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Utilization of low-grade iron ore in ammonia decomposition

Nur Ezzah Faezah Othman, Hamzah Mohd Salleh, Hadi Purwanto*

Faculty of Engineering, International Islamic University Malaysia, Jalan Gombak, 53100, Kuala Lumpur, Malaysia

Abstract

Due to its cleanliness, fast energy cycle, and convenience of energy conversion, hydrogen has been regarded as the new energy source. Conventional process to produce hydrogen yield large amount of CO as byproduct. Moreover, the hydrogen storage and transportation have become the drawbacks in hydrogen economy. Thus, there has been increased interest in the hydrogen transportation medium as alternatives from the conventional process to produce and transport hydrogen. Ammonia has drawn worldwide attention as the most reliable hydrogen transportation medium. Through the decomposition of ammonia, hydrogen and nitrogen gas were produces as the byproduct without any CO or CO_2 emission. In this experiment, the ore were introduced as the medium for ammonia decomposition. The ore were put into quartz tube reactor and were dehydrated at 400°C for 1 hour, then hydrogen reduced for 2 hours before and undergone ammonia decomposition at 500-700°C for 3 hours. The effects of temperature to the % conversion of ammonia decomposition were also studied. Ammonia decomposition at higher temperature gives higher conversion. As seen in the results, the NH_3 conversion decreased with increasing time and the value after 3 hours of reaction increased in the sequence of 500°C<600°C< 700°C. During ammonia decomposition, nitriding of iron occurred. The relation between temperature and the nitriding potential, K_N is also investigated. The purpose of this study is to investigate the utilization of low-grade ore as medium for ammonia decomposition to produce hydrogen.

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Keywords: Hydrogen; hydrogen storage; hydrogen transportation; ammonia decomposition

* Corresponding author. Tel.: +6-03-6196-5753; fax: +6-03-6196-4477.
E-mail address: hadi@iium.edu.my

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1. Introduction

Hydrogen is conventionally produced from fossil fuel either by steam reforming, methane cracking, and carbon dioxide decomposition methods[1]. Conventional processes such as steam reforming, authothermal reforming and partial oxidation yield large amount of CO as a byproduct[2, 3] which would cause problems of poisoning of the reforming catalyst[2]. Studies in the generation of clean hydrogen have become recent interest in developing polyelectrolyte membrane fuel cells car for fuel cell application[4, 5]. However, one of the main problems is of hydrogen supply. Some proposed ways to transport hydrogen are by using liquid hydrogen directly, hydrogen storage materials, or reformation of chemical hydrides such as hydrocarbon. Ammonia, NH_3 has drawn worldwide attention as hydrogen transportation medium[6]. The operated process produces no carbon monoxide, CO or carbon dioxide, CO_2 gasses however, nitrogen, N_2 gas is produced instead as the only co-product[4]. Primary iron resources in Malaysia, hematite, is expected to be in shortage in the near future. Low-grade iron ore is an attractive alternative domestic iron ore resource however it contains low Fe content, high amount of gangue material and combined water[7, 8]. Since Malaysia has low-grade iron ore resources such as goethite, it could be utilized and become good alternative for iron resources through some treatment processes via dehydration of iron ore[9]. The removal of combined water via dehydration process would create pores within it and increased the surface area of ore. Ammonia decomposition with low-grade ore produced hydrogen and nitrogen. The nitriding of metal is also associated with the ammonia decomposition reaction. During ammonia decomposition, the ammonia gas will react with the iron ore at the iron surface, yielding hydrogen and nitrogen gasses to atmosphere. However, due to the surface reaction between ammonia gas and iron phase, it is necessary that the dissolution of nitrogen in iron phase occurs via the dissociation of ammonia at the surface, followed by the dissolution of nitrogen in iron and the formation of nitrogen gas to the atmosphere. The schematic diagram of ammonia decomposition process with ore is illustrated in Fig.1.

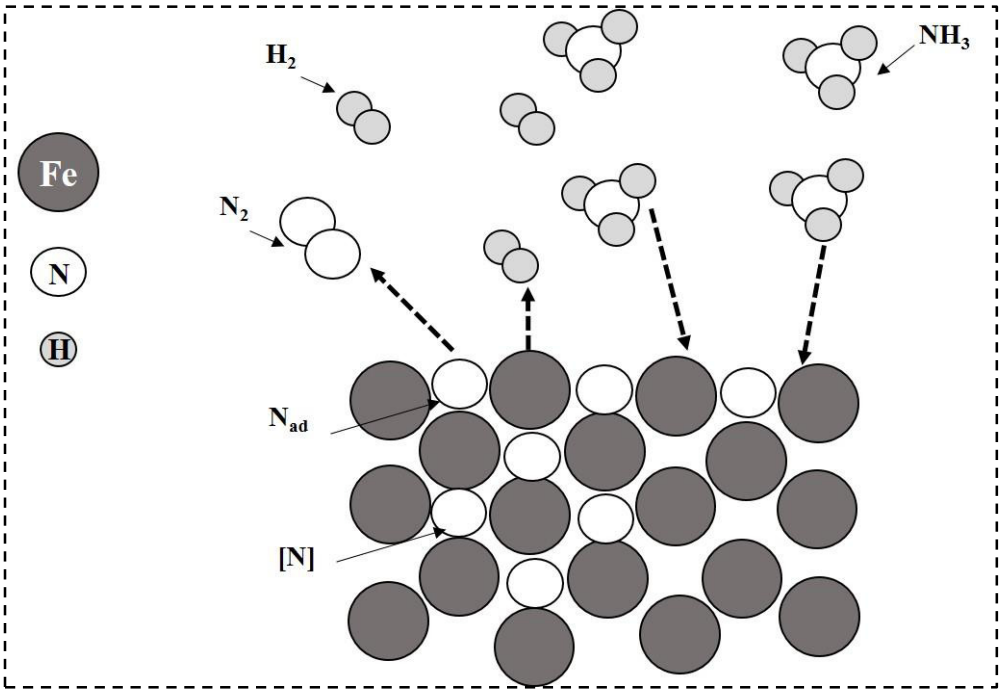

Fig. 1. Schematic diagram of ammonia decomposition process with iron ore