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Photodecomposition Effect of Metal doped TiO_2 System (I)

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To study photocatalytic mechanism of metal doped TiO_2, we investigated photodecomposition effect, photocurrent effect and antibacterial effect. When aluminium content was 2 wt %, photodecomposition effect was better than the others. Silver doped thin films had high photocurrent efficiency and antibacterial effect. This reactions were caused by dissolved oxygen in solution and oxygen adsorbed on surface of thin films.

Key words : photocatalyst, dopped Ag effect, photodecomposition, photocurrent, antibacterial

INTRODUCTION

Various application of photocatalytic reactions in environmental purification have been demonstrated. Most of these have involved the purification of air and water using the strong oxidizing power of TiO_2 photocatalysts under intense UV light irradiation. The photocatalytic degradation of pollutants in solution is attracting considerable attention in terms of applications to environmental problems. Absorption of UV radiation by TiO_2 results from the electronic band structure of this semiconductor. In support for the involvement of $O_2^{\cdot-}$, Cai et al. have reported that addition of superoxide dimutase, which converts the relatively unreactive $O_2^{\cdot-}$ to H_2O_2, greatly increases toxicity to HeLa cells photosensitized by TiO_2 [1]. The mechanism underlying the photobiological activity of TiO_2 is not yet well understood. As basic approach, we investigated photdecomposition effect and photocurrent and anti-bacterial effect.

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MATERIALS AND METHODS

Preparation of thin film. The film was prepared by thermal decomposition of titanium acetylacetonate dissolved ethanol. The substrate was heated at 440°C. This temperature is optimum condition which has the highest crystallinity and photocarrier generation efficiency [2]. We used spray pyrolysis method and spray rate of nitrogen gas remained 12 L/min. The concentration of Al used as dopant was prepared by

weight %. Dipped Al doped TiO_2 film into 0.1M $AgNO_3$ sol solution during 5 hrs.

X-ray Diffraction Pattern. The crystal structure and the crystallinity of thin film prepared on the glass sustrate were investigated by XRD in θ-2θ geometry. CuK_α (λ=1.5418Å) source were used, and the scanning range was between 2θ -10 and 80°.

Scanning Electron Microscope. The surface morphology of thin film was evaluated by the SEM micrographs.

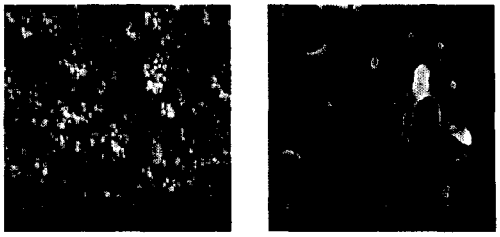
Photocatalytic Effect. The photocatalytic effect of thin films was evaluated by measuring the concentration change of 1.0M acetaldehyde as a function of UV irradiation time.

Photocurrent Effect. The photoelectrochemical cell consisted of a three electrode system with Ag/AgCl as the reference electrode and platinum wire as the auxiliary electrode. Thin film prepared on ITO substrate was used as working electrode.

Antibacterial Effect. To investigate catalytic mechanism of metal oxide thin film, we carried out anti-microbial efficacy test. Two strains of bacteria, *E. Coli* and *S. aureus* were treated with metal oxide thin film.

RESULTS AND DISCUSSION

Figure 1 shows SEM photographs of aluminium doped titanium oxide. We were observed homogeneous particle size distribution in undoped titanium oxide thin film. But aluminium doped thin film was a rough surface and porous particles. In order to study photocatalytic activity, we were carried into photodecomposition experiment of acetaldehyde under UVA irradiation. The aluminium doping concentration in the film was changed from 0 wt % to 8 wt %. From XRD data, we couldn't exactly structural characterization because thin films were observed as



(a) 3,000 X (b) 50,000 X

Figure 1. SEM photographs of Al(8%)/TiO_2.

amorphous state. Photodecomposition percent of TiO_2 by the aluminium content change are summarized in Table 1. Aluminium doped titanium dioxide had the highest photodecomposition percent when the aluminium content was 2 wt %. Photodecomposition percent and photocurrent

Table 1. Photodecomposition percent of Al/TiO_2 films in 1.0M CH_3CHO.(Irradiation time : 3hrs)

Al (wt %)	0	2	4	6	8
Photodecomposition (%)	43.8	54.3	47.3	54.0	45.3

effect of film adsorbed silver on Al/TiO_2 were shown in Figure 2 and Table 2. Silver activated thin films was better

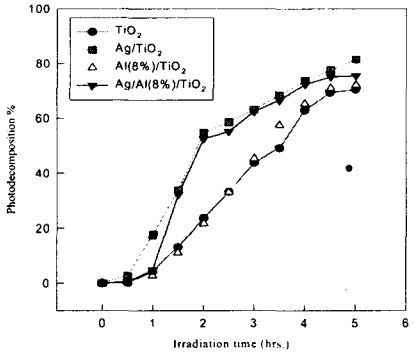


Figure 2. Photodecomposition % of Ag/Al/TiO_2 films in CH_3CHO.

photoactive materials than aluminium activated compounds. The basic mechanism of TiO_2 photocatalysis involves the formation of electron-hole pairs by UV absorption and the reaction of these charge carriers with chemical species at the surface. The photogenerated holes in the valence band diffuse to the surface, and their strong oxidizing power,

Table 2. Photocurrent effect of metal oxide thin films

Working electrode	Without CH_3CHO (μA)	With CH_3CHO (μA)
TiO_2	13.9	0.70
Al(2%)/ TiO_2	2.18	3.16
Ag/TiO_2	8.5	9.6
Ag/Al(2%)/TiO_2	1.35	15.25

quickly react with adsorbed water molecule to produce hydroxyl radical (·OH), and oxidize acetaldehyde. Meanwhile, electrons in the conduction band react with molecular oxygen in the solution to produce the superoxide radical anion (O_2^-) [3]. Table 3 shows antibacterial effect for *E. Coli* after 24 hrs in the dark state. Antibacterial effect was observed by silver ion adsorbed on Al/TiO_2 surface. This

Table 3. Antibacterial effect of thin films for *E. Coli* in dark state. (after 24hrs)

Samples	Sterilization percent of bacteria (%)
TiO_2	18.5
Al/TiO_2	24.5
Ag/Al/TiO_2	99.9

mechanism was presumed by oxygen adsorbed on surface of thin films.[4] Silver activated compounds were better photoactive materials than aluminium activated compounds.

CONCLUSION

To study photocatalytic mechanism of silver doped thin films, we have investigated photodecomposition property and photocurrent and antibacterial effect.

1. Silver activated compounds was better photoactive materials than aluminium activated compounds.
2. Silver doped metal oxide system had antibacterial function.
3. This reactions was caused by dissolved oxygen in solution and oxygen adsorbed on surface of thin films.

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