Studies on Generation of Hydrogen by Water Splitting Method using Metal

[1]Sandhya S. Gedam, [2]Hitesh Rawate, [3]A. K. Goswami, [4]Ganesh S. Bajad, [5]Ashutosh Kr Chaudhary
[1,2,3]University Institute of Chemical Technology, NMU, Jalgaon-425001, India
[4]Shri Guru Gobind Singhji Institute of Engineering & technology, Nanded-431606, India
[5]Vishvesvaraya National Institute of Technology, Nagpur-440001, India

Abstract : Depleting reserves of petroleum fuel and increasing consequence of use of these fuel forces that use to develop the alternative energy sources. One method of the producing on-demand hydrogen for fuel cells is through the use of aluminium by water spitting method. This can be used for applications as well as portable handheld devices, onboard generation for vehicles or as large as a hydrogen refueling center. Hydrogen has all types of properties to be an ideal future fuel. The main problem is use of hydrogen as a fuel is its availability and transportation. In this project, we evaluated the method of production of hydrogen from water splitting reaction using metal hydrogen. The sodium hydroxide used as an activation agent. Experimental investigation of hydrogen generation with different parameter has been studied in a flow reactor. Effect of parameter like flow rate of activator ranges from 0.2 ml/min to 10ml/min and concentration of the activator ranges from 0.5N to 1.5N. These parameters were optimized for the generation of hydrogen. The above method implies that the flow rate and the concentration of the activator is directly proportional to the time required.

IndexTerms : **Concentration, Flow reactor, Flow rate, Water Splitting Reaction.**

I. INTRODUCTION

The current fossil-fuel based economy is considered generally unsustainable due to resource as well as environmental constraints [1]. One possible alternative is the development of hydrogen-based economy, as hydrogen is an abundant and environmentally friendly fuel [1,2]. However, it should be noted that free hydrogen does not occur naturally and need to be generated by various means [2]. The need for high pressure storage systems is one of the problem to the large-scale utilization of hydrogen as a fuel. The production of on-demand hydrogen, thereby bypassing the storage system requirement, could be greatly aid in making the hydrogen economy a reality [3].

One method of the producing on-demand hydrogen for fuel cells is through the use of aluminium by water splitting. This can be used for applications as small as portable handheld devices, onboard generation of vehicles or as large as a hydrogen refueling center [2]. However, the utilization for aluminium for generating on-demand hydrogen is critically dependent on control of the rate of hydrogen generation from the reaction [3]. This rate of hydrogen generation can be optimized by different parameters such as, concentration and flow rate of the activator. Moreover, controlling the rate of hydrogen generation from the aluminium-water reaction has not been well studied. Present work focused on aluminium. Unlike hydrogen and aluminium are easy to transport and store. When metal is placed into the atmosphere, it is covered by oxide film which protects metal from further corrosion, thus providing the safety of its storage and transportation. Like hydrogen and aluminium are renewable. It has the high calorific value, high concentration in the earth's crust and high current production level. So, aluminium can be regarded as perspective energy carrier and has a good chance for large scale integration in global energy storage [2]. To provide the correct feasibility study this work will be started from aluminium production process analysis which will examine the whole chain from ore to metal. During this analysis the material and energy balance would be considered. Then the technologies which use aluminium as fuel or energy source [1], will be reviewed. Technologies differ from each other mainly by aluminium oxidation method.

When aluminium is oxidized film, which provides the safety of aluminium storage and transportation creates an obstacle to efficient utilization of aluminium within power plants. To increase the efficiency of aluminium based energy generation technology the special actions such as alloying with certain elements, chemical activation addition, mechanical or mechanochemical treatment, heating and other are applied. The objective of this work is such methods overview including technological principle, efficiency, urgent problems and possible applications areas.

1.1 Water splitting

As the name suggest water splitting is the simple reaction in which water is split into hydrogen and oxygen. Efficient water splitting results in a better hydrogen economy. Metals are reacts with water to release hydrogen. Normally, the oxide layer on the surface of aluminium does not allows the water to make contact with aluminium and these various metals are used as an activator to deplete this oxide layer. In the presence of sodium hydroxide [4,7], aluminium react with water to generate hydrogen gas. Also, other metals can give the same reaction but aluminium is among the most effective material among them. It is safer, cheaper and easier metal [5,6].

