양생기간이 TiO_2 나노튜브 보강 시멘트 페이스트의 광촉매 효과에 미치는 영향

Effect of Curing Period on Photocatalytic Effect of TiO_2 Nanotubes-reinforced Cement Paste

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Abstract

With the development of nano-reinforcement technology and the increasing concern for environmental issues, TiO_2 nanomaterials have received wide attention as an additive besides carbon nanomaterials that can be used to enhance the mechanical properties of cement-based materials. Also, TiO_2-based materials can allow cement-baned materials with photocatalytic capability, providing a potentially effective approach to reduce environmental problems. In this work, compressive strength, splitting tensile strength, and degradation of methylene blue solution were used as target to assess the effect of TiO_2 nanotubes on the mechanical strength and photocatalytic effect of hardened cement paste at different curing time. According to the strength results, the optimum amount of TiO_2 was identified as 0.5% of the weight of cement. Meanwhile, the TiO_2 nanotubes-reinforced specimen exhibited better photocatalytic effect in the early stage of curing.

키 워 드 : TiO_2 나노튜브, 나노 강화, 광촉매 효과, 시멘트 페이스트
Keywords : TiO_2 nanotubes, nano-reinforced, photocatalytic effect, cement paste

1. 서 론

As part of a novel research trend in construction materials, nano-modification technology contributes to the further development of cement-based materials. It has been suggested that nanomaterials can increase the mechanical strength, durability, ductility, and hydration reaction of cementitious materials. Moreover. nanomaterials with special capabilities provide new properties to cement-based materials, such as TiO_2 nanomaterials with photocatalytic properties. Because of the addition of photocatalysts, building materials get new properties such as air purification and self-cleaning. This is one of the future topics for environment-friendly building materials. Our previous research1) confirmed that the mechanical properties and hydration reaction rate of cementitious materials can be improved when TiO_2 nanotubes (TNTs) was incorporated. However, the optimal amount and photocatalytic effect of TNT in cementitious materials were not further investigated. Thus, the purpose of this work was to investigate the mechanical strength and photocatalytic effect of TNTs-reinforced cement paste at different curing stages. In detail, the compressive and splitting tensile strength of reinforced specimens with different amounts of TNTs was assessed to find the optimal amount of TNTs, Meanwhile, the photocatalytic effect of the reinforced specimens was evaluated by ultraviolet-visible (UV-vis) spectroscopy of methylene blue (MB) solution concentration changes.

2. 재료 및 방법

Ordinary Portland cement (OPC) obtained from Sungshin Co. Ltd. Korea was utilized for the production of

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cement paste. The TNTs used in this study was synthesized in our laboratory by hydrothermal method[2] using anatase titanium dioxide powder (n-TiO_2) with particle size less than 25 nm from Sigma Aldrich. The compressive and splitting tensile strengths were tested at 1, 7, and 28 days using reinforced cement paste containing various amounts of TNTs. The photocatalytic activity of the prepared specimens was evaluated by detecting the concentration of methylene blue (MB) solution as the target under ultraviolet light (PM-1600UVH, NDT Advance, Japan) irradiation. Figure 1 shows a schematic diagram of the photocatalytic effect testing setup.

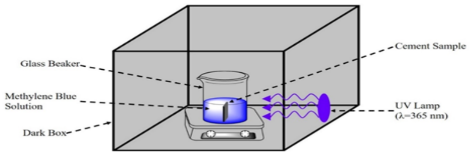

Figure 1. Schematic diagram of photocatalytic effect test

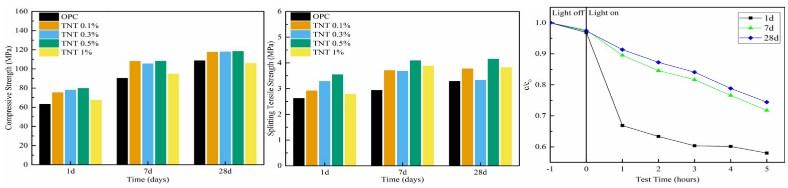

Figure. 332. Compressive strength (left), splitting tensile strength (center), and normalized concentration of MB solution (right).

The w/c ratio of all specimens was 0.4.

3. 결 과

The mechanical strength and photocatalytic effect results of the specimen were shown in Figure 2. As curing was going on, the strength of the cement was gradually increasing, at the same time, with the increase of TNTs content, the compressive strength and splitting tensile strength of the cement pastes containing TNTs showed a trend of increasing before decreasing at the same curing time, and the optimal amount was found to be 0.5% of the cement mass. This was attributed to the nucleation effect, filling effect, and bridging effect of nanotubes, i.e., the large specific surface area of TNTs provided more nucleation sites as well as growing space for the hydration products, which led to a more dense cement structure. At the same time, the tubular structure connects the micro cracks. Finally, the mechanical strength of the sample was improved. According to the mechanical strength results, we used a sample containing 0.5% TNTs to test the photocatalytic effect. The photocatalytic effect of the specimen tended to decrease with curing, while the best photocatalytic effect occurred at the early stage of the curing (1 day). This may be due to the TiO_2 covered by the generated hydration products, which caused its photocatalytic reaction to being inhibited when irradiated by UV light, thus reducing the photocatalytic effect. Based on the above, in this work, we compared the mechanical strength of cement pastes containing different amounts of TNTs and found that the optimum amount of TNT was 0.5% of the cement mass. Also, the samples with excellent mechanical strength were used to test the photocatalytic performance, and it was found that the photocatalytic effect was inhibited as curing proceeded.

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참 고 문 헌

1. H Jee, Characterization of Titanium Nanotube Reinforced Cementitious Composites: Mechanical Properties, Microstructure, and Hydration, Materials, 2019.5
2. T. Kasuga, Formation of Titanium Oxide Nanotube, Langmuir, pp.3160~3163, 1998.5