

ANALYSIS OF HYDROGEN GAS AS FUEL BY ELECTROCHEMICAL REACTION AND ITS USES IN POPULAR PUBLIC TRANSPORT TO LIVE GREEN IN EVERYDAY LIFE.

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Abstract:-

The potential use of hydrogen fuel to address the problems of climate change and energy sustainability is attracting a lot of attention. Hydrogen has the potential to revolutionize a number of industries, including transportation, power production, and industrial processes, thanks to its abundant supply and clean nature. The current status of hydrogen fuel, its production processes, storage and transportation issues, as well as its effects on the environment and energy systems, are all covered in this abstract. It also emphasizes the difficulties and possibilities brought on by the widespread use of hydrogen fuel. The abstract emphasizes the need for more research and development to fully realize hydrogen's potential as a future source of clean, adaptable energy.

Keyword: Hydrogen, electrolysis, PEM, SMR, biomass, UAV

1. Introduction

With the potential to revolutionize numerous industries and lessen our reliance on fossil fuels, hydrogen fuel is emerging as a promising energy source for the future. Hydrogen, a plentiful and clean resource, has the potential to help us solve a number of our current energy and environmental problems.

Climate change mitigation is one of the significant effects of hydrogen fuel. Hydrogen emits no harmful emissions, such as carbon dioxide and particulate matter, when it is used in fuel cells or combustion engines. All that is left behind is water vapor. This makes hydrogen an appealing replacement for conventional fossil fuels, assisting in the reduction of greenhouse gas emissions and the fight against air pollution.

Hydrogen fuel is incredibly versatile in terms of its applications. It can power a variety of uses, such as transportation

2. Literature review

2.1 Zero Emissions:

The Mirai has a number of benefits over gasoline-powered vehicles, including zero emissions operation. Water vapour is the only byproduct of hydrogen fuel cell vehicles, which helps to improve air quality and lower greenhouse gas emissions.

2.2 Reduced Carbon Footprint:

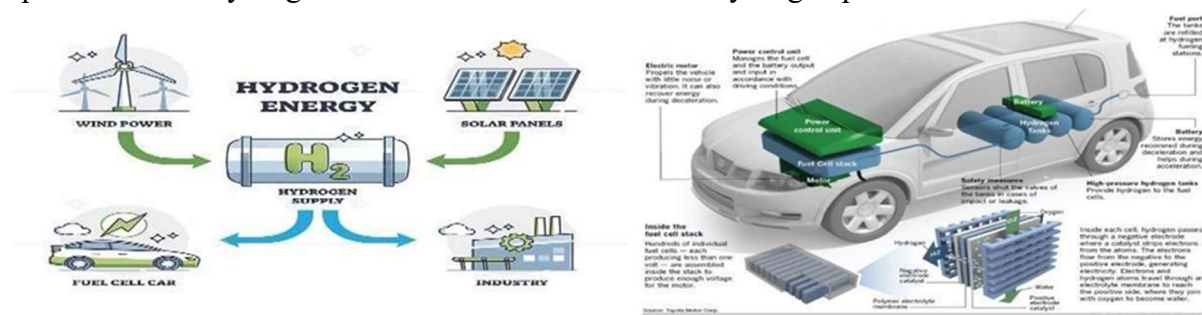
The Mirai is an environmentally friendly option because hydrogen production techniques like electrolysis powered by renewable energy sources can significantly reduce the carbon footprint associated with hydrogen fuel production.

When combined with clean production techniques, hydrogen can be produced from renewable resources, offering the potential for a sustainable and renewable energy ecosystem.

2.3 Energy Efficiency:

When compared to petrol powered internal combustion engines (ICE), hydrogen fuel cell vehicles like the Mirai are more energy-efficient. A higher proportion of the energy in hydrogen can be converted into useful work by fuel cell systems, increasing efficiency and lowering energy waste.

