Engineering a Bifunctional Metal: Organic Framework for Efficient and Cost-Effective Hydrogen Production and Storage

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Hydrogen is one of the cleanest forms of energy storage that, when burned, produces only water as a byproduct. Nevertheless, the use of hydrogen is greatly limited due to the costly materials used to produce it from water, along with the extreme conditions needed to store it. This project presents a modification of MIL-101(Fe), a metal–organic framework (MOF), for bifunctional, efficient, and cost-effective green hydrogen production and storage. To prepare the desired material, the MIL-101(Fe) was in situ loaded with activated carbon (AC) in a solvothermal synthesis. Then, the synthesized MOF was post-synthetically doped with nickel in a facile step. The novel Ni-doped MIL-101@AC MOF was characterized using PXRD for crystallinity, SEM & TEM for morphology and structure, and BET for surface area. Afterward, linear sweep voltammetry (LSV) and chronoamperometry were performed to evaluate the material's electrocatalytic performance and stability. TEM images showed that carbon had been introduced successfully in the large cavities of the MIL-101(Fe), which initiated more adsorptive sites for H2 adsorption. The synthesis modifications resulted in a 19.6% improvement in the specific surface area and a 26% enhancement in hydrogen storage compared to MIL-101(Fe). This material exhibited a current density of 4.7 mA cm-2 at 1.5V, which is 13.6% higher than the benchmark electro-catalyst, IrO2, that is 6,700 times the preparation cost. This novel material has the potential to reduce our dependency on costly and less efficient materials for hydrogen production and pave the way for clean hydrogen storage applications in vehicles, housing, and off-grid storage.

Awards Won:
First Award of $5,000
Regeneron Young Scientist Award
Arconic Foundation: 1st Award
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: NOT TO BE READ -- $200 cash prize for each Enrichment award recipient
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: Mawhiba Universal Enrichment Program awards (and a $200 cash prize)