KnE Engineering

ICBSA 2018
International Conference on Basic Sciences and Its Applications
Volume 2019

Conference Paper

Photoreactor Design by Clay Pottery Modification with TiO_2 Coating in Peat Water Purification

Kasman Ediputra[1,2], Hermansyah Aziz[1], Emriadi[1], and Syukri[1]

[1]Faculty of Mathematics and Natural Sciences Andalas University, Padang-25163, Indonesia
[2]Faculty of Education, University of Pahlawan Tuankutambusai Riau, 28411, Indonesia

Abstract

Clay pottery Has been modifications used as a container of water for household needs. The modified of Clay pottery as photocatalyst reactor so that the surface area of the sample will be more readily exposed by Ultraviolet, the inner side of the Clay pottery is coated with TiO_2 sol gel method of split coating technique. The TiO_2 paste is prepared by dissolving 5 gr of TiO_2 (anatase) powder in 20 mL of ethanol. After the coating process, the Clay pottery is allowed to dry in the open air. Photoreactors are arranged in such a way that a mirror is installed to reflect sunlight appropriately. The results of crystal structure testing with x-ray diffractometer (XRD) showed that more coatings were done causing crystal quality of TiO_2 thin films to increase with known anatase crystal structure. Test results of COD and BOD values indicate that photocatalyst reactor from Clay pottery modification can reduce the content of BOD by 4.80mg/l and COD by 30.40 mg/l. The organic substance and the acidity level of the peat water samples appear to be reduced is indicated by PH 6.82.

Keywords: photoreactor design, split coating, organic pollutants

Corresponding Author:
Kasman Ediputra
edi.putra1@gmail.com

Received: 19 February 2019
Accepted: 5 March 2019
Published: 16 April 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICBSA Conference Committee.

1. Introduction

Surface water and groundwater pollution is a serious problem in the industrial community, so it is important to develop a process to clean up contaminated aquatic, and to provide clean water for industrial facilities. Photocatalytic detoxification, using titanium dioxide, is a promising method for this purpose. Heterogeneous photocatalysis has recently emerged as an efficient method for purifying water. This can be regarded as one of the new advanced oxidation technologies for water purification [1, 2].

Photocatalytic oxidation reactions have great potential with mineral organic compounds to carbon dioxide, water vapor and inorganic substances by sunlight the concept of "clean technology and green purification" for the purification of polluted air and water [2, 3].

Photocatalytic phenomena on the surface of TiO_2 can be applied to degrade organic compounds which can then be used to decompose various organic compounds containing harmful aromatic rings which are industrial waste products into harmless compounds such as water and carbon dioxide [4–6].

If the semiconductor TiO_2 (anatase or rutile) absorbs Ultraviolet (UV) light with wavelength l=380 nm electrons and positive holes are formed on the surface of the semiconductor, which can initiate the redox reaction of chemicals that contact the semiconductor. It has been reported that in aqueous media the system is capable of producing hydroxyl radicals (OH) [3]. The hydroxyl radical is a strong oxidizing species, at pH=1 having an oxidation potential difference of 2.8 Volts relative to the hydrogen electrode. With such enormous potential, most organic compounds in water can be oxidized [5, 7]. Scheme of TiO_2 activities can be seen from Fig.1.

