微粒子の構造化と光触媒材料への応用に関する研究

Study on Nanostructurization Material and its Application for Photocatalytic

13503

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成果の概要

Titanium dioxide (TiO_2) is one of the prospective catalysts because it possesses excellence properties (e.g., chemical and thermal stability, harmless, and inexpensive). With these advantages, the production of photocatalyst material with low cost production will be achieved. However, pure TiO_2 is only can be activated under UV light. Therefore, preparation of TiO_2 with high photocatalytic performance is inevitable. Extensive efforts have been devoted to solve the above problem. One of the methods is by combining TiO_2 with other material semiconductor. As an alternative of photocatalyst, tungsten trioxide (WO_3) has been proposed as a good candidate. WO_3 has been widely studied because an excellent prospective material for a wide range of applications due to its affinity for visible light. Therefore, combination of TiO_2 and WO_3 becoming an interesting subject in the photocatalytic field.

Here we reported the synthesis of composite

WO_3/TiO_2 Nanoparticles using a flame spray-pyrolysis method.^[1] Ammonium metatungstate (AMT) and titanium isopropoxide (TTIP) were used as a WO_3 source and TiO_2 source, respectively. The mass ratio of AMT/TTIP was varied: 0/100; 10/90; 25/75; and 100/0. The effect of mass ratio on the particles morphology and photocatalytic activity is shown in Fig. 1. The results showed that the particle size decreased (from 89 to 24nm) by increasing AMT amount. We also found that the increases in the AMT amount influenced the decreases in band gap energy, and increases in photocatalytic activity. Below than 25 wt% of AMT, the change of photocatalytic activity is mainly influenced by band gap energy. However, the surface area also plays important role in the change of photocatalytic activity.

Based on the previous research, the next subject we focused on the optimization of WO_3 material for photocatalytic application. Many researches about this material have been reported, especially the use

Fig. 1 The effect of AMT amount on the physical and chemical properties of the prepared particles.

of WO₃ nanoparticles for catalyst material. The use of nanoparticles is effective to improve photocatalytic performance. However, the special treatment regarding to the reuse or removal after photocatalytic process is needed. Therefore, design material in larger size with good performance is important.

Here, nanostructurization of WO₃ nanoparticles with controllable porous structure using spray drying method has been successfully.^[2] WO₃ nanoparticles (7 nm) and Polystyrene (PS) sphere (250 nm) were used as WO₃ source and template, respectively. To control the porous structure, mass ratio of PS/WO₃ was varied from 0.00 to 0.40. Pt was added as co-catalyst material. The effect of mass ratio of PS/WO₃ on the particle morphology and photocatalytic activity is shown in Fig. 2. We also analyzed WO₃ particles prepared from ammonium tungstate pentahydrate (ATP). The results showed that the number porous structure increased by increasing PS ratio. 0.32 was the optimum mass ratio to produce particles with highly ordered macroporous structure. The broken particles

Fig. 2 The effect of PS/WO₃ mass ratio on the particles morphology and photocatalytic activity.

were produced when the mass ratio was above 0.32. Photocatalytic activity increased by changing the morphology of particles. WO₃ particles from ATP have a lowest performance because of the lowest surface area. Aggregated WO₃ particles have a lower performance than WO₃ NPs. However, by adding porous structure, photocatalytic activity was higher than WO₃ NPs. The presence of Pt NPs considerably improved the photodegradation rate. It can be concluded that the presence of porous structure and Pt NPs is effective to enhance photocatalytic activity.

参考文献

- [1] Arutanti O., Nandiyanto A.B.D., Ogi T., Iskandar F., Kim T.O., Okuyama K.: "Synthesis of composite WO₃/TiO₂ nanoparticles by flame-assisted spray pyrolysis and their photocatalytic activity", Journal of Alloys and Compounds, 591 (2014) 121-126.
- [2] Arutanti O., Nandiyanto A.B.D., Ogi T., Kim T.O., Okuyama K.: "Influences of porous structurization and Pt addition on the improvement of photocatalytic performance of WO₃ particles", ACS Applied Materials & Interfaces, 7 (2015) 3009-3017.

外部発表成果

論文発表

1. Arutanti, O., Nandiyanto A. B. D., Ogi T., Iskandar F., Kim T. O., Okuyama K.: “Synthesis of composite WO_3/TiO_2 nanoparticles by flame-assisted spray pyrolysis and their photocatalytic activity”, *Journal of Alloys and Compounds*, 591 (2014) 121–126.
2. Arutanti, O., Nandiyanto A. B. D., Ogi T., Kim T. O., Okuyama K.: “Influences of porous structuring and Pt addition on the improvement of

photocatalytic performance of WO_3 particles”, *ACS Applied Materials & Interfaces*, 7 (2015) 3009–3017.

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1. Arutanti Osi, Ogi Takashi, Nandiyanto Asep Bayu Dani, Okuyama Kikuo: “Synthesis of WO_3 Particles with Controllable Crystallite and Particle Sizes Using A Spray-Pyrolysis Method and Their Photocatalytic Performance”, PP09-007, 2014 International Aerosol Conference, Busan, Korea (Aug. 28–Sep. 2, 2014).