

Modification of organic molecule structure for photocatalytic hydrogen production in water medium

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Renewable hydrogen production is key for establishing clean energy systems because hydrogen can be used as a clean energy source in hydrogen fuel cells and a hydrogen-driven society. We have developed the novel donor-bridge-acceptor type organic molecule for dye-sensitizer [1-4] on metal oxide semiconducting photocatalyst for photocatalytic hydrogen production (Fig. 1). TiO₂ is a known UV-light-responsive photocatalyst and when the surface of TiO₂ is coated with a donor-acceptor organic dye and is simply irradiated with visible light (>420 nm), it produces hydrogen gas in water that contains sacrificial reagents. To increase the hydrogen productivity and photocatalytic stability, we systematically investigated modifications of the organic-dye sensitizer using a synthetic organic approach. When the dye sensitizer introduced a terthiophene group as a “charge separation spacer,” the dye showed good hydrogen productivity at 4400 turn of number (TON) and an apparent quantum efficiency of 1.6% at 420 nm. The dye showed a longer charge-recombination lifetime of 85 ps, whereas without a spacer group, the recombination lifetime of the dye was 0.2 ps with a nine-times lower TON of 483 [1]. This value is higher than that of a commercially available rare-metal-organic complex dye at 438 TON (Ru-dye called N719). I covered the photocatalyst with a hydrophobic group. The hydrophobic group reduced electron leakage from the photocatalyst to the water solution. This improved charge collection at the hydrogen-production site, thereby improving the hydrogen productivity by as much as a factor of two compared with materials without a hydrophobic coating [2]. Generally, a carboxylic group is used as the coordination-anchoring group at the interface between a dye sensitizer and the TiO₂. Instead, a multi-pyridyl group is used as the hydrogen-bonding anchoring group for TiO₂. This group showed high stability during photocatalytic reactions, with no delamination occurring, in contrast to the case of chemical coordination with a carboxylic group. The hydrogen-bonding system showed no change in the rate of hydrogen production, even after 80h [3].

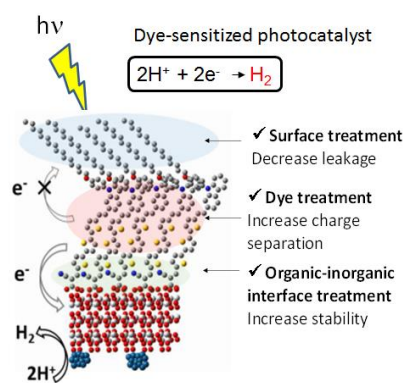


Fig. 1: Summary of organic dye sensitized photocatalytic hydrogen production

References

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