Functional Nanomaterials for Hydrogen Production and CO_2 Reduction

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The growing demand for reducing CO_2 emissions has significantly impacted the manufacturing industry. As a major global supplier of automobile components, DENSO CORPORATION has been actively addressing challenges in developing new technologies aimed at promoting environmental sustainability. These efforts include the development of high ionic conducting electrolyte for fuel cells and the implementation of electrochemically driven CO_2 direct air capture.[1,2] To further accelerate these efforts, we have been pioneering advancements in functional materials from both scientific and engineering perspectives.

In this talk, I will introduce our two recent studies related to chemical conversion using unique materials design principles. The first is the fabrication of an electrode in the form of a nanostructured textile with a cantaloupe-rind pattern for producing hydrogen from high-temperature water vapor using electricity.[3] The textile electrode maintained high mechanical integrity as well as high active site density at high temperatures. Furthermore, applying an AC voltage to this textile electrode at an elevated temperature reduced aggregated metal particles restoring its nanostructure, effectively counteracting the inevitable particle aggregation on demand to achieve high performance and extended lifetimes in high-temperature electrolysis cells.

The second topic arises from our fundamental research into the chemical conversion potential of borophane, a two-dimensional nanosheet consisting of hydrogen and boron in 1:1 ratio. Borophane is an attractive hydrogen storage material due to its high maximum mass storage density of 8.4 % and its ability to release hydrogen at moderate temperatures. By exploiting these features, we have discovered that flowing CO_2 over borophane at elevated temperatures can yield methane and ethane, indicating the potential of borophane as a catalytic platform for promoting C–C coupling.[4,5]

The details and the impact of controlling structures at the nanoscale will be discussed, highlighting the potential of these materials for efficient chemical conversions.

References

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