The Effect of TiO_2 Composition on The Self Cleaning on A Glass Surface

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Abstract. One of the technologies that are being developed for self-cleaning applications is to utilize TiO_2 photocatalytic material through a photocatalytic chemical reaction process assisted by the energy of ultraviolet rays. Photocatalytic effect decomposes the impurities in the form of organic compounds. TiO_2 synthesized by using precursor of $TiCl_3$. The synthesis uncorporates ammonia washing and calcination at 300°C for 4 hours to obtain TiO_2 anatase. TiO_2 solution was coated on the glass sample in the form of paste made by mixing PEG 4000, chloroform, and TiO_2 powder. TiO_2 composition was varied, i.e. 0 gram, 1 gram, 1.5 grams, 2 grams, 2.5 grams and 3 grams, while PEG and chloroform amounts fixed for all variations observed. Coatings were was under taken by the doctor blade technique. Self cleaning testing was using two types of impurities, namely mud and dyes. The test was done in two ways, namely hydrophilic and photocatalytic properties tests. The results showed that the best self-cleaning properties was obtained on the sample with a composition of TiO_2 of 3 grams with the ability to eliminate impurities up to 96% under direct sun and 74% in UV radiation. It has a transmittance difference of up to 58.8%. The hydrophilic properties depend on photocatalytics. However, due to profuse agglomeration of TiO_2 the hydrophilic properties decreases.

Keywords: anatase, PEG, self cleaning, TiO_2

I. Introduction

One of the technologies developed for self-cleaning applications is the use of photocatalytic TiO_2. TiO_2 photocatalytic effect can decompose organic compounds that stick to CO_2 and H_2O[1]. Another effect of the photocatalyst is becoming more hydrophilic nature when illuminated with UV light or sunlight. Research on this topic conducted by many researchers [2]-[6]. The use of TiO_2 in the paint showed the best self-cleaning properties of the sample with 2% TiO_2 witch a ratio of anatase: rutile is 90: 10 [7]. Research on the application of TiO_2 as antifogging and self cleaning by spraying on the windshield [8] showed that the TiO_2 improve antifogging properties and self cleaning. Polyethylene glycol (PEG) has been successfully used to distribute TiO_2 on engineering plastics as antifogging and self cleaning agent [8]. In this research, PEG 4000 used as a dispersant to prevent aglometing of TiO_2. In this study used materials TiO_2 and PEG 4000 to be applied to the glass in order to know the influence of the composition of TiO_2 on the ability of selfcleaning properties on a glass surface using PEG 4000. Particularly dispersant to determine the effect of TiO_2 composition of the hydrophilic nature and composition influence on the TiO_2 photocatalytic properties.

II. Experiment Method

A. Nano-TiO2 Synthesis

In this study used TiO_2 synthesized with the main ingredient of $TiCl_3$. TiO_2 synthesized expected 100% anatase structure. TiO_2 synthesized using coprecipitation method [9] wherein $TiCl_3$ 10 ml stirred together with 4.7 ml of distilled water and 0.3 ml of HCl 37% using a magnetic stirrer at a temperature of 45°C at a constant speed of magnetic stirrer for 2-3 minutes. Then added 20 ml of HCl 37% and wait until the purple aqueous solution. After it was added NH_4OH 25% 50 ml and continue stirring for 5 minutes, then round off while the magnetic stirrer for 5 minutes under temperature conditions remain 45°C. The solution was stirred again by adding more NH_4OH 50 ml every 5 minutes until the solution changes colour to white and produces a precipitate. The solution is allowed to stand about a day until all the resulting sediment settles in the bottom glass beaker, then washing using distilled water up to the smell of ammonia (NH_4OH) is missing. The precipitate that had no smell of ammonia is then calcined at 300°C temperature for 4 hours to obtain 100% anatase phase. The results of the calcination smoothed by using a mortar to a powder TiO_2 fine. Synthesis of TiO_2 done several times to get the required amount of TiO_2. Characterization of TiO_2 synthesized done to ensure 100% anatase phase. Characterization is done by using X-ray diffraction (XRD). Besides being able to show the structure of TiO_2 anatase or not by referring to

JCPDS 89-4921, also obtained FWHM values to search for TiO_2 particle size, using the formula:

$$\text{Particle size} = 0.89\lambda \times \text{FWHM} \times \cos\theta \qquad (1)$$

wherein 0.89 is a constant value, and λ is the wavelength of the x-rays used in the testing XRD0 that is 15406 Å.

