European Online Journal of Natural and Social Sciences 2014; www.european-science.com
Vol.3, No.3 Special Issue on Environmental, Agricultural, and Energy Science
ISSN 1805-3602

Hydrogen Selection: A Fuel Suitable for environment as an opportunity for teaching green chemistry

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Abstract

With emergence of green chemistry, some scientific principles, approaches and methods appeared. One of its advantages is human and environment health. Green chemistry is a dynamically social, economic, and scientific adjustment. Increasing consumption of fossil fuels and the shortage of these resources on one hand and seriousness of other problems derived from the increase of environmental pollutants have made politicians and programmers in energy sector mobilize their expertise in order to be able to carry out structural researches on how to change energy carriers. In comparison with other fuels, hydrogen, if mixed with oxygen without producing common pollutants, can become a kind of energy with high efficiency due to its high thermal value; hence, all other industries including automobile industry have commenced to conduct broad researches on how to use this energy. Using hydrogen with fuel cell depicts a bright future. In the long run, hydrogen, as the best choice and the most economic fuel, has high potential to be used in fuel cell automobiles. Iran's development depends on the use of fuel cell technology. In near future, fuel cell will compete with ignition engines. Therefore, hydrogen production and saving solar energy using photo - catalytic decomposition can be considered as a suitable way to solve some of the problems that we addressed. Nowadays, many students are interested in preserving and surviving environment. They want to know how human activity and chemical industry affect our planet health. So, chemistry and its correct teaching provide a suitable opportunity to start discussing chemistry, environment and human health.

Keywords: Environment, Green Chemistry, Fuel cell, Hydrogen Fuel, Solar Energy, Photo-chemistry

Introduction

In 1997, climate change commission introduced Kyoto protocol with the goal of controlling greenhouse gases concentration in atmosphere at a level that can prevent human dangerous intervention in climate; as with the protocol, industrialized countries are required to reduce greenhouse gases.

In 1980s, scientific evidence showed that the release of greenhouse gases derived from human activities creates dangers for the climate of the world. Therefore, public opinion felt to form an international commission and agreement to solve this problem. The ultimate goal of this conversion and other relevant legal instruments approved by the members of the conference are: 1) controlling the concentration of greenhouse gases in atmosphere so that human activities do not damage natural ecosystem and ecosystems can naturally adapt themselves to climate change, 2) making sure that food security is not threatened, 3) sustainable economic development is created. On the other hand, renewable energies become more widespread in the supply chain of energy in the world.

Renewable energies are very crucial for developing countries like India, Saudi Arabia, etc.; because they are importing the products of technologies that they do not have that technology. Hence, renewable energies play an important role in international policies and programs including programs of the United Nations to achieve sustainable development. The present system of energy consumption has some problems. In recent decades, a great deal of researches, in the world, has been conducted to address and solve these problems. Almost all resources of renewable energy are alternatively available. They, themselves,cannot be transferred or saved so they cannot be used as fuels in transportation sector. So far, the most important and common fuels to be used in transportation are petrol and gas oil. Automobiles that use petrol or gas oil release harmful material and pollutants that have complicated chemical combinations and produce ozone in atmosphere. Although, different strategies have been adopted to reduce pollution including technical repair of automobiles and installing systems to control the release of pollutants in exhaust pipes on automobiles in developed countries, these plans or strategies have not sufficiently reduced ozone production and other pollutants in big cities. When fossil fuels are burnt, they are mixed with the oxygen in the air and produce de oxide carbon; if the burning is not complete, Carbon monoxide, a very poisonous substance, is produced instead of Carbon dioxide. Some of atoms of carbon in the fuel compositions are accumulated on each other unburned and carbon partials. They exit with unburned hydrocarbons from automobiles exhaust pipes as smoke. Also, unburned hydrocarbons are released and vaporized with some fuels before entering the engine. Then, in vicinity with sun light, they are mixed with nitrogen oxides created by the ignition in the engine and produce ozone.

