Dual co-catalyst loading to enhance Z-scheme water splitting using non-oxide photocatalyst sheets

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Photocatalyst sheets made of $SrTaO_2N$ and $La_5Ti_2Cu_{0.9}Ag_{0.1}O_7S_5$ (LTCA) as oxygen and hydrogen evolution photocatalysts, respectively, and carbon nanotube (CNT) as a conductor show activity in Z-scheme water splitting (1). However, the activity of the resulting photocatalyst sheet degraded gradually during the reaction. In this work, we report an improvement in the stability of the activity of the photocatalyst sheet by co-loading Ir and CoO_x as cocatalysts and TiN and CNTs as electron mediators on $SrTaO_2N$.

$SrTaO_2N$ was prepared by flux-assisted method by heating a mixture of Ta_2O_5, $SrCO_3$ and NaCl under an ammonium flow. CoO_x was loaded by impregnation/reduction method on all samples from $Co(NO_3)_2$ solution, while TiN and CNTs were loaded as requested from titanium tetraisopropoxide/H_2O_2 aqueous solution and a suspension containing CNTs, respectively. Ir species was loaded by microwave-assisted solvothermal method from $IrCl_3$ in an ethyleneglycol/H_2O solution. LTCA was prepared as previously reported (1). LTCA/CNT_{sus}/$SrTaO_2N$ photocatalyst sheets were prepared by filtration of a suspension containing 30 mg of each photocatalyst in an aqueous solution (10% methanol, pH 10), which was added with CNT_{sus} and stirred for about one minute before filtration.

Fig. 1 shows the time course of water splitting reactions of selected samples. In comparison to the standard sample using $SrTaO_2N$ loaded with CoO_x, TiN, and CNTs (Fig. 1a), the sample using $SrTaO_2N$ with the additional loading of Ir species exhibited noticeably improved stability, probably because it promoted water oxidation and suppress self-oxidation of the oxynitride, even though the initial water splitting activity was hardly changed (Fig. 1b). When TiN was absent (Fig. 1c), the durability of the sample was slightly lowered, suggesting that the Ir species may also play a role as an electron extractor.

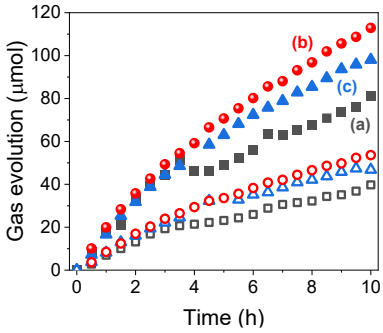

Fig. 1. Time courses of gas evolution during Z-scheme water splitting using LTCA/CNT_{sus}/$SrTaO_2N$ photocatalyst sheets. $SrTaO_2N$ were modified with (a) CNT/TiN/CoO_x, (b) CNT/TiN/Ir/CoO_x, and (c) CNT/Ir/CoO_x, respectively.

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