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Investigation of the Unique Co-catalytic Function of AlB_2 in Photocatalytic Overall Water Splitting

Effective co-catalysts are crucial for enhancing the activity of water splitting photocatalysts. While metals and transition metal oxides are commonly utilized as co-catalysts, we discovered that the intermetallic compound AlB_2 also functions as a cocatalyst. We demonstrated that AlB_2 powder improves the activity of the **$KCaSrTa_5O_{15}$ (KCSTO)** photocatalyst through simple mechanical mixing. In this study, we investigated how the synthesis conditions, composition, and loading amounts of AlB_2 affect its co-catalytic activity.

We synthesized **KCSTO** by solid-state reaction. AlB_2 was prepared by solid-state reaction of a mixture of elemental Al and B powders in evacuated sealed quartz tubes. For **Sample 1**, a mixture (Al:B = 1:2) was heated at 900 °C for 4 h. For **Sample 2**, a mixture (Al:B = 1.3:2) was heated at 900 °C for 3 h, followed by slow cooling from 900 °C to 800 °C over 1 h. These AlB_2 samples were then mecha-nically mixed with **KCSTO**. Photocatalytic activity was measured using an internal irradiation flow cell with a 400 W high-pressure Hg lamp.

According to X-ray diffraction patterns **(Fig. 1a)**, **Sample 1** contained a consi-derable amount of AlB_{12}, with only a minor byproduct of α-Al_2O_3. For **Sample 2**, the formation of AlB_{12} was almost suppressed. Photocatalytic measurements with these **AlB_2-KCSTO** composites (**Fig. 1b**) con-firmed that overall water splitting occurred in all cases, exhibiting a stoichiometric H_2:O_2 ratio of 2:1. **Sample 1** showed ca. 3 times higher activity compared to pristine **KCSTO**. Notably, **Sample 2** achieved the highest photocatalytic activity. In conclusion, by adjustments of the raw material composition and temperature profiles during AlB_2 synthesis could prevent byproduct AlB_{12} formation and consequently achieve a high co-catalytic performance.

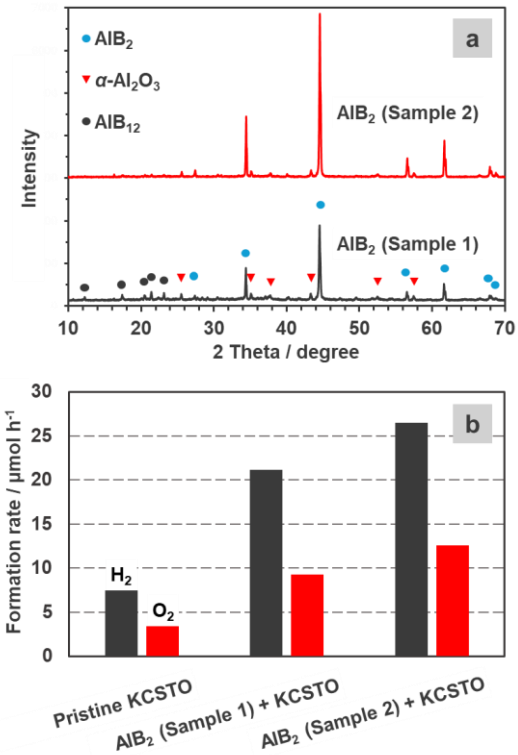

Fig. 1 XRD patterns of AlB_2 (a) and photocatalytic activity results using these samples (b).