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Advanced Catalytic Materials and Processes in Hydrogen Technology

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Abstract-

The study will examine the advanced catalytic materials that are used for enhancement of the rate of any chemical reaction and especially in context of hydrogen. The catalysis of the reaction related to hydrogen by using such catalyzing materials like metal oxides, nano particles of metal oxides and zeolites will be elaborated in this study. The discussed catalytic materials like zeolites and others are explained with the data obtained from the recent research and relevant information. The advantages of zeolites along with its details and chemical properties and structural properties will be hold into account in this study. The uses and disadvantages are also going to be discussed in this research. The uses and catalytic property of metal oxides will be also explained in this study along with their advantages and disadvantages and their reaction with hydrogen.

Keywords – Hydrogen as energy source, Zeolites, Metal oxides, Nano particles, Hydrogen business models

I. INTRODUCTION

Hydrogen is considered as a sustainable secondary energy source which is efficient and clean. Hydrogen can be obtained from renewable source of energy as well as it can also be obtained from traditional fossils. The renewable sources of energy are wind energy, tidal electricity energy, solar energy and others and they are mainly used for industrialization and transportation [1]. There are multiple ways of hydrogen production and its application that are about to break the outdated ways of energy conversion like conversion of electrical energy from obtained from burning coal. Hydrogen produces water on combustion when it is reacted with any metal oxide. Water has the property of deep decarbonization of the terminal consumption of energy. This is the reason behind the development of the hydrogen energy technology as it has become an essential for innovation of multi - energy supply systems which are based on the eco-friendly or green energy [2].

Hydrogen energy technology primarily includes three major steps that are, Production of Hydrogen, transportation and storage of hydrogen and the last is the applications. The catalytic process has an extremely essential role in the process of hydrogen production, transportation,

storage and applications. As it is observed that the methods used for the production of hydrogen, typical catalytic conversion processes are involved in it. Shift reaction, steam reforming, and electro catalytic water splitting is some of the major processes in which plays a crucial role in the catalytic conversion process [3]. The transportation process of Hydrogen is mainly the process which involves the charging and discharging of the hydrogen by using the pair of catalytic reaction by the help of dehydrogenation of cycloalkanes, and corresponding aromatic's hydrogenation.

Ways to produce hydrogen	Process
Gasification	Reaction of natural gas with high temperature steam.
Electrolysis	Splitting of water into hydrogen and oxygen by the use of electricity.
Fermentation	Sugar- rich feedstocks are fermented to produce hydrogen.

II. OBJECTIVES

- To examine the advanced catalytic materials
- To scrutinize the effects of zeolites as catalyst along with its uses
- To explain the advantages and disadvantages of Zeolites
- To elaborate metal oxide as catalyst along with its nano particles

III. METHODOLOGY

The catalytic materials are the substances that are involved in speeding up of the chemical reaction and saving time along with giving desired result. The latest materials and process for carrying out catalysis emphasizes the use of new and existing materials for the application of catalysis. The latest catalytic materials that are used nowadays for increasing the speed of the chemical reaction are zeolites, mesoporous materials, micro porous materials, monocrystals and metal oxides are the best examples. These substances do not undergo a change among themselves yet they bring change in the reaction rate with their involvement. The development of hydrogen energy field directly affected by the efficiency and effectively of the catalysis reaction.

