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The Effect of PVA and PEG Infusion on Titania Antibacterial Coating

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Abstract. Indonesia has great potential of the Solar energy, irradiated by the Sun throughout the years. Cotton textiles antibacterial has been prepared by coating Titania (TiO_2) with Polyethylene glycol (PEG) and Polyvinyl alcohol (PVA) as adhesives. The method of depositing cotton using a simple dip coating. Cotton dry for 15 minutes with a halogen lamp, after the deposition process. Then, we do the antibacterial activity test using Plate Count Method. As a result, the coated cotton textiles with Polyvinyl alcohol (PVA), Polyethylene glycol (PEG) has antibacterial properties. Characterization by the Attenuated Total Reflectance (ATR) obtained that Titania (TiO_2) surely adhere on the sample. From Attenuated Total Reflectance (ATR) characterization we conclude that Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) is not affecting the antibacterial ability of Titania (TiO_2). But the infusion of Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) on Cotton increases the stiffness value of Cotton.

1. Introduction

In this globalization era, there are many problems caused by bacteria. In the public hospital facility, textiles such as clothes, bedsheet, curtain or the wall can be bacteria contaminated. Virus and fungus from blood, feces, urine, vomit and other body secretion that caused infection [1]. Modification textile surface with nanoparticle and inorganic nanocomposite prospect to be antimicrobial [2]. Titania (TiO_2) has unique characteristics in terms of high stability, shelf life, safety, and large antibacterial microorganisms. The photocatalyst is the activated catalyst when illuminated by the light and has a simple mechanism [3]:

$$\text{Photocatalyst material} + h\nu \rightarrow e_{cb}^{-} + h_{vb}^{+}$$

Titanium (TiO_2) in nature generally has three phases consisting of anatase and rutile with a tetragonal structure. Another phase is brookite with an orthorhombic structure.
The anatase phase were used as an electron collecting layer in organic photovoltaic and were also used as a catalyst for nanotube and nanoribbon. Explanation the photocatalyst mechanism in this experiment are: UV Light induce the formation of electron pairs, which are the charge carriers that react with H_2O, OH- and O_2 to produce hydroxyl radicals (•OH) and radical superoxide anions ($O_2^{\bullet-}$),

which causes decomposition of almost all organic molecules on TiO_2 surfaces[4,5]. The bacteria is one of organic molecule. Bacteria are groups of microorganisms with prokaryotic cells (do not have a membrane-bound nucleus). The bacteria we used in this experiment were Gram-negative bacteria and Gram-positive bacteria. Escherichia Coli (E. Coli) is Gram-negative bacteria, (2 µm length, 0.7 µm diameter and 0.4-0.7 µm width) [4]. Staphylococcus Aureus (S. Aureus) is the Gram-positive (diameter is between 0.7 and 1.2 nm) [6]. After we successfully prove the ability of Technical Grade Titania (TiO_2) Anatase to degrade bacteria. Now we try to coat the dispersion into cotton with Polyvinyl alcohol (PVA) and Polyethylene glycol PEG as crosslinker. In this study, we want to identify the effect of infusion Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) in dispersions coated on cotton. We do characterization by plate count method and Attenuated Total Reflectance (ATR) to identify the chemical bound and Stiffness tester to count stiffness value of cotton after coating.

2. Materials and Method

2.1. Sample Preparation

We use material consist of Technical Grade Titania (TiO_2) anatase, PVA (Polivynyl Alcohol), PEG Polyethylene glycol (PEG-6000) (pH 5,5-7,0), 1 gram Polyvinyl alcohol (PVA) (pH 5-7) and deionized water. The Comercial Cotton purchased from mart for substrate. For bacteria we use bacteria gram negative and positif i.e Staphylococus Aureus and Eschercia Coli. Both of them, easily found in human area and cause many infections. Experiment method performed on cotton fabric as organic substrate. Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) both of similar variation dissolved in 50 ml of deionized water. at 70 ° C, then add TiO2 (1g and 10g) with stirring for 60 minutes, then cover the dispersion by immersion coating as shown in the illustration below.