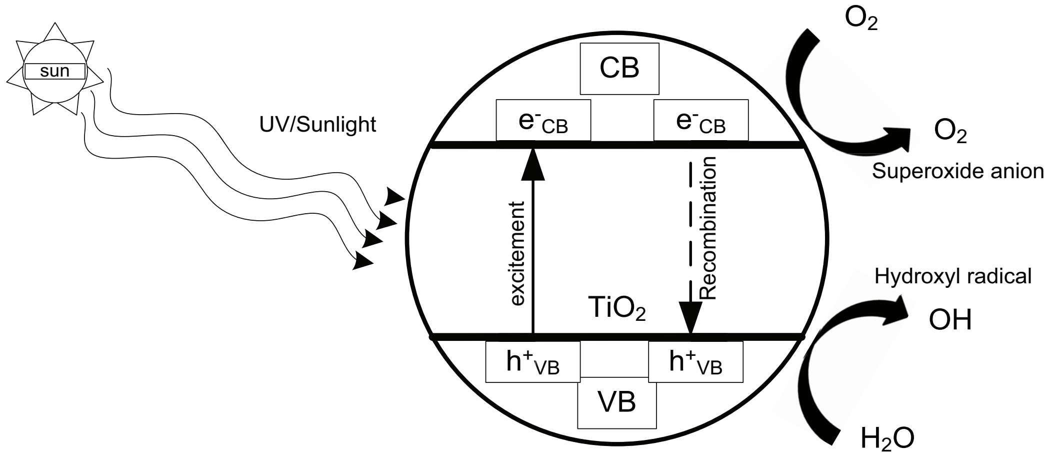

Figure 1: TiO_2 activity.

Clay pottery is generally used by the community as a container for water, or also used as a reservoir of water needs. Clay pottery size is smaller than the jars, but the function and its functionality can be considered the same.

In this study, researchers used Clay pottery as a container or reactor for photocatalytic reactions to purify the peat water, because the Clay pottery is easy to obtain, the economical price and dehydrogenation process for the removal of organic components by heating to 400°C temperatures will not be damaged. Then to be applied in application will be more efficient [8].

Sunlight has a 10% UV content, but two-thirds of the 10% is reflected by ozone in the Earth's atmosphere, only one-third of the 10% UV reaches Earth, the UV can be reflected, based on the reflection principle of this light, intensified in the process of purifying the peat water with support a mirror. The highest UV intensity based on the index ranges from 11:00 to 13:00 [7, 9].

2. Materials and Methods

Materials Used In Research are TiO_2, Ethanol, Peat Water (Sample), Laboratory glass equipment, magnetic stirrer, Oven, XRD. pH meter.

2.1. Reactor design

Clay pottery has Cuted to acquired more widespread and irradiation with UV. The inner side of Clay pottery has been cut is smoothing by an abrasive and washed thoroughly and dried. Weighed 1 gram of TiO_2 powder and then added 4 ml of ethanol and stirred with magnetic stirrer for 30 minutes at 300 rpm for homogeneity. The pasted TiO_2 is superimposed to the inner surface of the Clay pottery, and flattened with a spatula. After the coating process, the TiO_2 coated Clay pottery is allowed to dry in the open air. Then ready to dehydrolyze at 400°C for 10 minutes to get the organic material to evaporate. Placed a mirror on the Clay pottery side of the four wind direction and arranged the mirror slope to focus on the Clay pottery with the diameter of the mirror surface adjusted to the clay pot diameter of 15 cm, as shown in the following Fig. 2.

2.2. Purification process (Peat water)

50 ml of sample water (peat) into a Clay pottery coated container Pasta TiO_2 (batch photochemical reactor). Irradiated with sunlight with variations of irradiation time 2, 4, 6, 8, and 10 hours at 11.00-13.00 for 5 days with UV index 11 and above [1]

