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# High-pressure hydrogen production from formic acid and the separation of $H_2/CO_2$ under high-pressure conditions

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Formic acid (FA) is considered as a promising liquid organic hydrogen carrier for the fuel cells. FA is well-known compound to transfer into $H_2$ and $CO_2$. With its properties, we concerned FA as the source of high-pressure or supercritical $CO_2$ and $H_2$ without compressor and these high-pressure gases can utilize for not only the high-pressure hydrogen for FCVs, but also the various chemicals for solvent and reagents. In our presentation, we would like to show the development of the continuous production of high-pressure $H_2/CO_2$ over 120 MPa without any compressor, and easy separation method from the generated gases of $H_2/CO_2$.

For the development of the high-pressure gas generation system by the decomposition of FA, we used the Ir complex ([Cp*Ir(4,4'-dihydroxy-2,2'-bipyridine)($H_2O$)][$SO_4$]) as a homogeneous catalyst. The catalyst can successfully produce the high-pressure gas with a high rate (TOF = 2500 $h^{-1}$ at 30 MPa) even at the temperature of 80$^oC$ for several hours. In the high-pressure conditions (supercritical conditions), Ir complex is deactivated gradually, then we developed durable catalyst under the conditions, and the catalyst can generate supercritical $CO_2/H_2$ for longer time. We also demonstrated the high-pressure $H_2/CO_2$ gas separation by cooling the gas to change the supercritical to gas-liquid phase.

We also applied the heterogeneous catalyst for the high-pressure $H_2$ generation toward the industrial application. A palladium nano-particle on graphene oxide (Pd/PDA-rGO)) was used for the reaction, and the catalyst can effectively catalyze the decomposition of FA to produce high-pressure $H_2/CO_2$ over 35 MPa and the catalyst can be easily separated after the reaction.

Ours system has a potential to be used as a simple and easy to handle system for the generation of high-pressure $CO_2$ and $H_2$ and these separated high-pressure gases can be used for the variety of application such as fuel cell vehicles.