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Prospective Of Hydrogen in Automobile Transport

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PROSPECTIVE OF HYDROGEN IN AUTOMOBILE TRANSPORT

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Abstract
This article demonstrates the importance of hydrogen application as an energy carrier for the future in the automobile transport, and the main components of hydrogen-powered vehicles comparing with battery electric vehicles taking into account the main issues of producing and storage of hydrogen gas. Moreover, it is devoted to ecologically friendly method of producing hydrogen considering the Decree of the President of the Republic of Uzbekistan "On the Program of Measures for the Further Development of Renewable Energy, Improving Energy Efficiency in the Economy and Social Spheres for 2017-2021".

Key words: hydrogen, fuel cell vehicles, electrolysis, DSSCs.

ПЕРСПЕКТИВА ВОДОРОДА НА АВТОМОБИЛЬНОМ ТРАНСПОРТЕ

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Аннотация
Данная статья демонстрирует важность применения водорода в качестве энергоносителя для будущего автомобильного транспорта, а также основных компонентов водородных транспортных средств по сравнению с электромобилями с аккумуляторной батареей с учетом основных вопросов производства и хранения газообразного водорода. Кроме того, он посвящен экологически чистому способу получения водорода с учетом Указа Президента Республики Узбекистан «О программе мер по дальнейшему развитию возобновляемой энергетики, повышению энергоэффективности в отраслях экономики и социальной сфере на 2017-2021 годы».

Ключевые слова: водород, транспортные средства на топливных элементах, электролиз, DSSCs (Сенсибилизированный красителем солнечный элемент).

In most recent decade, as to prevent environmental pollution on the planet all car-manufacturing countries are paying more attention to the development of producing zero emission vehicles. Today the most developing zero emission vehicles are hydrogen fuel cell and battery electric vehicles [1,2]. Toyota, Ford, Hyundai, GM, and Honda car manufacturers are considered to engage producing hydrogen fuel cell vehicles. Currently Northern America dominates having hydrogen fuel cell vehicles, stations, and market. However, Japan is expected to be dominate by 2023 in Asia-Pacific countries [3]. Australia is known as hydrogen fuel supplying partner to Japan. Toyota manufactured its Toyota Mirai traveling 550 km with single refueling. In order to develop hydrogen fuel cell vehicle market, Toyota offers 3 year free refueling with hydrogen fuel [4].

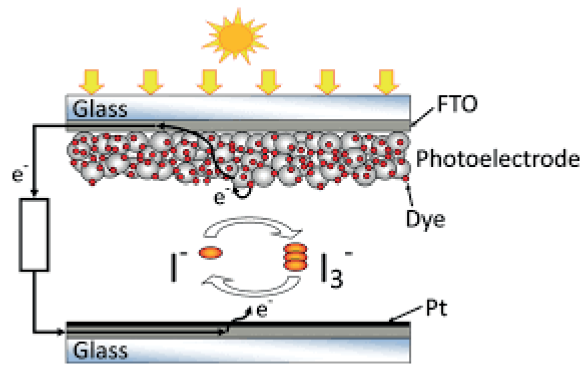
How is hydrogen produced?

Hydrogen is the most abundant gas in the universe but it is not existed in the pure form on Earth's crust. Getting hydrogen in its pure form is not easy. Currently, there are two the most commonly used methods of producing hydrogen. They are steam reforming and electrolysis of water [5,6,7].

Steam reforming is a process at a high temperature which steam reacts with hydrocarbon fuel to produce hydrogen [8].

Many hydrocarbon fuels are applicable to be reformed to get hydrogen. Among hydrocarbon fuels, natural gas is mainly used in the steam reforming process [9,10]. But, the critical point is that the hydrogen fuel cell vehicles and battery electric vehicles are not environmentally friendly if electricity needed to get hydrogen for FCVs and to charge EVs comes from a power plants which are mainly burn fossil fuels. The burnt fossil fuels cause pollution that our technologies are intended to avoid. Nevertheless, it is less expensive method to get hydrogen.

Electrolysis is the process, which splits water to hydrogen and oxygen by passing electric current through water [11].



There are not only two methods to produce hydrogen up to now but also there are other ways, too. Nowadays, all over the world engineers, and scientists, are working on hydrogen energy and its producing methods, which are less costly, less polluting, more efficient, reliable, and safe ways. Today, the use of dye-sensitized solar cells (DSSCs) can environmentally and cost effectively influence on electrolysis of water to produce hydrogen [12]. DSSCs are developing and the most efficient solar technology, which are transforming artificial and natural light into electricity by ecological way, which was invented by Professor Michael Graetzel and Brian O'Regan. Dye-sensitized solar cells are often called graetzel cells or briefly, DSSCs [13].

Figure 1: Structure of DSSC

Main components of DSSCs are:

Semiconductor – TiO2

Sensitizer (dye)

Redox mediator – I-/I-3

Counter electrode – platinum

Mechanical support – FTO (Fluorine-doped Tin Oxide) glass coated with TiO2 [14,15].

One problem arises on DSSCs, which is no stability of liquid electrolyte at varying temperatures. The electrolyte can freeze and expends at low and high temperatures, respectively. Freezing causes reduction of power and physical damage whereas expanding leads to difficulty on sealing the panels. Currently, replacing liquid electrolyte with a solid is under progressing field of research.[16,17].

