TiO_2 입자 크기 및 구조가 시멘트 페이스트 광촉매 효과에 미치는 영향

Influence of TiO_2 Particle Size and Structure on its Photocatalytic Effect in Cement Paste

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Abstract

With the increasing importance of environmental issues, the cementitious materials with self-cleaning or photocatalytic properties by introducing TiO_2 materials have been gaining a lot of attention. In this work, the influence of TiO_2 particle size and structure on its photocatalytic effect in cement paste was investigated. The degradation of methylene blue solution was used as the parameter for evaluating the photocatalytic effect of micro-TiO2 (m-TiO_2), nano-TiO2 (n-TiO_2), and TiO_2 nanotube (TNT). Moreover, the effect of these three TiO_2 materials on the cement hydration products was characterized by X-ray diffraction (XRD) and thermgravimetric analysis (TG). According to the results, it can be found that all of the TiO_2 materials promoted the formation of hydration products, especially TNT. On the other hand, the m-TiO_2 exhibited a better photocatalytic effect compared to other materials.

키 워 드 : 광촉매, 비표면적, 입자 크기, 구조, 시멘트 페이스트
Keywords : photocatalysis, anatase TiO_2, specific surface area, particle size, structure, cement paste

1. 서 론

Nano-modification technology plays a key role in the development of cementitious materials as part of a new research direction in construction and building materials. It has been shown that the incorporation of nanomaterials can enhance the mechanical strength, durability, ductility, and hydration reaction of cementitious materials. In addition, the incorporation of nanomaterials into cementitious materials has led to some new properties. For example, the incorporation of TiO2 nanomaterials with photocatalytic properties into cement-based materials, as the addition of photocatalysts offers air-purifying, self-cleaning, self-sterilizing and anti-fogging properties to the building material. This is definitely one of the prospective subject in the field of environment-friendly building materials. Our recent research1) confirmed that the mechanical properties and hydration reaction rate of cementitious materials can be improved when TNT was incorporated. However, the photocatalytic effect of TNT in cementitious materials was not widely investigated. Therefore, the goal of this work is to investigate the photocatalytic effect of three TiO2 materials with different sizes and structures in hardened cement paste. The photocatalytic effect of the different materials in hardened cement was evaluated by ultraviolet-visible (UV-vis) spectroscopy of methylene blue (MB) solution concentration changes. Transmission electron microscopy (TEM) and X-ray diffraction (XRD) were used to observe the morphology of the raw materials and to detect the cement hydration products.

2. 재료 및 방법

Ordinary Portland cement (OPC) obtained from Sungshin Co. Ltd. Korea was used for the production of cement paste. The micro-sized titanium oxide (IV), anatase (m-TiO2) used in this work was purchased from FUJIFILM Wako Pyre Chemical Company, Japan. The titanium (IV) oxide powder, anatase (n-TiO2) was purchased from Sigma Aldrich,

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while this powder was also used as a raw material to synthesize TNT via hydrothermal method.1),2) The photocatalytic activity of the prepared specimens was evaluated by detecting the concentration of methylene blue (MB) solution as an organic pollutant under ultraviolet light (PM-1600UVH, NDT Advance, Japan) irradiation. Figure 1 shows a schematic diagram of the testing equipment. The water-cement ratio of the cement samples was 0.4 and the samples were mixed with 1 wt% of three different TiO2 materials, respectively.

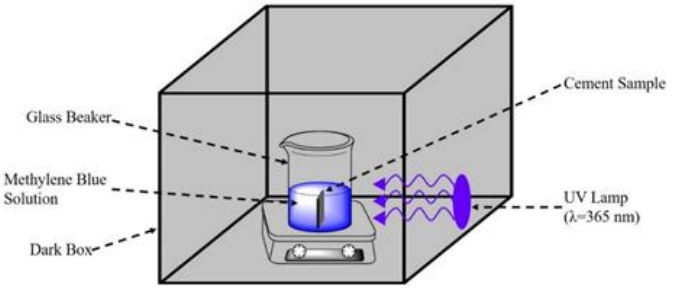

Figure 1. Schematic diagram of photocatalyst test setup

3. 결 과

The TEM of TNT synthesized by hydrothermal method and the XRD spectra of the three TiO2 materials used in this work are shown in Figure 2. The TNT clearly showed a long, straight, hollow tubular structure. The diffraction peaks of micro-TiO2 and nano-TiO2 at 25.3°, 37.8°, 48.0°, 53.8°, 55.0°, 62.6°, and 68.7° were corresponding to (101), (004), (200), (105), (211), (204), and (116) planes, respectively.

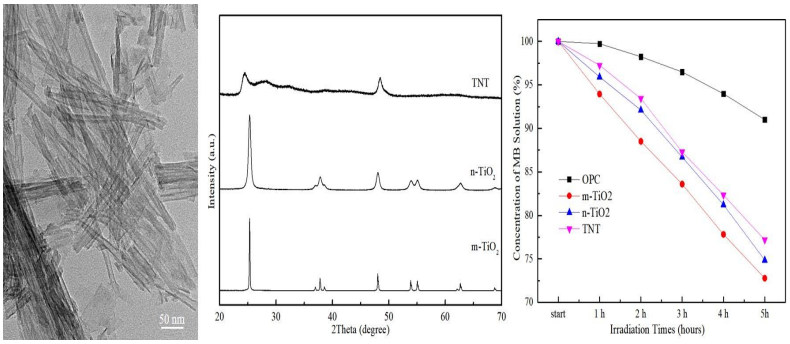

Figure 2. TEM result of TNT (left), XRD patterns for m-TiO2, n-TiO2, and TNT (center) and variation in concentration of MB solution (right)

The diffraction spectrum of TNT was similar to the results obtained by other researchers3), and the two obvious peaks were located at 24.5° and 48.3°. Figure 3. The pictures showed the variation of methylene blue solution concentration under UV light. The degradation of methylene blue solution with OPC was attributed to the decomposition of the methylene blue itself, and the cement paste containing m-TiO2 exhibited the best degradation efficiency for organic dyes under the same conditions. This is because m-TiO2 particles provide a higher available surface area for the adsorption and reaction of macromolecules such as methylene blue.

4. 결 론

In this work, we compared the photocatalytic effect of three different TiO2 materials in cement paste. As a result, we found that m-TiO2 exhibitied the best photocatalytic degradation of organic dyes to cement under the same conditions.

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