As compared to petrol-powered cars, the Toyota Mirai and other hydrogen fuel cell vehicles offer a number of benefits. They offer zero-emission driving, a smaller carbon footprint, greater energy efficiency, longer ranges, and quicker refueling times. Vehicles like the Mirai hold significant potential in the transition to a sustainable and effective transportation system thanks to improvements in hydrogen infrastructure and renewable hydrogen production.



Demerits

It is crucial to recognize that there are obstacles in the way of the widespread use of hydrogen fuel in the drone and public transportation sectors. Significant funding and collaboration between various stakeholders are needed to establish a strong hydrogen infrastructure that includes production, storage, and distribution. To further prevent accidents and reduce potential risks, it is crucial to ensure the safe handling and storage of hydrogen.

Hydrogen fuel has a lot of potential as a practical way to lessen pollution in public transportation and increase drone endurance. With its many benefits, such as emission- free combustion and effective energy storage, hydrogen fuel presents a promising substitute for traditional fossil fuels.

We can greatly reduce air pollution, enhance air quality, and lessen the negative effects of greenhouse gas emissions by using hydrogen- powered cars and drones.

Incorporating hydrogen fuel cells into buses, trains and even taxis can completely transform the public transportation sector. Only water vapour is released by hydrogen- powered vehicles, which eliminates harmful pollutants like carbon dioxide, nitrogen oxides, and particulate matter that cause smog and respiratory illnesses. By using hydrogen as a clean energy source, we can lower the carbon footprint of public transportation, improving the sustainability and health of our cities.

3. Methodology

3.1 Methods to produce hydrogen fuel

There are various ways to make hydrogen fuel, each with advantages and things to keep in mind. Here are a few typical approaches:

- 1) The most widespread method of producing hydrogen, steam methane reforming (SMR), is responsible for most of the hydrogen produced worldwide. Methane, a natural gas, and steam at a high temperature are reacted to create hydrogen and carbon monoxide. The water-gas shift reaction is then used to transform the resulting mixture into hydrogen.
- 2) Biochemical Reactions: Some microbes, including bacteria and algae, can produce hydrogen through biochemical reactions like fermentation and photosynthesis. The effectiveness and scalability of these techniques still need to be improved through additional study.
- 3) Gasification of biomass: Syngas, which is made of hydrogen, carbon monoxide, and other gases, can be produced by gasifying biomass, such as agricultural waste or forestry residue. The hydrogen, which can be separated from the syngas and used as fuel, is then purified.
- 4) Hydrogen and oxygen are separated from water using the solar-thermal water splitting technique. The endothermic reaction is propelled by high-temperature solar reactors, and the process efficiency is increased by using specialized materials or catalysts.
- 5) Electrolysis: Electrolysis is the process of separating water (H₂O) into hydrogen (H₂) and oxygen (O₂) gases using an electric current. Alkaline and proton exchange membrane (PEM) electrolyzer are the two main types of electrolyzers that can be used for it. PEM electrolyzers use a solid polymer membrane, whereas alkaline electrolyzers use a potassium hydroxide electrolyte solution. Electrolysis is a green method of producing hydrogen because it can use renewable energy sources like solar or wind power.

It's important to remember that the method used to produce hydrogen fuel can have a big impact on both its price and environmental impact. There is ongoing research and development to enhance

current production techniques and investigate novel approaches to hydrogen production as the need for clean and sustainable hydrogen increases.

3.2 Uses of hydrogen fuel in rocket

Rocket fuel and spacecraft propellants frequently use hydrogen, especially in the form of liquid hydrogen (LH₂). It is a great option for space exploration because of its special qualities. A list of the benefits of using hydrogen fuel in rocketry is provided below:

High Energy Efficiency: Because hydrogen has a high energy-to-mass ratio, it offers a lot of energy per unit of fuel. Compared to other propellants, this property enables rockets to carry a larger payload while using less fuel. As a result of hydrogen's high energy efficiency, space missions can carry more payload and travel farther.