Clean fuels have natural chemical and physical properties that make them cleaner than gas with its current compositions in the act of ignition. During ignition, these fuels produce less unburned Hydrocarbon and the release material resulted from the ignition has limited chemical activity to create ozone and other poisonous substances. Furthermore, using alternative fuels reduces the Increase and accumulation of carbon dioxide that makes the earth wormer.

Processing fuels lead to producing hydrogen, carbon monoxide and carbon dioxide as the main products. Common fuels used in this process are: Gasoline, methanol, ethanol, natural gas; among them, petrol is used more than the others due to being liquid and therefore being easily pumped as well as better distribution, further expansion, lower volume, earlier processing. The optimal temperature of these fuels is different in different pressures. Some of these temperatures are analyzed in the following chart.

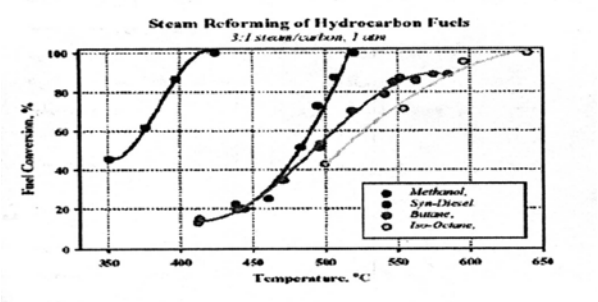

Figure 1. The Temperatures of the Process of Steam Reform For Different Fuels

Using Cuo/Zno/A12o3 catalyst, the temperature, 250-260 degree, is a suitable temperature for the process of methanol steam reform. Recently, catalysts like Nobel and non-Nobel metals that are associated with Zirconium, lanthanumand Sryvm have received enough attention- particularly for hydro carbons. Experiments have shown that some non -Nobel metals like Nickel, Copper, Iron

and Cobalt when are linked with these ancillary substances become active like precious noble metals such as Platinum and palladium (in temperature below 700 degree). However, reformer temperature must be kept at around this level by ignition and in this case; thermal exchange is an important challenge. Then, the produced gas must be dried and its Carbon monoxide, that is one of ancillary substances in reform reaction, must be extracted.

Introducing alternative fuels and carrying out research on the possibility of using these fuels are of prime importance owing to technical and economic considerations and massive resources of some of these fuels in Iran as well as growing trend of consuming hydrocarbon fuels that damage environment and public budget. The following table shows fuel consumption and its costs.

Table 1. The Costs of Fuels Based On Their Consumptions

Real cost) Gj($/	**Predicted lossB)Gj($/**	**Final cost A)Gj($/**	**yield**	**Use**	**fuel**
C=A+B					
15.34	11.50	3.82	0.800	Personal	
13.70	11.50	2/20	0.800	Industry	Brown coal
13.63	11.50	2.13	0.380	Electricity	(pit-Coal)
-	-	-	-	Transportation	
13.16	4.71	8.45	0.800	Personal	
9.80	4.71	5.09	0.800	Industry	methane
9.83	4.71	5.12	0.380	Electricity	
-	-	-	-	Transportation	
22.88	9.71	13.17	0.800	Personal	
17.54	9.71	7.83	0.800	Industry	
15.35	9.71	5.64	0.380	Electricity	petrol
	20.05	9.71 110.34	0.250	Transportation	
15	0	15	0.80	Personal	
12	0	12	1	Industry	
15	0	15	0.38	Electricity	hydrogen
	8.14	0	8.14	0.70	Solar energy
11.4	0	11.4	0.33	Transportation	

Nowadays, in twenty first century, the importance of “education” is clear and obvious for everyone and students have access to theoretical and descriptive areas of chemistry in various kinds of books but most of them are unable to make necessary relation among theoretical chemistry, their life and environment. Students can make optimal usage of their theoretical knowledge in laboratory.

