Zirconium Oxide Carrier Catalysts for Plasma-Catalytic Ammonia Decomposition

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Abstract: The energy demand is growing, and the most commonly used energy sources are fossil fuels. Due to environmental problems, hydrogen is considered as a modern energy source. An ammonia can be the carrier of hydrogen. One of the decomposition methods of NH_3 is non-equilibrium plasma in plasma-catalytic systems. Discharge power, initial NH_3 concentration, and active phase of the catalyst influenced the ammonia decomposition.

1. Introduction

The development of the modern economy is based on the use of energy and increasing the productivity and competitiveness of technological processes. The energy demand is growing worldwide, and the most commonly used energy sources are fossil fuels. Due to environmental problems, new and renewable energy sources, carriers of energy, and methods of transporting these carriers are sought. One of the modern energy carriers may be hydrogen, obtained from renewable sources i.e. biogas, bio-alcohols, or water electrolysis. It is expected, that using hydrogen as a fuel, contribute to increasing the climate neutrality of industry and transport by reducing carbon dioxide emissions. A significant challenge is to develop an effective and economical method of transportation and storing hydrogen due to its low density and small molecular size. Hydrogen can be stored by using various techniques, including binding hydrogen in chemical compounds. The most promising is ammonia because it contains 17.8% hydrogen by weight. Ammonia can be liquefied easily and during its decomposition, no harmful products are emitted into the atmosphere. One of the decomposition methods is non-equilibrium plasma in plasma and plasma-catalytic systems [1 - 3]. The aim of the study was an investigate the effect of the plasma-catalytic system with a gliding discharge and solid bed of catalyst on the hydrogen-obtaining process.

2. Methods

Ammonia decomposition was conducted in the plasma-catalytic system with gliding discharge and a solid bed of supported catalyst [2]. Three kinds of catalysts containing Co, Ni, or Fe supported on zirconium oxide were used. An ammonia-nitrogen mixture was prepared from ammonia of 2.85 N purity and nitrogen of 5 N purity and introduced to the reactor with a constant flow rate of 180 l/h. Ammonia concentration was in range 0.5-0.9. The gas flow rate was regulated by the Bronkhorst mass flow controllers. The ammonia concentration was analyzed by a Thermo Scientific TRACE 1600 gas chromatograph and hydrogen and nitrogen were analyzed by a Chrompack CP 9002, both with a detector TCD. The discharge power was regulated by a thyristor power regulator. The reactor was powered with a current of 50 Hz. High voltage was obtained using a Fart Resinblock 2000 high-voltage transformer [2, 3].

3. Results and Discussion

The discharge power and initial concentration of ammonia influenced the plasma-catalytic ammonia decomposition process. With the increase of discharge power ammonia conversion was increased rapidly. The effect of the initial concentration of ammonia was more distinct at discharge power above 250 W. The highest ammonia conversion was obtained at discharge power 400 W and NH_3 initial concentration 0.5 in nitrogen (Fig. 1A). Energy consumption calculated for hydrogen obtaining depends only to a small extent on the discharge power. However, the increase in the ammonia initial concentration reduces the energy consumption significantly (Fig 1B).

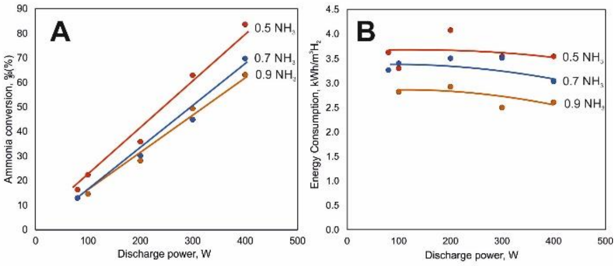

Fig.1. Effect of discharge power and initial NH_3 concentration on ammonia conversion (A) and Energy consumption (B).

4. Conclusion

Plasma-catalytic systems can be an efficient method for ammonia decomposition. Initial ammonia concentration and discharge power strongly influenced the process. The catalysts supported by zirconium oxide are active in the ammonia decomposition process, so it is possible to reduce the energy consumption of hydrogen obtaining. This is particularly important when a plasma-catalytic system will be used for hydrogen recovery from ammonia as an H_2 carrier.

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References

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