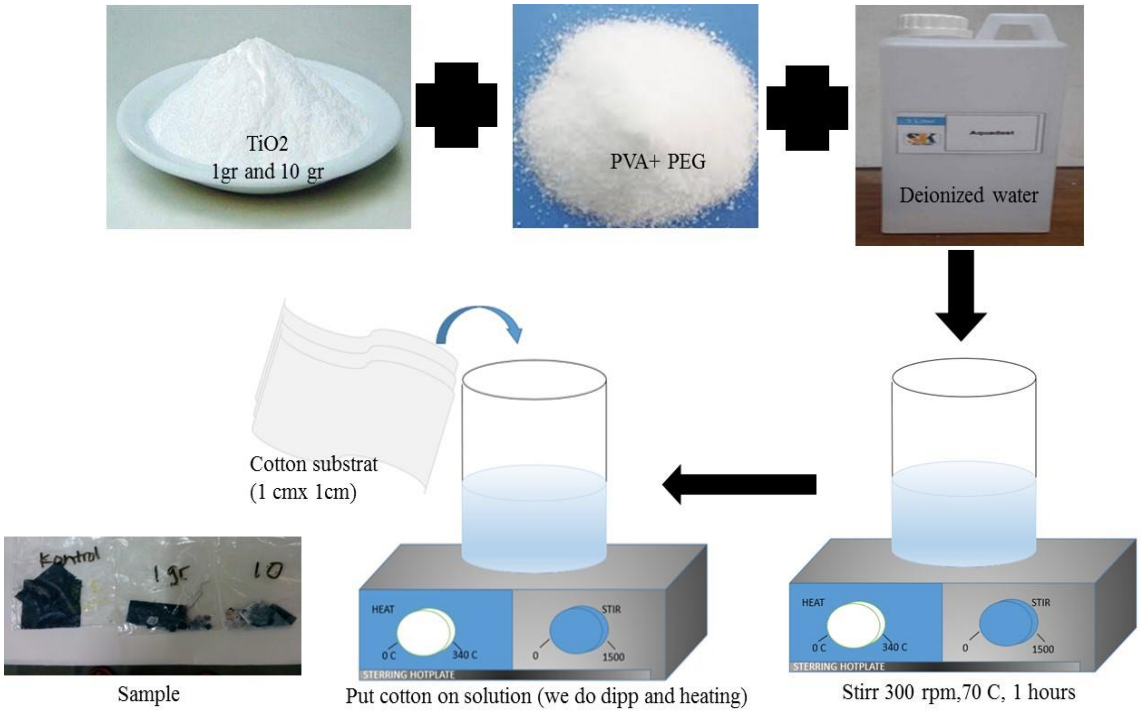


Figure 1. Illustration of experiment.

2.2. Sample Characterization

We do sample characterization to discover the same antibacterial ability of the same method as previous experiment by margaretta et al [7]. To discover the effect of Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) infusion we use Atomic Transmittance Reflectance to Investigate chemical bond between different chains of atoms in a polymer or other in sample. We also do Stiffness measurement in Balai Tekstil Bandung.

3. Results and Discussion

3.1. Plate Count Method

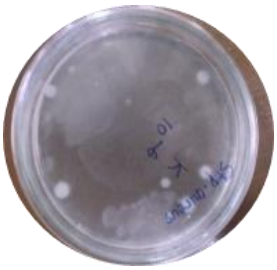
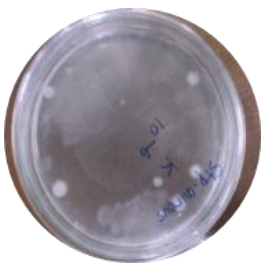
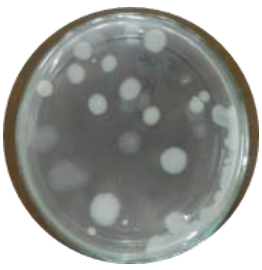
The antibacterial activity is identified by the plate count method, focusing on test cotton antibacterial abilities. Quantitative results from manual calculations are shown in table 1. The data consist of three types of samples, the first was a sample control, the second was a sample 1 (coated with 1 gram of Titania) and sample 2 (coated with 10 grams of Titania). The results show the percentage of antibacterial in CFU / ml. try to use antibacterial simply tested method with the manual calculation of the percentage of the antibacterial ability.

