

# Plasmon-induced artificial photosynthesis systems

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We have demonstrated plasmonic photocurrent generation from visible to near-infrared wavelengths without deteriorating photoelectric conversion using electrodes in which gold nanorods are elaborately arrayed on the surface of a TiO<sub>2</sub> single crystal.<sup>1-3</sup> We have also reported the stoichiometric evolution of oxygen via water oxidation by irradiating the plasmon-enhanced photocurrent generation system with near-infrared light.<sup>4-6</sup> In the present study, we developed a plasmon-assisted water splitting system that operates under irradiation by visible light; the system is based on the use of two sides of the same strontium titanate (SrTiO<sub>3</sub>) single crystal substrate.<sup>7</sup> The water splitting system contains two solution chambers to separate hydrogen (H<sub>2</sub>) and oxygen (O<sub>2</sub>), respectively. To promote water splitting, a chemical bias was applied by pH values regulations of those chambers. The quantity of H<sub>2</sub> evolved from the surface of platinum, which was used as a reduction co-catalyst, was twice of O<sub>2</sub> evolved from an Au nanostructured surface. Thus, the stoichiometric evolution of H<sub>2</sub> and O<sub>2</sub> was clearly demonstrated. The hydrogen evolution action spectrum closely corresponds to the localized surface plasmon resonance spectrum, indicating that the plasmon-assisted charge separation at the Au/SrTiO<sub>3</sub> interface promotes water oxidation and the subsequent reduction of a proton on the backside of the SrTiO<sub>3</sub> substrate. We have elucidated furthermore that the chemical bias is dramatically reduced by plasmonic effects, which indicate the possibility of constructing an artificial photosynthesis system with low energy consumption.

According to the analogous method of the water splitting system, we have successfully constructed the artificial-photosynthesis system which produces the ammonia by a photofixation of a nitrogen molecule based on visible light irradiation.<sup>8</sup> Unlike the water splitting system, ruthenium is used as a co-catalyst instead of a platinum for the ammonia synthesis, and not a solution system but a gas system is used to reduce nitrogen gas. The action spectrum of the apparent quantum efficiency of ammonia evolution showed good agreement with the plasmon resonance spectrum. Therefore, we succeeded in photoelectrochemical synthesis of ammonia by the visible light irradiation through the plasmon-induced charge separation.

## References:

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