Preparation of TiO_2-Bamboo Leaves Ash Composite as Photocatalyst for Dye Photodegradation

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ABSTRACT

Textile waste containing dye can generate environmental problems especially for human. Therefore some techniques are developed to overcome the impact of toxic contaminant from dyes residue, one of these is the photocatalysis technique. The photocatalysis mechanism TiO_2 is a popular photocatalyst and in order to improve its activity the composite formation with a some solid support are attempted. The development of TiO_2 composite with a sustainable support source; bamboo leaves was conducted. The composite was prepared by dispersing titanium isopropoxide into bamboo leaves ash (BLA) followed by calcination process. Hysicochemical characterization of the photocatalyst was performed by using XRD, gas sorption analyzer and SEM-EDX analysis. By the characterization it is found that BLA contains silica in highest percentage and furthermore TiO_2 in the mixed anatase and rutile phases were formed the composite.

Key Words: *Bamboo leaves; Photodegradation; TiO_2; TiO_2-SiO_2.*

1. Introduction

Bamboo is a kind of plants widely grown in Indonesia and also one of the fastest growth plants. Until now, its utilization is very wide especially in building and architecture mainly related to its stem, but for leaves the utilization is very limited or sometime it let to be rubish.

In other side, photocatalytic treatment of dye waste is one of interesting and popular mechanism in environmental issue. Photocatalytic treatment is more usefull compared to adsorption process and usually it utilize titanium dioxide (TiO_2) as main photocatalyst(Andriantsiferana et al., 2013). For economy and effectivity reasons, the some modifications of TiO_2 are attempted, one of this is immobilizing TiO_2 into a stable solid support such as MCM-41, zeolite, kaolinite or silica(Choi et al., 2010; Gao et al., 2012). The immobilization into silica is considerable for preparing low cost photocatalyst since silica can be derived from such plants waste or called as biogenic silica material.

Considering that bamboo leaves are plant waste, in this work, the preparation of TiO_2 immobilized silica was prepared by biogenic silica from bamboo laves (TiO_2-Bamboo leaves ash/ Ti-BLA) in that the bamboo levaes were used without any treatment(Kowa et al., 2014). The study focused on the preparation, characterization and photocatalytic activity of Ti-BLA and the photocatalytic study in dye degradation. Methylene blue (MB) as chosen as dye model for the study refer to some studies reported.

2. Materials and Methods

2.1. Materials

Bamboo leaves were obtained from a village plantation in Klaten, Central of Java, Indonesia. Some chemicals in analytical grade consist of MB, titanium isopropoxide, isopropanol were purchased from Merck, Germany.

2.2. Instrumentation

The instruments utilized for physicochemical character analysis are gas sorption analyzer NOVA 1200e Data Analysis package Ver 20, Difraction Sinar- X (XRD) Shimadzu X6000, SEM EDX, Spectrofotometer UV-Vis HITACHI U-2010, FTIR Nicolet Avatar.

2.3. Method

Bamboo leaves ash (BLA) was prepared by calcination using furnace in optimal temperature of 700 ^{0}C for 2 hours. The aim of calcination is to remove organic content in the leaves and raw silica material was obtained. Ti-BLA was prepared by mixing titania precursor obtained by diluting titanium into isopropanol. The mixture was stirred overnight after the addition of acetic acid. The gel obtained was dried and then calcined at 400^{o}C for 2h.

Photocatalytic activity of Ti-BLA was tested into MB dye degradation by mixing the powder of Ti-BLA and MB solution in photocatalytic reactor. The schematic representation of the reactor is presented in Figure 1.