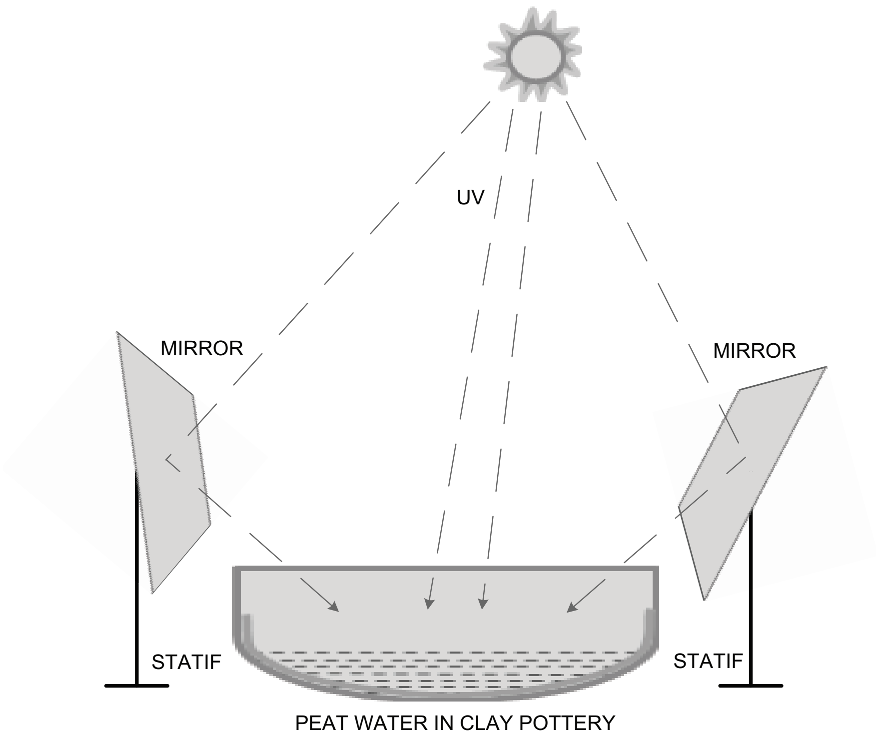

Figure 2: Photoreactor design.

3. Results and Discussions

3.1. TiO_2 phase analysis

TiO_2 is characterized using XRD. The X-rays used are derived from Cu with a wavelength of 0.15406 nm and from an angle of 20°- 80°. From the results of this characterization can be seen crystal phase. The phase determination of the TiO_2 powder is carried out by comparing the peaks on the characterization results, it is known that TiO_2 dominantly contains anatase phases [10]. Characterization TiO_2 showing of anatase peaks in XRD spectrum can be seen from Fig. 3.

The spectrum shows peaks with "A" symbols at 25.2 ° 38.80°, 48.10°, 55.02° and 62.50° confirm the anatase structure. The peak XRD intensity of the sample reflects that the nanoparticles formed are crystals and the broad diffraction of peaks shows a very small crystal size [11]. Titanium dioxide with an anatase structure better degrades pollutants and is better as a photocatalyst than rutile structures [12]. a little influence on the XRD pattern when comparing the catalyst and without being exposed to sunlight because the pattern shows the photocatalyst structure and only has a small effect after degradation occurs on the surface of the photocatalyst layer [1, 11].