Clean Combustion: When combined with an oxidizer, typically liquid oxygen (LOX), hydrogen fuel burns cleanly and effectively, yielding a combustion process that only produces water vapour as a byproduct. As a result, hydrogen is a sustainable option, especially for space missions where reducing pollutants and debris is essential.

High Performance and Thrust: Hydrogen-powered rocket engines can produce high thrust, allowing for faster spacecraft acceleration and greater maneuverability. Since hydrogen has a high specific impulse (Isp), a measure of its propulsive efficiency, rockets can travel farther and perform better overall thanks to this property of hydrogen.

Hydrogen fuel is versatile and compatible with a variety of rocket engine designs, including both conventional chemical engines and cutting-edge propulsion systems like hydrogen fuel cells. By enabling flexibility in rocket design, this adaptability improves mission adaptability and spacecraft performance.

Hydrogen is one of the most plentiful elements in the universe, making it a sustainable and long-term fuel option for space travel. Hydrogen is also renewable. It can be made using a variety of techniques, including sustainable biomass conversion techniques or electrolysis powered by renewable energy sources.

In conclusion, high energy efficiency, clean combustion, high thrust and performance, versatility, and its abundant and renewable nature are all benefits of using hydrogen fuel in rocketry. These qualities place hydrogen in a key position as a space exploration propellant, allowing for more ambitious and long-lasting missions that push the limits of human knowledge and discovery outside of the Earth's atmosphere.

3.3 Uses of hydrogen fuel in drone sector

With several benefits over traditional battery-powered drones, hydrogen fuel is emerging as a potential game-changer in the drone industry. The advantages of hydrogen fuel for the drone industry are enumerated as follows:

- 1) Extended Flight Time: Compared to drones powered by conventional batteries, hydrogen fuel cells offer significantly longer flight times. Hydrogen-powered drones are suitable for a variety of applications that call for prolonged aerial surveillance, monitoring, or data collection due to their increased capacity for energy storage and transport.
- 2) Hydrogen-powered drones can be refueled much more quickly than batteries can be recharged, which reduces downtime. Drone operators can quickly complete turnaround times and minimize downtime during operations by simply replacing hydrogen fuel cartridges or refilling the fuel cell rather than having to wait for hours to recharge.
- 3) Hydrogen fuel cells are a great option for drones because of their relatively light weight and compact design. Since hydrogen fuel cells have a small form factor, they are simple to integrate into drone platforms without significantly expanding their size or weight. This increases payload capacity and operational effectiveness.
- 4) Environmental friendliness: The only byproduct of hydrogen fuel cells' operation is water vapour, which results in zero emissions. In comparison to drones powered by

fossil fuels, hydrogen-powered drones have a smaller carbon footprint and produce less pollution. Drones running on hydrogen fuel are in line with sustainability objectives and rules intended to reduce environmental impact.

- 5) Hydrogen fuel cells have the ability to be scaled up or down to accommodate a variety of drone sizes and power needs. Due to their adaptability, hydrogen fuel cells can be used in a variety of drone platforms, from small commercial drones to large industrial or military UAVs, to meet a range of operational requirements.

The use of hydrogen fuel in the drone industry holds significant promise for extending flight times, improving operational efficiency, and enabling environmentally conscious aerial missions, even though there are still obstacles to be overcome, such as infrastructure for hydrogen refueling and cost considerations. The full potential of hydrogen-powered drones will probably soon be realized thanks to ongoing developments in infrastructure and hydrogen fuel cell technology.

3.4 Uses of hydrogen fuel in car

With many advantages over conventional petrol or diesel-powered cars, hydrogen fuel is being investigated more and more as a practical substitute. The benefits of hydrogen fuel for the automotive industry are listed as follows:

Zero Emissions: Operating emission-free is one of the hydrogen fuel cell cars' biggest benefits. The only byproduct of using hydrogen as a fuel in a fuel cell vehicle is water vapour, so there are no greenhouse gas emissions or contributions to air pollution. This makes hydrogen-powered vehicles a viable option for lowering carbon emissions and enhancing air quality.