B. Sample Preparation

Samples here is a glass surface coated with a solution of TiO_2. After synthesis of TiO_2 completed in line with expectations, then the sample preparation. In this sample preparation includes two stages that make TiO_2 solution that will be superimposed and then coating them on glass to be tested characteristics. Preparation of TiO_2 solution to be applied is made by mixing 10 grams of PEG 4000 and 25 ml of chloroform is stirred with a magnetic stirrer at room temperature for 5 minutes until all of the PEG dissolves completely and there are no lumps. Then the TiO_2 powder is inserted and continue stirring until evenly for 5 minutes. TiO_2 powder composition used in this study is 0 gram, 1 gram, 1.5 gram, 2 grams, 2.5 grams and 3 grams of the amount of PEG and chloroform was the same every sample. Then TiO_2 coated on the glass. The glass used in this research is plain clear glass with dimensions of 10cm x 5cm x 0.3cm, and the amount of glass used is 3 pieces in each setting. TiO_2 coating solution refers to the doctor Blade technique of glass that has been coated TiO_2 wait until dry with only aired to be dried in about a day until all the layers dry evenly.

C. Self Cleaning Testing

Tests performed include hydrophilic properties testing and photocatalytic properties testing.

1) *Hydrophilic Testing*: nature of a test to determine the angle formed between the glass surface and tangential line of the radius of water droplets. Measurements were performed with three different conditions by sunlight that can be accepted by the glass sample, on the terrace, and indoors.

2) *Photocatalytic Testing*: the photocatalytc testing done in several ways, namely by the drying in the sun to sample impurities mud and dye, with a quick immersion into the water, as well as irradiation with UV light. For testing in the sunlight, the samples that have been granted an impurity weighing 0.5 grams then dried under direct sunlight during 40 hours. After that, the sample is weighed again to determine how many impurities are missing. Then dipped quickly into the water and then dried and weighed. This is done also for the UV irradiated samples. Other photocatalytic testing in order to know self-cleaning properties is done by giving the dye on the surface of the sample. Prior to drying, all samples that have been prepared beforehand measured its absorbance and transmitance. After the sample is dried in direct sunlight for 40 hours, then measured again the absorbance and transmitance value after drying. Absorbance and transmittance value before and after drying was compared to see the difference in the color degradation that occurs in the dye attached to the TiO_2 layer.

III. Results

Here are the results and a discussion of the characteristics of TiO_2 synthesized as well as self-cleaning characteristics which include hydrophilic testing and photocatalytic testing.

A. Synthesis TiO2 Results

TiO_2 is synthesized with the main ingredient $TiCl_3$ expected 100% anatase and nanoscale. Testing of the TiO_2 synthesized to know the result expected, XRD test was done. The XRD test results (Figure 1) it shows that the first peak appeared in number 25.2577°. Comparing these peaks with reference JCPDS 89-4921 for anatase TiO_2 where the reference appears first peak at a value of about 25°. It shows that the synthesized TiO_2 in anatase structure.

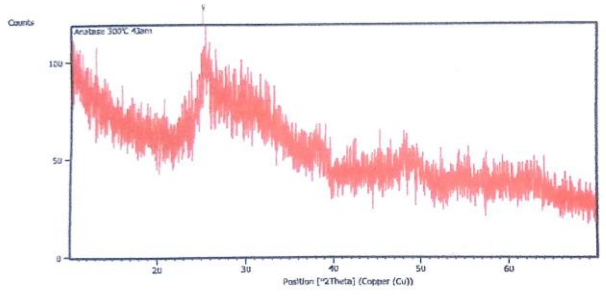

Fig.1 XRD testing result of TiO_2 synthesized

From the graph of the XRD results were also obtained FWHM value which of this values can be calculated to obtain the particle size of the TiO_2. FWHM value is 0.9792. After calculating the TiO_2 particle size with equation (1) obtained amounted to 8.2233nm.

B. Effect of TiO_2 Composition to The Contact Angle

The resulting contact angle on the surface of TiO_2 is affected by the concentration of TiO_2 used and measurement conditions. It is shown on the measurement results are plotted as in Figure 2.

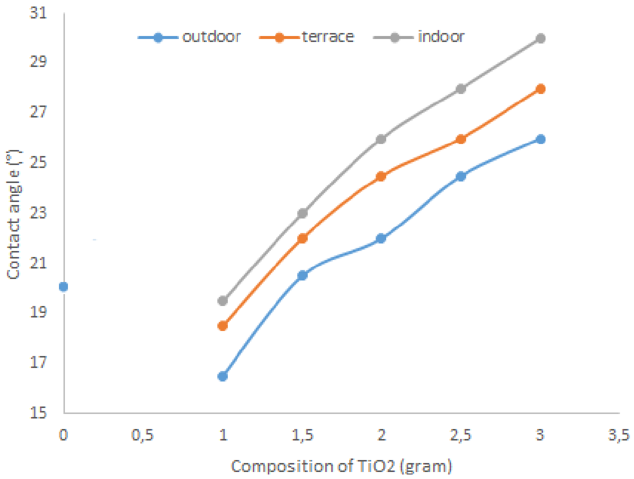

Fig. 2 Effect of TiO_2 composition of the contact angle.