Therefore, it is of prime importance to use correct scientific methods to understand every theoretical writing. Understanding chemistry will become easier through doing different experiments. Nowadays, what draws the attention of scholars is that how we can teach students that they are ready to face new problems in an unpredictable world and they are able to solve its problems. Educational experiences of developed countries show that textbook is never enough for teaching educational objectives of science and learning it (content selection, teaching and learning methods, assessment method). As a result, we should not only suffice to speaking and hearing. The goal of teaching science to students is teaching scientific principals and using these to develop social and personal life. It is not easy learning of information; doing research about it requires equipment and facilities that help student observe, feel and experience educational materials in order to make students able to use this knowledge in their future life. Therefore, chemistry science must be taught in a way that emphasizes on the association among life, industry, technology and society and students are able to use their knowledge in their life. New processes in laboratories can prevent industrial pollutants and produce new products that are environment-friendly. This growing technology minimizes using dangerous substances in designing and producing products; therefore, it offers a very different method for reducing pollution. The term, green chemistry, is associated with designing products and processes that decrease or devastate production and use of dangerous substances. Hydrogen is the most significant alternative as a clean fuel and new energy carrier. Abundance, easy production from water, unique consumption and natural environmental profitability of hydrogen are among the properties that make hydrogen different from other alternatives like Ethanol and methanol. Hydrogen can be produced using different kinds of primary energy resources and use it in all cases and applications of fossil fuels; hydrogen completes renewable resources of energy and makes them available in any time and place in a suitable way and offers them to the consumer. In comparison with other kinds of energy, hydrogen can be converted into other forms of energy with higher efficiency and cleaner ignition. Using hydrogen with fuel cells depicts a bright future. The system of Hydrogen energy is a renewable, comprehensive, imperishable, stable and permanent system due to independence from primary resources of energy. Hence, it is predicted that in near future, hydrogen production and consumption prevails over all parts of global economy and stabilizes hydrogen economy. The horizon of hydrogen economy has quickly grown in order to be able to utilize hydrogen as a kind of energy that has capacity of being stored and saved; on the other hand, hydrogen economy is seeking to extract hydrogen from renewable resources and replace fossil fuels with hydrogen. Factors that made hydrogen economy follow these objectives are:

*Oil and the end of its resources***:** Evidence suggests that oil resources in the world are rapidly decreasing. Such a problem made scientists and specialists take serious steps to replace oil with other forms of energy. Two thirds of oil resources in the world are in countries like Iran, Saudi Arabia, Kuwait and Iraq. This is a factor that has made scientists try to find asupplier source of energy. Among other resources for energy that have attracted scientist's attention are renewable resources like solar energy, wind energy and other renewable resources. Hydrogen is a kind of energy carrier that can be obtained from renewable resources and use it as a source of energy that has transfer or movement capability.

Air Pollution: Air pollution is increasing in cities everyday due to using fossil fuels. This limits using automobiles in big cities in the world. Burning fossil fuels creates acid rains, sulfur compositions and nitrogen acids that are harmful for human health. Using hydrogen as a kind of fuel in automobiles can be regarded as an important step to control air pollution in big cities.

Global Danger: Concern over world climate change due to the release of greenhouse gases like CO2 and CO is increasing. Most countries in the world want to reduce the release of greenhouse gases produced by burning fossil fuels and agreements such as Kyoto Protocol has been reached. Hydrogen production in large scale as a kind of renewable energy will completely solve the problem of carbon release. Even the hydrogen that is extracted from natural gases in large scale releases a little carbon.

What should we do? Physical and chemical properties of hydrogen have made it a suitable fuel for the above-mentioned usages. Hydrogen gas is regarded as the most important source of energy production and transfer in the current century. Generally, hydrogen is a kind of energy with high energy density per unit mass and very low level of pollution. By burninghydrogen, water, a very important substance, is produced. One of the other advantages of hydrogen is that it can be produced from different resources.

The goal of hydrogen economy is transferring hydrogen in the form of hydrogen. This can solve the big problem of electricity that cannot be stored. It also reduces the costs of transferring energy. Hydrogen turns into liquid at lower temperature that is a light fuel for rackets, airplanes and astronautically uses. Existence of natural gas pipes can be affordable for transferring hydrogen from 500 to 800 kilometers.

