Development of Nano TiO$_2$ Coated Cement Surface Degradation Properties by the Photocatalytic

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Abstract. The objectives of this study were 1) to investigate the stability of Colloid Nanoparticles by using diffusion aid, 2) to study the TiO$_2$ nanoparticles on the cement surface, and 3) to study the organic degradation behavior of the nanoparticles on the cement surface by the Photocatalytic. The study of the stability of the dispersant found that Polyethyleneglycol (PEG) MW 4000 was more effective in dispersing nanoparticles than other materials. The sample size was 5x5x1 centimeters, and cemented to water/cement ratio of 0.4, and hydration cement for 28 days at room temperature. Surface was grinded and sprayed coating of TiO$_2$ nanoparticles on the cement surface with Air Brush. Then, the SEM confirmed it. There were nanoparticles attached to the cement surface and in the porous area of the cement. Methylene blue (MB) concentrations of 0.01, 0.03, and 0.05 mg/L for 3 hours under UV light (in UV box) were measured. The TiO$_2$ nanoparticles could decompose organic matter by the Photocatalytic. The observation of the reduced absorbance of the nano TiO$_2$ coated cement surface was measured with UV-Vis technique. It was ensured that nano TiO$_2$ coated cement surface was able to decompose organic substances and apply them effectively to outside walls or cementitious materials.

1. Introduction

Thailand is geographically tropical. There is a risk of exposure to microorganisms accumulated in the environment, especially the moisture cement wall. The cement wall is dirty from fungus. In this research, the researchers wanted to develop the cement surface that could eliminate the pathogenic microorganisms by the Photocatalytic [1-3]. The objectives of this study were 1) to investigate the stability of Colloid Nanoparticles by using diffusion aid, 2) to study the behavior of TiO$_2$ nanoparticles on the cement surface, and 3) to study the organic degradation behavior of the nanoparticles on the cement surface by the Photocatalytic.

2. Experimental

In this study, TiO$_2$ nanoparticles used were from China. The main crystalline structure was Anatase, with an average diameter of 21 nm and specific surface area of 50 m$^2$/g. Then, the researchers synthesized the colloidal TiO$_2$ by using 4 dispersants: 1. Polyethyleneglycol 2. Sodiumsilicate 3. Ammoniumacetate 4. Magnesiumchloride. The comparison of the dispersant concentration were at 0.5%, 1.5% and 2.5% by weight. Apply the solution to the ultrasonic machine for 30 minutes to make the nanotitania particles dispersed uncluttered[4]. It was determined that the most stable concentration was applied to the specimen. Cemented samples were mixed with water/cement ratio of 0.4 and samples size is 5x5x1 cm and hydration cement for 28 days at room temperature, wash with ultrasonic...
machine and place in room temperature for 3 days, and then coated with nanoparticles without painting. After that, the work was sprayed with colloidal material of nanotitania on the cement surface with air brushes on both sides of the cement surface. The confirmation of cementitious attach of nanotitania particles was observed by SEM. The photocatalytic activity test was carried out in 0.01 ml, 0.03 and 0.05 mg/l methylene blue (MB), at 3 hours under UV light (in UV box) at constant light intensity. This study observed on the decomposition of Beer Lambert's law by measuring the concentration of MB before \((C_0)\) and after testing \((C)\) in the UV-Box by using UV-Vis technique.

