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ABSTRACT:

Materials for Sustainable Catalytic Hydrogen Production

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The world is heading toward the decarbonization of the energy sector, and hydrogen has been identified as one of the key players in this scenario, meaning that its production must keep pace with the foreseeable surge in demand. While electrocatalytic production can directly harness sustainable energy inputs, thermocatalytic processes will be as critical due to their easier scalability and lower capital costs. Despite their obvious differences, the two processes share the common need to employ robust and cheap catalysts, limiting, or even eliminating, noble metals without scarifying activity and stability. There are multiple strategies to achieve these goals. For instance, a lower defectivity of the metal nanoparticles reduces the coke formation sites thus increasing the catalyst's lifetime [1]. Alternatively, the addition of an acidic promoter to noble metals can improve the activation of organic molecules [2]. The exploitation of the right amount of acidity can be also applied to non-noble metals, like Cu, resulting in higher hydrogen production rates [3]. When hydrogen purity is the objective, such as for applications involving fuel cells, then adding In to a Cu catalyst was found to promote the hydrogen selectivity during the methanol steam reforming reaction [4]. Indium can also be used to promote Ni-based catalysts making them as stable as noble metal catalysts through the formation of a protective Ni-In alloy shell that competes with the insertion of C into the Ni core [5]. Finally, Co-Fe catalysts supported on carbon nanofibers proved to be a valid alternative to noble metal catalysts for the oxygen evolution reaction as they showed remarkable durability and activity when tested on anion exchange water electrolyzers for long time. Despite these and many other findings, much work is still needed before reaching acceptable performances in hydrogen production using renewable sources.

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