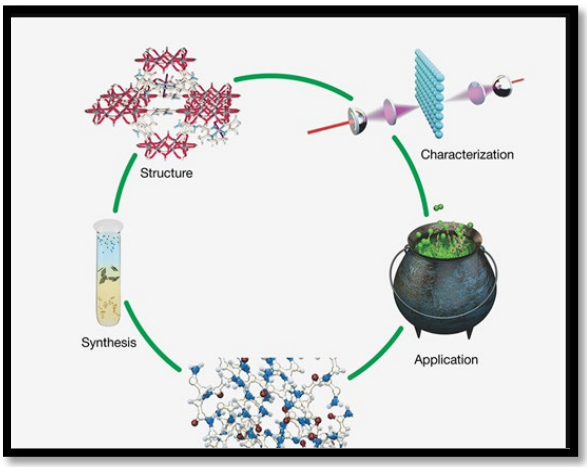

Figure 1: New Catalytic Systems

IV. ZEOLITES ALONG WITH ADVANTAGES

Zeolites are one of the most essential advanced catalytic material that is plays a crucial role in the hydrogen technology. Zeolites are actually alkaline earth metals and they are hydrated aluminosilicates. There are total 40 natural zeolites are discovered in the last two hundred years. Some of the common zeolites are chabazite, analcime, laumontite mordenite and others [4]. Zeolites are mainly made up of mixture of aluminium and silicon compounds and are used mainly in detergents, drying agents, water purifiers and more. Zeolites are micorporous material, these micros porous are interconnected through channels and the range of the diameter of the pores is starting from 0.2 to 2 nano meter. Zeolites are extremely useful due to its properties that are as given, high adsorption capacity, partitioning of the products and reactants, having a high surface area, the molecular dimensions of the pores, modulating the electronic properties of the active sites [5]. Preactivaing the molecules by the help of strong electric field and molecular confinement when the molecules are in the pore is one of the crucial property of zeolite that makes it a strong and useful catalyst. Zeolites are actually crystalline solid structures made up of oxygen, aluminium and silicon. The frame of the zeolites are mainly forms a frame with channels and cavities within which relatively molecules of small size, water and cations can reside in it [20].

V. DISADVANTAGES OF ZEOLITES

Along with such advantages of Zeolites there are certain disadvantages of this catalyst. The some of the main disadvantages of zeolites are its high sensitivity to deactivation by the process of irreversible adsorption and blockage of the secondary products [6]. Another disadvantage of

zeolite is the utilisation of the micro porosity of the catalyst in case of synthesis of the bulky or heavy molecules. The greater polarisation property of functional compound like zeolites, it is extremely difficult to change or exploit the shape of them in case of the reactions, as compared to in the case of exploitation of the shape of hydrocarbons.

Primary alcohols and the molecules derived from liquid biomass are interesting compounds which can be used as a source of hydrogen. These compounds are converted into hydrogen by using the process of steam reforming by utilising the moderate condition of reaction [7]. Zeolites are used for its unique properties like high thermal stability, hydrophilic and acidic properties, and well structured of the pores and topology. Zeolites are better option than conventional catalysts in case of catalysation of the reaction because zeolites have great acidic strength and they are extremely used in multiple chemical reactions [8]. Zeolites have the capability of adsorbing hydrogen; it is observed that the zeolites that are activated by the use of Palladium have shown high intensity of hydrogen adsorption capacity [9].

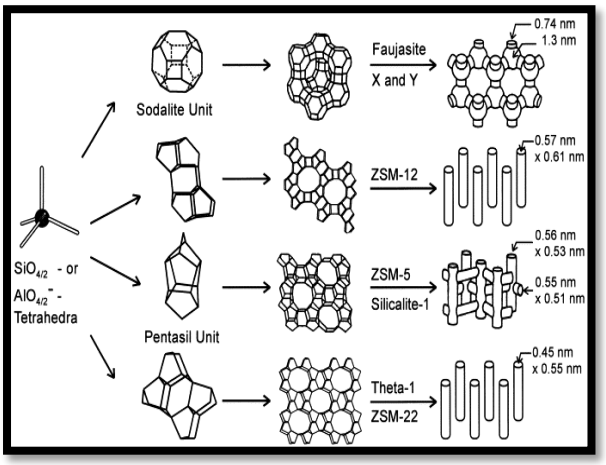

Figure 2: Catalysis of Zeolites

VI. METAL OXIDES

Metal oxides are one of the most essential catalytic materials that have its direct impact on the hydrogen technology. Oxides are basically catalysts that support noble metal catalysts. Metal oxides are essential materials for the biosensor and sensor application [10]. The reaction of metal oxides with hydrogen results in the formation of metal and water as the product of the reaction. Metal oxides are extremely essential and have multiple uses in chemical reaction due to its properties. The widely used metal oxides are involved in a reaction due to its property of acting as a catalyst for the enhancement of the speed of reaction.

