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Sustainable hydrogen obtained through the assistance of ethanol: The paths of a technology that can change the vehicle sector

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Abstract:
Ethanol is an excellent source of hydrogen, specially, when it is generated in an electrochemical reforming system, operated at low temperatures, represented by the following reactions, in alkaline medium:

Anode reaction: $C_2H_5OH + 12OH^- \rightarrow 2CO_2 + 9H_2O + 12e^-$ (1)

Cathode reaction: $12H_2O + 12e^- \rightarrow 6H_2 + 12OH^-$ (2)

Overall reaction: $C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 6H_2$ (3)

Reaction (3) represents the reforming of ethanol at low temperatures, 25 °C – 85 °C. This reaction is similar to a steam reforming process (operating at high temperatures: 600 °C – 800 °C). The energetic demanded to produce 1 mole of H_2, in an electrochemical reforming ethanol cell, is + 58 kJ/mol, with a cell voltage of 0.084V, that it is much smaller than that from water electrolysis (+ 286 kJ/mole with cell voltage of 1.23 V), leading to a lower electric consumption. The relatively slow kinetics limitations of reactions (1) leads to cell voltage of 0.7 – 0.9 V, for the ethanol electrolysis cell operating at 1 A cm^{-2}, while for water electrolysis the cell voltage is much higher, of 1.8 – 2.0 V, operating at the same conditions. Thus, the electrochemical reforming of ethanol demands the development of efficient, low-cost, and stable catalysts for anodic and cathodic, targeting large-scale and abundant materials must be developed. NiFe, NiB, MoS_2 appear as a promising material and it were selected as a candidate for cathodes in electrolysis of ethanol reforming cell. MoS_2 is a special material because its activity varies depending on how many layers, defects, and edges sites are exposed, which higher edges sites, number of defects and number of layers (1 - 3 layers – almost bi-dimensional material) are factor that increase its activity toward HER. Thus, incorporation of electrodeposited MoS_2 into a high area carbon matrix doped with a nitrogen was used in this study. NiFe was prepared by electrodeposition and NiB was obtained by powder metallurgy. On the other side, PdNi/C_{BP} nanoparticles, prepared from the method of chemical reduction of metallic precursors in solution containing carbon of high surface area was used as anode. The operational voltage of the reforming cell using MoS_2 as cathode and PdNi/C_{BP} as anode, operating at j = 10 mA/cm^2, was of 0.961 V, while for, NiFe and NiB the cell voltage was as low as 0,623 V, at the same operational conditions, showing that MoS_2, NiFe, NiB and, PdNi/C_{BP} are a high efficient system for hydrogen generation.