3. Results and discussion

3.1 Synthesis of colloidal TiO\(_2\)

The researchers synthesized colloidal titanium dioxide, using four dispersants: 1. Polyethyleneglycol 2. Sodiumsilicate 3. Ammoniumacetate 4. Magnesiumchloride \([4,5]\). The comparison of the concentrations of the four dispersants were at 0.5\%, 1.5\% and 2.5\% by weight, which was carried out for 15 days as shown in Fig. 1 (a) (b) (c) (d) and (e). Polyethyleneglycol (PEG) with a molecular weight of 4,000 had the potential to make the nanoparticles more dispersible in water than any other substance shown in Fig. 1 (b). The polymer that adsorbed on the TiO\(_2\) nanoparticle leads to steric repulsion between particles and averts the agglomeration of nanoparticles. Based on some researches, several polymers were used for steric stabilization of TiO\(_2\) nanoparticles. Polyethylene glycol (PEG) and polyacrylamide (PAM) for steric stabilization TiO\(_2\) sols were used by Diess et al \([6]\). The TiO\(_2\) sols Coated with PEG promotes the stability of these sols at pH below 3 and concentration up to 30 g.l\(^{-1}\). However, the polyacrylamide (PAM) stabilized sols of concentration close to 100 g.l\(^{-1}\) at pH up to 5, which lead to long-term stability of these sols \([7]\). If the colloidal titanium dioxide particles were well dispersed, the nanotitania particles would spread to the cement surface. This type of coating was applied to the cement surface to test for the organic substances decomposition.

![Figure 1. Colloidal titanium dioxide in days 15 (a) No dispersing agent (b) Polyethyleneglycol (c) Sodiumsilicate (d) Ammoniumacetate (e) Magnesiumchloride](image)

3.2 Cement sample production

The sample size was 5x5x1 centimeters, and cemented to water/cement ratio of 0.4, and hydration cement for 28 days at room temperature in Fig. 2 (a). Physical appearance of the sample was rough. Surface grinding was required to give smooth surface and uniform spraying of nanotitania can be assumed. Then, the cement sample was cleaned with ultrasonic machine to allow the cement powder to come out and leave it to dry for 3 days at room temperature shown in Fig. 2 (b) and (c). The cement sample was sprayed coating of TiO\(_2\) nanoparticles with PEG dispersant on the cement surface with Air Brush in Fig. 2 (d)
3.3 Testing

3.3.1 Confirmation of cementitious attach of nanotitania particles by SEM. The nanotitania was very small at the nanometer level which could not be seen with the naked eyes or normal microscope. Nanotitania particles which attached to the surface of the cement were confirmed by using scanning electron microscope (SEM) shown in Fig.3. In Fig.3 (a) 60,000 times SEM showed that there was a nanoparticle attached to the sample surface in the circle. This confirmed that nanotitania particles attached to the sample surface in a scattering pattern. At 60,000 times SEM could not be seen within the cement porous. Fig.3 (b) at 100,000 times SEM showed that the nanoparticles embedded and distributed in the cement porous in the circle. When increasing the magnification at 300,000 times in the 200 nm range as shown in Fig. 3 (c), it was found that the nanoparticle attached to the surface and the porosity of the cement sample. To observe exactly what was found in the image, the observation of SEM was a real nanoparticle. The researchers increased in 500,000 times in the 100 nm range to measure the size of nanoparticles. Fig. 3 (d) showed that the size of nanoparticles at the surface was approximately 25 nanometers. A group of nanoparticles might be found larger than 25 nanometers. The researchers were able to confirm that the colloidal coating of colloidal titanium particles was at the nano level. Nanotitania particles were attached to the surface and porous at the surface of the cementitious specimen to be tested with MB. It was also possible that the nanoparticle-coated specimens could be used to decompose the organic material by photocatalytic test.

3.3.2 Photocatalytic activity test. Methylene blue concentrations of 0.01, 0.03 and 0.05 mg/l were used as a molecular organic reagent for the photocatalytic activity test. We applied the TiO$_2$ coated cement sample in MB for 3 hours under UV light (in UV box) at a constant light intensity to substitute the reaction in natural light with UV light from a UV box that was darker than the UV in the sun for reducing the study period that shown in Fig.4 (a). Uncoated cement sample soaked in MB for 3 hours to test the porosity effect to absorb MB shown in Fig.4 (b). Due to the nature of the porous cement, which might adversely affect the absorption of organic matter into the porous cement. We wanted to know the efficiency of the organic decomposition of nanoparticles attached to the cement surface. This experiment was conducted to compare the effect of immersion of cement coated with nanotitania nanoparticles in MB solution. Then, the decreasing of MB concentration in UV box was measured by Beer Lambert’s Law.
Figure 4. Cement Sample Soaked in Methylene Blue