Density of hydrogen energy in liquid state is $0.852 \times 10^4\ {}^{KJ}/_{lit}$یا$12 \times 10^4\ {}^{KJ}/_{Kg}$. This is one of the main advantages of hydrogen. One of the other advantages of hydrogen is that it burns without producing flame that is called Catalytic burning.

Hydrogen Production Methods

Reforming of natural gas, crude oil and coal, Electrolysis of water-Thermochemistry - Hydrogen production from Biomass and Hydrogen production fromalgae,and different kinds of bacteria- photo catalytic hydrogen production from substances it contains such as water and so on.

Why is it necessary to use solar energy in Iran?

Solar energy is a clean source of energy. The amount of solar energy we received per day is average 18MJm and if we multiply this figure by the area of the country, a very big figure is obtained that is not comparable with our fossil energy; our solar energy is a thousand times more than our consumed energy and oil. If we just use one percent of our land,with average yield of 10 percent of our solar energy, we can supply our need for energy and can export this energy to other countries.

What Important Sources Are There In Iran To Produce Hydrogen?

Biomass gas was also another source of energy that our ancestors used. This gas is produced from animal waste in an anaerobic bacteria environment. In fact, these anaerobic bacteria can convert organic waste in an anaerobic environment into hydrogen (2%), methane (48%) and Carbone dioxide (50%) and use the heat to cook food and warming. This method is common in India and China. Luckily, we have abundant solar energy in our country. Wind and water can also help this energy and we can use these two kinds of energy too. We have used these two kinds of energy by building dams and wind turbines.

A Suggestion for Saving Hydrogen

Optimized Nano composite materials are produced to save hydrogen with high density. Nano composite material are produced and tested with catalysts, Nano carbon tube as big as controlled Nano-tube. A systematic process is followed to design and produces this product in order to control

the level of growth of Nano carbon and facilitate Hydrogen absorption and desorption processes. Nano-scale material has regular physical properties due to their size and shape. A single-walled carbon nanotube(SWCNT) has the same structure as a single sheet graphene roll. Due to the existence of big surfaces with relatively low volumes, SWCNT is considered as one other selected materials for saving energy at large scale.

Hydrogen Production and Saving Solar Energy Using *Photo- Catalytic decomposition of Water in Fuel Cells*

In photo- electrochemical processes, water is decomposed in one stage and in one machine and hydrogen and oxygen are produced. In this process, solar energy and Electrolysis are used to separate partials of water from each other. Photo -electrochemical machine receives photovoltaic cell of solar energy and uses an electrode. Photovoltaic machine provides the amount of voltage required for decomposing water (about 1,6 v) and electrochemical reaction is done on the surface of Catalyst and electrolyte. Photo- biologic process has been designed based on the capacity of some organism: Green algae of turquoise bacteria and fermented bacteria that are used as catalyst to produce hydrogen from water. Fuel cell converts chemical energy into electric energy. This conversion is direct and has high efficiency. Water, heat and electricity are produced from the reaction between hydrogen and oxygen. Indeed, chemical reaction between oxygen and hydrogen in fuel cell produce clean energy. The only by product of this process is water. Different kinds of fuels are used in different fuel cells and different Electrolytes are used in them.

$H_2O \rightarrow 4H^+ + 4e^- + O_2$:

$4H^+ + 4e^- \rightarrow 2H_2$:

$2H_2O \rightarrow 2H_2 + O_2$:

The Amount of Water Needed

Theoretically, Nm3 124 hydrogen is can be produced from one liter of water but we consider the amount of water used about 25% because the two kinds of gas produced are humid and some water is wasted.

This is very important that the system can work like a closed system. If the fuel cell uses air instead of pure oxygen, some water is still wasted.

