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ヘリウムプラズマ誘起ナノ構造酸化タングステンの光触媒応用

Photocatalytic application of helium plasma induced nanostructured tungsten oxides

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Tungsten trioxide (WO_3) is an n-type semiconductor with a narrow band gap from 2.4 to 2.8 eV and has a good response to the visible light of 400-500nm. However, the photocatalytic activity of a WO_3 semiconductor without any suitable optimization is relatively low [1]. It was revealed that fiberform nanostructured tungsten is formed on tungsten surface by helium plasma irradiation under certain conditions [2]. So we can use the morphology control strategy i.e. nanostructured WO_3 to enhance the photocatalytic activity of WO_3-based photocatalysts.

In the previous study, Komori *et al.* already demonstrated that the partially oxidized nanostructured tungsten was an excellent photocatalyst for the degradation of methylene blue (MB) under the near-infrared light (λ>800nm)[3]. In the present study, we investigated the best oxidation ratio of nanostructured W oxides as photocatalysts under visible light.

The nanostructured surface was formed by the helium plasma irradiation in the linear plasma devices NAGDIS-II (Nagoya Divertor Simulator) to the tungsten substrate which was provided by Nilaco Corporation with 99.97% purity. Prior to helium irradiation, W bulk samples were polished and after polished ultrasonically cleaned in deionized water and methanol, and then dried in air at room temperature. To investigate the effect of different oxidation ratio to photocatalytic activity, after irradiation, the nanostructured W bulk samples were heated in an electric furnace to 100℃, 150℃, 200℃, 250℃ and 300℃ for 30min.

The surface chemical compositions and valance of nanostructured W oxide bulk samples were investigated by X-ray Photoelectron Spectroscopy (XPS). The surface chemical composition determined by the peak fitting to W4f spectra were shown in Table1. We can find that as the heating temperature increases, the oxidation ratio also increases.

Photocatalytic activities of all the samples were evaluated by degradation of the methylene blue (MB:$C_{16}H_{18}N_3SCl$) aqueous solution as a model pollutant under visible light irradiation (400-510nm). Since the partially oxidized sample would have more WO_3/W interface sites than the other samples, it is suggested that the WO_3/W interface on the nanostructured surface should be more active sites for the degradation reaction than the fully oxidized sample.

Table 1 The surface compositions evaluated by XPS W 4f spectra

	Calcined sample				
Fuzz W	100℃, 30min	150℃, 30min	200℃, 30min	250℃, 30min	300℃, 30min
W(0) (%)	58.43	54.65	34.40	8.72	0
WO_2 (%)	17.06	20.51	14.39	0	0
WO_3 (%)	24.51	24.84	51.21	91.28	100
WO_2+WO_3 (%)	41.57	45.35	65.60	91.28	100

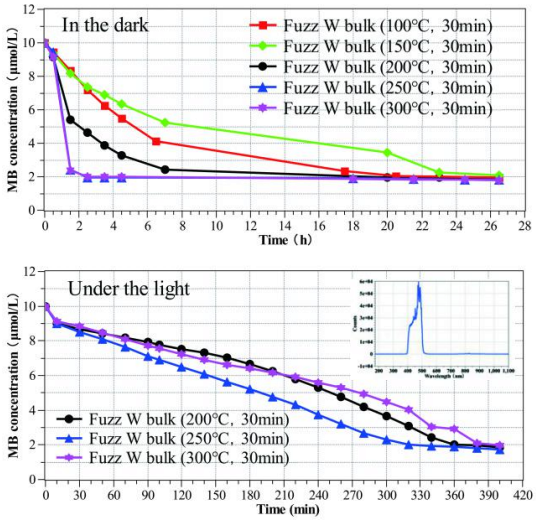

Figure 1 Time courses of the MB concentration in aqueous solution with calcined samples at 100℃, 150℃, 200℃, 250℃ and 300℃ for 30min under the visible light.

References

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