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Hydrogen Evolution from Ethanol via the Nano-catalytic Activity of Ni–B Alloy in Alkaline Medium as a Catalytic Cathode Material

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To significantly decrease the annual release of greenhouse gases from fossil fuel combustion, we must address the rising global energy demand and consumption. Immediate actions are being formulated for a swift transition away from fossil fuels. An alternative and effective low-carbon fuel is green hydrogen, which is recognized as an excellent carbon-free energy carrier. The production of green hydrogen through water electrolysis requires a high amount of energy. This water electrolysis process combines the hydrogen evolution reaction with the thermodynamically unfavorable oxygen evolution reaction. By substituting the kinetically slow oxygen evolution reaction with a more favorable one, this electrocoupled process becomes user-friendly, combining two synergistic electrocatalytic systems to co-produce high-purity H_2 on the cathode and valuable products on the anode, all while maintaining low energy consumption and high Faradaic efficiency. A barrier exists that can be addressed by a low-cost, carbon-free electrolytic hydrogen production technology facilitated by alcohol/biomass oxidation, which replaces the oxygen evolution reaction. The Ni–B system is well-known, and with an adequate chemical composition balance, it can produce several intermetallic stable compounds, such as NiB, Ni_2B, Ni_3B, monoclinic (m-Ni_4B_3) and orthorhombic (o-Ni_4B_3), after accurate heat treatment [1]. The study employed a Ni-B phase diagram to produce $Ni_{66}B_{33}$ and $Ni_{75}B_{25}$ (wt.%) via high-energy ball milling (MAE). The resulting alloys underwent heat treatment to form Ni_2B and Ni_3B intermetallic compounds, which were then tested for catalytic activity in the Hydrogen Evolution Reaction (HER) while showing inactivity in ethanol and CO_2 reduction tests, based on non-noble metal for operation in alkaline medium (1 or 4 mol L^{-1} KOH in absence and presence of 1 mol L^{-1} ethanol under the temperature range of 25 – 85 °C). The measurements were made in a typical two electrodes metal electrolysis cell, the gap between electrodes of 6 cm^2 was of < 2 mm. All catalysts were characterized by X-ray diffraction, Differential Scanning Calorimetry (DSC) for the phase transformation temperatures, TEM and SEM. Two class of materials were developed: (i) Ni_2B and (ii) Ni_3B intermetallic compounds. The synthesis method used for preparation of Ni/B intermetallic were grinding the metallic components in a ball mill. After grinding, the materials were heat treated at various temperatures under inert argon atmosphere according to the phases diagram. The Ni_2B intermetallic showed an improvement of the HER in the ethanol, while the HER on the Ni_3B was inhibited in the presence of ethanol, showing the less efficient dependence of the HER on this material in the presence of ethanol, as shown in Fig. (a and b). As results, show that Ni_2B, are totally compatible with the concept of active material for the HER and inactive catalysts for ethanol reduction, showing a prospectus to avoid the use of ion exchange membranes. Ni_2B-HER is very good and similar to the Pt electrode in alkaline medium and the electro-deposit was not sensitive to ethanol reduction.

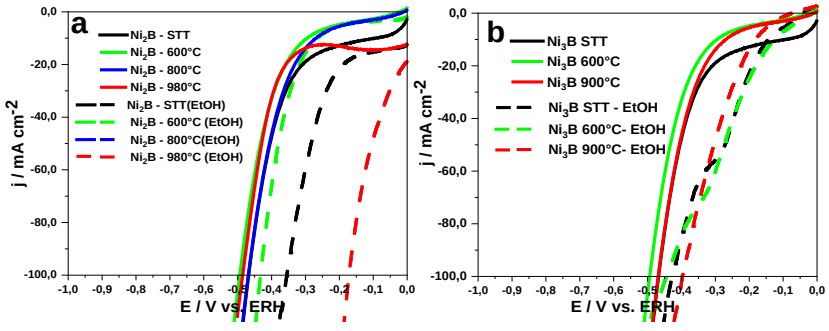

Figure 1: (a) Ni_2B Current-potential curves in ethanol where enhancement of HER vs. decreased overpotential and increased current density for catalytic at 980ºC. Similarly, for the Ni_3B, as shown in **Figure (b).**

Referências

[1] M. Nazarian-Samani, et all., Materials Letters, 64 (2010) 309–312.

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