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Review Article

A Review on Reforming Reactions with Emphasis on Methane Reforming

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ABSTRACT

Methane reforming reactions are important for hydrogen production synthesis from natural gas. Three important types of reforming reactions are steam, oxygen and carbon dioxide reforming. Each of these reactions has its own advantages and disadvantages. Methane is favorite source of hydrogen. Fuel cells can directly convert chemical energy into fuel. Steam reforming of methane (SRM) is well established process to produce H_2 for FC. In current review, research and studies on various aspects of reforming reactions are summarized.

***Key words**: Catalyst, activity, oxidation, Pressure, temperature.*

INTRODUCTION

The natural sources of fuels are depleting day by day. Other sources such as wind energy, solar energy are being explored. [1-5] The waste heat recovery, regeneration and co-generation are other means minimize heat requirement. [6-10] Hydrogen production in efficient manner is very important aspect in investigations in energy sector. Natural gas and crude oil contains Alkanes, (saturated hydrocarbons). There is a big challenge to researchers in direct conversion of methane, the dominating component in natural gas, into key chemical products. Fuel cells are being explored for hydrogen production. [11-15] Reforming or partial oxidation of natural gas producing synthesis gas is commonly used method for hydrogen production. Many technologies such as reforming of natural gas, Water electrolysis, gasification of coal, photo electrolysis, high temperature decomposition of water, biomass are being explored for hydrogen production. Many investigations are reported on reforming reactions. These investigations are aimed at studying comparative yield by using different catalysts, sources of hydrogen and temperature conditions. The current review summarizes research and studies on reforming reactions.

A REVIEW ON REFORMING REACTIONS WITH EMPHASIS ON METHANE REFORMING

An investigation was carried out by Zhang et.al. in order to improve a small-size gasification unit. [16] According to this research the reaction temperature has important impacts on semicoke catalyzed methane gas mixture. The catalytic activity of reforming can be enhanced by the addition of water vapor. The study carried out by them indicated that the semicoke can reduce the activation energy of the reforming reaction. Dong et.al studied methane reforming reactions over Ni/MgO catalyst for hydrogen production. [17] They carried out steam reforming of methane (SRM), partial oxidation of methane (POM), and oxy-steam reforming of methane (OSRM). The catalyst showed high activity and good stability in all the reforming reactions. Fakeeha et.al evaluated the selectivity and yield of hydrogen over γ-

Al_2O_3 supported and Sr promoted Ni based catalysts from CH_4-CO_2 reforming. [18] They observed that that selectivity and yield of H_2 increased with the increase of reaction temperature and the optimum reaction temperature was 700^0C.Dry reforming of methane over Nano Ni Polyol catalysts was investigated by Naeem et.al. [19] They produced syngas from the process. The dry methane reforming is considered environmental friendly due to the fact that, it utilizes two major greenhouse gases (CH_4 and CO_2).They prepared the catalyst in ethylene glycol medium with polyvinylpyrrolidone as a nucleation-protective agent. They produced the catalyst with high activity, stability and minimum coking rate during DRM.

According to Roh et.al the reforming methods attracting the researchers are, steam was reforming, oxy-CO_2 reforming. [20] Carcadea et.al carried out an investigation on steam methane reforming. [21] In their simulation studies, they considered two domains (reforming and permeating areas). In their investigation, they determined the maximum value of temperature in the sweep area of the porous membrane reactor. According to the results obtained by them, in the sweep area, the temperature was up to 450°K. The temperature, on the reforming side of the membrane was 617° K. Their study gave better knowledge of the reactions involved in steam methane reforming process. Halabi presented an experimental and modeling study for an improved process of sorption enhanced catalytic reforming. [22] In his investigation, he used novel catalyst/sorbent materials for low temperature high purity H_2 with in situ CO_2capture.His investigation indicated that direct production of high H_2 purity and fuel conversion (>99%) is achieved with low level of carbon oxides impurities (<100 ppm). According to him, the enormous reduction of the reactor size, material loading, catalyst/sorbent ratio, and energy requirements are driving forces behind use of Rh/Ce_Zr1-α O_2 catalyst and K_2CO_3–promoted hydrotalciteprocess. Roh and Jun carried out an investigation on hydrogen production for fuel cells by low temperature methane steam reforming process. [23] According to their thermodynamic equilibrium analysis, it is possible to operate methane steam reforming at low temperatures. They proposed a scheme for the low temperature methane steam reforming. The scheme was aimed to produce H_2 for fuel cells by burning both unconverted CH_4 and H_2 to supply the heat for steam methane reforming. From their investigation, it was concluded that that low temperature methane steam reforming is possible with stable activity.