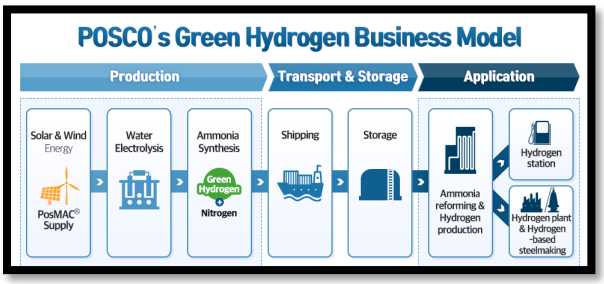

Figure 3: Hydrogen business models

Metal oxides are good adsorbents; they act as a super conductors and semiconductors in some of the cases. These oxides acts as ceramics and anti fungal agents, small scale of hydrogen production can be done using the metal oxides. Metal oxides also contribute in the generation of renewable sources of energy, the formation of such oxides support and provide them heat resisting property [11].

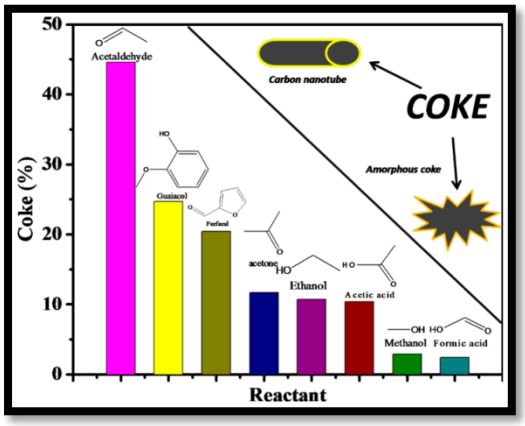

Figure 4: Catalysis of Mixed Metal

Metal oxides has multiple use in chemical reactions, in case of its activity as a catalyst in a chemical reaction it can be elaborated that sometimes these oxides helps by supporting the active phase of the chemical reaction [13]. Certain elements and compounds like silica, mesoporous oxide, alumina and others have the property of influencing the property of catalysis due to more than one reason like synergistic properties, due to the effects of thermal conductivity, the electron conductivity and others [14].

VII. NANO PARTICLES OF METAL OXIDE

The nano particles of the metal oxides increases its application and uses to a potential level. The application of nano particles includes its uses in microelectronics, sensing of gases, biomedicine, energy storage, environmental decontamination, ceramic fabrications, its use as catalyst in a chemical reaction and others [15]. Metal oxide nano particles have some properties that make it important for the discussion here, those properties are, and the process of preparation of metal oxide nano particles is simple. Nano particle of desired size can be engineered easily, the shape and porosity of the nano particle can also engineered in a simple way, these nano particles do not show any swelling variations when are used in a chemical reaction for catalysis [16]. There are different chemical systems in context to the affinity of the hydrogen, like hydrophilic and hydrophobic chemical systems. The metal oxide nano particles can be easily incorporated in the hydrophilic as well as the hydrophobic chemical reaction systems. The negative charge on the surface of the nano particles makes them extremely reactive and easily functionalizing by various molecules [17].

Metal oxides allows the extraction of greater power by the purification and recycling of the gases like argon, neon and others as all of these are noble gases. The energy so extracted from the purification and recycling of the inert gases or noble gases are utilised for the storage and capturing of the carbon, storage of chemical energy. The energy such produced is also used for the production of the solar panels and the production of pure hydrogen is also associated with the use of this energy [12].

The significant advantages of the nano particles of metal oxide are , the structural changes of these nano particles allows the altering of the parameters of the cell and altering of the lattice symmetry. The electrochemical characteristics can be changed because of the effect of quantum confinement [18]. The chemical activity and the conductivity of the nano particles is influenced by the drastic increase in the band gap caused due to the changes made in the surface properties of the nano particle [19].

