광촉매가 코팅된 플라스틱 광섬유를 이용한 VOC 광분해반응

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Photodegradation of VOCs by Using TiO_2-Coated POF

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Abstract

In this study plastic optical fibers(POFs) were considered as light-transmitting media and substrates for the potential use in photocatalytic environmental purification system. After the characteristics of POFs in terms of light transmittance and absorption were determined at the beginning, the detailed investigation was further performed through the photocatalytic degradation of trichloroethylene (TCE), iso-propanol and etc. with TiO_2-coated optical fiber reactor systems (POFR). It is concluded that the use of POFs is preferred to quartz optical fibers(QOFs) since the advantages such as ease of handling, lower cost, relatively reasonable light attenuation at the wavelength of near 400 nm can be obtained. Various geometrical reactor shapes have been constructed and applied for the last one and half years. For the use of POF in water phase treatment, however, more detailed scientific and engineering aspects should be envisaged. This case requires a suitable mixture to obtain more stable and innocuous immobilization of photocatalyst on POF.

1. Introduction

Environmental remediation using photocatalyst has been the most intriguing issue in many countries for the past decade. While various research areas on photocatalysis have been studied, the immobilization of photocatalyst on a specific substrate, in particular, has attracted many researchers'attention due to the versatility of application. In this study, plastic optical fibers(POFs) were considered as light-transmitting media and substrates for the potential use in photocatalytic environmental purification system, comparing with that of quartz optical fibers(QOFs). It is concluded that the use of POFs is preferred to QOFs since the advantages such as ease of handling, lower cost, relatively reasonable light attenuation at the wavelength of near 400 nm can be obtained. And also, this system has been identified to achieve two main goals; transfer of light and volumetric reaction among the various immobilized reactor system.

2. Theory

The incident light on one end of fiber transmits to the other end by total reflection if clad(made of fluorinated PMMA, F-PMMA) exists which has lower refractive index than core. Once the clad is peeled off and then photocatalyst is coated on the surface of the fiber, refracted light can be absorbed due to higher refractive index of photocatalyst than that of core material. The core of the optical fiber can be made of quartz or polymer (mostly polymethyl methacrylate, PMMA). The former has relatively lower light attenuation(102 ~ 1 dB/km at the range of 300 ~ 800nm), but it is very difficult to handle and its cost is expensive. For this reason plastic optical fibers(POFs), which are inexpensive, flexible, resilient, tough, and weather resistant at temperature range of 55 ~ 70 ℃, were chosen to achieve the same goals of OF systems and resolve the aforementioned problems of the QOFs simultaneously. Using POFs in photocatalytic system can be promoted by the fact that the light attenuation difference hardly affects the reactivity in such a short length of transmittance and solar light and UV-A lamp in the absence of light < 300 nm does not degrade POFs'core structurally.

3. Experimental

Pretreatment of POFs could not be done either thermally or physically because the materials of core and clad is very similar to each other. Solvation using appropriate solvent was finally chosen to remove the clad of POF. After removing the clad from POF with 1 mm diameter, the resulted diameter should be close to 0.98 mm(matched with data by supplier). Clear proof of change in diameter of the POF was obtained by SEM(JSM 5900, JEOL) taken at various time scales(Fig. 1).

Selection of chemicals to immobilize photocatalyst on the surface of stripped optical fiber was main research topic in using POFs. For about two years of trial, suitable binder-like chemical(we call it "SM") has *recently* been identified and under investigation in terms of stability, light characteristics, harmfulness, etc(Fig. 2). In addition, reactors of various shapes(cylindrical, rectangular, filter-type etc.) have been designed and tested using a couple of probe materials to obtain promising results that support superiority of this POF system. Light sources were a 1 kW Xenon lamp(from Oriel) and UVBLBs with different size(output power). Gas chromatograph(GC w/electron capture detector and mass selective detector, Hewlett Packard 5890) and FTIR were main tools for analysis.

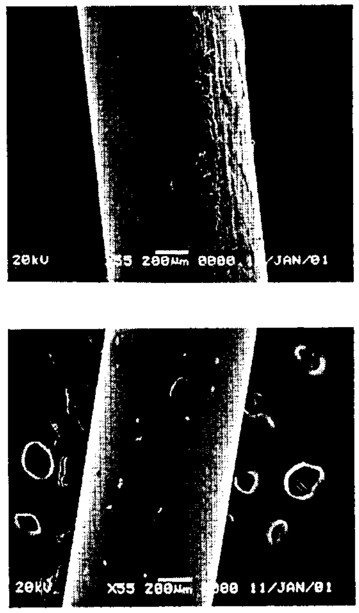

Fig. 1. SEM of treated POF in acetone for 30 sec(left, wrinkled clad layer shown) and for 5 min(right, clad removed clear surface shown).

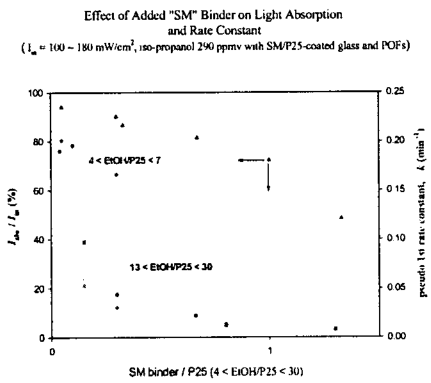

Fig. 2. Effect of added "SM" binder on light absorption and rate constant(iso-propanol 290 ppmv in 650 ml reactor).

4. Results and Discussion

Before performing various experiments, light transmittance characteristics of QOF and POF were investigated and compared qualitatively. In the case of POF the amount of light transmitted was lower than in QOF and also in particularly light with a wavelength less than 300nm can not be transmitted via POF. This range of light is to be absorbed by PMMA, will structurally degrade PMMA. While the stripped fiber has lower light transmittance ability due to refraction at the exposed surface, the coated fiber has much lower transmittance with increasing coating times due to the light absorption by TiO_2. The effect of POF diameter, coated thickness, number of fibers, and length of fibers has been identified(*Solar Energy Materials and Solar Cells*, **in press**) and used as basic data for further engineering design. A gas chromatograph and FTIR study showed that reaction byproducts, which actually proved that photocatalysis happened in POF system.

5. Conclusions

The use of POF in photocatalysis with an appropriate light source turned out promising in terms of high efficiency and widened fields of application. Eventually, the difference of reactivity between POF and QOF was negligible under our conditions. Various light sources could be used with POF because they do not irradiate light with wavelength shorter than 300 nm. The low cost of raw material and fragility also enhanced the versatility of POF system.