1.2 Water splitting by aluminium

Aluminium reacts with water to produce hydrogen gas. As aluminium has high calorific value, it has high cost and can only used for minimum amount of hydrogen. But aluminium foil is easily available in stores with less costs as compared to pure metal. Also, the advantage of using aluminium food grade foil is that is increases the surface area available for the reaction. For more surface area we can use aluminium powder, but it will lead to high temperature and pressure conditions which will be uncontrollable.

The initial reaction consumes sodium hydroxide and produces both hydrogen gas and an aluminates byproduct. After the saturation point aluminates compound decomposes into sodium hydroxide and aluminium hydroxides in the form of crystalline precipitates.

1) $Al + 3\ H_2O + NaOH \rightarrow NaAl(OH)_4 + 1.5\ H_2$

2) $NaAl(OH)_4 \rightarrow NaOH + Al(OH)_3$

Overall:

3) $Al + 3\ H_2O \rightarrow Al(OH)_3 + 1.5\ H_2$

In this process, 1 kg of aluminium can produced upto 1.3 Litre of hydrogen from water. In fuel cell this technique is used to produce electrically and also recovers the half of the water previously used. The reaction between aluminium and water is exothermic, these reactions can operate under less temperatures and pressures. The reaction is slow and its negative effects can be minimized by changing experimental parameters like temperature, concentration of activator etc.

II. MATERIALS AND METHODS

2.1 Instruments and chemicals used

We have used micro flow injectors manufactured by Nee Era Pump systems, INC. Sodium Hydroxide (NaOH) pallets 98 % pure, (LobaChemie). Distilled water is used in all applications of water in this experiments. Metal used as regular food grade aluminium foil named ALUFO manufactured by Nagreeka Indcon Products Pvt. Ltd. The composition of the foilhas not been tested as it is manufactures by certified company.

2.2 Optimization of parameters flowrate and concentration

The basic aim of the conducted experiments was to optimize the flow rates and concentration of NaOH which is used as a activator in the reaction of aluminium and water so as to know at what flow rate and concentration of the amountof hydrogen generated is more takes less time for the complete conversion of aluminium.
We have used 0.5N, 1N, 1.5N, NaOH in this experiments on flow rates of 0.2 ml/min, 0.5 ml/min, 1 ml/min, 3 ml/min, 5 ml/min, 7 ml/min and 10 ml/min.

2.3 Production of Hydrogen

Cleaned the equipments with distilled water. Charged the syringes with NaOH solution. After that setting the syringe pump at the required flow rate. Then collected the displaced water and measured it by weighing balance. Calculated the net hydrogen collected or generated.

