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Enhanced Photocatalytic Water Splitting by Liquid Phase Plasma Irradiation over Perovskite Photocatalysts

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Highlights

- The photocatalysis of water was estimated by liquid phase plasma irradiation.
- Hydrogen evolution from water photocatalysis has studied over perovskite photocatalysts
- The effect of liquid phase plasma was evaluated in the water splitting.
- The photocatalytic activities of the perovskite photocatalyst.

1. Introduction

Photocatalysis is an efficient method for hydrogen production because it can be obtained sustainably using solar energy. This process is attractive economically compared to other methods, such as a steam reforming process and water electrolysis [1]. Photocatalytic water splitting is effective for converting solar energy to hydrogen as a clean and renewable hydrogen energy [2]. The development of high photosensitive catalysts has been studied under UV and visible light illumination. In particular, visible light sensitive photocatalysts for hydrogen generation from water have attracted considerable attention. In addition, light sources are as important as the photocatalysts in a photochemical reaction. Although a range of light sources have been employed in photocatalysis, few studies have examined photocatalysis for hydrogen generation using liquid phase plasma (LPP) by irradiation into water directly.

Hydrogen evolution from water photocatalysis has studied over perovskite photocatalysts. A liquid phase plasma has applied in the photocatalysis as a light source. The effect of the liquid phase plasma irradiation was investigated for hydrogen evolution on the photocatalysts. Perovskite photocatalysts were prepared by hydrothermal synthesis. Effect of metal loading on the perovskite photocatalysts are also evaluated in the photocatalysis. We have compared to the photocatalytic activities for hydrogen production between the irradiation of the liquid phase plasma and UV light irradiation.

2. Methods

TiO_2 (P25, Degussa), consisting of anatase and rutile was used as a parent photocatalyst. Ni, Fe, and Co ions were introduced as the metal ions loaded onto the TiO_2 photocatalysts. The metal-loaded TiO_2 photocatalysts were prepared using the typical incipient wetness impregnation method. The metal ions were loaded on the TiO_2 at a 2 wt% theoretical content. The perovskite photocatalysts were prepared by hydrothermal reaction. The prepared materials are characterized using XRD, FE-SEM, TEM, and DRS.

Distilled water was employed as the reactants. The TiO_2, metal-loaded TiO_2, and $SrAl_2O_4$ perovskite were introduced as photocatalysts in the photocatalytic reaction The amounts of reactants and photocatalysts were adjusted as 200 mL and 0.5 g, respectively. The photocatalytic reaction was carried out for water in a completely air-free system connected to a gas chromatograph (GC). The gas products produced during the reaction were carried by a N_2 carrier gas at a continuous flow to the GC. The temperature of the LPP reactor was maintained at 25 ^oC with cooling water. The gas products were analyzed by GC (Younglin, M600D) equipped with a thermal conductivity detector and a molecular sieve 5A packing column.

The electric discharge was generated from a needle-to-needle electrode system in a double annular tube reactor in a liquid. The plasma in the liquid reactant was generated by the plasma power supply. A bipolar pulse power supply with high frequency (Nano Technology Inc., NTI-1000W) was used to generate the pulsed electrical plasma discharge in the liquid directly.

3. Results and discussion

Hydrogen was obtained in the gas products with a small amount of oxygen from the photocatalysis of water. No new liquid products were observed during the photochemical reaction. Fig. 1(a) presents the rate of hydrogen evolution from water using LPP without photocatalysts, and with TiO_2 photocatalyst addition. A small amount of hydrogen was evolved by LPP irradiation despite the lack of a photocatalyst. The rate of hydrogen evolution increased with increasing irradiation time. The amount of hydrogen production was increased significantly on the TiO_2 photocatalyst. Fig. 1(b) presents the rate of hydrogen evolution on metal oxide photocatalysts. The rate of hydrogen evolution on $SrAl_2O_4$ photocatalyst was slightly higher than on the TiO_2 photocatalyst. In addition, the hydrogen evolution on $Ni/SrAl_2O_4$ was increased with Ni ion loading. This result was derived from the improved in photosensitivity with the Ni loading. This is due to the extended photoresponsible range.

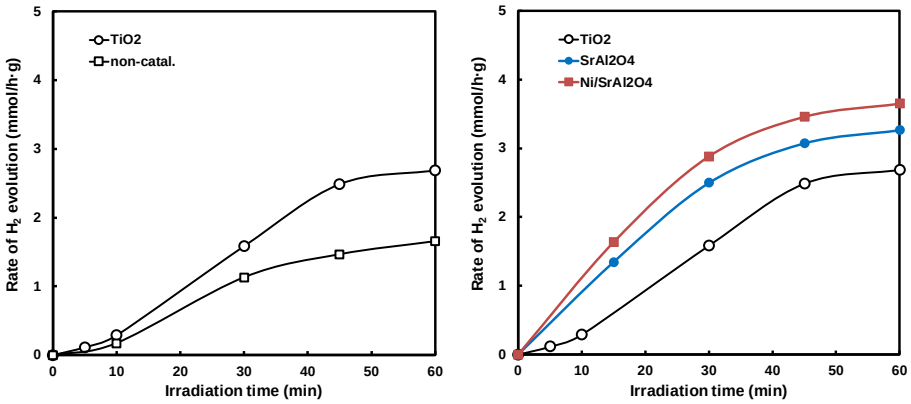

Figure 1. (a) Hydrogen evolu ion from water photocatalysis using LPP on various photoreaction conditions. (b) Rate of hydrogen evolution on Ni-loaded TiO_2 and TiO_2 supported on CNF.

4. Conclusion

Hydrogen was generated in the photodecomposition of water through the liquid phase plasma irradiation without photocatalysts. The rate of hydrogen evolution was increased by the photocatalysis with perovskite photocatalysts. Photocatalytic activity was improved significantly with metal loading on the perovskite photocatalysts. The rate of hydrogen evolution on the photocatalysis using the liquid phase plasma was significantly enhanced even four times compared to the rate obtained from UV light-driven hydrogen generation

References

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Keywords
photocatalysis; water splitting, liquid phase plasma; perovskite