IOP Conf. Series: Journal of Physics: Conf. Series **795** (2017) 012064 doi:10.1088/1742-6596/795/1/012064

Preparation of TiO_2 photocatalyst with the matrix of palm wood (*Arenga pinnata*) waste in the photodegradation of *batik* wastewater

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Abstract. The study aimed to the preparation of TiO_2 photocatalyst with the matrix from palm wood waste whose has lignin and cellulose content. TiO_2 photocatalyst with the matrix from the wastewater of palm wood waste (TiO_2/pww) was used as photocatalyst in photodegradation of *batik* wastewater. TiO_2 solid was dissolved in ethanol and aquadest, added with the powder of wood palm waste and stirred with a magnetic stirrer for 16 hours. Then separation was carried out using buchner and filtrate and residue were obtained. The filtrate was disposed and the residue was calcined with various temperatures for 3 hours. The temperatures in this research were 100 °C (TiO_2/pww-100); 200°C (TiO_2/pww-200); 300°C (TiO_2/pww-300). Analysis and characterization of TiO_2/wwp were conducted using X-ray diffraction (XRD) and spectrophotometer Fourier Transform Infra Red (FTIR) methods. Photocalalytic TiO_2/wwp use the batch system in a reactor with UV light 40 watts, 220 volts and length wave 360 nm the plate magnetic stirrer. Liquid waste batik adds TiO_2/wwp with time variation. At XRD analysis showed that the preparation of TiO_2/pww could be done on the heating TiO_2/pww temperature of 100°C and 200°C. At the temperature of 300°C, it was indicated that the lignocelluloses in palm wood waste were burned, meaning that few lignocelluloses remained. The result of FTIR analysis showed clearly that at the temperature of 300°C, a few spectrum of lignocelluloses remained in palm wood waste, while at a temperature of 100°C and 200°C, spectra of lignocelluloses of palm wood waste remained. The result of photocatalysis test indicated that TiO_2/pww could reduce 40%, 72%, 81% and 64% COD for TiO_2 (control), TiO_2/pww-100, TiO_2/pww-200 and TiO_2/pww-300, respectively.

1. Introduction

TiO_2 photocatalyst has some advantages; it is non-toxic agent with high photoactivities, stability, affordable price, and capability to work under ultraviolet light of sun light spectrum. Photodegradation of organic compounds, like acetaldehyde, dimethyl sulfide, dimethyl disulfide and methyl mercaptan use TiO_2 photocatalyst [1]; new methylene blue [2]; lignin [3]. The use of TiO_2 photocatalyst in the form of powder to process wastewater is generally practical; however, this powder will form suspension in wastewater solution. This cause solution to become turbid and therefore light absorption by substrate is less perfect. As a consequence, photicatalyst is getting less effective. Moreover, the separation of photocatalyst solid from the solution, for recovery or regeneration, is difficult to be done.

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One of efforts to improve TiO_2 activity as photocatalyst is by creating thin layer of TiO_2. Modification has been done by putting TiO_2 with various metal oxide, active carbon [4] [5]; and chitosan [6]. Other innovative modification has been using organic compounds, like cellulose [7] [8]; and lignocellulose [9]. Coloring agents that are widely used in textile industry are black, red, and golden yellow remazols. In staining process, only 5% of these compounds are used, while the rest 95% will be disposed as wastewater. These compounds are stable enough, and hence, they are very difficult to be degraded in the nature. Furthermore, they are harmful for environment, and particularly, in high concentration, they can increase COD (Chemical Oxygen Demand). This triggers researchers to conduct this research, which aims at synthesizing TiO_2 by using the matrix of palm wood waste which contains lignin and cellulose. TiO_2 with the matrix of palm wood waste is utilized as photocatalyst in the photodegradation of *batik* wastewater. In this research, study on TiO_2 synthesize with the matrix of palm wood waste, the effect of calcination temperature in the synthesis, and the effect of time variation in the application of *batik* wastewater management.

2. Numerical Methods

Approximately 50 mL TiO_2 solid was dissolved in ethanol and aquadest, and 10 g of palm wood waste powder was added and then stirred using magnetic stirrer in 16 hours. Afterwards, separation was carried out using buchner which later produced filtrate and residue. Filtrate was disposed and residue was calcined with various temperatures in 3 hours. The temperature variations in this study were 100°C, 200°C; and 300°C. Analysis and characterization were conducted using X-ray diffraction (XRD) and spectrophotometer Fourier Transform Infra Red (FTIR) methods. Photocatalysis test of TiO_2/pww was done using batch system in reactor which was equipped with 40 watt and 220 volt lamp at 340-390 nm wavelength, and magnetic stirrer plate. *Batik* wastewater was added with TiO_2/pww by considering time variation. After TiO_2/pww with the greatest *batik* waste water degradation activity was obtained, time optimization was carried out with time variations of lighting duration in UV reactor, i.e. 6, 12, 24, 36 and 48 hours, respectively.