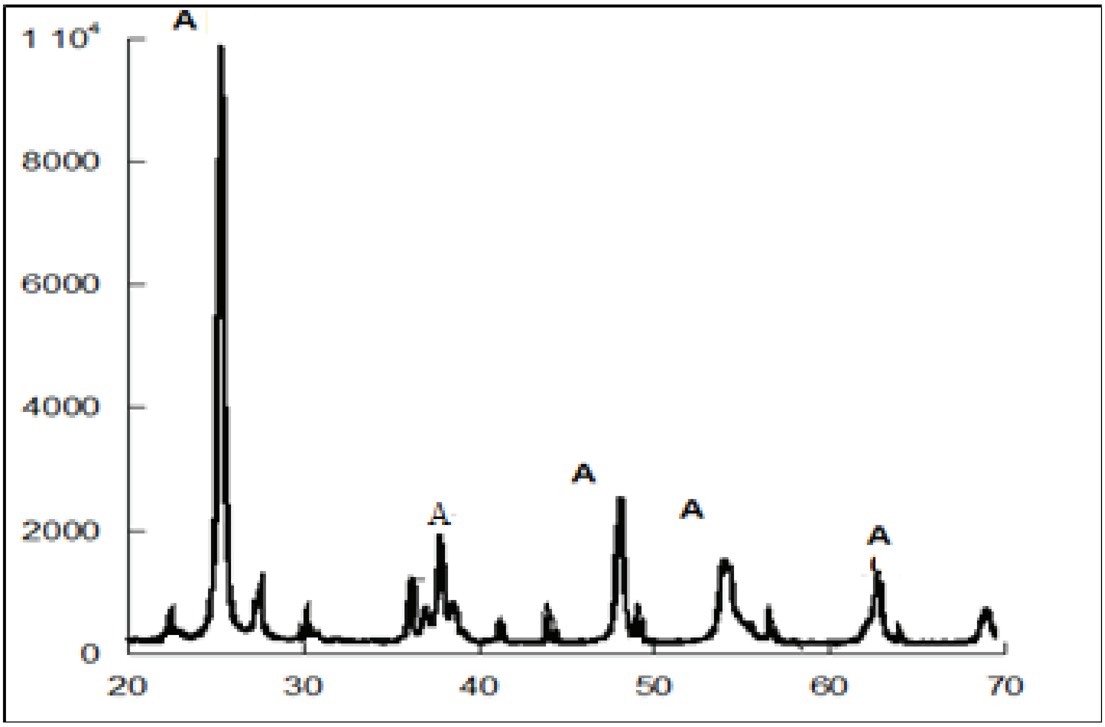

Figure 3: Characterization of TiO_2 with XRD.

3.2. Peat water analysis

Ultraviolet rays with wavelengths below 400 nm, where the electrons will be excited from the valence band across the band gap toward the conduction band, producing holes in the valence band and electrons in the conduction band. The TiO_2 hole in the valence band reacts with water molecules or OH^- ions and produces strong hydroxyl (OH) radicals of the oxidizing compound [7]. The hydroxyl radical will decompose organic pollutants such as humic acid in liquids into gases which then evaporate or become other harmless substances [5]

The measurement of the peat water absorption spectrum aims to determine the resilience of TiO_2 layer by continuous irradiation every 2 hours with 4 times repetition usage [1, 2] [5] The irradiation is do in the range from 11:00 to 13:00 for 5 days. The irradiation is done by replacing the sample (peat water) every 2 hours, and measuring each absorbance [1]. Photoreactor studies for the analysis of pH, COD, BOD using mirrors and those not, are shown in Table.1.

This is done to determine the stability of TiO_2 layer to water degradation. Peat water pH measurements before purification were obtained 4.75. These results indicate that water contains several organic compounds such as humic acid, fulvic acid, and humin. After radiation with sunlight and the Clay pottery layer with TiO_2 shows an increase in

Table 1: pH, COD and BOD data of peat water.

Time (h)	PH		COD		BOD	
	Non design	Mirror design	Non design (mg/l)	Mirror design (mg/l)	Non design (mg/l)	Mirror design (mg/l)
0	4.75	4.75	355.8	355.8	190.8	190.8
1	5.24	5.7				
2	5.38	6.28	348.2	282.3	180.2	140
3	5.61	6.37				
4	5.76	6.51	308.5	261.2	160.8	138.2
5	5.79	6.65				
6	6.02	6.68	308.4	260.5	148.3	133.8
7	6.22	6.72				
8	6.37	6.74	272.6	255.2	134.5	127.5
9	6.45	6.8				
10	6.47	6.82	258.2	244.4	128.7	122.2

pH. Then Radiation for pH measurement is done up to 10 hours. It can be seen that the difference from reactor without modification and which has been modified with this mirror can be seen from the curve of Fig. 4.

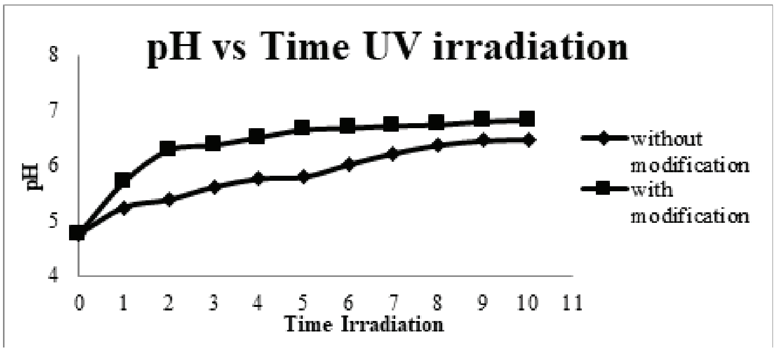

Figure 4: pH of peat water.