In Figure 2 shows that the sample with 1 gram TiO_2 has the smallest contact angle compared with other TiO_2 composition on the samples. This shows that the composition of TiO_2 coated on the glass affect the contact angle formed. Then the value of the contact angle is generated on the composition of TiO_2 1 gram is equal to 16.5° for measurements in the sunlight, 18.5° for measurements on the terrace, and 19.5° for measurements in the room by lighting the lamp. Based on the results obtained, the measurement condition also affects the contact angle formed, where all three conditions used to get sun exposure is different. The value of the contact angle for a place exposed to direct skylight has a contact angle of the smallest, it is because TiO_2 when the skylight will undergo a process of photocatalyst where the presence of the process that will make the contact angle of water will decrease so that it becomes increasingly hydrophilic.

From Figure 3 shows the amount of impurities is missing at most after the irradiation for 40 hours using a UV lamp is on the sample with a composition of TiO2 amounted to 3 grams with a value of 16%. As for the value of impurity missing after quick immersing, the most also on the sample with a composition of TiO2 by 3 grams, with 74% of the total impurities are given.

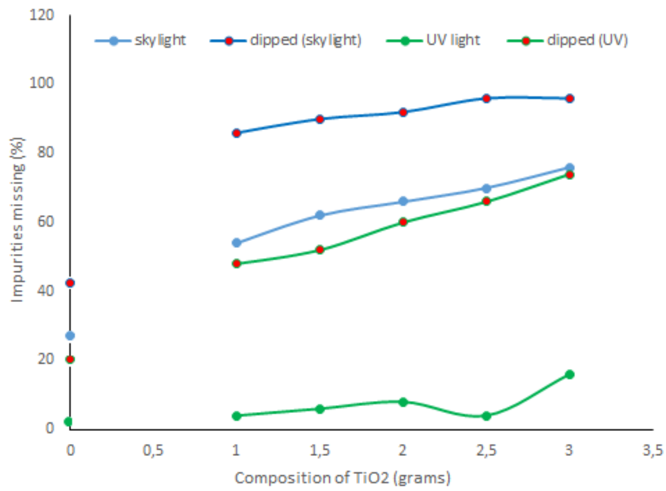

Fig. 3 Effect of TiO2 composition of impurities missing

C. Effect of TiO_2 Composition of The Gradations of Color Impurities

Datas of transmittance and absorbance value at initial measurement of all the samples have a value that is not much different. Transmittance value after skylight irradiated for 40 hours obtained the greatest value contained in the sample with a composition of TiO_2 as much as 3 grams.

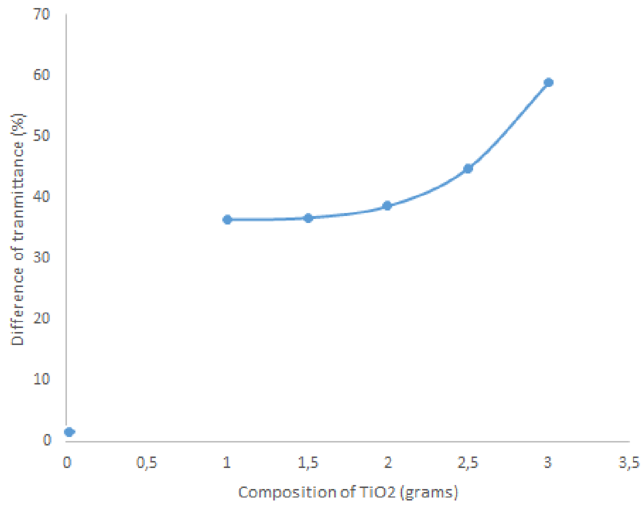

Fig. 4 Effect of TiO_2 composition of the difference value of transmittance between before and after skylight irradiated

The difference in transmitance value shown in Figure 4. The values shown in the composition of TiO2 as much as 0 grams has a transmittance value of the difference is very small, it shows that there is no major change in the transmittance value on the sample without TiO_2 (zero on composition of TiO_2). It can be seen that the difference in transmittance value gains with the rise of compositions TiO_2.

Based on the results obtained can be said that best self-cleaning properties are that the sample have the greatest transmittance value. So samples which have self-cleaning properties it is best to sample the composition of TiO_2 as much as 3 grams.

IV. Conclusions

Photocatalytic properties of the best owned by the sample with a composition of TiO_2 as much as 3 grams of the ability to remove impurities up to 96% in the drying in the sun and 74% of UV radiation, and has a transmittance difference of up to 58.8%. Also hydrophilic properties strongly influenced by photocatalytic, but several incompatibility hydrophilic nature of the sample caused by the aglomeration of TiO_2 powder in the surface layer.

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