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Short communication

Aluminum and aluminum alloys as sources of hydrogen for fuel cell applications☆

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Abstract

Production of hydrogen using aluminum and aluminum alloys with aqueous alkaline solutions is studied. This process is based on aluminum corrosion, consuming only water and aluminum which are cheaper raw materials than other compounds used for in situ hydrogen generation, such as chemical hydrides. In principle, this method does not consume alkali because the aluminate salts produced in the hydrogen generation undergo a decomposition reaction that regenerates the alkali. As a consequence, this process could be a feasible alternative for hydrogen production to supply fuel cells. Preliminary results showed that an increase of base concentration and working solution temperature produced an increase of hydrogen production rate using pure aluminum. Furthermore, an improvement of hydrogen production rates and yields was observed varying aluminum alloys composition and increasing their reactive surface, with interesting results for Al/Si and Al/Co alloys. The development of this idea could improve yields and reduce costs in power units based on fuel cells which use hydrides as raw material for hydrogen production.

Keywords: Hydrogen production; Aluminum; Aluminum alloys; Caustic corrosion

1. Introduction

The development of H_2 fuel cells for vehicles, stationary and mobile applications has been an active area of research during the past 30 years [1]. Nowadays, this research is also important to reduce greenhouse gas emissions from the burning of fossil fuels. Several automotive companies have come up with innovative design features in their prototypes [2]. Although hydrogen is an attractive fuel alternative for the future, attractive methods for hydrogen production and storage must be employed in order to maintain its positive profile. There are different mature methods for hydrogen production [3]. These methods are basically based in fossil fuels, including more than 90% of the industrial hydrogen production [4]. Fifty-five to 60% of the hydrogen being produced in the world today is made by steam reforming of natural gas. Hydrogen is also produced by water electrolysis, its most important industrial process not based on fossil fuels at the moment, but the costs of CO_2-free hydrogen production are at least €20 GJ^{-1}, which does not compare with the present prices of oil or natural gas, about €5 GJ^{-1} [5]. Therefore, the development of new technologies for hydrogen production not based on fossil fuels is becoming increasingly important to provide a clean fuel over the 21st century [6,7].

Nowadays, there are no practical ways of storing large amounts of hydrogen once the criteria of capacity, safety, and refuelling are considered [8]. For instance, hydrogen containing vessels, whether they are high pressure gas-containing cylinders or liquid containing vessels, have significant and lingering safety problems. Some new technologies, such as hydrogen storage on metals, graphitic adsorbents or carbon nano-tubes, are being explored but they are far away from practical applications [9,10].

Generation of hydrogen for fuel cell applications by reaction of chemical hydrides with aqueous solutions reduces storage weight and/or volume over high pressure or cryogenic storage [11]. However, hydrogen production from hydrides also has some disadvantages: hydrides are expensive raw materials considering current hydrogen prices and most of them are unstable and sensitive to air moisture. On the other hand,

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