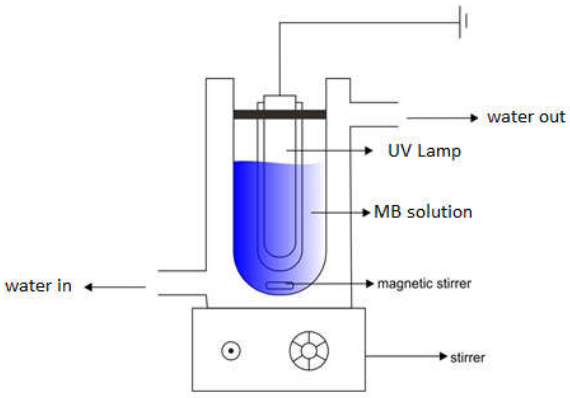


Figure 1. Schematic representation of photocatalytic reactor

The reaction variable was the use of UV light in the photodegradation reaction. The sampling was conducted in certain time and the absorbance of the solution was analyzed using UV-Vis spectrophotometer HITACHI U-2010.

3. Results and Discussion

3.1. Material characterization

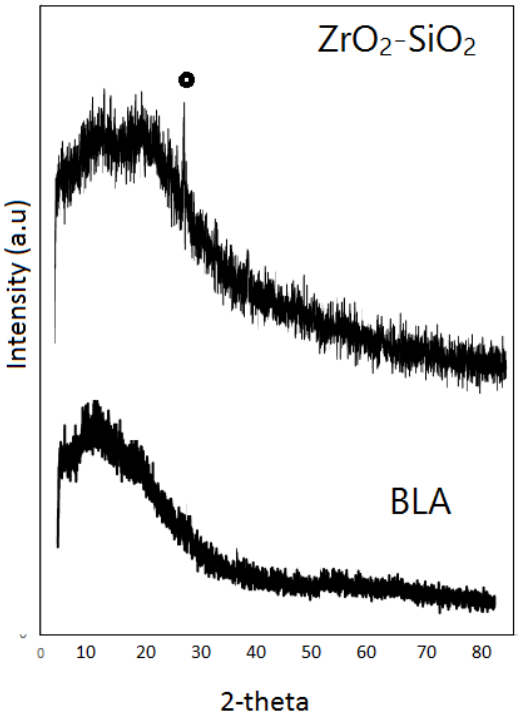


Figure 2. XRD pattern of materials

XRD pattern of the Ti-BLA compared to BLA is presented in Figure 2. From the pattern it is concluded that the formation of TiO_2 is occurred as represented by the the reflection at around 25° which is related to the presence of anatase phase of TiO_2.

Table 1. Surface parameter data of Ti-BLA compared with BLA

Parameter	Ti-BLA	BLA
BET Specific surface area (m^2/g)	90.35	14.45
Pore Radius (Å)	123.34	14.05
Pore Volume (cc/g)	0.468	0.036

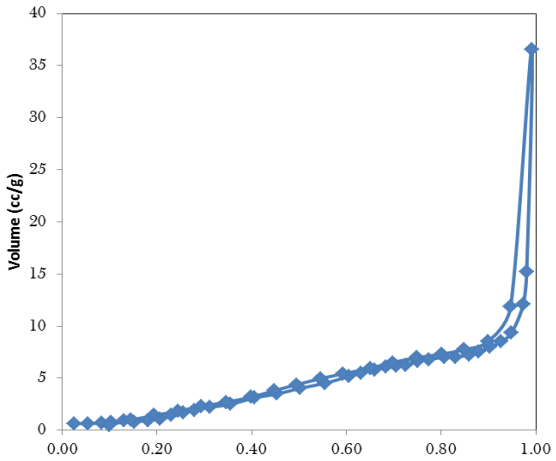


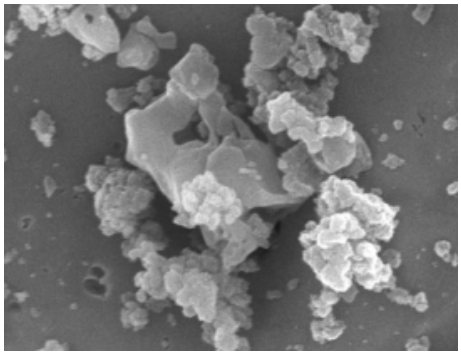
Figure 3. Adsorption-desorption profile of Ti-BLA

Furthermore Table 1 present the specific surface area, pore volume and pore radius of the Ti-BLA was measured based on adsorption-desorption pattern as depicted in Figure 3.

