ISSN: 2692-5397
Modern Concepts in Material Science
DOI: 10.33552/MCMS.2020.03.000567
Iris Publishers

Mini Review

Hydrogen Production For Sustainable Environment: Perspective

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Received Date: October 26, 2020
Published Date: November 11, 2020

Abstract

Hydrogen acts as an effective energy carrier, which cleanly produces water on its combustion as the only product can be considered as clean fuel for future. Globally, hydrogen is widely attentive in energy sector, which utilizes in power generation, heat distribution, energy storage, transportation and fuel cell applications. It is one of the potential key elements with ability to reduce the current issues such as climate change, energy security, automotive emission and environmental sustainability. However, this transition involves tremendous technological and scientific limitations for hydrogen based energy process. This short report aims to outline the issues related about production of hydrogen which is future energy carrier building-block of sustainable energy system.

Keywords: Hydrogen; Energy carrier; Production process; Environment; Sustainability

Hydrogen: An Overview

Hydrogen is the lightest and most abundant chemical element in the Earth's crust, but it is invariably linked up with all other elements to produce various hydrogen-containing sources and utilizes it in the form of energy. Energy plays a key role in current economic development, due to its significance in automobiles sector and industrial sector. Hydrogen is clean, safe and versatile energy carrier. Hydrogen liberates higher quantity (three times) of energy (39.4 $kWhkg^{-1}$) than that of any other liquid hydrocarbons (13.1 $kWhkg^{-1}$) fuels during its combustion process. Hydrogen is very important as a clean fuel ($H_2+O_2 = H_2O$ + Energy). Traditionally, hydrogen can be produced by numerous resources of fossil fuels, such as biomass, natural gas, coal, landfill crops and other renewable energy resources like electrolysis, solar and wind. The current few conventional processes for hydrogen production (almost~95%) are produced from fossil fuels by steam reforming of methane, partial oxidation of methane and auto-thermal reforming [1-3] processes. According to IEA Hydrogen Technology Collaboration Program (TCP), 2019, annual average hydrogen production is 70 million tons worldwide mainly through oil refining industries from various processes like, ammonia production fuel cell application and methanol production [4].

Therefore, It is of both scientific and practical challenge to explore other alternatives for the production of CO-free hydrogen in the current situation, where hydrogen acts as energy carrier.

Methods for Hydrogen Productions

Currently, there are few methods for production of hydrogen;

a) Steam reforming of methane is endothermic method (eq.1), where pure water is used as an oxidant at 700-1100 °C temperature range and nickel as catalysts. This endothermic reaction results into mixture of carbon monoxide and hydrogen called synthesis gas; however, removal of carbon monoxide increases whole process economics to achieve pure hydrogen yield. Further, carbon monoxide gas passed over metal oxides for water gas shift reaction (eq.2) to get pure hydrogen along with other by-products formation (CO, CO_2 and other hydrocarbons) [1-3]. The current conventional method for hydrogen production is steam reforming process. Steam reforming of methane reaction

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad (1)$$

Water-gas shift reaction

$$CO + H_2O \rightarrow CO_2 + H_2 \quad (2)$$

b) Partial oxidation of methane (eq.3) is an exothermic process in presence of air/oxygen, which is much faster but produces less hydrogen than that obtained from steam reforming of methane.

$$CH_4 + ½O_2 \rightarrow CO + 2H_2 \text{ (+ heat)} \quad (3)$$

c) Auto-thermal reforming of methane is a combination of steam reforming of methane and partial oxidation in presence of air and water vapor mixture to produce hydrogen (eq.4).

$$4CH_4 + O_2 + H_2O \rightarrow 4CO + 10H_2 \quad (4)$$

d) Catalytic methane decomposition is a promising process that simultaneously produces CO- free hydrogen with potential use in fuel cells & valuable carbon-nano materials (CNF/CNT) as by-products (eq.4). It is extensively studied along with fundamental studies [5-7]. Fuel cells are environmentally greener option for converting chemical energy into electrical energy. Also, clean solid carbon prevents risk of storage & transportation. Moreover, catalytic methane decomposition is simpler & economical process with lower operating conditions over other reforming technologies. However, technical challenge to develop long sustainable catalysts with high carbon capacity for process commercialization is needed.

$$CH_4 \rightarrow C + 2H_2 \quad (5)$$

e) Electrolysis is one of notable method to produce green hydrogen, where an electric current splits water into hydrogen and oxygen gas by using electricity input. This is one of the important methods for clean and green hydrogen production with zero-carbon footprint in this process [8-9].

f) Biomass gasification is another process of converting solid biomass fuel into gaseous combustible gases (CO, H_2 and traces of CH_4) via thermochemical reactions [10]. This process has great benefits of converting liquid and gaseous fossil fuels into value-added products such as, methanol, ethanol, biodiesel, and bio-oils, which can be used to generate hydrogen. The major limitation for this process is biomass availability. In addition, it requires higher land use than other processes and it is both food-limited and carbon-constrained resource.

General Summary

Overall, everyone needs to rethink about all the intermediate processes for hydrogen production in terms of carbon-free sustainable energy and hydrogen capital economy along with reduced environmental emissions, which are the most important factors in these current existing natural-gas processes.

Acknowledgement

Author sincerely acknowledge the support from Australian Alumni Grant Scheme Award AAGS-2020/21 (successful application AAGS2020072) on “Catalytic methane decomposition for hydrogen production”.

Conflict of Interest

No conflict of interest.

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