From the curve of Fig. 4, it appears that the pH increases during peat water irradiation with the utilization of sunlight. After 10 hours of exposure the pH increase to 6.47 for the rector without modification and 6.82 on the reactor with modification. This is because the longer peat water is exposed to sunlight, there will be oxidation reactions triggered by the presence of TiO_2 photocatalyst in the reaction resulting in decrease in the content of organic pollutants such as humic acid and can improve water quality. More and more OH radicals are formed so that the reduction of humic acid increases the pH [1, 2].

Test results of COD and BOD values indicate that photocatalyst reactor from Clay pottery modification can reduce the content of COD and BOD measurements performed every two hours or every day after irradiation. COD reduction of peat water with mirror design and those can be seen from the curve of Fig. 5.

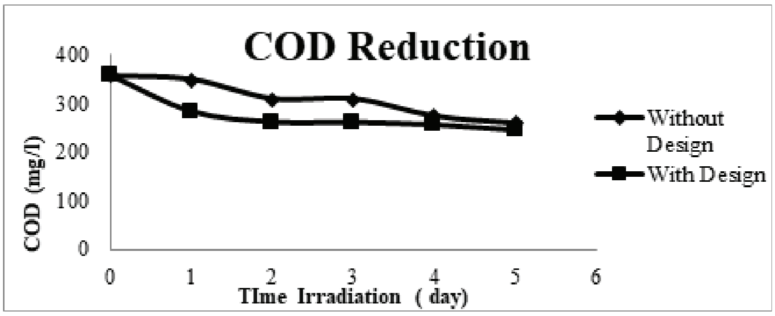

Figure 5: COD reduction of peat water.

The COD values obtained on the unmodified reactor were 355.8 mg/l down to 258.2 mg/l, whereas the modified reactor at COD price 355.8 mg/l decreased to 244.4 mg/l. Then for the BOD price also decrease shown by following Fig. 6.

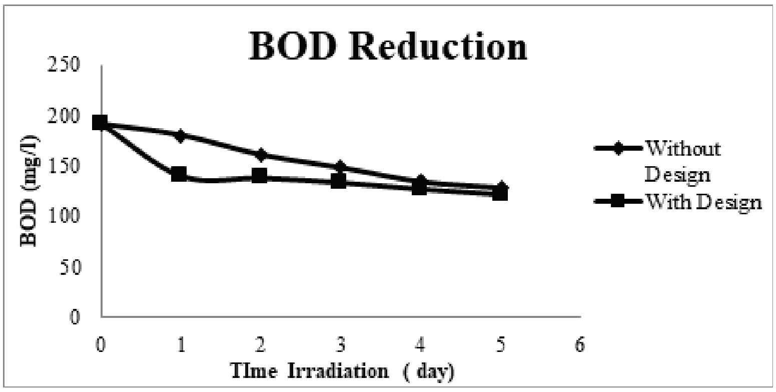

Figure 6: BOD reduction of peat water.

From Fig. 6. it can be seen that there was a decrease in BOD price from 190.8 mg/l to 128.7 mg/l in reactor without modification and reactor with BOD modification of 190.8 mg/l dropped to 122.2 mg/l. data and graft obtained by modifying Clay pottery can increase the UV intensity as evidenced by the increase in pH and lower the COD and BOD levels of the peat water more.

This shows that the initial pH value is the main factor affecting the rate of COD removal. A possible explanation of this phenomenon is that the concentration of OH^- ions increases with the pH value of the solution. The higher pH value promotes the decomposition of water, resulting in more OH radicals for effective oxidation or degradation of organic acids, thus obtaining a higher COD removal rate [13].

Then repeated use of the photocatalytic reactor will reduce the reaction stability of TiO_2, characterized of absorption of UV by TiO_2 surface. Decrease photoreactor stability shown by following Fig. 7.