Usage of DSSCs to produce hydrogen by electrolysis of water shows fascinating results in the development of hydrogen fuel cell vehicles. Furthermore, large-scale deployment of DSSCs to generate electrical energy can cause to the development of renewable energy and improving energy efficiency in the world.

Application of hydrogen

Hydrogen powered cars are often called Fuel Cell Vehicles or Fuel Cell Electric Vehicles. Their working principle is different from conventional vehicles. Like internal combustion engine cars, fuel cells take the fuel from a tank. The fuel is in the form of highly pressurized hydrogen gas. The only difference between fuel cell vehicles and conventional vehicles is the fuel does not burn in the internal combustion engine in the FCVs; on the contrary, it is chemically reacted with oxygen, producing electricity and water as byproduct. Produced electricity is supplied to power the electric motor, which drive the vehicle [18,19]. Moreover, it is possible to use stored hydrogen in the internal combustion engine, directly. 1 kg of hydrogen has energy content of 130-140 MJ which is the same amount of energy of 1 gallon (=3.48kg) of gasoline. Even, thermodynamic efficiency levels are almost the same 20-25%. But cost of 1 kg of hydrogen is 3 times higher than that of 1 gallon of gasoline [20,21,22].

Main components of hydrogen fuel cell vehicles

1. A) Fuel Cell - a chemical cell which converts chemical energy of fuel (hydrogen gas) and oxidizing agent (mostly oxygen) into electricity through chemical reaction between them. In this reaction, only byproduct is considered water and nitrous oxide if oxidizing agent is air [23]. B) Fuel Cell Stack collects relatively small amount of electricity generated by individual fuel cells. Each of hundreds of fuel cell generates less than one-volt electricity. Collecting them together, fuel cell stack produces enough power to propel the car [24].

2. Hydrogen storage tank stores hydrogen gas compressed at extremely high pressure to increase driving range. In the development of fuel cell application, hydrogen storage stays a key issue. Hydrogen can be stored in the form of gas or super-cooled liquid. The most common one is known

as compressed hydrogen gas. Compressed hydrogen gas is stored in a high-pressure tank located either in the trunk or under the floor of vehicle. There are four type of high-pressure vessels. Type I - metallic vessel, Type II - thick metallic liner hoop wrapped with a fiber–resin composite, Type III - metallic liner fully wrapped with fiber–resin composite and Type IV - polymer liner fully wrapped with fiber– resin composite. Nowadays, Type IV vessel (polymer liner fully wrapped with fiber – resin composite) is considered as a good (not the best) technological solution for the gaseous hydrogen storage in a high-pressure tank. Some specifications of type 4 polymer liner with composite material are: mass of hydrogen stored – 2kg at 700bar (15oC), mass of empty tank – 53.6kg, inner volume – 52L, maximum absolute refilling pressure – 700bar [25].

3. Electric motor. Similar to an electric car, hydrogen cars have electric motor, placed near the vehicle's front wheels. The electric motor gets power from electricity generated by the fuel cell and it can also source energy through regenerative braking technology, where electric power is stored in a battery pack (nickel-metal-hydride battery). The stored energy is later drawn out to supply torque and power. Electric motor propels the vehicle more quietly, smoothly, and efficiently than an internal combustion engine and requires less maintenance [25].

4. Motor control. The power control unit governs the flow of electricity generated in the fuel cell. Moreover, it administrates input and output of battery depending on driving conditions. The amount of electricity converted and fed to the electric motor is based on the input delivered from the accelerator pedal. Motor controller has a microcontroller that regulates and redirect electric current. [25,26].

Battery electric vehicles

In general, working principle of battery electric vehicles and of hydrogen fuel cell vehicles are similar. The main difference is electric cars use stored energy in batteries whereas fuel cell vehicles possess stored fuel which later reacts to produce electricity [27]. Main components of battery electric vehicles are considered electric motor, control unit, and battery [28]. There are three major type of battery technologies, which are applied to the electric cars. They are Lithium–Ion Batteries, Lead-Acid Batteries, and Nickel-Metal-Hydride Batteries. They are charged with electricity from an external source. Electric vehicles have limitations about the range they covered with a single charge of battery [29]. Moreover, the more powerful battery the more its increase in weight. As hydrogen fuel cell vehicles store more fuel in the tank and use it to produce electricity during the motion, they do not have the same traveled distance limitation as battery electric vehicles have.

Summary

Battery electric vehicles and hydrogen fuel cell vehicles are not competing technologies but they are similar and complementary. Both of them are hoped to be alternative to internal combustion engine vehicles as they have zero emission and do not burn the fossil fuel directly. In order to make them actual "green automobiles" we will have to avoid methods of producing electricity by burning fossil fuels. Using environmentally clean methods of producing electricity such as wind power, hydropower, nuclear power and DSSCs are promising alternative to burn coal to generate electricity. Methods declared above produce little or no polluting emissions at all. When most of electricity being generated in Uzbekistan come from these sources, automobile industry of Uzbekistan will start new period of producing cars, which are "green automobiles".

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