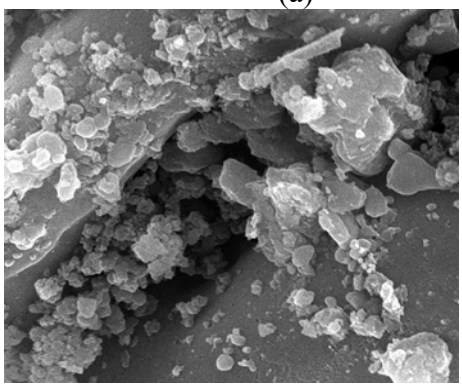
The pattern of adsorption-desorption profile suggest the micropore structure of material since it is refer to the IUPAC type III – adsorption-desorption curve classification. The pattern is commonly found in the amorphous structure and silica based materials.

Surface modification of BLA affects to the increasing BET SSA, pore volume and pore radius. The data are in line with the surface morphology as presented by SEM profile in Figure 4. The formation of pores in the composite occurs during the hydrolysis

reaction of titanium precursor and also calcination process.
The data are in line with the XRD pattern in that the anatase phase formation detected come from the significant crystallite size of titania particles on BLA surface. Theoretically both the presence of TiO_2 phase and specific surface area are important factors in the photocatalysis mechanism.



(a)



(b)

Figure 4. SEM profile of (a) BLA (b) Ti-BLA

The profiles suggest that TiO_2 immobilization into BLA gives TiO_2 distribution on surface.

3.2. Photocatalytic activity

Photodegradation was done using methylene blue with the concentration of 10^{-3} M. Kinetic of MB degradation by varied treatment: with UV illumination and without UV illumination is presented in Figure 5.

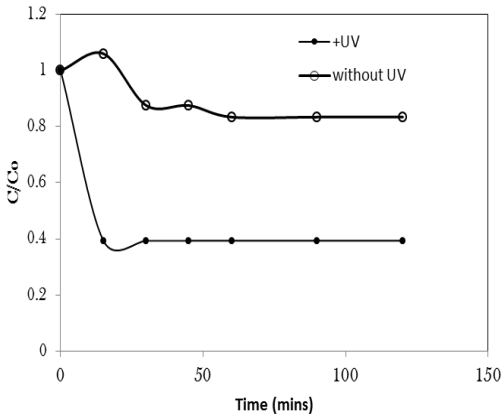


Figure 5. Kinetic of MB degradation over varied treatment

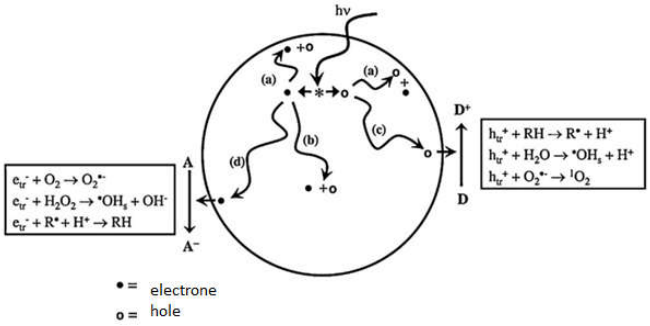


Figure 6. Photocatalysis mechanism(Ana Primo , Tiziana Marino, Avelino Corma, Raffaele Molinari, 2011)

The kinetic of MB degradation shows that the utilization of UV in the photodegradation give rapid MB degradation compared with the reaction without UV. When the photocatalyst was irradiated by

UV-light, then it would produce an electron excitation and producing the hole which is then strongly produce radical *OH for further oxidation of MB (Figure 6).

From the kinetic data it is also concluded that the presence of TiO_2 gives contribution strongly to the MB oxidation.

4. **Conclusion**

Bamboo leaves ash showed the effectiveness as TiO_2 support as indicated by the increasing surface parameter data and photocatalytic activity in MB degradation.

Acknowledgement

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