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Characterization of Flame-generated TiO_2 Deposited Activated Carbon Fibers (ACF)

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Abstract. Even though activated carbon fibers (ACF) have been attractive due to high specific surface area and uniform micropore structure, there are only a few reports about the photocatalyst immobilization on ACF or their photodegradation behavior for removal of organic pollutants. In this study, ACF were selected as adsorptive support for photocatalyst immobilization. As photocatalysts, TiO_2 nanoparticles were synthesized by using a N_2-diluted and oxygen-enriched co-flow hydrogen diffusion flame. The visible flame length of 150mm was obtained by direct photographs. Flame temperature was measured by rapid insertion measurement technique with a R-type (Pt/Pt-13%Rd) thermocouple which was in wire shape (127μm diameter). TiO_2 particles were sampled by using a high temperature particle sampler and then were coated on ACF filters. The sampling was carried out at 70mm and 110mm above the burner. The structure of TiO_2 particles was analyzed by XRD. TiO_2 coated ACF filters were characterized by FESEM-EDX and BET analyses. TiO_2 particles on ACF filters were found to be agglomerated particles and the size of primary particles was approximately 50nm. The structure of TiO_2 particle was anatase-phase crystalline structure. The specific surface area of TiO_2 coated ACF filter was enhanced to be 1700~1860m^2/g, depending on the sampling location, and the pores were micropores, regardless of the sampling location.

1. Introduction

Activated carbon fibers (ACF) are a type of highly microporous carbon materials [1], which are commercially available in the form of fiber tows, cloths (fabrics), papers, mats and felts [2]. ACF have a larger micropore volume and a more uniform micropore size distribution than granular activated carbons (GAC), and thus are considered to have a larger adsorption capacity and greater rates of adsorption and desorption. However, it is still interesting to enhance the pollutant reduction

activity of ACF, for example, by using a functional metal coating technology [3]. In this paper, we propose a coating method on ACF with flame synthesized TiO_2 nano particles.

2. Methods

Fig. 1 shows the experimental set up. As photocatalyst, TiO_2 nanoparticles were synthesized by using a N_2-diluted and oxygen-enriched co-flow hydrogen diffusion flame. TiO_2 particles were sampled by using a high temperature particle sampler and then were coated on an ACF filter which was located in the sampling duct. The sampling was carried out at 70mm and 110mm above the burner.

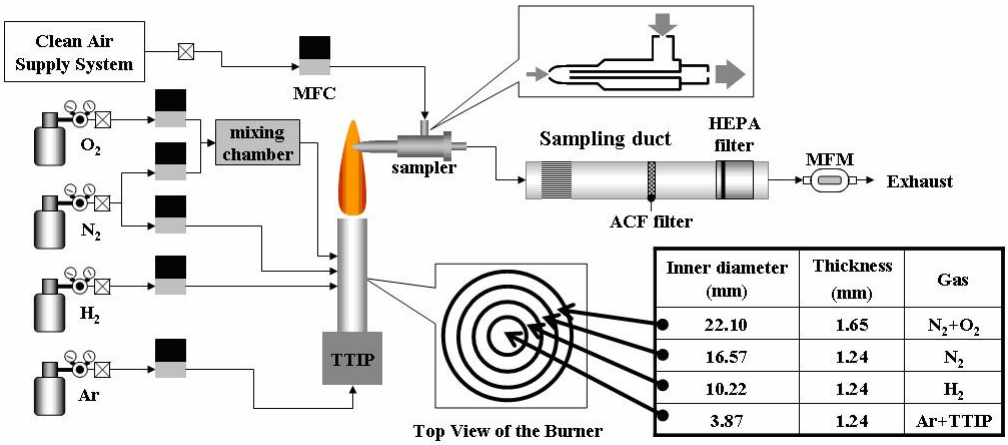

Fig. 1 Experimental setup.

The visible flame length of 150mm was obtained by direct photographs in Fig. 2. Flame temperatures were measured by rapid insertion measurement technique with an R-type (Pt/Pt-13%Rd) thermocouple which was in wire shape (127μm diameter) and the results are shown in Fig. 2. The structure of TiO_2 particles was anatase-phase crystalline structure (2Θ =25.5°) which was analyzed by XRD, as shown in Fig. 3.

