVA and UVC lamps. Observation time was carried out for 5 h (0, 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 min) with each sampling test every 30 min and 3 repetitions of each sample, then the absorbance value was determined. The results obtained were measured using UV-VIS and then averaged the results of the three repetitions carried out.

The first step is to make a 15 ppm humic acid solution with a pH of 3 (acidic). Take 15 mL of concentrated humic acid, put it in a 500 mL beaker, add distilled water to the glass mark and measure the pH of the solution using a pH meter, add HCl until the pH of the humic acid solution becomes 3 (acid). Added TiO_2/Fe_3O_4 with a ratio of 2:1 which had previously been calcined using a furnace at 250 °C for 2 h, as much as 1 g of TiO_2/Fe_3O_4 with a ratio of 2:1 was put into a beaker containing a solution of humic acid.

2.1 Synthesis of TiO_2/Fe_3O_4

The synthesis of TiO_2/Fe_3O_4 was carried out using a ratio of 2-propanol, distilled water and titanium butoxide 3:1:1, put into a 500 mL beaker then stirred using a magnetic stirrer until homogeneous and became a precursor solution. Then, 100 mL of the precursor solution was poured into a 500 mL beaker and added 5 g of solid Fe_3O_4 to obtain a ratio of 2:1 and then placed on a stirring rod. Pour 100 mL of distilled water into a measuring cup containing TiO_2/Fe_3O_4. Enter the distilled water into a 50 mL burette to facilitate the addition of aquadest slowly while stirring using a stirrer until well mixed. Wait 24 h until the solution forms a precipitate, then the liquid above the precipitate is removed and the precipitate is poured into a vaporizer to be dried in an oven at 105 °C for ± 5 h. The resulting solid is then ground and put into a crucible to be calcined at 250 °C for ± 2 h.

2.2 Photocatalytic Activity Test

The steps taken are to make a 15 ppm humic acid solution with a pH of 3 (acidic). Take 15 mL of concentrated humic acid, put it in a 500 mL beaker, add distilled water to the glass mark and measure the pH of the solution using a pH meter, add HCl until the pH of the humic acid solution becomes 3 (acid). Added TiO_2/Fe_3O_4 with a ratio of 2:1 which had previously been calcined using a furnace at 250 °C for 2 h, as much as 1 g of TiO_2/Fe_3O_4 with a ratio of 2:1 was put into a beaker containing a solution of humic acid. Then the percentage of degradation was measured using UVA and UVC rays. The best light results were obtained, then the percentage of degradation was measured with the addition of 10 mg and 20 mg $CaCO_3$. The results of this research are how efficient the various variations of research are used, the efficiency of this study can be concluded with the results of the percentage of degradation obtained, which was calculate using Eq. (1).

$$\%\text{Colour}\ \underline{\text{removal}} = \frac{^{\text{Co}-\text{Ct}}\text{x}100\%}{\text{CO}} \quad (1)$$

where Co and Ct are the initial and dye concentrations at time t, respectively (Fig. 2).

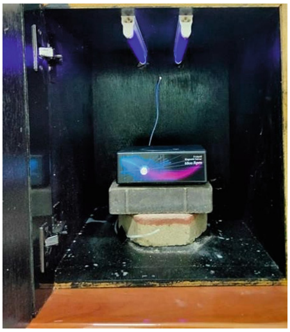

Fig. 2. Reactor design of photocatalytic test

3 Result and Discussion

3.1 Effect of Ultraviolet Rays

Base on Fig. 3. In the first experiment using a standard solution of humic acid pH 3 using humic acid with a concentration of 15 ppm, 15 mL of concentrated humic acid solution was taken and then poured into a measuring flask then diluted using distilled water to 500 mL, poured into a measuring flask. in a reactor containing UVA and UVC lamps. The photocatalyst process was carried out for 5 h with sampling every 30 min and repeated 3 times. Then during the observation process, the solution must always be stirred using a magnetic stirrer. Variations of UVA rays with a degradation percentage of 87.032%. In the second sample using UVC with the results of the degradation percentage of 85.495%. The best percentage of degradation using UVA light is 87.032%. This can occur because the use of UVC light causes other aromatic compounds or other carcinogenic chemical compounds contained in the solution to turn into photodegradation targets[4].