Over the course of 3 hours, we observed the color change of Methylene Blue. The blue color of the solution was reduced from the standard solution. The absorbance was measured by UV-vis technique at concentrations of 0.01, 0.03 and 0.05 mg/l in three batches in Fig. 5 (a) (b) and (c), respectively. The first was the standard solution shown in the line MB001mM_std Abs., MB003mM_std Abs. and MB005mM_std Abs. The second was the solution obtained after immersion in uncoated cement with nanotitania particles as shown in line MB001mM_c3h Abs., MB003mM_c3h Abs. and MB005mM_c3h Abs. The last solution from the cement sample was coated with nanotitania nanoparticles and immersed in MB under UV light in the UV box shown in line MB001mM_cn3h Abs. MB003mM_cn3h Abs. and MB005mM_cn3h Abs.

Figure 5. The graph shows the absorption of the Methylene Blue solution.
Fig. 5 (a) showed the absorption of the solution at 0.01 mg/l. The wavelength was 664 nm. The first was a standard solution. The absorbance was 0.52. The second was the solution obtained after immersion in uncoated cement with nanotitania particles. The absorbance was 0.37. The absorbance was reduced from the standard solution by about 28.8% with the effect of cement porous absorbing. The third was the solution from coated cement with nanotitania nanoparticles was immersed Methylene Blue under UV light in a UV box with an absorbance of 0.28. The absorbance decreased from the standard solution of 46.1%. The effect of the cement porosity and nanotitania nanoparticles on the cement surface was effective when exposed to light. Fig. 5 (b) showed the absorption of the solution at 0.03 mg/l. The wavelength was 664 nm. The first was a standard solution. The absorbance was 1.42. The second was the solution obtained after immersion in uncoated cement with nanotitania particles. The absorbance was 1.10. The third was the solution from coated cement with nanotitania nanoparticles was immersed Methylene Blue under UV light in a UV box with an absorbance of 0.99. The absorbance was decreased from the standard deviation of 29.28%. The effect of the cement porosity and nanotitania nanoparticles on the cement surface was effective when exposed to light. Fig. 5 (c) showed the absorption of the solution at 0.05 mg/l. The wavelength was 664 nm. The first was a standard solution. The absorbance was 2.15. The second was the solution obtained after immersion in uncoated cement with nanotitania particles. The absorbance was 1.98. The absorbance was reduced from the standard solution by about 9.8% with the effect of cement porous absorbing. The third was the solution from coated cement with nanotitania nanoparticles was immersed Methylene Blue under UV light in a UV box with an absorbance of 1.44. The absorbance was decreased from the standard deviation of 32.71%. The effect of the cement porosity and nanotitania nanoparticles on the cement surface was effective when exposed to light. Because of the porosity of cement, it was beneficial to absorb organic matter in this area, working with nanotitania nanoparticles coated at the surface and into the porous cement. The results were in lower absorbance, which meant more organic degradation. Even though we tested the concentration of the Methylene Blue at the increased concentrations of the first and the second sets, the cement surfaces coated with nanotitania particles still exhibited organic degradation. Under the light, the test results were based on the assumption. When using real estate in buildings, it was more effective to work together.

4. Conclusion
It was proposed to develop self-cleaning cement by light accelerator reaction. The sample cement surface was coated with colloidal titanium nanoparticles. Using four dispersing agents, it was found that the dispersant agent Polyethylene glycol (PEG) with a molecular weight of 4,000 was more effective in dispersing nanoparticles than others. The nano-TiO\textsubscript{2} nanoparticles were sprayed onto the cement surface. Confirmation of nanoparticle attachment with SEM, it was found that nanoparticles were attached at the surface and porous of the sample specimens. The coated cement was tested by photocatalytic activity test for 3 hours in UV box with 0.01, 0.03 and 0.05 mg/l MB. On the cement surface at constant light intensity, nanotitania particles could decompose organic matter in light acceleration. Observation of the reduced absorbance from UV-Vis technique was able to assure that the coated cement was able to decompose the organic substance and applied it to the outside walls or cementitious materials in the sunlight effectively.

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