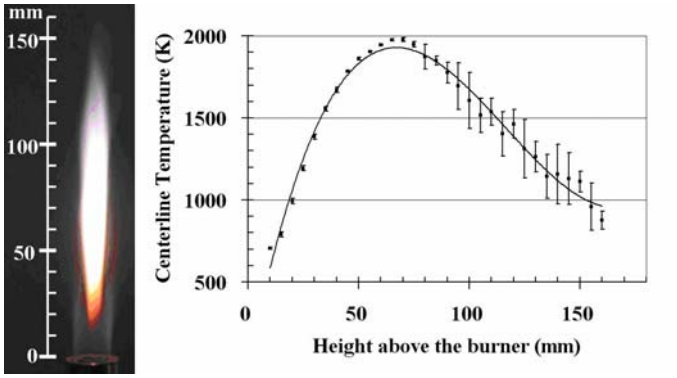

Fig. 2 Direct photograph and temperature of flame.

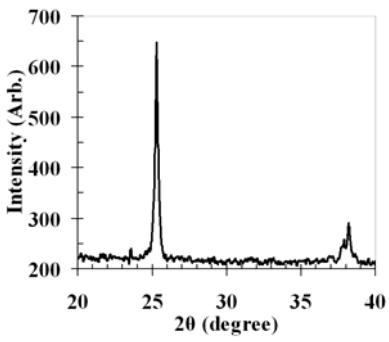

Fig. 3 XRD analysis of generated particle.

3. Results

TiO_2 coated ACF filters were characterized by field emission scanning electron microscopy (FESEM, JSM-6500F, JEOL, Japan), energy dispersive X-ray spectroscopy (EDX, JED-2300, JEOL, Japan) and BET analyses. TiO_2 particles on ACF filters were found to be agglomerated particles and the size of primary particles was approximately 50nm, as shown in Fig. 4. The concentration of TiO_2 particles which were sampled at 70mm was higher than that of particles sampled at 110mm, since the temperature at the location of 70mm was higher than the temperature at the location of 110mm.

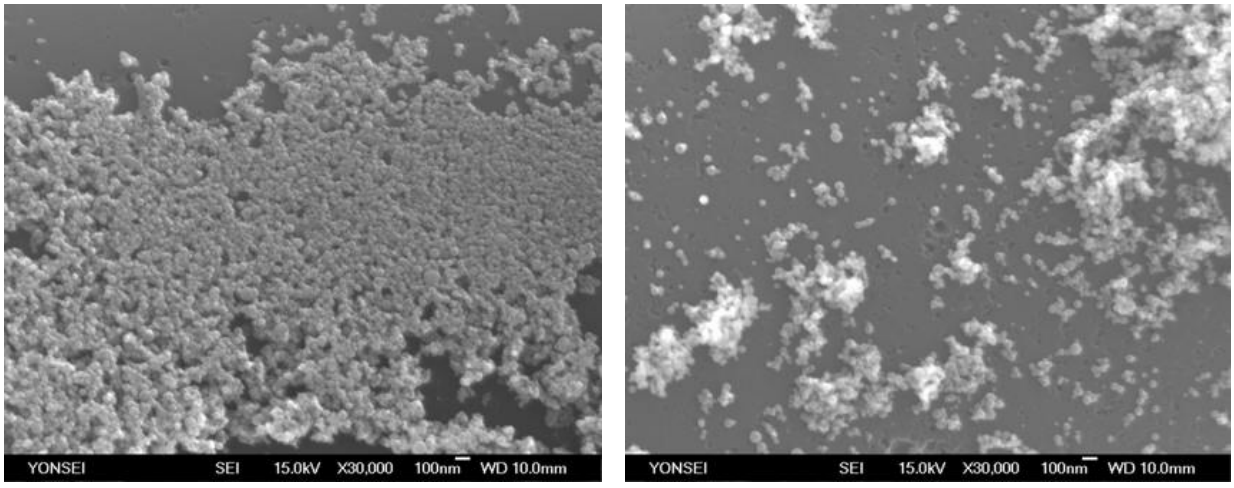

Fig. 4 FESEM images of TiO_2 particles on ACF filters at the sampling location of 70mm (left) and 110mm (right).