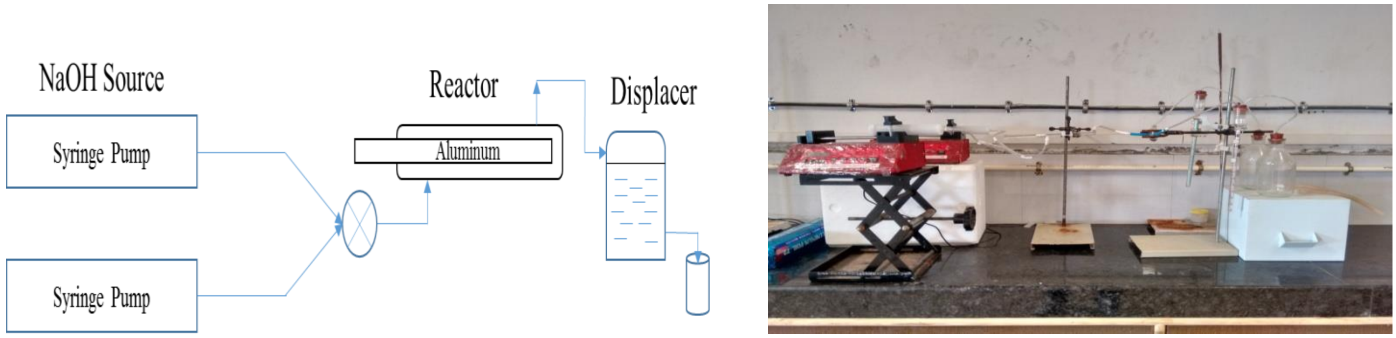


Figure. 1 : Experimental setup of Production of hydrogen

III. RESULT AND DISCUSSION

The following graph shows that, as the flow rate of activator (aq. NaOH) increases the rate of generation of hydrogen also increases and the time required for complete conversion of Aluminum decreases.

Time (sec)	Volume of hydrogen Produced(ml)	Time(sec)	Volume of hydrogen produced(ml)
1	3.092	13	92.943
2	7.508	14	100.095
3	12.742	15	106.029
4	19.113	16	110.833
5	26.072	17	115.117
6	33.653	18	118.17
7	41.61	19	120.821
8	49.532	20	123.354
9	58.135	21	125.333
10	67.131	22	126.312
11	75.996	23	126.93
12	84.541	24	127.498

Table 3.1 Volume of hydrogen produced from 0.5 N NaOH

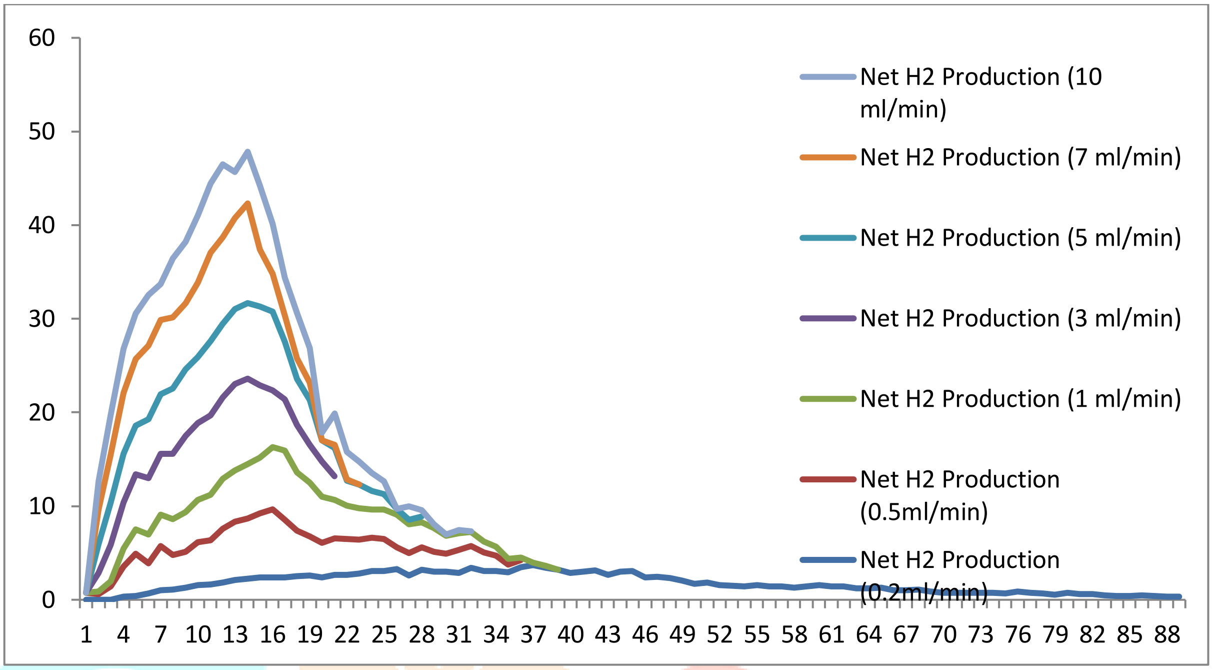


Figure 3.1. Graph of Hydrogen generated Vs. Time of 0.5 N NaOH at different flowrates