Abdel-Aaland Abdelkreem explained challenges and progress in methane conversion. [24] According to them, there is an immense and powerful potential in efficient and economic conversion of methane to more valuable products. They discussed three routes. These routes of syngas (CO/H_2) production provide two sub routes, methane to gasoline (Mobile) and hydrocarbons (Fisher-Tropsh) conversion. Other two options are catalytic methane decomposition, CMD and direct methane conversion, DMC. Munera et.al investigated the catalytic production of hydrogen through the carbon dioxide reforming of methane. [25] They carried out reaction in plug flow reactor and in a dense Pd/Ag membrane reactor. They studied the activity and stability of Pt/La_2O_3 and compared it to the Rh/La_2O_3 solids. They observed that the Rh (0.2%)/$La_2O_3$was much more stable than the Pt/La_2O_3formulations.Neiva and Gama discussed the importance of natural gas reforming. [26] According to them, the catalyst is an indispensable element in the reforming of the methane process. Catalyst carries out functions aimed to activate, accelerate, optimize, direct interactions or block interactions. Paul used LaCrl-,Ni,0_3 Perovskite catalysts for methane steam reforming. [27] He observed that catalysts work well from 700 to 900 K for methane conversion. Also he observed that catalyst was more active at higher nickel content than at the lower nickel content. Ross carried out studies on the catalytic conversion of natural gas to useful products.[28] He discussed important subjects such as steam reforming, oxidative coupling and CO, reforming of methane. Emphasis of his studies was on the development of novel catalysts for these processes. According to him, steam reforming was a major use of natural gas for the production of hydrogen in the petrochemical industry and for methanol synthesis. Thermodynamic analysis of methane dry reforming was carried out by Ying. [29] He carried out an investigation on the thermodynamic aspect of methane dry reforming at reforming temperature from 500 to 1000K at atmospheric pressure. Also he studied reaction at different methane to carbon dioxide ratios. He used Gibbs free energy minimization method. The results of his experiments showed that the product distribution was affected by the temperature.

CONCLUSION

Methane is favorite source of hydrogen. Fuel cells can directly convert chemical energy into fuel. Steam reforming of methane (SRM) is well established process to produce H_2 for FC. Reforming or partial oxidation of natural gas producing synthesis gas is commonly used method for hydrogen production. Many technologies such as reforming of natural gas, water electrolysis, gasification of coal, photo electrolysis, High temperature decomposition of water, biomass are being explored for hydrogen production. Many investigations are reported on reforming reactions. Research and studies on reforming reactions have been summarized in review.

REFERENCES

1. Vinod Kumar Verma, Ivan Sunit Rout, A.K.Rai, Abhishek Gaikwad, "Optimization of Parameters Affecting the Performance of Passive Solar Distillation System by using Taguchi Method", IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE), 2013, 7(2), 37-42.
2. A. F. Al-Hamadani, S. K. Shukla, "Water Distillation using Solar Energy System with Lauric Acid as Storage Medium", International Journal of Energy Engineering, 2011, 1(1), 1-8.
3. Sunil Jayant Kulkarni, "Solar Distillation: A Review", International Journal of Research (IJR), 2014, 1(11), 1171-1176.
4. Sunil Jayant Kulkarni, "Tidal Energy: A Review", International Journal of Research (IJR), 2015, 2(1), 55-58.
5. Syed Shah Khalid, Zhang Liang and Nazia Shah, "Harnessing Tidal Energy Using Vertical Axis Tidal Turbine", Research Journal of Applied Sciences, Engineering and Technology, 2012, 5(1), 239-252.
6. Kulkarni SJ, Kherde PM., "A review on studies and research on heat recovery, regeneration and cogeneration", Int J Res Rev., 2015, 2(9), 584-589.
7. R. Saidur, M. Rezaei, W.K. Muzammil, M. H. Hassan, S. Paria, M. Hasanuzzaman, "Technologies to Recover Exhaust Heat from Internal Combustion Engines", Renewable and Sustainable Energy Reviews, 2012, 16, 5649-5659.
8. Mojtaba Tahani, Saeed Javan, And Mojtaba Biglari, "A Comprehensive Study on Waste Heat Recovery from Internal Combustion Engines using Organic Rankine Cycle", Thermal Science, 2013, 17(2), 611-624.
9. Kyaw Thu, K.C. Ng, B.B. Saha and A. Chakraborty, "Overall of Heat Transfer Analyses of a Heat-Driven Adsorption Chiller", 2010 International Symposium on Next-generation Air Conditioning and Refrigeration Technology,17-19 February 2010, Tokyo, Japan, 1-10.
10. M. Dubey, A. Arora, H. Chandra, "Review on Waste Energy Recovery Systems", International Journal of Innovative Research in Science, Engineering and Technology, 2014, 3(12), 18356-18387.
11. Kulkarni SJ, "A Review on Studies and Research on Fuel Cells", Int. J Res Rev., 2016, 3(1), 77-80.
12. A.Boudghene Stambouli, E. Traversa, "Fuel Cells, an Alternative to Standard Sources of Energy", Renewable and Sustainable Energy Reviews, 2002, 6, 297–306.
13. Vijay A. Sethuraman, and John W. Weidner, "Analysis of Sulfur Poisoning on a PEM Fuel Cell Electrode", Electrochimica Acta, 2010, 55(20), 5683-5694.
14. Pranab K. Barua, D. Deka, "Electricity Generation from Bio-waste Based Microbial Fuel Cells", International Journal of Energy, Information and Communications, 2010, 1(1), 77-92.