Elements of TiO_2 coated ACF filters were tabulated in table 1. TiO_2 coated filter of sampling location of 70mm had more Ti and O atoms than TiO_2 filter of sampling location of 110mm.

Table 1. Characteristics of ACF filters by FESEM-EDX

	ACF filter (sampling@70mm)		ACF filter (sampling@110mm)	
Element	mass%	atom%	mass%	atom%
C	89.61	93.79	91.64	94.86
O	6.66	5.23	5.75	4.47
Ti	3.73	0.98	2.61	0.68
Total	100	100	100	100

Specific surface area (m^2/g) and specific micropore area (m^2/g) of ACF filters were obtained by N_2 adsorption at 77 K by using a Micromeritics ASAP 2010. Fig. 5 shows that specific surface area of TiO_2 coated ACF filter was enhanced to be 1700~1860m^2/g, depending on the sampling location. The specific surface area of ACF filter having TiO_2 particles which were sampled at 70mm was higher than that of ACF filter with TiO_2 sampled at 110mm. It was found that the pores were micropores, regardless of the sampling location.

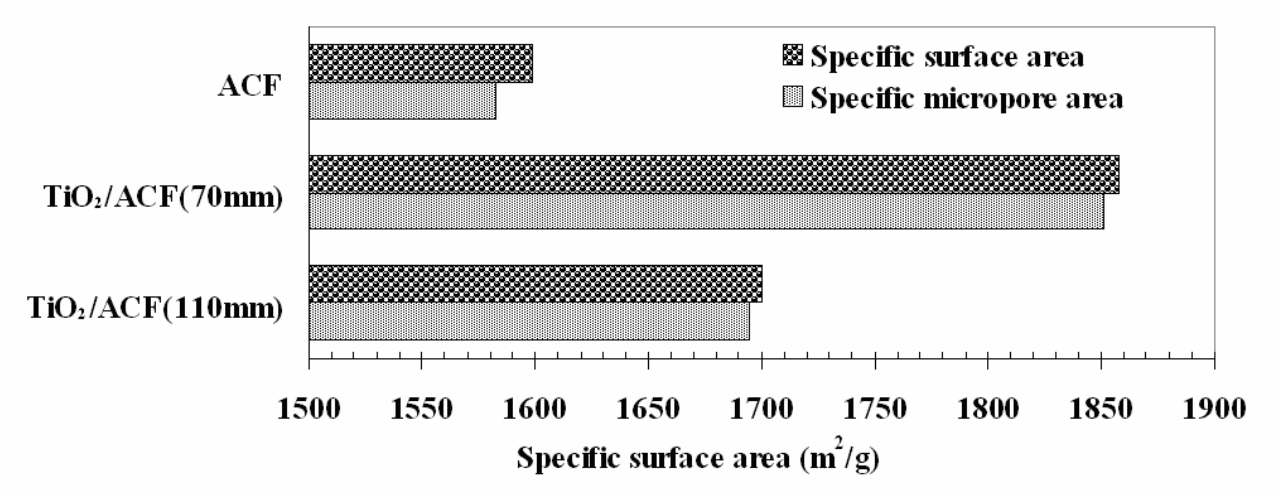

Fig. 5 Specific surface area and micro specific surface area of TiO_2/ACF filters.

4. Conclusion

In this study, ACF were selected as adsorptive support for TiO_2 nanoparticles immobilization. TiO_2 particles were synthesized by using a N_2-diluted and oxygen-enriched co-flow hydrogen diffusion flame. TiO_2 particles were sampled by using a high temperature particle sampler and then were coated on ACF filters. The sampling was carried out at 70mm and 110mm above the burner. The structure of TiO_2 particles was analyzed by XRD. TiO_2 coated ACF filters were characterized by FESEM-EDX and BET analyses. TiO_2 particles on ACF filters were found to be agglomerated particles and the size of primary particles was approximately 50nm. The structure of TiO_2 particle was anatase-phase crystalline structure. The specific surface area of TiO_2 coated ACF filter was enhanced to be 1700~1860m^2/g, depending on the sampling location, and the pores were micropores, regardless of the sampling location.

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