Table 1. Results of Colony Counts and Percentage Inhibition Tested by Plate Count Method

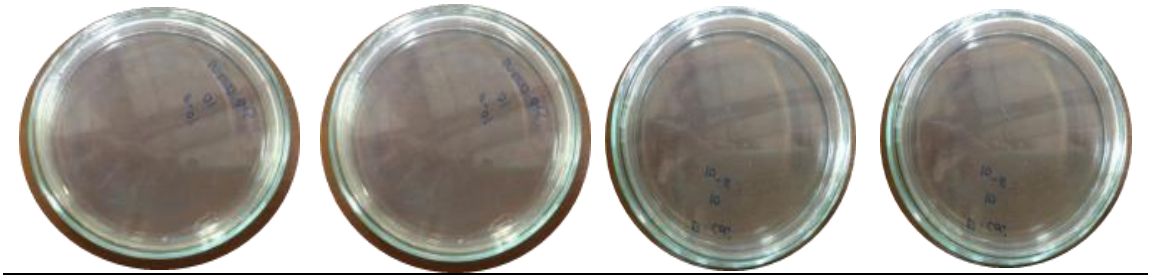
Treatment	**E. Coli (colony) [CFU/ml]**				**S. Aureus (colony) [CFU/ml]**			
Plate	**1**	**%**	**2**	**%**	**1**	**%**	**2**	**%**
Control	276×10^6	97 %	263×10^6	97%	220×10^6	96%	212×10^6	96%
Sample 1	2×10^6	99 %	3×10^6	98.8 %	2×10^6	99%	2×10^6	99%
Sample 2	0	100 %	0	100%	0	100%	0	100%

TiO2 technical grade show its efficacy inhibits the growth of Bacteria. The table shows that the number of bacteria in the sample is reduced compared to the control. The difference in the photocatalytic activity of photocatalyst with the different structures closely related to surface area and particle size. Particles bulk structure anatase more reactive than rutile and brookite. This caused by anatase has band gap energy higher 3,2 eV than Rutile in 3,1 eV. So anatase has definitely photocatalytic activity better [8]. Figure below shown us the plate containing the bacteria growth control and growth of bacteria inhibited by antibacterial photocatalyst Titania (TiO_2) in every variation.

Table 2. Plate Count Method picture after incubation (a. sample control [7], b sample 1, c sample 2)

Plate *S. aureus*		**Plate** *E.Coli*	
1	**2**	**1**	**2**
a.Control			
			
b.Sample 1 (TiO_2 :1 gr)			

c.Sample 2 (TiO_2 :10 gr)



From the manual colony counting from the table 1 above. We can conclude that both of the sample cotton after coating has the antibacterial tendency. The variables that can kill bacteria, such as temperature and pH, are still within the range of bacteria that can live. E.Coli bacteria can live in range temperature between 10ºC- 40ºC with pH above 5. And S. aureus can live in temperature between 4ºC- 48ºC [9] dan pada pH 4.5-9.3[10]. Whereas E.Coli bacteria die at pH below 5 and S. Aureus pH below 4.2. The test temperature conditions is 32ºC, it is still in the condition of E. coli and S. aureus bacteria can live [10].

3.2 Effect of Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) on Cotton

Because TiO_2 irradiated by UV-Light, band gap produced electron and hole pair then caused redox reaction in surface of TiO_2. Effect from electron excitation from valence band to conduction band, the negatively charged electron and oxygen banded be O_2^- Whereas positively charged *hole* and water will produce Radical hydroxyl [11]. Radical hydroxyl caused pressure oxidation and reduced cytoplasmic eukaryotic and prokaryotic cells, causing cell damage on bacteria [12]. We do ATR characterization and we get the result showed in Figure 3a.

