

Green Energy and Technology



Sarah Farrukh · Xianfeng Fan ·  
Kiran Mustafa · Arshad Hussain ·  
Muhammad Ayoub · Mohammad Younas

# Nanotechnology and the Generation of Sustainable Hydrogen

 Springer

# **Green Energy and Technology**

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Arshad Hussain · Muhammad Ayoub ·  
Mohammad Younas

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Sarah Farrukh   
School of Chemical and Materials  
Engineering  
National University of Sciences and  
Technology  
Islamabad, Pakistan


Kiran Mustafa   
Department of Chemistry  
The Women University Multan  
Multan, Pakistan

Higher Education Department  
Punjab  
Pakistan

Muhammad Ayoub  
Department of Chemical Engineering  
Universiti Teknologi Petronas  
Perak, Malaysia

Xianfeng Fan  
Department of Chemical Engineering  
University of Edinburgh  
Edinburgh, UK

Arshad Hussain  
Department of Chemical Engineering  
National University of Sciences and  
Technology  
Islamabad, Pakistan

Mohammad Younas   
Department of Chemical Engineering  
University of Engineering and Technology  
Peshawar, Pakistan

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*I want to dedicate this work to my parents “Abdul Hafeez,” “Jamila Hafeez”; my husband “Farrukh Hanif”; and my darling son “M. Sarim Janjua,” as without their support and guidance, I am unable to achieve anything in my life.*

—Sarah Farrukh

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—Kiran Mustafa.

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# Chapter 1

## Introduction



With the ever-increasing population, the energy demands of the world are continuously increasing. Already existing sources of energy like fossils fuel are harmful for the environment and also depleting day by day. The need of the hour is to look for the sustainable fuels which can satisfy the modern requirements of humans. Hydrogen is the promising alternative to the conventional fuels because of high energy contents, zero greenhouse gas emissions, and low environmental impacts. However, generation and storage of hydrogen involve several difficult procedures to increase the efficiency, and nanotechnology plays an imperative role in increasing the efficiency of these methods. The chapter will explain the various areas of sustainable hydrogen production and storage which employs services of nanotechnology.

### 1.1 Hydrogen Energy

The report issued by international energy agency states that the energy demands of the world will be twofold by the year 2030 [1]. The consumption of the power varies directly with the human population. The increase in human population resulted in incremental demand of the energy. The population of the world is assumed to be tripled by the year 2030. The most common form of energy is methane or natural gas which includes one carbon atom and four atoms of hydrogen. In order to obtain the maximum of the available resources on earth, the world has started to convert the energy from one form to the other. The fossil fuel energy resources are depleting fast along with being the cause of pollution and global warming. The world is now looking toward renewable energy. Different renewable energy sources like wind energy, solar energy, and waves are promising alternatives to the conventional fossil fuels. However, they are not enough to meet the demands of ever-growing population. From the past few years, hydrogen has emerged as promising fuel and its demand will be skyrocketing in the coming years [2].

**Table 1.1** Energy contents of different fuels

Fuel	Energy content (MJ/Kg)
Hydrogen	120
Liquefied natural gas	54.4
Propane	49.6
Aviation gasoline	46.8
Automotive gasoline	46.4
Automotive diesel	45.6
Ethanol	29.6
Methanol	19.7
Coke	27
Wood (dry)	16.2
Bagasse	9.6

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Hydrogen is a renewable energy as it is generated from the sources which are inherently renewable such as water. Hydrogen can be converted to the applicable forms of energy such as electricity via the application of small devices like fuel cells. When the hydrogen is converted to electrical energy the by-product is water which is harmless. Other than environment friendly, the energy contents of the hydrogen are also very high. The comparison of energy contents of different fuels is depicted in (Table 1.1).

The hydrogen fuel is important source of clean energy and is significant in overcoming the problem of fossil fuel shortage and has high extension usage. Moreover, the fossil fuels are major cause of harmful pollutants such as oxides of carbon, sulfur, and nitrogen which are produced as the by-product of fossil fuel combustion resulting in the global warming [5]. Different factors of fuels which influence the environment and its efficiency are given by different indicators such as environmental impact factor (EIF), greenization factor (GF), and the content of hydrogen factor (HCF) as shown in Fig. 1.1. The representation of the data in Fig. 1.1 depicts that the hydrogen fuel has lowest impact factor and highest greenization factor, hence making it one of the cleanest fuels.

Hydrogen gas must be produced on large scale and has been researched extensively, in terms of sources for hydrogen generation, methods of hydrogen extraction from various hydrogen sources, processes and techniques of hydrogen storage, and transportation and use of hydrogen in various electronic devices [5]. Sustainable hydrogen can be generated from various different resources, such as water [6], hydrogen sulfide [7], ammonia [8], hydrocarbons [9], biomass [10], etc. Different methods of extraction are involved in hydrogen production from these sources. After hydrogen generation, the next big step is the storage of hydrogen. The H<sub>2</sub> cannot be used as gaseous fuel in various electronic devices as the medium of fuel, it must be stored in a way that can ensure portable applications as well as automotive purposes [11].