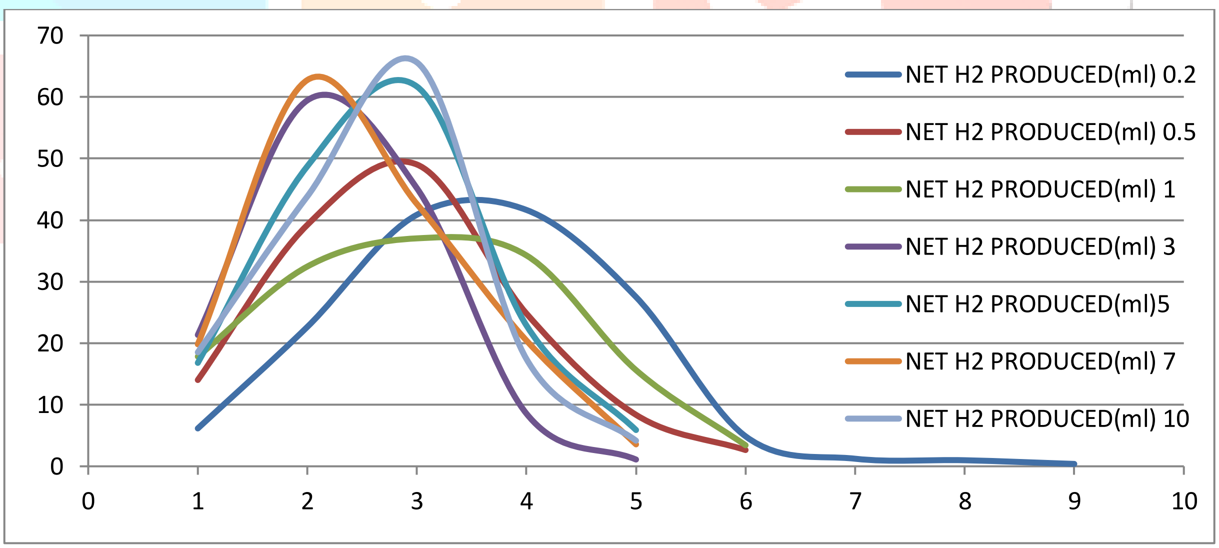
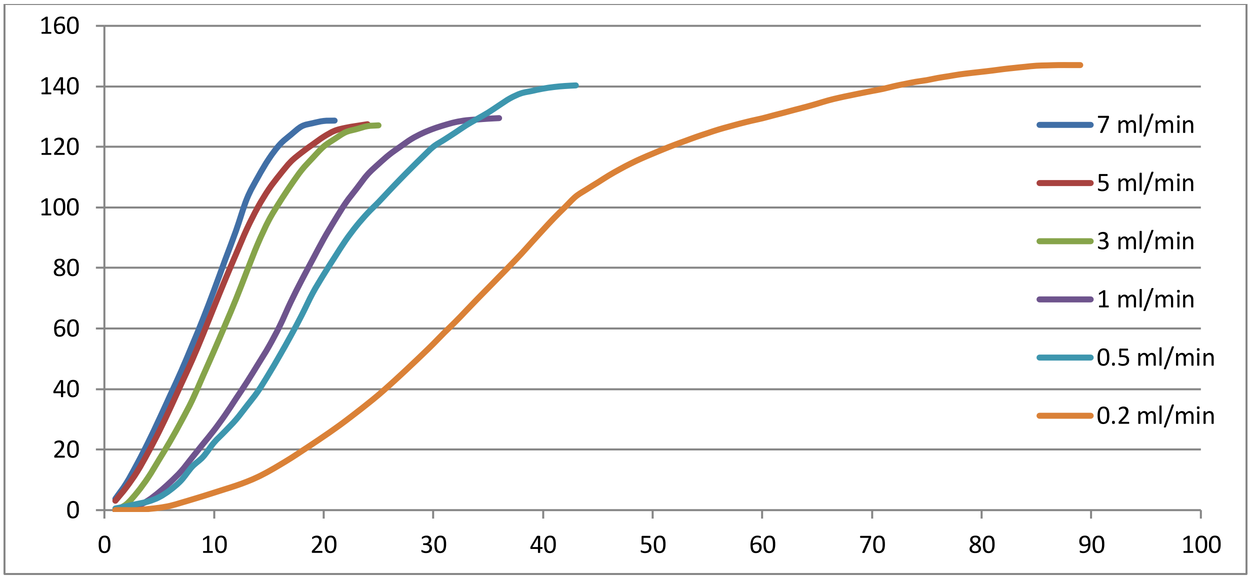