Hydrogen fuel has a high energy density, which translates to a large amount of energy being stored per unit of weight, as well as a long range. As a result, compared to battery-powered electric vehicles, hydrogen fuel cell vehicles can travel farther. The range of hydrogen fuel allows for longer drive as compare to petrol, diesel and EVs (electric vehicles).

The "Fusion," developed by General Motors (GM) in conjunction with NASA and other partners, was the first hydrogen fuel cell vehicle in the world. The 1966 Fusion was a prototype vehicle designed to demonstrate hydrogen's potential as a substitute fuel for cars.

A hydrogen fuel cell system that produced electricity by electrochemically reacting hydrogen and oxygen was used to power the Fusion. The car had a sleek, lightweight body made of fiberglass and aluminum that was designed for increased efficiency.

Two electrodes were separated by an electrolyte membrane in the Fusion's fuel cell stack. The cathode (negative electrode) received oxygen from the air, while the anode (positive electrode) received hydrogen gas. An electrical current was produced as the hydrogen molecules moved through the anode and released electrons that did so by moving through an external circuit. Water vapour is the only byproduct created at the cathode when oxygen molecules combine with electrons and hydrogen ions that have already crossed the membrane.

The Fusion's top speed was roughly 80 miles per hour (130 kilometers per hour), and it had a range of about 150 miles (240 kilometers). It highlighted the environmental advantages and energy adaptability of hydrogen while showcasing the potential of hydrogen fuel cells as a clean and effective power source for transportation.

Although the Fusion was only ever a prototype and was never put into production in large quantities, it set the stage for subsequent developments in hydrogen fuel cell technology. Commercial models like the Toyota Mirai, Hyundai Nexa, and Honda Clarity Fuel Cell are the result of years of research and development by numerous automakers and academics into hydrogen fuel cell vehicles.

The Fusion and other early hydrogen fuel cell vehicles made significant contributions to the development of hydrogen as a practical substitute for fossil fuels, the advancement of sustainable transportation, and the move towards a hydrogen-based economy.

Another notable hydrogen fuel cell car developed by Toyota is the second-generation Toyota Mirai. Building upon the success of its predecessor, the new Mirai offers improved performance, design, and environmental benefits. Let's explore its features and advantages over petrol cars in terms of the environment and efficiency.

Specifications:

Powertrain: The Toyota Mirai uses a cutting-edge hydrogen-to-electricity fuel cell system to drive an electric motor. The electric motor has a power output of 128 kW (172 horsepower) and 300 Nm of torque, and it performs quietly and smoothly.

Range: The Mirai's extended range of about 650 kilometers (404 miles) on a full tank of hydrogen enables longer journeys with fewer stops for fueling.

Refueling Time: Refueling a Mirai with hydrogen only takes a few minutes and is just as convenient as refueling with regular petrol.

4. Conclusion

In conclusion Hydrogen fuel cells could also significantly improve the endurance and capabilities of drones. Drones can travel farther and complete more difficult tasks thanks to hydrogen fuel cells' longer flight times and quicker refueling options compared to conventional lithium-ion batteries. This is advantageous for operations requiring extended endurance, such as aerial surveillance, package delivery, and emergency response operations.

Additionally, the adaptability of hydrogen fuel makes it a practical choice for off-the-grid or remote locations with limited access to conventional energy infrastructure.

Electrolysis can be used to create hydrogen by utilizing renewable energy sources like wind or solar energy, providing a decentralized and sustainable energy solution for both drone operations and public transportation.

Despite these difficulties, hydrogen fuel has undisputed advantages in lowering pollution and boosting endurance. By embracing this clean energy source, we can open the door to a greener, more sustainable future where drones can complete tasks quickly and effectively and public transport systems emit little pollution. To promote innovation, speed up adoption, and realize the full potential of hydrogen fuel in the transportation sector, governments, businesses, and researchers must work together and invest in hydrogen technologies.

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