Ammonia Cracking in Atmospheric Plasma Discharge for Clean H_2 Production

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Highlights

- H_2 was achieved from NH_3 decomposition.
- H_2 yield increased linearly with plasma power.
- 2.5% of H_2 concentration was obtained for an energy consumption of 2.4 kJ/L.

1. Introduction

The potential use of hydrogen as an energy carrier is currently of vital importance due to its sustainable nature to contribute towards a cleaner fuel. The extensive use of fossil fuels for the production of energy has led to a significant amount of environmental impact along with the depletion of the non-renewable source of energy [1]. Therefore, H_2 is seen to have a greater potential to store and provide enormous amount of energy compared to other hydrocarbon fuels.

Today, the majority of H_2 is produced from the reforming of natural gas, coal gasification and electrolysis; the former contributing towards the most amount of H_2 demand [2]. Recently, ammonia (NH_3) as a hydrogen carrier has gained a lot of importance for the production of green hydrogen. NH_3 is approximately 18% H_2 by weight which makes it almost 50% higher compared to compressed H_2 in terms of H_2 density [3]. Heterogeneous catalysis of NH_3 for the production of H_2 has been extensively used with various active components ranging from noble metals such as Ru, to other metal catalysts [4, 5]. Decomposition of NH_3 using plasma is a preferable alternative for energy efficient H_2 production. Different types of non-thermal plasma, particularly dielectric bed discharges are preferred for its effective coordination with catalysts. Non-thermal plasma provides high-energy electrons and excited particles at atmospheric conditions capable of sustaining various chemical reactions at low temperatures.

This work uses a rotational gliding arc discharge for the cracking of ammonia. Particularly, a mixture of N_2 and NH_3 was exposed to gliding arc plasma which was driven by an AC 400Hz high voltage. Different parameters were investigated to study their effects on the overall H_2 yield and NH_3 decomposition.

2. Methods

The gliding arc reactor consisted of a copper high voltage conical electrode which was enclosed in a cylindrical shaped ground electrode. The plasma was generated using a 400Hz transformer connected to a frequency converter (Sampoong Power Co., Ltd., Korea). The feed gases (N_2 and NH_3) were controlled using Mass Flow Controllers (AFC500, Atovac Co., Korea). The inlet gas to the reactor and the plasma treated gas components were analyzed in GC (iGC7200) equipped with a thermal conductivity detector.

3. Results and discussion

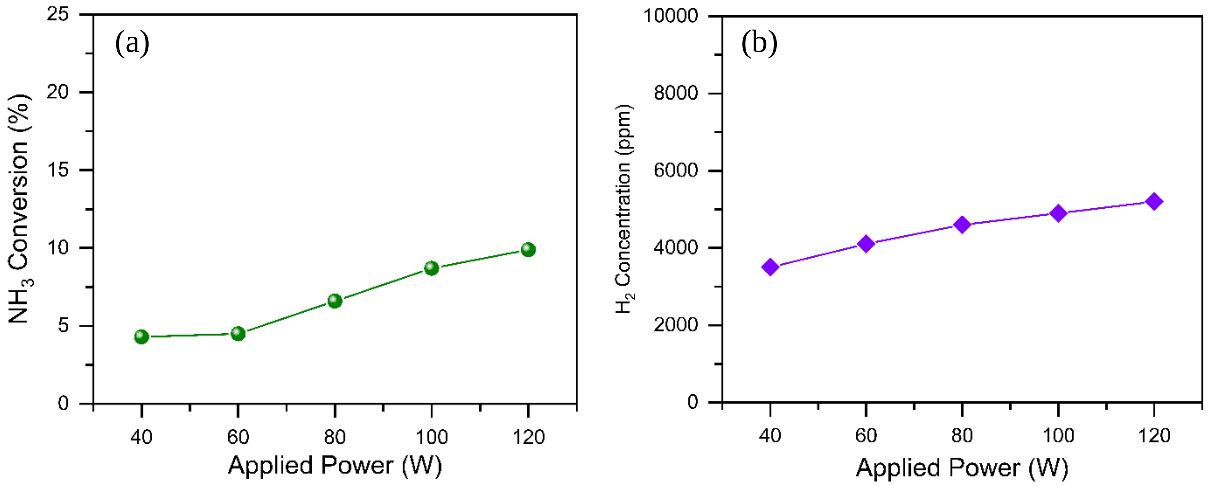

Figure 1. (a) NH_3 conversion and (b) H_2 concentration in the reactor outlet at a total flow rate of 3.5 L/min (NH_3 content =10%)

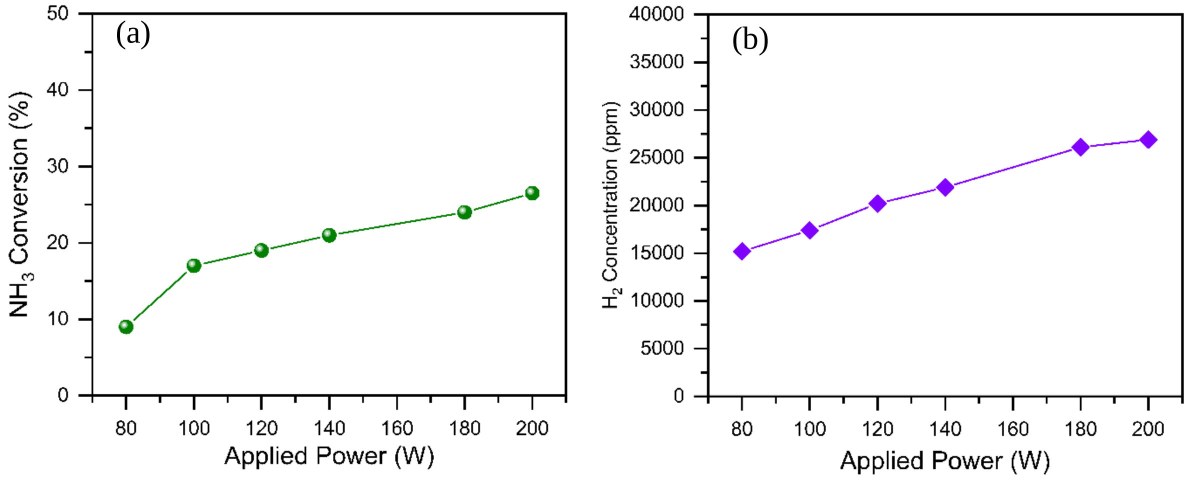

Figure 2. (a) NH_3 conversion and (b) H_2 concentration in the reactor outlet at a total flow rate of 5 L/min (NH_3 content = 10%)

4. Conclusions

This work shows the potential of nonthermal gliding arc plasma in H_2 production from ammonia. the applied power and the gas flow rate were found to affect the H_2 yield. Around 2.5% of H_2 concentration was achieved for a specific input energy of 2.4 kJ/L.

References

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Keywords

Non-thermal plasma, Ammonia decomposition, Rotational gliding arc, H_2 production.