Storage Technologies	Gravimetric Capacity (kWh/kg)	Volumetric Capacity (kWh/L)	Cost ($/kWh)
H_2 Gas @ 700 bar	1.9	1.3	16
Complex Metal Hydrides	0.8	0.6	16
Chemical Hydrides	1.6	1.4	8
Liquid Hydrogen	2	1.6	6
US DOE Goals for 2015	3	2.7	2

Figure 5: Storage technologies used in Hydrogen experiments

VIII. PROBLEM STATEMENT

The research explains the latest or advanced catalytic materials that are playing crucial roles in the hydrogen technology. There are some catalysts that have their influence in reacting with hydrogen and their affinity for hydrogen is quite high. The production of water after the combustion of hydrogen is an important factor aas water is itself a part of the ecosystem. Hydrogen is the prime source in the near future for the generation or conversionof energy from one form to another without generating any pollution that will harm the environment. Hence, hydrogen technology is extremely useful for the human beings in meeting the demand of the energy and decreasing the extent of pollution in the environment.

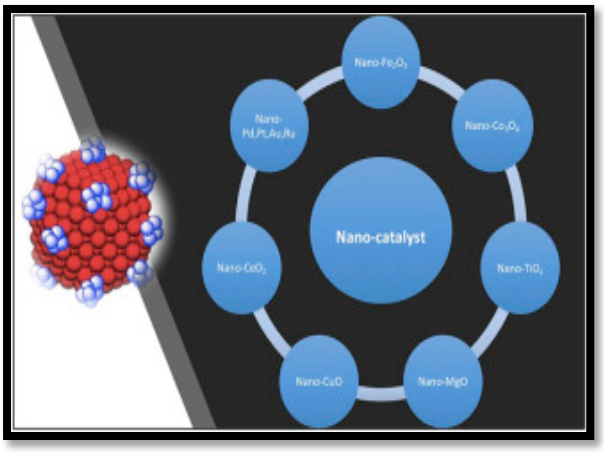

Figure 6: Organic Transformation by using Nano particles

The hydrogen based chemical reaction requires catalyst in order to increase the rate of the reaction. Some of the catalysts that react with hydrogen and are used in hydrogen technology are elaborated in the above research. The zeolites are some of the most useful and extremely reacting material that is used for the chemical reaction catalysis. They are nearly about 20 kinds of zeolites that are discovered till now. This research provides the information that is up to date and relevant with the data got from the recent discoveries about the facts related to the hydrogen technology along with its uses. Pollution and global warming are the two alarming factors for the whole world and that requires some effective steps to be taken to tackle the danger that is going to emerge in the near future if the present situation continues like this [20].

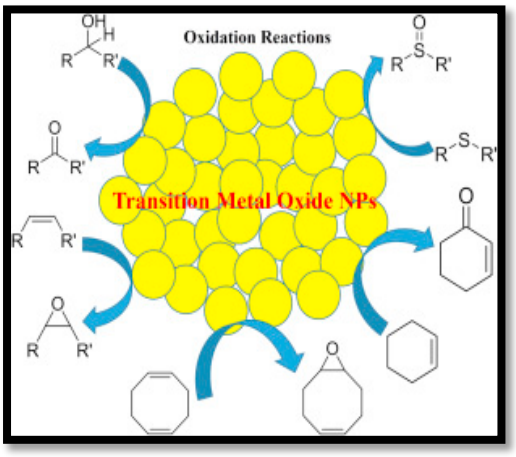

Figure 7: Nano particles of Transition metals as catalyst

CONCLUSION

The advanced catalytic materials enhancing the rate of reaction and are also enhancing the process related to hydrogen development. Hydrogen related power generation is an extremely efficient option for the future generation in order to maintain the non- renewable sources for the generation of the energy as it is going to be exhausted in the near future. The use of the energy generated from renewable sources of energy is eco-friendly reduces the threatening factors to the environment. Metal oxides and zeolites play crucial role in the development of hydrogen technology and are extremely reactive to hydrogen. The uses of zeolites and metal oxides have certain advantages and disadvantages that are discussed in this research.

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