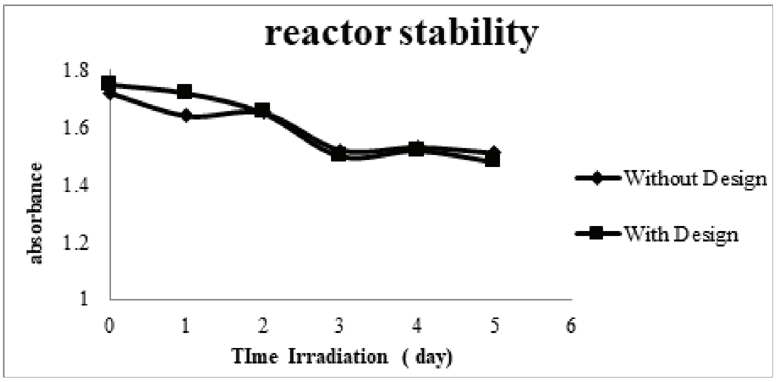

Figure 7: Reactor stability.

4. Conclusions

The modified using mirror and coated TiO_2 Clay pottery can be used to improving UV absorbing as a photocatalytic reactor in peat water purification processes, such as by raising peat water pH from 4.75 to 6.82 and COD down from 355.8 mg/l to 325.4 mg/l. So that the acid component in peat water can be removed. Then repeated use of the photocatalytic reactor will reduce the reaction stability of TiO_2.

References

[1] J. Of, A. Hermansyah, U. Andalas, E. Munaf, and U. Andalas, “Biomaterials supported with titania as photocatalyst in peat water purification,” vol. 7, no. JUNE 2015, pp. 192–197, 2016.

[2] B. Boutra, “A Review: Titanium Dioxide Photocatalysis For Water Treatment Farid Madjene Lamine Aoudjit Sadek Igoud Hafida Lebik,” vol. 3, no. 10, pp. 34–39, 2013.

[3] A. Fujishima, T. N. Rao, and D. A. Tryk, “Titanium dioxide photocatalysis,” J. Photochem. Photobiol. C Photochem. Rev., vol. 1, no. 1, pp. 1–21, 2000.

[4] Google, Cloud Vision API. Accessed 2018. 2018.

[5] D. Y. Nasution, “DEGRADASI FOTOKATALITIK LARUTAN ASAM BENZOAT DENGAN TITANIUM DIOKSIDA (TiO2) SEBAGAI KATALIS,” pp. 27–30.

[6] M. R. Hoffmann, S. T. Martin, W. Choi, and D. W. Bahnemannt, “P=0.05298 *,” p. 216, 1995.

[7] K. Nakata and A. Fujishima, “TiO2 photocatalysis: Design and applications,” J. Photochem. Photobiol. C Photochem. Rev., vol. 13, no. 3, pp. 169–189, 2012.

[8] R. Bergamasco et al., “Drinking water treatment in a gravimetric flow system with TiO2coated membranes,” Chem. Eng. J., vol. 174, no. 1, pp. 102–109, 2011.

[9] O. Engelsen and A. Kylling, “Fast simulation tool for ultraviolet radiation at the earth’s surface,” Opt. Eng., vol. 44, no. 4, p. 041012, 2005.

[10] P. Pori et al., “Structural studies of TiO2/wood coatings prepared by hydrothermal deposition of rutile particles from TiCl4 aqueous solutions on spruce (Picea Abies) wood,” Appl. Surf. Sci., vol. 372, pp. 125–138, 2016.

[11] T. Theivasanthi and M. Alagar, “cp070321 Alto Paraiso de Goias.pdf.”

[12] T. Ohno, K. Sarukawa, and M. Matsumura, “Crystal faces of rutile and anatase TiO2 particles and their roles in photocatalytic reactions,” New J. Chem., vol. 26, no. 9, pp. 1167–1170, 2002.

[13] D. Yang, B. Wang, H. Ren, and J. Yuan, “Effects and mechanism of ozonation for degradation of sodium acetate in aqueous solution,” Water Sci. Eng., vol. 5, no. 2011, pp. 155–163, 2012.