3. Results and Discussion

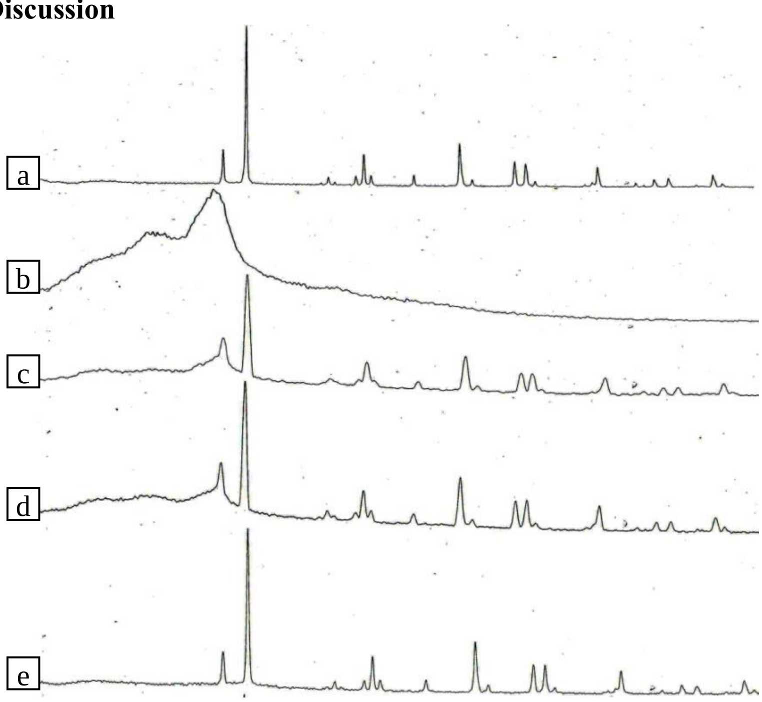

Figure 1. XRD. (a) TiO_2; (b) palm wood waste (pww) (c) TiO_2/pww-100; (d) TiO_2/pww-200; (e) TiO_2/pww-300

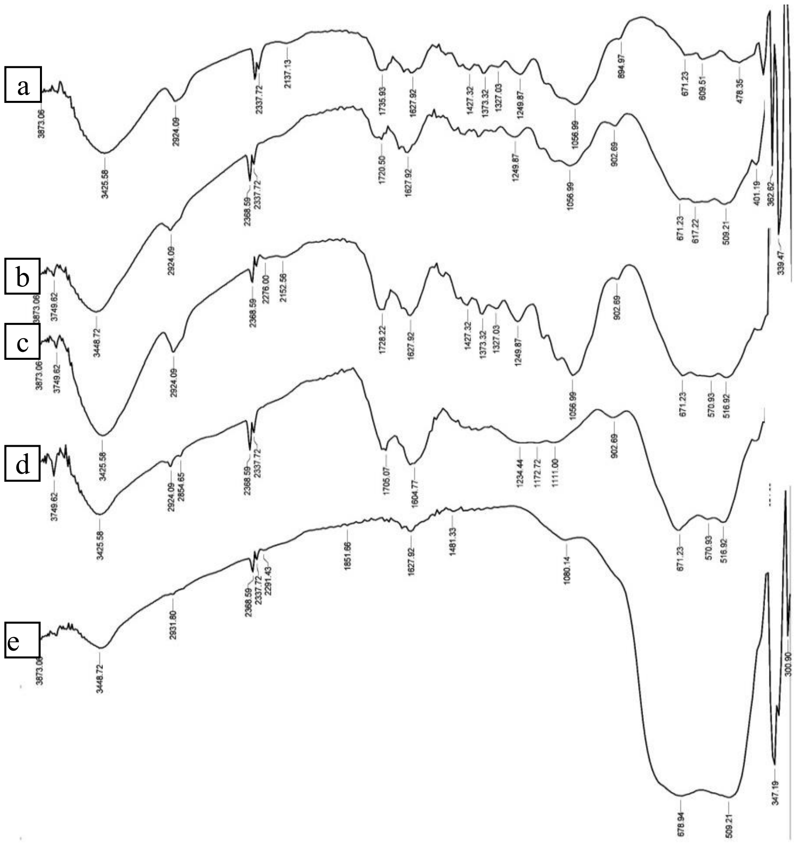

Figure 2. FTIR. (a) palm wood waste (pww); (b) TiO_2/pww-100; (c) TiO_2/pww-200; (d) TiO_2/pww-300; (e) TiO_2

Photocatalyst was made by dissolving TiO_2 in ethanol and water, and adding several grams of palm wood waste (lignin-cellulose). This process yielded solid which was later heated with various temperatures in 3 hours. Photocatalyst produced was later characterized using XRD and FTIR. In the structure model of lignin and cellulose, $–CH_2OH$, –OH, –C–O– and $–OCH_3$ group in aromatic chain appeared. Oxygen in this group was rich with free electrons, and therefore, it could interact with metal cations. Moreover, lignin heating would form pores which could increase the surface area as an attachment space for the other materials.

