Water splitting using particulate photocatalysts

Kazunari Domen

[1]RISM, Shinshu University, 4-17-1 Wakasato, Nagano-shi, Nagano 380-8553, Japan.
[2]Office of University Professors, 2-11-16 Yayoi, Bunkyo-ku, Tokyo 113-8656, Japan.
E-mail: domen@shinshu-u.ac.jp, domen@chemsys.t.u-tokyo.ac.jp

Abstract

Overall water splitting using particulate photocatalysts has been attracting attention as a means of large-scale renewable solar hydrogen production [1]. The author's group has studied various semiconductor oxides, (oxy)nitrides, and (oxy)chalcogenides as photocatalysts. The apparent quantum yield of overall water splitting using the $SrTiO_3$ photocatalyst has been improved to 95% in the near-ultraviolet region by refining the photocatalyst and cocatalyst preparation (Fig. 1) [2]. This quantum efficiency is the highest ever reported, indicating that particulate photocatalysts can drive the uphill overall water splitting reaction as efficiently as the photon-to-chemical conversion process in photosynthesis. In addition, the author's group has also been developing panel reactors for large-scale applications [3]. A solar hydrogen production system with a light-receiving area of 100 m^2 was recently built, and its performance and system characteristics are under investigation.

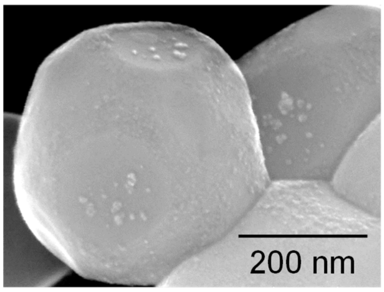

Fig. 1. A scanning electron microscope image of an Al-doped $SrTiO_3$ photocatalyst loaded with cocatalysts site-selectively.

For practical solar energy harvesting, it is essential to develop photocatalysts that are active under visible light irradiation. Ta_3N_5 and $Y_2Ti_2O_5S_2$ photocatalysts are active in overall water splitting via one-step excitation under visible light irradiation [4,5]. Particulate photocatalyst sheets efficiently split water into hydrogen and oxygen via two-step excitation, referred to as Z-scheme, regardless of size. In particular, a photocatalyst sheet consisting of La- and Rh-codoped $SrTiO_3$ and Mo-doped $BiVO_4$ splits water into hydrogen and oxygen via the Z-scheme, showing a solar-to-hydrogen energy conversion efficiency exceeding 1.0% [6,7]. Some other (oxy)chalcogenides and (oxy)nitrides with long absorption edge wavelengths can also be applied to Z-schematic photocatalyst sheets.

In my talk, the latest progress in the development of photocatalytic materials and their reaction systems will be presented.

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[2] Takata *et al.*, *Nature*, **2020**, 581, 411.
[3] Goto *et al.*, *Joule*, **2018**, *2*, 509.
[4] Wang *et al.*, *Nat. Catal.*, **2018**, *1*, 756.
[5] Wang *et al.*, *Nat. Mater.*, **2019**, *18*, 827.
[6] Wang *et al.*, *Nat. Mater.*, **2016**, *15*, 611.
[7] Wang *et al.*, *J. Am. Chem. Soc.*, **2017**, *139*, 1675.

Biography

Kazunari Domen received Ph.D. (1982) honors in chemistry from the University of Tokyo. Dr. Domen joined Chemical Resources Laboratory, Tokyo Institute of Technology in 1982 as Assistant Professor and was subsequently promoted to Associate Professor in 1990 and Professor in 1996. Moved to the University of Tokyo as Professor in 2004, and Cross appointment with Shinshu University as Special Contract Professor began in 2017. Became the University Professor of the University of Tokyo in 2019.