Ammonia synthesis from urea using an electrochemical approach

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Background

Ammonia is a very important chemical due to various applications such as reducing agent in selective catalytic reduction (SCR) process in power plants and diesel engines, manufacturing of fertilizers, precursor to nitrogenous compounds and so forth. Ammonia can be synthesized from urea through the hydrolysis reaction:

$$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2 \quad (1)$$

The electrochemical oxidation of urea has been investigated at the Center for Electrochemical Engineering Research (CEER) for the purpose of producing hydrogen using Ni based catalysts [1], the reaction is summarized below:

$$CO(NH_2)_2 + H_2O \rightarrow N_2 + 3H_2 + CO_2 \quad (2)$$

It is expected that during the electrochemical oxidation of urea, some of the urea molecules could be converted into ammonia via hydrolysis:

$$CO(NH_2)_2 + H_2O \xrightarrow[\Delta]{NiOOH} 2NH_3 + CO_2 \quad (3)$$

By modifying reaction conditions, the ammonia production (Eq. 3) could be promoted over hydrogen production (Eq. 2) using an applied voltage [2], therefore resulting in higher yield of ammonia when compared to urea hydrolysis. The objective of this research is to investigate the optimal conditions for high yield of ammonia thus developing a technique of urea to ammonia conversion suitable for SCR applications.

Methodology

A reactor was developed at CEER for the production of ammonia from urea. This reactor was used for both chemical and electrochemical methods based experiments to convert urea to ammonia. The reactant solution used for this investigation consists of urea and potassium hydroxide (KOH). For the electrochemical method, Ni-based catalyst material was used as anode, while the cathode was Ni foil. This study focuses on the effect of various parameters including applied voltage, reactor temperature, and concentration of urea and supporting electrolyte (KOH) to establish the optimal operating conditions to maximize the ammonia production rate.

Results

Preliminary results indicate that the yield of ammonia produced through the electrochemical process is higher than the thermal hydrolysis process. These results will be presented and discussed during the meeting.

References

1. Boggs, B.K., R.L. King, and G.G. Botte, *Urea electrolysis: direct hydrogen production from urine.* Chemical Communications, 2009(32): p. 4859-4861.
2. Botte, G.G., *Electolytic Cells and Methods for the Prodcution of Ammonia and Hydrogen*: US Patent 0095636 A1, Apr. 16, 2009.