Uniform Coating of TiO_2 Thin Films on Polypropylene Particles by Plasma Chemical Vapor Deposition Process

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Abstracts: We coated TiO_2 thin films on particles by a rotating cylindrical plasma chemical vapor deposition (PCVD) process and investigated the effects of various process variables on the morphology and growth of thin films. The polypropylene (PP) particles were rotated with the cylindrical PCVD reactor and they were coated with TiO_2 thin films uniformly by the deposition of thin film precursors in the gas phase. The TiO_2 thin films were coated on the PP particles uniformly and the thickness of thin films almost proportional to the deposition time. The TiO_2 thin films grew more quickly on the PP particles with increasing rotation speed of the reactor. This study shows that a rotating cylindrical PCVD reactor can be a good method to coat high-quality TiO_2 thin films uniformly on particles.

1. Introduction

The particles coated with TiO_2 thin films can be applied for pollutnat removal and H_2 production by TiO_2 photocatalysis and, for high efficiency of these applications, it is quite important to coat the TiO_2 photocatalysts uniformly on the surface of the particles. There are several types of reactor for dry particle coating, such as furnace reactor, flame reactor, photo-induced chemical vapor deposition (CVD) reactor, spray pyrolysis reactor, fluidized bed reactor, plasma CVD (PCVD) reactor, and arc plasma reactor[1-3]. The plasma chemical vapor deposition process has been widely used for preparation of high quality thin films and can also be used to coat the uniform thin films on particles. In this study, we coated the TiO_2 thin films on the polyethylene (PP) particles using the rotating cylindrical PCVD reactor and investigated the characteristics of the thin films on the particles for various process conditions.

2. Experiments

TiO_2 thin films were coated on the PP particles by using the rotating cylindrical PCVD reactor as shown in Fig. 1. A mechanical rotary vane pump was used for the evacuation of the gas stream from the reactor. The flow rate of TTIP as a source of Ti was controlled by changing the power of the ultrasonic nebulizer, and the TTIP was carried to the reactor with N_2 gas. The feed line for TTIP was heated to help the evaporation of TTIP droplets and also to prevent the condensation of TTIP. O_2 was supplied to the reactor separately from TTIP to prevent reaction between O_2 and TTIP in the feed line. The flow rates of all gases were controlled by mass flow controllers (MFC). A water-cooled spiral-shape coilelectrode is located outside the cylindrical reactor to generate the inductively coupled plasmas. The precursors for the TiO_2 thin films were generated from TTIP by plasma reactions in the gas phase. The rotation speed of the cylindrical quartz reactor was controlled by a DC motor. The morphologies and cross-sectional views of the TiO_2 films were analyzed by SEM. To calculate the net weight increase of the PP particles on deposition of TiO_2, we measured the total weight of all PP particles by high-resolution electronic scale with 1μg readability (Sartorius, model 4503 MICRO) before and after the coating processes. The thicknesses of the TiO_2 thin films coated on the PP particles were calculated from the net weight increase of the TiO_2 thin films by assuming that the thin films of TiO_2 were uniformly coated on all PP particles.