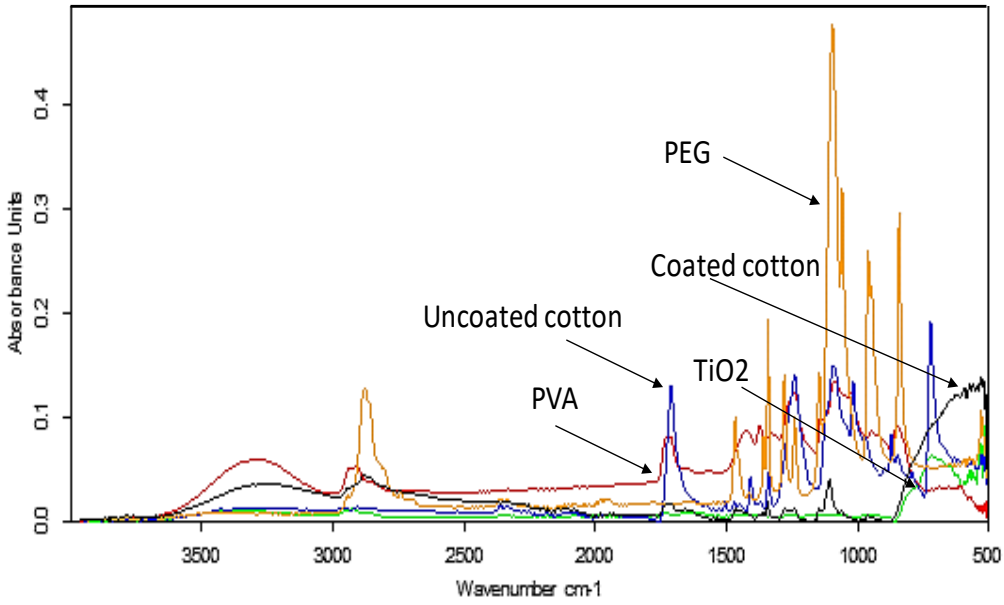


Figure 2 a. ATR chemical bound.

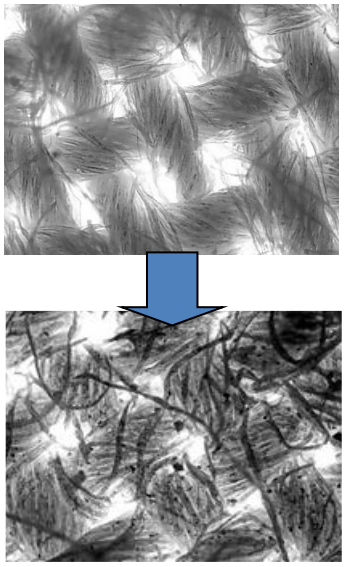


Figure 2b. Cotton picture from light microscope.

FTIR characterization results on samples of cotton shows that peaks 1006.73 C = O [11] is the culmination of ketones which indicates the presence of crosslinking Polyethylene glycol (PEG) and cotton. 720.93 peak is a characteristic possessed by Ti - O anatase TiO_2 where vibration characteristics are at 500-800 cm-1. Peaks 1714.29 C = O is the culmination of ketones which shows crosslinking reaction of Polyvinyl alcohol (PVA) [13]. From figure above showed the morphology of cotton taken with microscope. Before coating and after coating, shown different morphology. After coating the fiber become more rigid, the space between cotton fiber filled by TiO_2 dispersion. The fiber arrangement also become unorganized, different from initial conditions. In this figure we can see that there are thicker coated parts. The rigid condition of cotton did not same if we measured it from different position. In this case, for rigidity measurements we use repetitive measurement averages.

