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Hydrogen energy systems based on renewable electricity and its fundamental research

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Abstract

To carbon neutralization, fluctuated renewable energy such as solar or wind power must be widely introduced. Simultaneously, electricity imbalance of supply and demand in region and time must be solved. Hydrogen is expected an energy carrier as well as electricity and can solve imbalance of the electricity using electrolytic hydrogen production. For these applications, durability of electrolyzer to produce hydrogen or value-added chemicals under fluctuated power. In addition, low volumetric power density of hydrogen for transportation and storage should be significant issue. Based on above, we have studied on fundamentals for electrolytic processes to contribute hydrogen energy system establishment.

Alkaline water electrolysis is commercially used because of less expensive material cost, but it is instable under start and stop operation. To improve start and stop durability, we proposed that an accelerated durability test (ADT) protocol based on laboratory scale bipolar electrolyzer operation. Anode and cathode potentials of the bipolar electrolyzer become to almost same during stop operation with reverse current mechanism, so the potential fluctuation range is wider than start and stop operation of single cells or monopolar electrolyzers, and the ADT is a model of potential fluctuation under start & stop operation of bipolar electrolyzers [1-3].

To minimize polarization of proton exchange membrane electrolyzers, separation of polarizations is essential, and we proposed analysis procedure using double reference electrode with the edge shift of the electrodes [4].

Direct electrohydrogenation of toluene with water decomposition is efficient hydrogen energy carrier synthesis process using proton exchange membrane electrolyzer, and demonstration project is ongoing by ENEOS company in Brisbane. Reaction selectivity of electrohydrogenation against hydrogen evolution is essential, and electrocatalyst loading was optimized with electrode potential analysis [5, 6].

Finally, to establish hydrogen energy system, in which electricity and hydrogen work as flexible energy carrier, electrolytic processes will contribute for cross-sector coupling, but understanding of electrolytic process from both material and overall system is not enough. Therefore, further fundamental studies are essential for practical use of these electrolytic processes.

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