15. Zhen He, Largus T. Angenent, “Application of Bacterial Biocathodes in Microbial Fuel Cells”, Electroanalysis, 2006, 18(19), 2009-2015.
16. Guojie Zhang, Aiting Su, JiangwenQu, and Yannian Du, “A Novel Study of Methane-Rich Gas Reforming to Syngas and its Kinetics over Semi-coke Catalyst”, Hindawi Publishing Corporation The Scientific World Journal, Vol.2014, Article ID 707294, 1-6.http://dx.doi.org/10.1155/2014/ 707 294
17. Wen-Sheng Dong, Hyun-SeogRoh, Zhong-Wen Liu, Ki-Won Jun, and Sang-Eon Park, “Hydrogen Production from Methane Reforming Reactions over Ni/MgO Catalyst”, Bull. Korean Chem. Soc., 2001, 222(12), 1323-1327.
18. Anis H. Fakeeha, Ahmed A. Ibrahim, Muhammad A. Naeem and Ahmed S. Al–Fatesh, “Energy Source from Hydrogen Production by Methane Dry Reforming”, Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management Bali, Indonesia, January 7-9, 2014, 606-613.
19. Muhammad Awais Naeem, Ahmed Sadeq Al-Fatesh, Wasim Ullah Khan, Ahmed Elhag Abasaeed, and Anis Hamza Fakeeha, “Syngas Production from Dry Reforming of Methane over Nano Ni Polyol Catalysts”, International Journal of Chemical Engineering and Applications, 2013, 4(5), 315-320.
20. Hyun-Seog Roh, Ki. Won Jun, Seung Chan Baek, Sang Eon Park, “Highly Active and All round Catalyst for Methane Reforming Reactions: Ni/Ce-ZrO_2/θ-Al_2O_3”, Bull. Korean Chemical Society, 2002, 23(6), 793-794.
21. Elena Carcade, MihaiVarlam, IoanStefanescu, “Heat Transfer Modeling of Steam Methane Reforming”, Proceedings of 2012, COMSOL Conference, Milan, 1-5.
22. Halabi, M.H., “Sorption enhanced catalytic reforming of methane for pure hydrogen production: experimental and modeling”, Eindhoven: Technische Universiteit Eindhoven, 2011, pp.1-249. DOI: 10.6100/IR709035.
23. Hyun-SeogRoh and Ki-Won Jun, “Low Temperature Methane Steam Reforming for Hydrogen Production for Fuel Cells”, Bull. Korean Chem. Soc., 2009, 30(1), 53-56.
24. Hussein K. Abdel-Aaland Maha Abdelkreem, “Challenges and Progress in Methane Conversion: An Assesment”, Chemical Engineering, 2016, 1, 1-10.
25. J. Munera, S. Irusta, L. Cornaglia, E. Lombardo, “CO_2 Reforming of Methane as a Source of Hydrogen using a Membrane Reactor”, Applied Catalysis A: General, 2003, 245, 383-395.
26. Laedna Souto Neiva and Lucianna Gama, “The Importance of Natural Gas Reforming”, www.intechopen.com, 2010, 71-86.
27. Ram Chandra Paul, “Methane Steam Reforming over $LaCr_{l-x}$, Ni,0_3Perovskite Catalysts”, A thesis in confomity with the requirements for the Degree of Master of Applied Science Department of Chermical Engineering and Applied Chermistry University of Toronto,2000,1-111.
28. J.R.H. Ross, A.N.J. van Keulen, M.E.S. Hegarty, K. Seshan, “The Catalytic Conversion of Natural Gas to Useful Products”, Catalysis Today, 1996, 30,193-199.
29. Kong Zi Ying, “Thermodynamic Analysis of Methane Dry Reforming”, Thesis submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Chemical Engineering. Faculty of Chemical and Natural Resources Engineering University Malaysia Pahang, February 2013, 1-24.

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