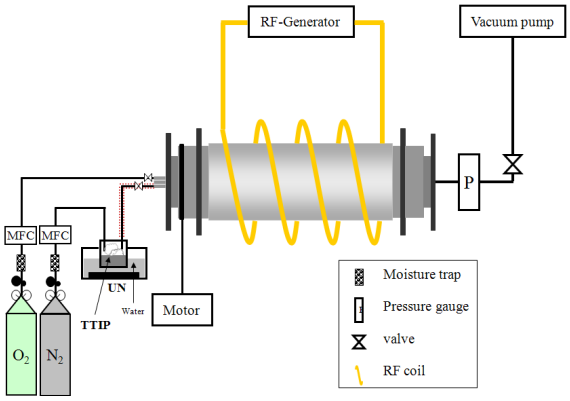
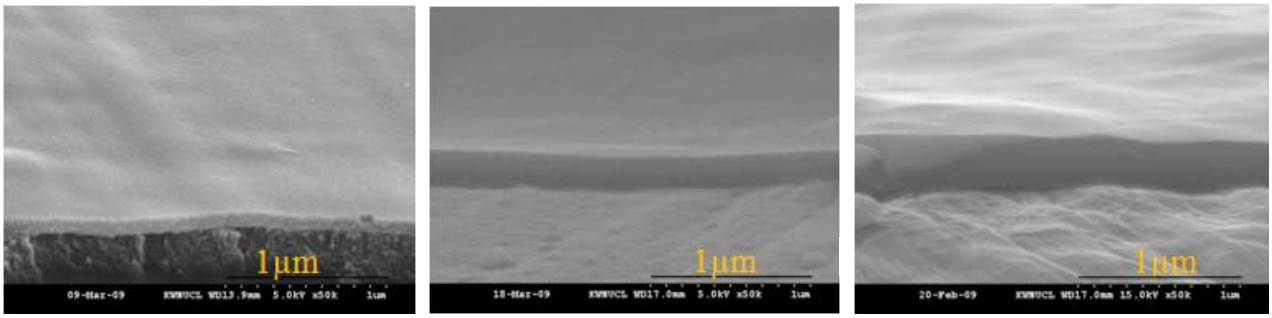


Fig. 1. Experimental schematic for particle coating.

3. Results and Discussion

Figs. 2 and 3 show SEM images of the cross section and the thickness of TiO_2 thin films coated on the PP particles for various deposition times, respectively. The precursors for the TiO_2 films were generated from TTIP by plasma reactions, and they deposited on the surface of the glass beads to become TiO_2 films. In Fig. 2, the TiO_2 thin films were coated on the PP particles uniformly. As the deposition time increases, the thickness of the TiO_2 thin films increases. In Fig. 3, the thickness of the TiO_2 thin films on the PP particles is almost proportional to the deposition time with the growth rate of about 21 nm/min based on the net weight of the TiO_2 thin films. Fig. 4 shows the thickness of TiO_2 thin films coated on the PP particles for various rotation speed of reactor. For the rotation speed of 3, 5, 10, 15, 20 rpm, the thickness of the TiO_2 thin films are 55, 100, 176, 252, 301 nm, respectively. As the rotation speed of the reactor increases, the number of PP particles staying in the gas phase increases proportional to rotation speed and the total surface area available for deposition of precursors on the particles also increases.



(a) 5 min (b) 10 min (c) 15 min

Fig. 2. SEM images of the cross section of TiO_2 thin film on the PP particles for various deposition times.

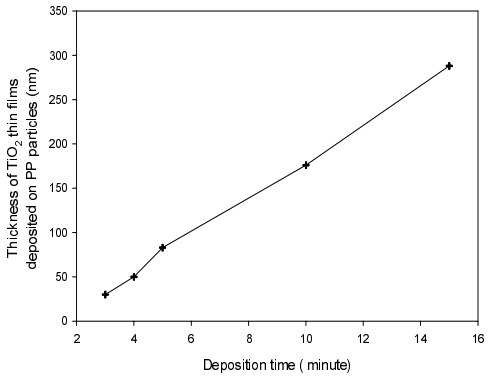


Fig. 3. Thickness of TiO_2 thin film on the PP particles for various deposition times.

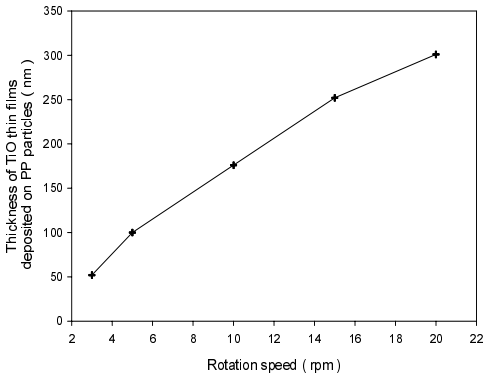


Fig. 4. Thickness of TiO_2 thin film on the PP particles for various rotation speed of reactor.

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