ENHACEMENT OF PHOTOCATALYTIC ACTIVITY ON TiO_2 PARTICLES MODIFIED WITH RF PLASMA

Kenji Yamada, Hiroyuki Nakamura, Shigenori Matsushima, Hirokazu Yamane, Teruki Haishi, and Kiyoshi Kumada

Kitakyushu National College of Technology, 5-20-1 Shii, Kokuraminami-ku, Kitakyushu city, Fukuoka 802-0985, Japan

A cold plasma is useful for surface modification of solid materials. In this work, plasma surface modification is tried to prepare visible-light active TiO_2 particles, of which the surface is doped with nitrogen.

The thin layer of the particles was formed on the surface of a glass substrate by spin-coating acetic acid solution of polyethylene glycol, in which the particles were dispersed, and then was sintered at 673 K for 30 min. The surface layer of the particles was treated with argon and nitrogen plasmas, in series. The discharge power was in the range of 50 W to 400 W and the discharge time was in the range of 2 min to 10 min. The discharge time of nitrogen plasma was the same as that of argon plasma.

Figure 1 shows UV-visible reflectance spectra of TiO_2 particles before and after plasma-treating with the argon and nitrogen plasmas. The plasma-treated surface layer of the particles revealed visible-light absorption, in addition to ultraviolet-light absorption. Figure 2 shows N_{1s} XPS spectrum on a surface of the plasma-treated TiO_2 particles. Binding state of nitrogen in the plasma-treated surface layer depends on the strength of the discharge power and the length of the discharge time, and influences the visible-light absorption. XPS broad peaks composed of N_{1s} peaks associated with N-N, N-H, and N-O bonds appeared in the range of 399 eV to 402 eV in the layer plasma-treated below 300W at times shorter than 5 min, whereas N_{1s} peak associated with Ti-N bond appeared in the range of 396 eV to 397 eV in that plasma-treated above 300 W at times longer than 5 min, in addition to the broad peaks. Water molecules adsorbed strongly on the surface of the particles will be able to remove from the surface of the particles with the argon plasma generated at high discharge power and prolonged discharge time. Emissions associated with Ti atoms and ions were observed in the nitrogen plasma during plasma-treating of the layer. Therefore it can be presumed that Ti-O bond scission takes place in the surface of the particles and active species of nitrogen are attacked to the Ti of the severed Ti-O bond to form Ti-N bond.

Photocatalytic activity of the plasma-treated particles was evaluated by using methylene blue and a xenon lamp. The percentage decomposition of methylene blue was increased by plasma-treating at high discharge power and prolonged discharge time. An increase in photocatalytic activity of the particles will be originated by the formation of Ti-N bonds which bring about the appearance of the visible-light activity.

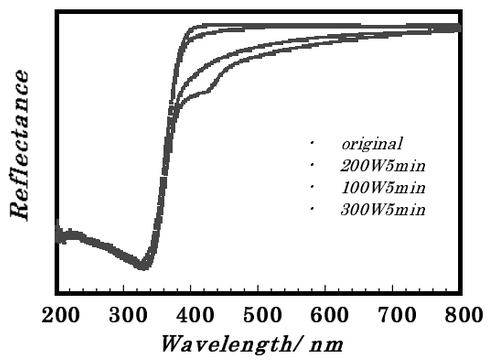

Fig.1. *UV-visible reflectance spectra of TiO_2 particles before and after argon and nitrogen plasmas.*

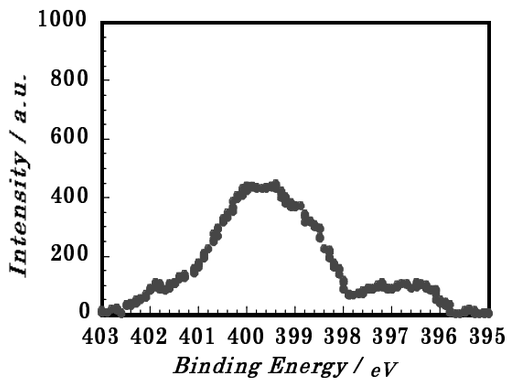

Fig.2. *N_{1s} XPS spectrum on a surface of TiO_2 particles plasma-treated at 400 W for 6 min.*