3.3 Stiffness Test on Cotton

The stiffness value test on Balai Besar Textile Bandung with Shirley Stifness Tester. The fiber arrangement of cotton consisting of two lanes, vertical threads are called warp and horizontal threads are called woof, horizontal layer coating on this thread cause the stiffness of cotton changes [14].

Table 3. Stiffness Value

	Before Coating (gr/cm)		After Coating (gr/cm)	
	woof	warp	woof	warp
Stiffness value	165.0	107.2	1357.0	1576.4

The stiffness value of coated fabric after coating process increases drastically. The value of initial cotton stiffness was 165.0 g/cm for woof lane and 107.2 g/cm for warp lane. It increases to 1357 g/cm for woof line and 1576.4 g/cm for warp lane. The value increases drastically because of uneven coating deposition on cotton. The solvent does not adhere well in textile. The textile from this experiment can't be used for clothing because it doesn't fulfil with the textile standard for clothing, but it could be useful for other purpose such as rain coat, curtain. The heating process increases the rigidity of cotton warp and woof directions. Mixed polymer Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) causes the fibers compact and more rigid.

4. Conclusion

In this study it is concluded that infusion of Polyvinyl alcohol (PVA) and Polyethylene glycol (PEG) do not affect the performance of coated TiO_2 in cotton as an antibacterial. Anatase TiO_2 can be a good antibacterial agent that can be activated by sunlight and halogen lights at night. Due to the temperature and pH used during synthesis also testing and incubation do not exceed the optimum of bacteria. Then it is confirmed that the degradation of bacteria is due to the TiO_2 photocatalyst process that produces hydroxyl radicals and destroys bacterial cells.

5. References

[1] Serpone N and Emeline A V 2002 *Int J Photoenergy* **4** 91-131
[2] Dastjerdi R, Montazer M 2010 *Colloids and Surfaces B: Biointerfaces* **79** 5-18
[3] Dizaj S M, Lotfipour F, Barzegar-Jalali M, Zarrintan M H, and Adibkia K 2014 *Materials Science and Engineering: C* **44** 278-284
[4] Fujishima A, Rao T N and Tryk D A 2000 *J. Photochem. Photobiol. C: Photochem. Rev.* **1** 1
[5] Utami F D, Rahman D Y, Sustini E, and Abdullah M 2019 *J Phys. Conf. Ser.* **1171(1)** 012030
[6] Jawetz E, Melnick J L, Adelberg E A, Brooks G F, Butel J S, and Ornston L N 1995 *Mikrobiologi Kedokteran.* (Alih bahasa: Nugroho & R.F.Maulany). Jakarta: Penerbit Buku Kedokteran EGC
[7] D O Margaretta, K W Permadi, D Y Rahman, and F D Utami 2019. Antibacterial Investigation Activity of Titania Anatase Technical grade on polypropylene sheet. *J Phys.Cof.Ser* 1204 012051
[8] Velasco E, Baldovino-Medrano V G, Eric M G, Sonia A G 2015 *Springer* **59** 378–386
[9] Adams M R, Moss M O 1999 *Food Microbilogy* Royal society of chemistry, Oxford: UK. p. 349
[10] Bennett R W, Monday S R 2003 *"Staphylococus aureus, Chapter 4*. In: MD Miliotis, JW Bier (Eds), *International Handbook of Foodborne Pathogens".* Marcel Dekker, Inc., New York
[11] Coleman H M, Marquis C P, Scott J A, Chin S S, Amal R 2005 *J.Chem Eng* **113:**55-63
[12] Suketa N, Sawase T, Kitaura H, et al. *An antibacterial surface on dental implants, based on the photocatalytic bactericidal effect*. Clin Implant Dent Relat Res. 2005;**7**(2):105-111
[13] Silverstein R M, Bassler G C, Morrill T C 1991 *Spectrometric identification of organic compounds* (New York: Wiley)

[14] Hill H 1992 *Indonesia's Textiles and Garment Industries*. Singapore: ISEAS

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