XRD analysis indicated that preparation of TiO_2/pww could be carried out in the heating of TiO_2/pww at the temperatures of 100°C and 200°C. At the temperature of 300°C, lignocelluloses in palm wood waste were totally burned or small amount of lignocelluloses remained (Figure 1). X-ray diffraction at 300°C dehydration showed crystal phase of microsphere composite TiO_2 in TiO_2/cellulose with X-ray diffraction pattern from cellulose component which disappeared [7]. In the FTIR analysis demonstrated clearly that small number of lignocelluloses spectra in palm wood waste remained at the temperature of 300°C and lignocelluloses spectra in palm wood waste also remained at the temperature of 100°C and 200°C (Figure 2). Compared to cellulosic/SiO_2 nanocomposites, OH stretching peak of 3418-3460 cm^{-1} [10] and 3421 cm^{-1} of lignin [11].

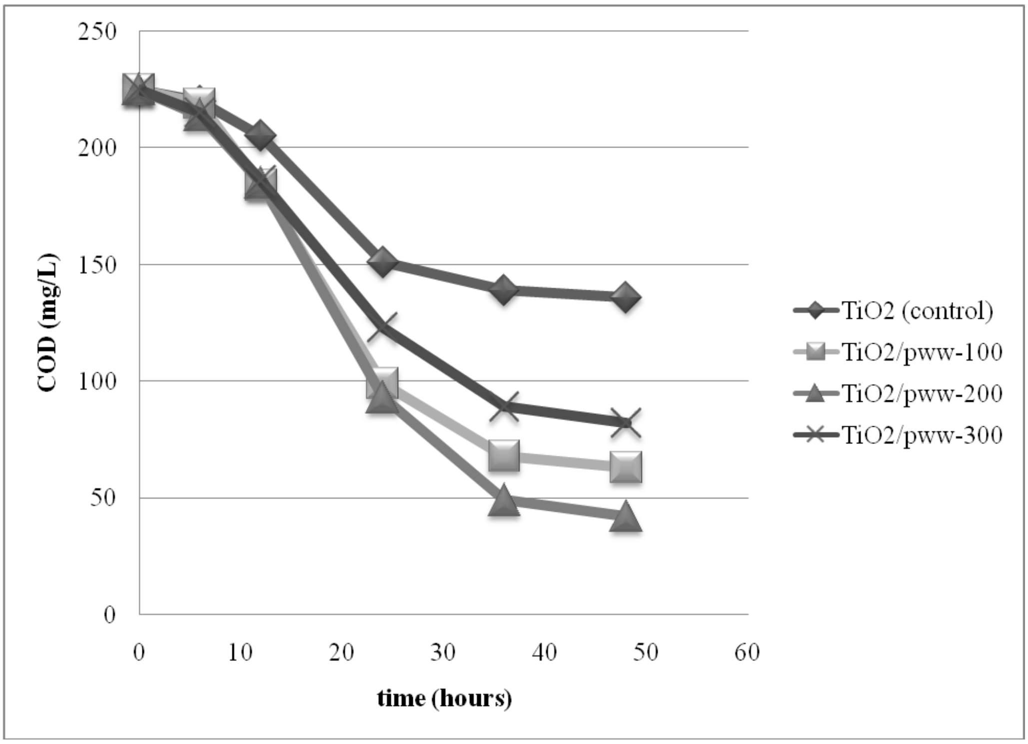

Figure 3. COD reduction in batik liquid waste on TiO_2 and TiO2/pww photocatalyst.

TiO_2/pww photoactivity testing was done by applying it as photocatalyst in photodegradation process of *batik* wastewater. The photodegradation was performed using batch system in a closed reactor equipped with UV lamp and magnetic stirrer plate. The process was accomplished by lighting the mixture which consisted of *batik* wastewater and TiO_2/pww powder, and stirring in certain duration. In photocatalyst test, TiO_2/pww was found to be able to reduce COD, i.e. approximately 40%, 72%, 81%, and 64%, respectively, for TiO_2 (control), TiO_2/pww-100, TiO_2/pww-200 and TiO_2/pww-300 (Figure 3). Acetaldehyde in cellulose/TiO_2 composite with UV radiation was reduced into 45%. Cellulose TiO_2 nanoparticles indicated high photocatalytic activities in MO degradation high concentration under weak UV light radiation. [9].

Conclusion

Preparation of TiO_2 photocatalyst with the matrix of palm wood waste can be used as TiO_2 photocatalyst which can significantly reduce COD in *batik* wastewater. The most effective TiO_2 photocatalyst in the photodegradation of *batik* wastewater is the preparation of TiO_2 with calcination temperature of 200°C.

Acknowledgments

Thankful is acknowledged to Directorate of Research and Community Service, Ministry of Research, Technology and Higher Education, Republic of Indonesia through Setia Budi University for the Doctoral Dissertation Research Grant under the contract numbers; between the Directorate General of Research Strengthening and Development and Kopertis Region VI, 644/M/KP/XII/2012, 23 December 2015, and between and Kopertis Region VI and Setia Budi University, 020/K6/KM/SP2H/ PENGEMBANGANKAPASITAS/2016, 4 May 2016. very grateful to Prof. Dr. Endang Tri Wahyuni, MS as dissertation supervisor for her helpful information and suggestion throughout this research.

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