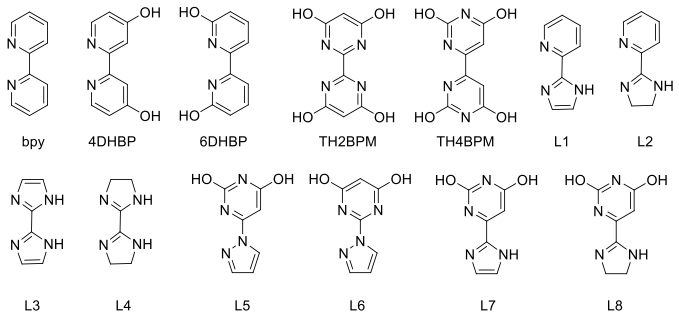
Hydrogen Production and Storage

Etsuko Fujita

Chemistry Division, Brookhaven National Laboratory, Upton, NY 11973-5000, USA

Hydrogen is a desirable alternative to fossil fuels for its availability from production from water using electricity from solar photovoltaics or by direct solar-to-chemical conversion. However, the storage is a problem. Formic acid (FA) has been attracted as a liquid-based hydrogen storage medium, even though the H_2 storage capacity is 4.4 wt%. Using a series of Cp*Ir (Cp* = pentamethylcyclopentadienyl) complexes incorporating the proton responsive bidentate auxiliary ligands, we successfully carried out the reversible conversion of CO_2/H_2 and FA under mild conditions in water by simply changing solution pH without using any organic additives. Several our catalysts can hydrogenate CO_2 at ambient conditions (i.e., 25 °C and 1 atm CO_2/H_2 mixed gas) in basic water. For FA dehydrogenation, we observed the evolution of 1 m^3 of H_2/CO_2 gases from 20 mol FA without any adjustment of the solution pH using a 10 μmol Cp*Ir catalyst, indicating complete decomposition of FA with a TON of 2,000,000. This result opens future opportunities for an on-board or on-site H_2 generation system from conc. FA. While H_2 is currently produced by steam reforming of methane with forming CO_2, it is important to produce H_2 using solar energy. We prepared tetra- and heptametallic Ru(II),Rh(III) polypyridine-type supramolecules and characterized the ability for catalytic H_2 production upon visible-light irradiation using a sacrificial electron donor. We are also investigating *Earth-Abundant HER* electrocatalysts such as nano-structured Mo or W carbide/nitride composites, which are durable and efficient catalysts in water (pH 1) and can be prepared by simple, environmentally benign methods.



The work carried out at Brookhaven National Laboratory and at AIST was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under contract DE-SC0012704 and by JST ACT-C Grant Number JPMJCR12Z0, respectively.