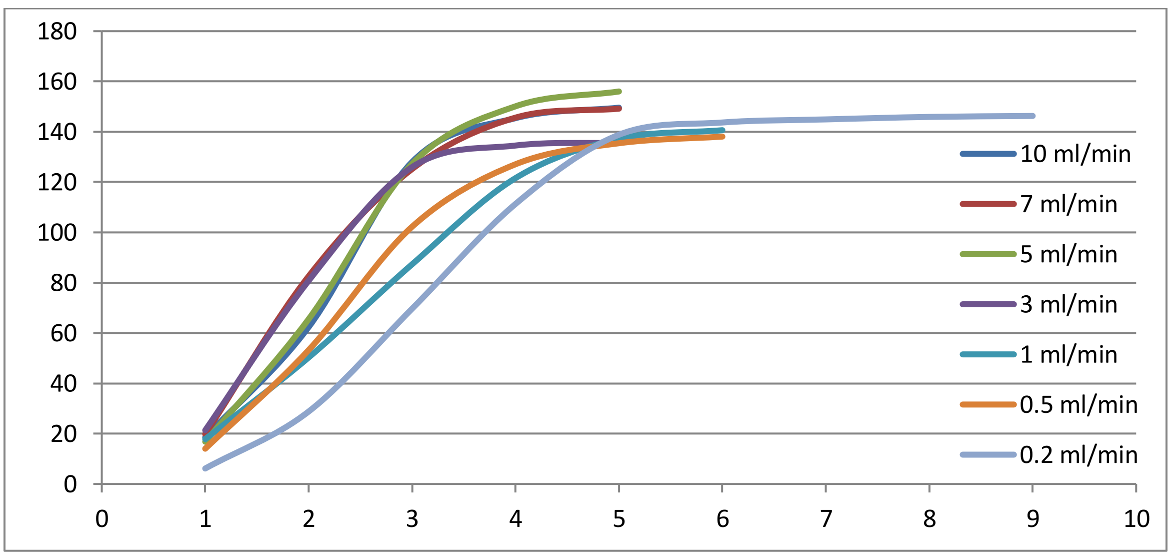
Figure 3.2. Graph of hydrogen generated vs. time of 1.5 N NaOH at different flowrates

If we change the flow rate of activator by keeping normality same, the rate of generation of hydrogen increases. And this result can easily understand from above graphs whereas the same result is seen in each graphwith different concentration of activator used. In above graph shows that rate of generation of hydrogen is maximum at maximum flow rate. That is at 10 ml/min flow rate. Decreases with flow rate up to 0.2 ml/min. Also from below cumulative graphs we can easily see that the time required for complete conversion of aluminum decreases with increase in flow rate ranging from 0.2 ml/min to 10 ml/min.



Time(sec)

Figure. 3.4. Shows the hydrogen generated vs. Time of 0.5 N NaOH at different flowrates (Cumulative)



Time (sec)

Figure3.5. Shows the hydrogen generated vs. time of 1.5 N NaOH at different flow rates (cumulative)

IV. CONCLUSION

Hydrogen has been produced from a spontaneous chemical reaction in an easy way and at relatively low cost by putting in contact with aluminium, obtained from aluminium foil and sodium hydroxide. The reactant aluminium gets totally reacted and dispersed in the reactions. The reaction between aluminium and dilute NaOH is feasible at atmospheric conditions and produces appreciable amount of hydrogen. With the increase in flow rate dilute NaOH, the rate of hydrogen generation increases and the time required for complete conversion decreases.

V. REFERENCES

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