Photocatalytic and photoelectrochemical CO_2 reduction with water as an electron donor

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Morphology controlled brookite TiO_2 nanorod with exposed crystal faces was developed. Exposed crystal surfaces play different roles such as oxidation and reduction, respectively. This property is a great advantageous for multi-electron reaction such as CO_2 reduction under UV light. We also investigated the co-catalysts loading effects for improving CO_2 reduction.

CH_3OH was obtained as a main product for CO_2 reduction over brookite TiO_2 under UV light. The photocatalytic activity of brookite TiO_2 is depends on its aspect ratio because the ratio between reduction site for CO_2 reduction and oxidation site for water oxidation on the surface of brookite TiO_2 was controlled by changing its aspect ratio. In order to improve the photocatalytic activity, an effect of metal cocatalysts loaded only on the reduction site of brookite TiO_2 was evaluated (Fig. 1). The photocatalytic activates of brookite TiO_2 nanorods loaded with Ag or Rh were about 10 times higher than that of brookite TiO_2 without co-catalysts loading. The apparent quantum efficiency of the CO_2 reduction reached to about 3 % under UV light. Furthermore, we had developed g-C_3N_4/WO_3 nanocomposite photocatalysts for CO_2reduction to generate methanol, CO, CH_4, and formic acid under visible light. These results will also be discussed in the presentation.

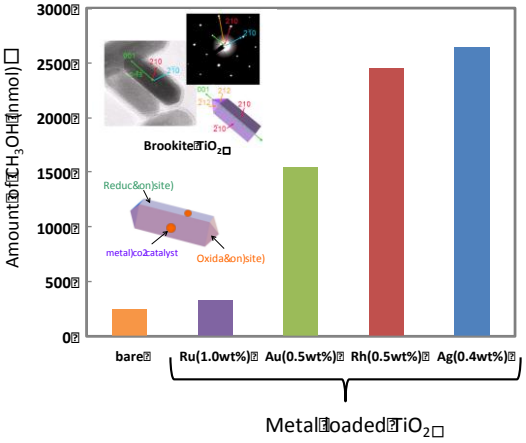

Fig. 1 Photocatalytic CO_2 reduction on brookite TiO_2 nanorod with or without co-catalysts loading under UV light.

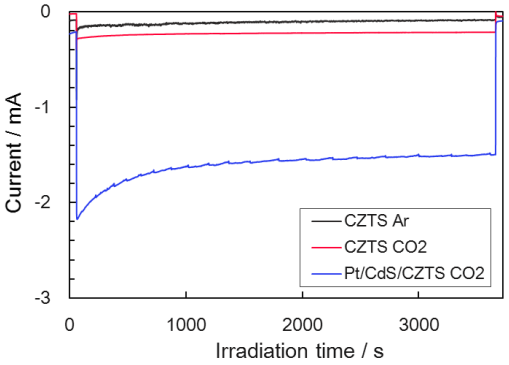

Fig.2 Photocurrent response as a function of irradiation time for CO_2 reduction over CZTZ covered with or without CdS.

We had also developed several kinds of photoelectrochemical CO_2 reduction system. Cu_2ZnSnS_4 (CZTS) electrodes modified with different n-type buffer layers (CdS and In2S3) were used as photocathodes for CO_2 reduction

under visible light irradiation ($420 < \lambda < 800$ nm) in aqueous media. Compared to a bare CZTS electrode, CZTS electrodes modified with n-type buffer layers (CdS and In2S3), by which a p–n heterojunction between CZTS and the n-type buffer layer is formed, showed a significant increase in the photocurrent assigned to CO_2 reduction. In addition, product selectivity of CO_2 reduction was improved by surface modification with an n-type buffer layer: that is, selective CO_2 reduction into CO was achieved by using a CdS/CZTS electrode, while HCOOH selectivity was observed over an In_2S_3/CZTS electrode. In this study, we investigated the photoelectrochemical properties of CZTS electrodes modified with n-type buffer layers (CdS and In_2S_3) in conjunction with the structural and optical properties, and we investigated their activity for PEC CO_2 reduction. The detailed results of photoelectrochemical reduction of CO_2 by CZTS and other our developed p-type electrode will be presented in the presentation.

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References:

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