Development of organic-inorganic composite materials using photo-stable dyes and dye-sensitized photocatalysts

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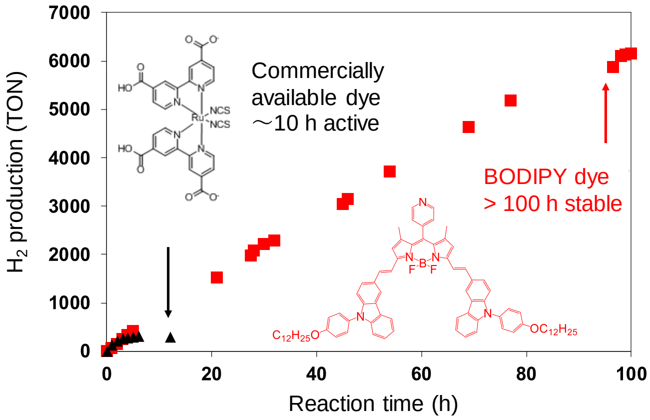
Production of hydrogen is key for establishing clean energy systems, because it can be used as a clean energy source in fuel cells. Although some semiconductors have decent visible-light-driven photocatalytic activity, many challenges still remain. Such challenges include improving the water splitting efficiency and stability of catalysts through the engineering of the semiconductor. Another approach for visible-light-driven photocatalytic water splitting for hydrogen production is a dye-sensitized photocatalytic water splitting system. A Ru-complex dye has high efficiency for dye-sensitized photocatalytic water splitting. Compared to metallic materials, metal-free organic dyes have the advantage of being environmentally friendly, abundant, and cost effective. Furthermore, it is easy to modify the energy gap by modifying the organic materials structure. I have made photocatalysts using dyes such as porphyrin, which although they have strong absorption in the visible light region they have weak absorption in the near-infrared region, which is a drawback toward efficient light-energy conversion.

Heterocyclic compounds, such squarylium or boron-dipyrromethene (BODIPY) dyes, show a sharp and strong absorption in the visible (red) to near infrared (NIR) region of the solar spectrum. More importantly, the absorption of these dyes thin films is quite wide, which is a great advantage for solar absorption. In this study, I focused on dyes that are the basic skeleton and evaluated their stability and activity to enable absorption in the near infrared region. The squarylium dye had strong absorption at 675 nm and could be expected to have high light-to-energy conversion, but its dye-sensitized photocatalytic activity was deactivated in 30 hours. On the other hand, the BODIPY dye can be synthesized in 3 steps and can absorb light up to 840 nm, and with further modification of the dye structure it can be expected to absorb in the near infrared region. When the photocatalytic activity was examined, stable catalytic performance was demonstrated, and the activity of the Pt-TiO_2 photocatalyst carrying a dye having a carbazole group was 249 μmol/gcat·h. Photocurrent measurements suggest that dye-sensitized photocatalytic activity is occurring. This result suggests that BODIPY organic materials are useful as novel dye-sensitized photocatalysts.



References

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