# Silver Bismuth Iodide Rudorffite for Photocatalytic $CO_2$ Reduction

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Photocatalytic $CO_2$ reduction is considered a promising strategy to resolve the global warming effect. Reducing $CO_2$ through photocatalytic systems can convert $CO_2$ into carbon-based fuels, such as carbon monoxide, formic acid, methanol, methane, etc. Many photocatalysts, such as including nitrides, sulfides, phosphides, and metal oxides, have been developed for photocatalytic $CO_2$ reduction. However, a wide band gap and a short lifetime of photoinduced charges are the most common drawbacks leading to poor $CO_2$ conversion efficiency. In this study, we developed a series of silver bismuth iodide (SBI) rudorffites, which are thought of as a next-generation photovoltaic material. A series of SBI rudorffites, including $AgBi_2I_7$, $AgBiI_4$, $Ag_2BiI_5$, and $Ag_3BiI_6$, can be obtained by manipulating the stoichiometric ratio of silver iodide (AgI) and bismuth iodide ($BiI_3$), and they exhibit high visible absorption ability, tunable bandgap, and suitable alignment of energy levels. The crystalline structure analysis shows that the silver-rich components exhibit hexagonal lattice structures, whereas the bismuth-rich component forms a cubic lattice structure. The crystal structure of SBI changed at a ratio of AgI/$BiI_3$ equal to 1.0. On the other hand, a portion of $Ag^+$ will be transformed to $Ag^{2+}$ by the interaction between Bi atoms, and the valence change can be confirmed by X-ray absorption spectroscopy. The photo-assisted Kelvin probe force microscopy was used to reveal the assessment of surface charge accumulation after irradiation as SBI are struck by different light sources with different wavelengths. Finally, $Ag_3BiI_6$ exhibits the highest photocatalytic activity and can convert $CO_2$ to CO or $CH_4$. The averaged CO and $CH_4$ production rates can achieve 0.23 and 0.10 μmol/g/h, respectively. $Ag_3BiI_6$ shows excellent potential as a novel photocatalysis for $CO_2$ reduction, and it also sheds light on the possibility of solving environmental contamination and sustainable energy crises.

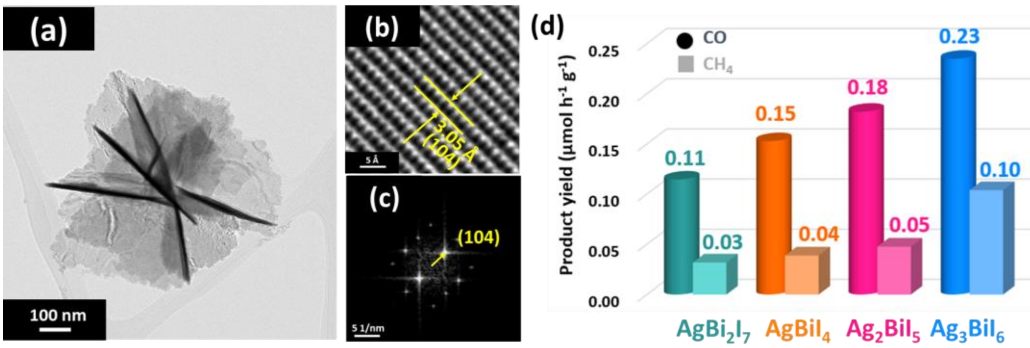


**Fig 1. (a)** TEM microstructure image, **(b)** high resolution TEM microstructure image, and **(c)** the diffraction pattern of $Ag_3BiI_6$. (d) Photocatalytic $CO_2$ reduction performance of a series of SBI rudorffites ($Ag_aBi_bI_{a+3b}$) under simulated solar light irradiation.