Necessary Equipment

Electrolyzer and fuel cell are the main parts of hydrogen saving and the capacity of each of them directly depends on the surface and area of the electrodes and the total amount of energy saved depends on the tank of hydrogen for storing that its volume depends on the amount of energy electorized at PV unit.

A) PEM Electrolyzer

Electrolyzer is composed of an electrode and a machine for separating gas for separating the produced hydrogen and oxygen from each other. Here, Tetrafluoroethylene sulfate solution is used as electrolyte and water as reagent. The amount of hydrogen produced depends on density. PEM electolyzer can work in a density higher than alkaline density($1 - 2\,{}^{A}/_{cm^2}$) and can produce hydrogen high purity of 99.999 from 60 to 90c.

Fuel Cell Yield

Fuel cell yield is usually defined based on the real yield of electrochemical reaction. This value is usually calculated with the following methods.

The amount of energy released during experiment between hydrogen and oxygen for producing water can be regarded as enthalpy (ΔH). This value is usually calculated based on the

experiment that depends on the conditions of the produced product of the reaction. In other words, water is produced in the form of liquid or gas.

In fuel cell, water is produced in the form of gas. So, enthalpy reaction can be calculated using the following equation.

$$\Delta H^{\circ}_{(gas)} = -2H2\frac{KJ}{mol_{water}} = -230\frac{Btu}{mol_{water}}$$

This value is based on the conditions of the laboratory, that is, the temperature of the environment is about 25c and atmosphere pressure is about kpa 1o1.325. of course, the effect of temperature is more important than the effect of pressure. At the highest temperature of fuel cell, volume changes are about 30% and this is the reason why fuel cell yield is lower in high temperature.

Since we cannot calculate the total energy released during experiment, we can calculate the amount of produced voltage of every fuel cell that acts based on this law using Gibbs Energy rule:

$$v_{cell} = -\frac{AG^{\circ}}{n.F}$$

In the above equation, n is the number of electrons in the reaction and F(fixed F Farad) is $96500\frac{C}{mole^{-}}$. And having ΔG in temperature and pressure conditions of doing the reaction that is about $-229\,{}^{KJ}/_{\text{mol water}}$, we have:

$$v_{cell} = \frac{-229KJ}{mol_{water}} \times \frac{1000J}{1KJ} \times \frac{mol_{water}}{2mol\ e^{-}} \times \frac{1mol\ e^{-}}{g6500c} = 1.187V$$

So, the most amount of voltage for this fuel cell with theoretical method is 1.187 volt. Therefore, using the relation and the ratio between voltage produced by fuel cell and the maximum theoretical voltage, we can obtain fuel cell yield:

$$Y_{cell} = \frac{V_{real}}{v_{cell}} \cong \frac{V_{real}}{1.187}$$

The really produced voltage has usually been measured between 0.5 and 0.6v. Similarly, fuel cell yield is considered to be about 40 to 50%.

The amount of the yield of PEM fuel cell has been shown in figure 2 based on its output power. The amount of yield for maximum power in it is about 38% and the amount of maximum yield in it is about 50% and power of 300 vats.

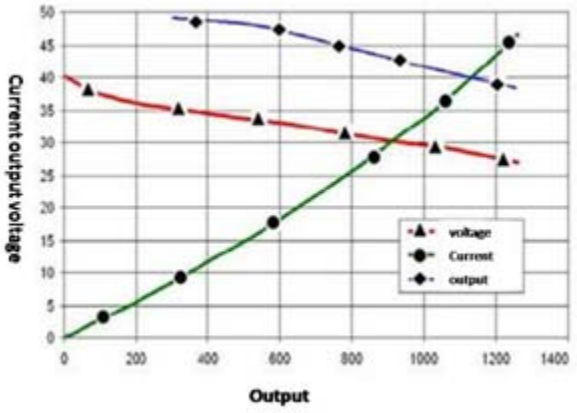

Figure 2. Characteristics of the fuel cell efficiency PEM

The Amount of Fuel Needed For Fuel Cell

Figure 3 has shown the amount of hydrogen needed for PEM fuel cell with different pressures based on output power of the fuel cell. When pressure is increased, the amount of hydrogen needed is decreased. Its reason is the relation between the speed of chemical reaction and hydrogen reaction because the cell consumes the same amount of fuel and hydrogen pressure increase improves its transfer to the surface of membrane to do the reaction.