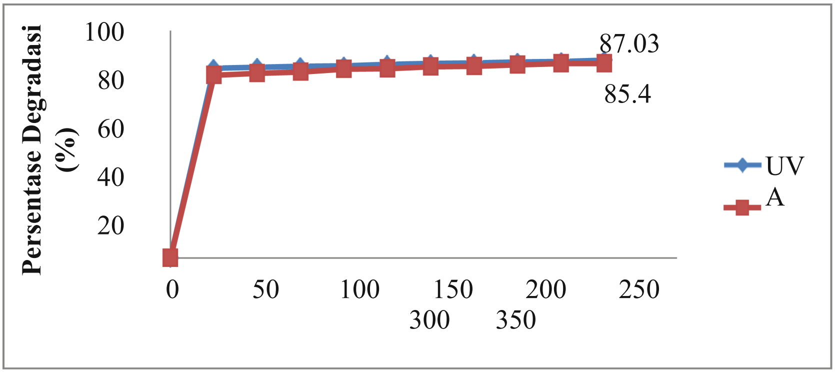

Fig. 3. Humic acid removal against ultraviolet ray

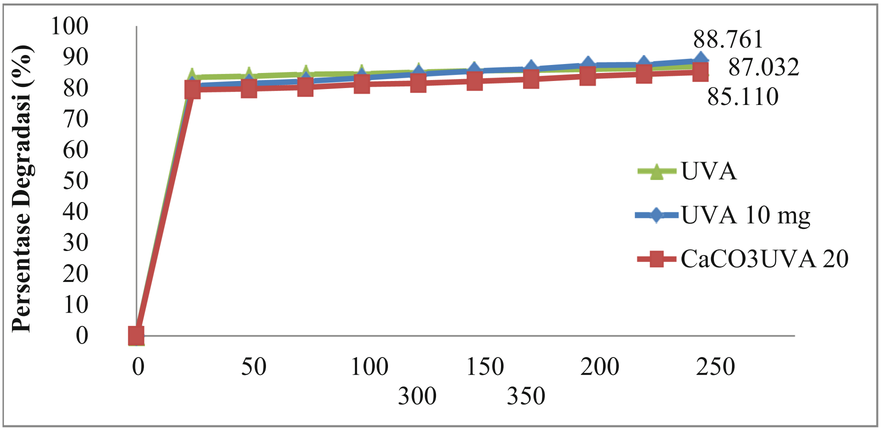

Fig. 4. Humic acid removal at various concentrations of $CaCO_3$

3.2 Variations Effect of $CaCO_3$ Concentration (Scavenger)

The catalyst used in this research is TiO_2/Fe_3O4. In this experiment, 1 g of catalyst material was used in a solution of humic acid with a concentration of 15 ppm with a pH of 3 (acidic). Then put $CaCO_3$ with various doses of 10 mg and 20 mg into each humic acid solution. The humic acid solution was put into a reactor that had been prepared and contained each of the UVA rays. This observation was carried out for 5 h with sampling every 30 min and repeated 3 times for each sample. Then the absorbance was measured using a UV-VIS spectrophotometer with a wavelength of 254 nm.

Base on Fig. 4. In the first sample using a dose of 10 mg $CaCO_3$ and get the percentage of degradation 88.761%. In the second sample, the dose of $CaCO_3$ was 20 mg and the percentage of degradation was 85.761%. The best percentage of degradation results is using a dose of $CaCO_3$ 10 mg with the help of UVA light when compared to a dose of $CaCO_3$ 20 mg with the help of UVA light and without using $CaCO_3$ using only UVA light with a degradation percentage of 87.032%. This can happen because $CaCO_3$ has an absorption surface that is able to degrade organic compounds if used in the right dose, and has the property of precipitating the catalyst in the photocatalyst process, so that the percentage of solution degradation using 10 mg $CaCO_3$ is higher than $CaCO_3$ without $CaCO_3$[5].

4 Conclusions

This research found two conclusions, the first is the effect of UVA and UVC rays in helping the catalyst material degrade humic acid, the percentage of UVA degradation is 87.032% compared to UVC which is only 85.495%. This is because the use of UVA rays is more effective than the use of UVC rays which can cause other carcinogenic compounds to be degraded and cause a lower percentage of degradation. The second conclusion is the effect of adding scavengers, namely $CaCO_3$ of 10 mg and 20 mg, has an impact in the form of increasing the percentage of humic acid degradation at 10 mg by

88.761% and when compared to 20 mg it is 85.110%. This is due to the nature of $CaCO_3$ which can help precipitate the catalyst compound but if it is added with the wrong dose it will affect the absorption of the catalyst compound used, because it can precipitate the catalyst material before degrading humic acid.

Acknowledgements. The authors would like to thank the Faculty of Engineering, Mulawarman University, Indonesia for funding this research.

Bibliography

1. Sarifuddin, E., Yosep, S. . & Isrun. Pengaruh Asam Humat Dan Fulvat Ekstrak Kompos Thitonia Diversifolia Terhadap Hgkhelat, pH Dan C-Organik Entisol Tercemar Merkuri. **5**, (2017).
2. Pradipta, A. ., Riri, E., Lintannisa, R. & Andita, U. Sintesis Nanokomposit Fe3O4/TiO2 Sebagai Fotokatalis Yang Dapat Diambil Kembali Dalam Fotoreduksi Limbah Ion Perak (I). *War. AKAB* **45**, (2021).
3. Ramadhan, A. K. . Degradasi Methyl Orange Menggunakan Fotokatalis TiO2-Zeolit Dan Ion Persulfat Sebagai Electron Scavenger. (2013).
4. Eker, G. & Melis, H. Effect Of UV Wavelength, Temperature and photocatalyst On The Removal Of PAHs From Industrial Soiil With Photodegradation Applications. *Environ. Technol.* **40**, (2018).
5. Simorangkir, D. G. ., Fahrizal, A., Ika, M. & Muhammad, B. Degradation Of Methylene Blue Using TiO2/UVC Photocatalyst And Role Of Scavengers. (2021).