UTILIZATION OF MALAYSIAN LOW GRADE IRON ORE AS MEDIUM FOR AMMONIA DECOMPOSITION

Nur Ezzah Faezah Othman, Hadi Purwanto and Hamzah Mohd Salleh
Faculty of Engineering, International Islamic University Malaysia, Jalan Gombak, Gombak, Selangor, Malaysia
E-Mail: hadi@iium.edu.my

ABSTRACT

Hydrogen has been regarded as the new energy source due to its cleanliness, fast energy cycle and convenience of energy conversion. Hydrogen storage and transportation difficulties have become major drawbacks in hydrogen economy. Conventional process of steam reforming produces large amount of CO as byproduct. Thus, ammonia has attract worldwide attention as new alternative for hydrogen storage as ammonia decomposition yields H₂ and N₂ as byproduct without any CO emissions. Low grade ore is used as medium for enhancing ammonia decomposition. This paper presents the study of low-grade iron ore as medium for ammonia decomposition. Malaysian low-grade iron ore was taken as the raw material in this experiment. Ammonia decomposition over iron ore medium were studied at temperature of 500-700°C. The nitriding potential of ore were also studied.

Keywords: ammonia decomposition, hydrogen, low grade iron ore, ammonia conversions and nitriding potential.

INTRODUCTION

Ruthenium- based catalysts has been reported as the most active catalyst for ammonia decomposition so far due to it high conversion of NH₃. However, due to its limited resources and high cost material, ruthenium catalyst becomes the obvious disadvantage especially for large scale applications. Ni- based catalyst is also widely used as catalyst; however, ammonia decomposition over Ni-catalyst requires operating temperature as high as 1000 °C [1]. In contrast, iron- based catalyst with availability and much lower cost demonstrates high reactivity of ammonia conversion at lower operating temperature. As stated by [2], they reported the use of limonite ore in catalytic ammonia decomposition for a hot gas clean up method. Earlier studies have also reported the used of ferrous dolomite and sintered iron ore were effective for decomposing a low concentration of NH₃ for ammonia decomposition at 900 °C [3]. Also, [4] reported that ammonia decomposition with hematite ore occurred at temperature of 430 °C which yield hydrogen and nitrogen. Ammonia had gained worldwide attention as new alternative for hydrogen transportation medium. Ammonia decomposition is endothermic process which produces hydrogen and nitrogen [4-5] with no CO emissions as byproduct [6]. This paper presents the study of low grade iron ore as medium for ammonia decomposition at temperature of 500-700 °C. The ammonia conversion to hydrogen and nitrogen were studied as well as the effect of temperature on the ammonia decomposition. Nitriding potential of ore were also investigated.

EXPERIMENTAL METHOD

The experiment was performed in a quartz tube reactor having internal diameter of 6 mm. Approximately 0.25 g of ore were charged into the fix bed reactor and were dehydrated up to 400 °C and held for 1 hour with heating rate of 10 °C/min under nitrogen flow. Prior to ammonia decomposition, the dehydrated ore were then heated to 500 °C and then treated with H₂ reduction for 2 hours to enhance the catalytic performance of ore. The hydrogen flow was stopped after constant flow of gas for 2 hours had been achieved. Then, before subjected to NH₃ decomposition, the N₂ flow in the reactor was restored to into nitrogen flow for 5 to 10 minutes to remove the excess hydrogen in the reactor. Decomposition of NH₃ over ores was conducted under pure NH₃ flow for 3 hours. The gas product were analysed using online micro GC while the mineral composition and characterization were performed using the XRD measurement and SEM analysis. This process was repeated by raising the temperatures to 600 °C and 700 °C to compare the effects of temperature to the ammonia conversions during ammonia decomposition.

RESULTS AND DISCUSSIONS

The low grade ore used in this present study which was taken from Chini area from Pahang state Malaysia was employed as the raw material. Mineral composition of the original ore consists of iron oxide species of 58.1% with the existence of other gangue minerals such as alumina, silica, mangan oxide, calcium, vanadium and titanium are shown as tabulated in Table-1. Ammonia decomposition using low grade iron ore as medium for ammonia decomposition at temperature of 500-700 °C. The ammonia conversion to hydrogen and nitrogen were studied as well as the effect of temperature on the ammonia decomposition. Nitriding potential of ore were also investigated.
iron ore is 8%. From the graph, it can be observed that decomposition starts at temperature of 200 °C. Continuous weight loss were observed in the temperature range of 200-400 °C. The total weight loss indicates the high combine water presence in the ore.

Table-1. Mineral composition of iron ore.

<table>
<thead>
<tr>
<th>Source of Iron ore</th>
<th>Fe</th>
<th>Si</th>
<th>Al</th>
<th>S</th>
<th>Mn</th>
<th>V</th>
<th>Ti</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chini (Pahang)</td>
<td>58.1</td>
<td>0.8</td>
<td>1.3</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
<td>6.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Figure-1. Thermal analysis of original iron ore.

Figure-2. Mechanism during ammonia decomposition.

Figure-3. Ammonia decomposition using ore as medium at 500 °C -700 °C.

Figure-4. Nitriding potential of ore at 500 °C -700 °C.

CONCLUSIONS

Figure-4 shows the nitriding potential of ore at 500 °C -700 °C. Decomposition of ammonia is associated with the nitriding of iron on the surface of the ore. This would results in the formation of iron nitride phase. As the operating temperature during ammonia decomposition is lower, the nitriding potential is higher. This is due to the higher concentration of nitrogen on the surface of ore during low temperature operation, which contribute to the formation of iron nitride.

REFERENCES


