태양광 응답형 ZnO/TaON 나노 복합체의 제조 및 광촉매 특성 평가

Synthesis of solar light responsive ZnO/TaON photocatalysts and their photocatalytic activity

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초 록: The effects of the preparation conditions of ZnO-modified TaON on the photocatalytic activity for degradation of rhodamine B dye (Rh. B) under simulated solar light were investigated. The ZnO/TaON nanocomposite were prepared by loading particulate Ta_2O_5 with ZnO using different ZnO contents, followed by thermal nitridation at 1123 K for 5 h under NH_3 flow (20 ml min.1). The asprepared samples were characterized by XRD, UV-Vis-DRS, and SEM-EDX. The results revealed that the band gap energy absorption edge of as prepared nanocomposite samples was shifted to a longer wavelength as compared to ZnO and Ta_2O_5, and the 60 wt% ZnO/TaON nanocomposite exhibited the highest percentage (99.2 %) of degradation of Rh. B and the highest reaction rate constant (0.0137 min^{-1}) in 4 h which could be attributed to the enhanced absorption of the ZnO/TaON nanocomposite photocatalyst. Hence, these results suggest that the ZnO/TaON nanocomposite exhibits enhanced photocatalytic activity for the degradation of rhodamine B under simulated solar light irradiation in comparison to the commercial ZnO, Ta_2O_5, and TaON.

1. 서론

Semiconductor photocatalysts have been attracted much attention because of their high photocatalytic activity and chemical stability. Various heterogeneous photocatalysts have been utilized for many practical applications such as the purification of water and soil polluted with organic compounds[1,2] and, the photocatalytic decomposition of toxic agents in water[3]. However, TiO_2 photocatalysts operate only under UV light of wavelengths shorter than 400 nm which means only 3.5 % of the solar light can activate these wide band-gap materials.[4] ZnO nanoparticles has many advantages, such as low price, large initial rates of activities, many active sites with high surface area, high absorption efficiency of light radiations, and environmental safety.[5] It has also been discovered that high photocatalytic activities in some alkaline and alkaline earth tantalates, including $NaTaO_3$, $KTaO_3$, $LiTaO_3$, $SrTa_2O_6$, $BaTa_2O_6$, and $Sr_2Ta_2O_7$.[6,7] However, most of these tantalum oxides have the band gap energies that are too large to use solar radiation efficiently. Recently, oxynitrides cotaining Ta^{5+} and Ti^{4+}, such as Ta_3N_5, TaON, and $Ta_2O_{5-x}N_y$ were also found to have the potential activity for water-splitting or decomposition of pollutants under visible-light irradiation. However, the photocatalytic activities of these nanoparticles were found to be low. Therefore, more efficient photocatalytic structures need to be developed.

2. 본론

In this study, the ball-mill method and thermal ammonolysis was used to prepare ZnO/TaON nanocomposite. The photocatalytic activity was performed by degradation of Rh B dye in aqueous solution under simulated solar light irradiation. The XRD patterns of the synthesized materials are shown in Figure 1. Figure 1(c) clearly shows the formation of TaON as a major phase, with small amounts of Ta_3N_5 phase. For ZnO/TaON nanocomposite, the intense peaks of TaON are dominant, and the weak peaks of ZnO are mixed as shown in Figures 1(d) and (e). It can be concluded that ZnO was successfully loaded on TaON through the ball-mill method. The photocatalytic activities of the ZnO, Ta_2O_5, TaON, 20 wt% ZnO/TaON, and 60 wt% ZnO/TaON nanocomposite were evaluated by the photocatalytic degradation of Rh. B under simulated solar light irradiation as a test reaction. The photocatalytic degradation of the Rh. B as a function of time is shown in Figure 2. Figure 2 indicates that 60 wt% ZnO/TaON nanocomposite prepared by thermal ammonolysis is more active for the degradation of rhodamine B after 240 min of reaction, and its performance is even better than the ZnO, Ta_2O_5, TaON, and 20 wt% ZnO/TaON.

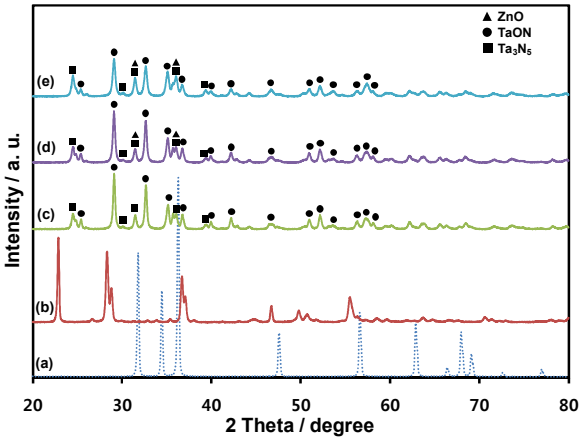

Figure 1. XRD patterns of (a) ZnO, (b) Ta_2O_5, (c) TaON, (d) 20 wt% ZnO/TaON, (e) 60 wt% ZnO/TaON nanocomposite.

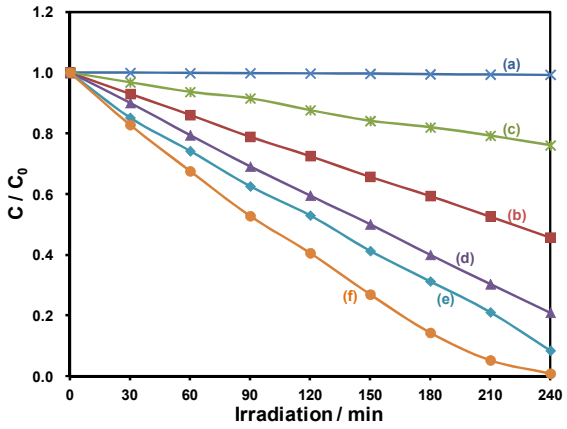

Figure 2. Photocatalytic degradation of the Rh. B dye (20 ppm) by different photocatalysts under simulated solar light: (a) Blank, (b) ZnO, (c) Ta_2O_5, (d) TaON, (e) 20 wt% ZnO/TaON, and (f) 60 wt% ZnO/TaON nanocomposite.

3. 결론

Solar-light-responsive ZnO/TaON nanocomposites were successfully prepared by the ball-mill method and thermal ammonolysis. Diffuse reflectance UV-Vis result of 60 wt% ZnO/TaON nanocomposite revealed a band gap of about 2.31 eV. 60 wt% ZnO/TaON nanocomposite has higher absorption than ZnO, Ta_2O_5, TaON, and 20 wt% ZnO/TaON in the visible region. ZnO/TaON nanocomposite exhibited good photocatalytic activity on the degradation of Rh. B dye under simulated solar light irradiation.

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