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ENERGY CONSUMPTION IN THE ELECTROLYTIC EVOLUTION OF HYDROGEN WITH IRON-NICKEL ELECTRODES

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Abstract

The possibilities to reduce energy consumption in the electrolytic hydrogen production using ionic activators added into an alkaline electrolyte have been investigated. Two cathode/anode systems, Fe/Ni and Ni/Fe were investigated. We have found that some activators, like *tris-(ethylenediamine)*Co(III) *chlorid*e complex in combination with the sodium molybdate can reduce energy needs per mass unit of hydrogen produced for more than ten percent in all investigated systems compared to those of non-activated electrolytes. Additionally, iron exhibits some special properties in this view.

Introduction

Hydrogen is becoming increasingly important as an energy medium for the 21st century. It ensures an energy storage function, easy distribution *via* gas lines and direct conversion to electricity. Fossil fuels especially oil, approach the exhausting world's supplies, as well as cause pollution generating greenhouse gases cited in the Kyoto agreements. As hydrogen does not exist on the Earth it must be produced. It will be necessarily obtained from water as the main raw material, but that requires energy. There are a large variety of production approaches. The most attractive method, in regard to greenhouse gas emissions, appears to be water electrolysis, using electric power sources that do not themselves produce greenhouse gases.

Among overall world technologies for hydrogen production today about 10% belong to the electrolysis. Use of this technology on the large scale is limited because of high-energy consumption. Thus, development of new methods and improvement of the existing ones is extremely important, especially in countries where electricity is relatively cheap or great excesses are available in some periods of the day or year.

Possible mechanism through which ionic activators increases electrolytic efficiency is the electrocatalytic effect of two, so called d-metals, deposited on the electrode surface, in the form of powder, providing at the same time very large surface area of active centers.

Experimental

Iron-nickel and nickel-iron combinations of electrodes were used in experiments to compare efficiencies of activated and non-activated systems in order to see the effect of iron as a cheap commercial material.

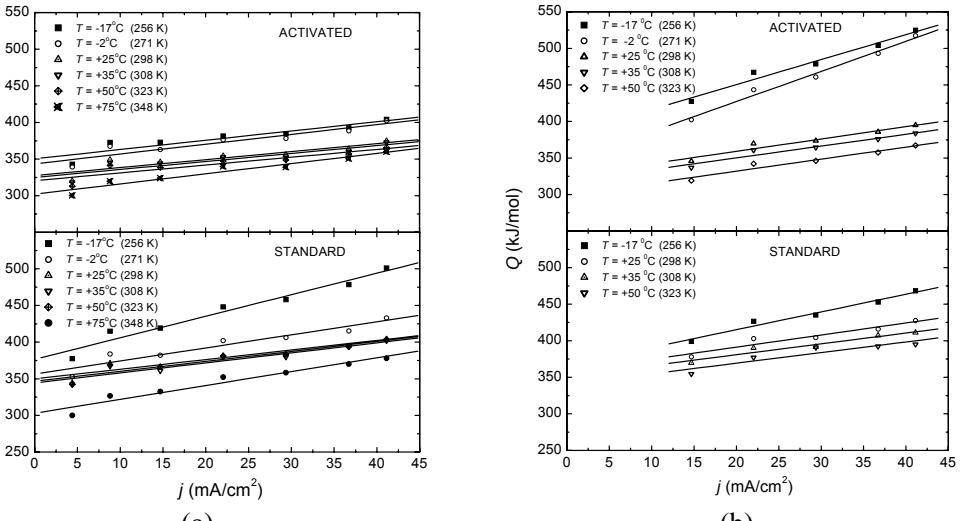
Similar investigations we have performed in our previous work to find out the efficiency of nickel in the same context. Also, further details about the experiment can be found in [1]. Additionally, a rough estimation of the economy of the activation oriented process is presented here. It is based on the life time and stability investigation of activators added [2].

Measurements were done both with the 'standard electrolyte' (30 wt% KOH) and 'activated electrolyte' (1×10^{-3} mol dm^{-3} of *tris-(ethylenediamine)Co(III) chloride* complex and 1×10^{-2} mol dm^{-3} of Na_2MoO_4, both laboratory made from p.a. chemicals, in the standard electrolyte. Cobalt [3] or molybdenum [4] deposited on the electrode surfaces during electrolysis have been known to increase the efficiency of the process. In this work we tried these elements together.

Results and Discussion

The energy requirement for the electrolytic process run was calculated using the relation: $Q = I\times U\times t$, where I and U are overall current and voltage through the cell, and t is the time of evolution of a certain volume of hydrogen. It was calculated as two thirds of the entire volume evolved in the cell.

The data were collected in a wide temperature range from –17 to about $+75^0$C, and arranged to show dependence of energy consumption (Q) as a function of current densities and temperatures.



(a) (b)

Fig. 1 Energy consumed to evolve one mol of hydrogen as a function of the current density at different temperatures for two *cathode-anode* combinations: Fe-Ni (a); Ni-Fe (b).

As shown in these figures, both the temperature and activation significantly reduce energy consumption. It is expected since both factors have catalytic effects on the hydrogen evolution reaction. However, at sufficiently high temperatures, activators influence becomes dominant.

There are some indications [3] that iron, if used as a cathode, is a specific material in this view. Our measurements also show that, especially at lower temperatures, iron is more efficient than nickel. Figure 2 illustrate this statement in regard to the nickel-cathode. This practically offers a possibility to optimize the process at another position on the temperature scale.

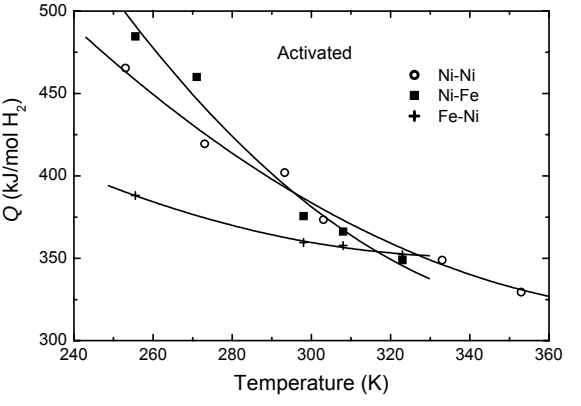


Fig. 2. Comparasion of the activation effects for different combinations of electrode materials (cathode-anode) at a current density of 30 mA/cm^2.

Conclusion

Nickel-iron combinations of electrodes were used as electrode materials in the electrolytic evolution of hydrogen from alkaline solutions. Behavior that iron exhibits, regarding activation with ionic activators, was shown in our experiments. On the basis of the obtained diagrams we estimated an average energy saving to be around 10 percent. That is advantageous since in practice, it should be more attractive electrode material due to lower price compared to that for nickel.

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