Comparison of Rh6G and MO dye degradation activities by electron beam irradiation under simulated sunlight

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1. Introduction

Metal oxides-based photocatalysts have been widely used for environmental remediation due to their low cost, high stability, and strong oxidizing ability. However, they suffer from several drawbacks, such as large band gap, high electron-hole recombination rate, and slow water adsorption on the photocatalyst surface. Therefore many efforts have been made to maximize the photocatalytic efficiency by modifying the structure and composition of metal oxides[1]. Carbon nanofibers (CNFs) are attractive candidates for enhancing the photocatalytic performance of metal oxides due to their high specific surface area and electrical conductivity. By depositing a photocatalyst on the surface of CNFs and serving as an electron acceptor, they can suppress the high electron-hole recombination of TiO_2-based photocatalysts. Furthermore, CNFs can facilitate the water adsorption on the photocatalyst surface by adsorbing dye molecules with their large specific surface area[2]. In this study, we aim to improve the adsorption and photoactive reactions for removing environmental pollutants by modifying the geometric and electronic structure of CNFs and catalysts via electron beam irradiation.

2. Methods and Results

2.1 TiO2/CNF Composite preparation process

PAN (polyacrylonitrile) 7wt% and solvent DMF are used as carbon fiber raw materials. As a photocatalyst, TTIP (titanium isoropoxide) is used. The polymer solution is heated at 60 degrees while stirring for 2h30m in a stirrer. The polymer solution is made into nanofibers through electrospinning. Afterwards, in order to activate the photocatalyst on the carbon fiber, a heat treatment process of stabilization conducted at 250℃ for 2h, carbonization at 1600°C for 5h20m in a nitrogen atmosphere, activation for 500°C and maintained 1h40m in a oxygen atmosphere. It is then ground to form a powder.

2.2 Electron-beam irradiation of TiO2/CNF composite

In Korea Atomic Energy Research Institute (KAERI) used an electron accelerator to irradiate electron energies of 2.5 MeV for a specific absorbed dose.

2.3 Photocatalytic activity under simulated sunlight

To evaluate the photocatalytic activity of TiO_2/CNF before and after irradiation, rhodamine 6G (Rh6G) and methyl orange (MO) were used. The photocatalyst powder was mixed with an aqueous solution of Rh6G and MO with stirring and illuminated with simulated sunlight (power density: 100 mW/cm2, AM 1.5). Small amounts of solution were extracted periodically.

2.4 Analysis

We investigated the effects of electron beam irradiation on the degradation of Rh6G and MO by TiO_2/CNF composites and the surface structure of the samples. We measured the degradation efficiency of Rh6G and MO by UV-vis spectroscopy to calculate the pollutant concentration. We also examined the changes in surface structure and photocatalytic activity of the photocatalytic nanoparticles deposited on carbon fibers by electron beam irradiation. The surface changes of photocatalyst and TiO_2/CNF were characterized using XRD, EDS, and XPS.

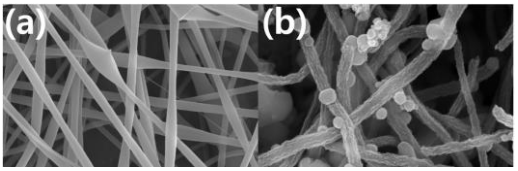

Fig. 1. FE-SEM images of activated by heat treatment before and after (a) electrospun polymer fibers, (b) activated carbon nanofibers after heat treatment

3. Conclusions

In this study, electron beam irradiation is expected to induce positive changes in the surface structure and photocatalytic activity of photocatalytic nanoparticles deposited on carbon fibers. For future research, it would be interesting to explore differentiated processing technologies distinct from the conventional photocatalytic doping technologies by conducting quantum beam irradiation experiments other than electron beam irradiation. Such experiments could reveal new insights into the mechanisms and effects of quantum beam irradiation on photocatalytic materials.

REFERENCES

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