Production of Hydrogen Using Waste Aluminium Dross: Secondary Source of Next Generation Fuel

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Abstract

The production of hydrogen is usually carried out by coal gasification and water electrolysis. Directly applying aluminium to produce hydrogen is expensive. To solve this problem, aluminium dross can be successfully used to supply for the metallic aluminium essential for aluminium-water reaction. As the amount of metallic aluminium is significant in waste aluminium dross, the utilization of waste aluminium dross for generation of hydrogen would be an alternative to pure aluminium. Hydrogen production using aluminium dross as a raw material has been a research area around the world. During the last two decades, the elaboration of the hydrogen-based economy has made important progress an account of numerous research such as the hydrogen fuel cell and the hydrogen cars. The hydrogen is released as a gas and the oxygen combines with aluminium to form aluminum oxide compounds. Using aluminum from this source to produce hydrogen has two impacts, one over the environment by recycling this waste and the second on the production cost.

In the chemical leaching, mineral acid/base reacts with metallic aluminium present in waste dross and evolution of hydrogen (H_2) takes place. In present study we are optimizing the process parameters to generate hydrogen (H_2) gas and purification as next generation fuel. The next-generation fuels i.e. hydrogen is very crucial to match the demands of the world. Fuel consumption per capital has increased radically in the present day and it is projected to rise as the technological advancement takes place. The growth in industrial and transport sector simply necessitates the research in the field of fuel and energy. The gross calorific value of hydrogen is nearly 39.4 kWh/kg compared to gasoline (12.89 kWh/kg). The value of hydrogen increases readily as the conventional fuels are limited resources and the prices of these fuels are increasing with the passing day. Taking the raw material as white waste aluminium dross, the generation of hydrogen is a great opportunity to explore and establish another method to efficiently produce hydrogen. The present research deals with the generation of hydrogen using acidic/basic solution and the recycling of waste aluminium dross for value addition.

Keywords: Waste aluminium dross, Hydrogen, Chemical leaching.

1. Introduction

The development of next-generation fuels is very crucial to match the demands of the world and of India as well. Fuel consumption per capita has increased radically in the present day and it is projected to further increase as technological advancement takes place.

In this scene of technological urgency, hydrogen comes into the picture. Hydrogen is an important fuel and source of energy. Compared to conventional fuels, the combustion of hydrogen gives rise to water vapor, whereas other fuels tend to release carbon dioxide and carbon monoxide. The gross calorific value of hydrogen is nearly 39.4 kWh/kg compared to gasoline (12.89 kWh/kg-1). The value of hydrogen increases readily as conventional fuels are limited resources and the prices of these fuels are increasing with the passing day.

Hydrogen is known as one of the best clean energy carriers because of its minimal impact on the environment regarding greenhouse gas emissions such as carbon dioxide and other gases [1-3]. Hydrogen can be used directly in molecular form, (i.e., as a fuel for vehicles) or indirectly to generate electricity for other industrial applications [4-7]. A major advantage which it has over other fuels is that it does not cause pollution because its burning reaction results in only water. Hydrogen is also an almost ideal fuel gas in terms of reducing smog when it is burned. However, safe storage and generation at low cost are technical challenges that need to be considered. For these reasons, new ways are sought to produce hydrogen at low cost from other sources than are known [8-10]. The alkali metals (such as sodium, potassium, and lithium) and alkaline earth (calcium, strontium, aluminium, magnesium, etc.) are very active when they come in contact with water, and react spontaneously, generating hydrogen and heat. Based on this chemical property, the hydrolysis reaction of pure aluminium powder is commonly used for high-purity hydrogen generation [6, 11]. Although the use of pure aluminium in reaction with water to produce hydrogen is a viable method, it is expensive, if one considers the cost of producing pure aluminium and the use of an alkali metal hydroxide, also an expensive product.

To handle this problem, secondary aluminium dross can be used as an ingredient for aluminum water reaction in acidic medium. Aluminium dross is a process reject of aluminium metal production [12]. The main constituents of dross are Al metal and its oxides. However, due to the increasing awareness of environmental issues, the need for maximum economy and the importance of value addition/recycling/reuse, the problem of dross utilization is presently attracting more attention. Aluminium dross represents a residue from primary and secondary melting processes. Drosses are classified according to their metal content into white and black dross. White dross is of higher metal aluminium content and is produced from primary and secondary aluminium smelters and re-melt shops, whereas black dross has a lower metal content and is generated during aluminium recycling (secondary industry sector). White dross may contain from 15 to 80 % recoverable metallic aluminium and it comprises a fine powder from skimming the molten aluminium. Black dross typically contains a mixture of aluminium oxides and slag, with recoverable aluminium content ranging between 8 to 20 %. The non-metallic residues generated from dross smelting operations are often termed ‘salt cake’ and contain 3 to 5 % residual metallic aluminium [13].

A conservative estimate of around 3 million tonnes of white dross and more than 1 million tonnes of black dross is being produced every year and about 95 % of it is landfilled. It was also reported that some portion of the dross is reprocessed by primary and secondary aluminium industries to recover metallic aluminium [14]. As the composition of aluminium dross is found to vary significantly from batch to batch, more focus is required to find potential applications for this material. Through cost-effective recovery processes, aluminium metal can be recovered by means of physical and chemical routes, metallic aluminium could be recovered by smelting and the rest of the metallic aluminium could be extracted by chemical leaching in the form of various salt such as alum/poly aluminium chloride/salts as water aids. During the chemical leaching process, hydrogen gas is generated which can be separated and purified to use as a renewable fuel.

In India, there is no organized sector in aluminium dross handling except metal recovery. Dross residue after metal recovery are disposed to landfill. The residue contains undesired elements such as nitride, fluoride, carbide and others which are likely to result in leaching of toxic metal ions of hydrogen; the aluminium dross used in this study has a metallic aluminium content around 15 percent.

4. Conclusions

- The research presents a process of effectively producing hydrogen using aluminium dross by acid reactions.
- Process shows that Al dross powder has a high hydrogen yield and hydrolysis rate, and that as the amount of dross in the mixture grows, more hydrogen will be created overall as more aluminium is made available for the reaction.
- The research illustrates an alternative process to produce hydrogen with waste aluminium dross as an alternative resource.
- The developed process is an alternative to conventional method and could be explored for commercial production of hydrogen. The work will enable generator of dross in recycling and management of waste.
- The process would definitely help dross processor for the complete utilization and value addition to achieve zero waste concept.

5. References

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