PRODUCTION AND USAGE OF LIQUID SOLAR FUELS

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Sustainable and clean energy resources using solar energy are urgently required in order to solve global energy and environmental issues. This lecture focuses on the combination of production of liquid fuels such as formic acid and hydrogen peroxide using solar energy, so called liquid solar fuels rather than gaseous hydrogen, and their use in direct liquid fuel cells.[1] In particular, photocatalytic production of hydrogen peroxide (H_2O_2) from seawater and dioxygen (O_2) in the air as a liquid solar fuel is combined with its usage in one-compartment H_2O_2 fuel cells.

We have developed a variety of photosynthetic reaction center models composed of organic electron donors and acceptors linked by covalent or non-covalent bonding, which undergo efficient charge separation and slow charge recombination.[2] The efficient charge-separation step has been successfully combined with the catalytic water reduction step with earth-abundant metal catalysts to develop efficient photocatalytic hydrogen evolution systems.[3] The photocatalytic oxidation of water with O_2 in the air to produce H_2O_2 has been achieved,[4-6] together with the development of one-compartment H_2O_2 fuel cells.[7-9] The photocatalytic oxidation of water with O_2 in the air was found to be enhanced significantly in seawater.[10] Thus, the combination of the photocatalytic H_2O_2 production from seawater and O_2 using solar energy with one-compartment H_2O_2 fuel cells provides on-site production and usage of H_2O_2 as a more useful and promising liquid solar fuel than H_2.[10,11] The solar-driven oxidation of H_2O by O_2 to produce H_2O_2 is also combined with catalytic oxidation of benzene by H_2O_2 to produce phenol, when the overall reaction is solar-driven hydroxylation of benzene by O_2, which is the greenest oxidant, with H_2O.[12,13]

References

1) S. Fukuzumi, *Joule*, **2017**, *1*, 689.
2) S. Fukuzumi, K. Ohkubo, T. Suenobu, *Acc. Chem. Res*. **2014**, *47*, 1455.
3) S. Fukuzumi, D. Hong, Y. Yamada, *J. Phys. Chem. Lett*. **2013**, *4*, 3458.
4) S. Kato, J. Jung, T. Suenobu, S. Fukuzumi, *Energy Environ. Sci*. **2013**, *6*, 3756.
5) K. Mase, M. Yoneda, Y. Yamada, S. Fukuzumi, *ACS Energy Lett*. **2016**, *1*, 913.
6) S. Fukuzumi, Y.-M. Lee, W. Nam, *Chem–Eur. J*. **2018**, *24*, in press.
7) Y. Yamada, S. Yoshida, T. Honda, S. Fukuzumi, *Energy Environ. Sci*. **2011**, *4*, 2822.
8) Y. Yamada, M. Yoneda, S. Fukuzumi, *Energy Environ. Sci.* **2015**, *8*, 1698.
9) S. Fukuzumi, Y. Yamada, *ChemElectroChem* **2016**, *3*, 1978.
10) K. Mase, M. Yoneda, Y. Yamada, S. Fukuzumi, *Nat. Commun*. **2016**, *7*, 11470.
11) S. Fukuzumi, Y.-M. Lee, W. Nam, *ChemSusChem*, **2017**, *10*, 4264.
12) Y. Aratani, T. Suenobu, Y. Yamada, S. Fukuzumi, *Inorg. Chem*. **2016**, *55*, 5780.
13) J. W. Han, J. Jung, Y.-M. Lee, W. Nam, S. Fukuzumi, *Chem. Sci.* **2017**, *8*, 7119.