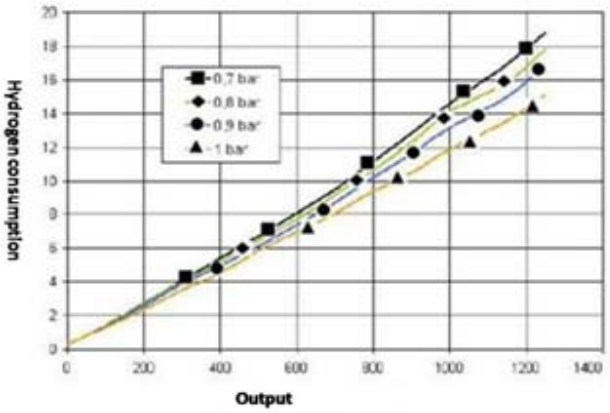

Figure 3. Use hydrogen fuel cell PEM.

Conclusions

At the present time, hydrogen is mostly produced from hydrocarbon. Hence, the cost of producing hydrogen is more than the common fuels and the cost of per unit consuming energy for hydrogen is higher than the cost of the same unit of energy for hydrocarbon.

Limited demand prevents the increase of hydrogen production. Although, there is increasing growth of sale for hydrogen in petroleum industry and refineries, the demand for hydrogen as a kind of energy carrier is low. The lack of demand for hydrogen with high purity in commercial market of energy has created little motivation in the industry to develop optimization of new technologies. World demand for energy is rapidly increasing and currently, inexpensive fossil fuels are gradually diminishing and will be finished during the next few decades. We have no way but using clean energy in order to be able to preserve these valuable fossil fuels for the future generations, prevent the damages to environment and meet the increasing demands for energy.

For localizing and promoting hydrogen technology, we need standards. Today, international standard organizations are active to complement and offer their hydrogen achievements. Maybe, regarding the open market of global sale, it appears that since hydrogen has some advantages, it must be able to fine its place in the market, but the reality is that if policies are based on removing limitations of Eco -energy, then the sustainable hydrogen economy makes sense because current prices are calculated regardless of the price of destroying environment. Based on the outlook of Eco energy, we reach the conclusion that world has been oriented toward gas fuels, particularly the most perfect of them that is hydrogen. Hydrogen fuel has created a revolution in fuel industry because it has remarkable properties like high efficiency, renewability and compatibility with environment.

References

Badri-Abid,(2009) Teaching chemistry. Tehran: MabnayKhard Pub, 242

Fujishima, A, Honda, K. (1972).Electrochemical photolysis of water at a semiconductor electrode. *Nature,* 238, 37–8.

Hofstein, A. (2007) The Laboratory in Science education: The state of the art , Chemistry Education Research and Practice, 8, 105-106

Ian, A. (2011) Practical work in secondary science Amines – on Approach, New York continuum Interacting al publishing Group, PP:14-18),(

Mange, Ni, Michael, K.H. Leung , Dennis, Y.C. Leung, K. & Summitry; (2007) A review and recent developments in photo catalytic water-splitting using TiO2 for hydrogen production, *Renewable and Sustainable Energy Reviews* ,11, 401–425

The-Vine Nguyen, Kinjo Kim, O-Bong Yang; (2005) Photo catalytic water decomposition for hydrogen production over silicotungstic acid–silica photo catalyst, *Journal of Photochemistry and Photobiology A: Chemistry*, 173 56–63

Suarez-González ,M. A., Blanco-Margareta ,A.M., &.Pena-Quintana,A., (2011) Review on hydrogen production technologies from solar energy, *International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Can aria (Spain)*, 13th to 15th April,