Feasibility of Electrolyzing Ammonia Effluents for the Production of Hydrogen

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Introduction

There are negative effects on the environment that are the result of poorly applied technological procedures such as waste water treatments that release toxic and dangerous chemicals. Chemical compounds used in the waste water treatment process are detrimental to the normal environmental conditions. One of the common compounds present in waste water or sewage plants is ammonia (NH_3). Ammonia is present in the waste water plants in low concentrations (0.5-2 mmol/L).[1,2] The technology being studied will remove ammonia from waste water during sewage treatment to produce hydrogen while returning clean water to the environment. A previous study in the Electrochemical Engineering Laboratory at Ohio University used high concentrations of ammonia in alkaline media and low temperatures (25-70°C) to electrolyze ammonia.[3] The objective of this paper is to evaluate the technical and economical feasibility of implementing this process (electro-oxidation of ammonia) for the removal of ammonia and the cogeneration of hydrogen.

In order to simulate waste water treatment plant conditions, low concentrations of ammonia are being evaluated in an alkaline solution of potassium hydroxide (KOH) and the same temperature range. The electrolysis of ammonia is environmentally sound as it produces pure hydrogen as a product which can be used in fuel cells, and releases nitrogen without any hazardous consequences.

Results and Discussion

Preliminary results for higher concentrations of ammonia (1M NH_3) in alkaline median (1M KOH) were obtained for a Raney Nickel-Platinum electrode design. Figure 1 shows the performance of the electrode in the presence of the potassium hydroxide alone and potassium hydroxide with ammonia in the higher concentrations stated above.

Using an electrode designed for higher concentrations of ammonia (same electrode used in Figure 1), a preliminary result has been obtained for low concentrations of ammonia (See Figure 2). Modifications will be made to the electrode to increase the peak current seen in Figure 2. The current peak at 1 M NH_3 is 310 mA (Figure 1) while the current peak for 2.76×10^{-3} M NH_3 is 60 mA (Figure 2). This difference shows the dependence of the concentration of ammonia on the electro-oxidation reaction.

The focus of the research is to optimize an electrode design for use in waste water treatment plant conditions, particularly low ammonia concentrations. The electrode will be designed to produce a high reactivity catalyst process in the effluent stream conditions. Current experiments are being developed with Raney Nickel Electrodes[4,5] plated with noble metals in order to increase their surface area. Characterization tools will be used to analyze the surface of the electrodes, such as Scanning Electron Microscopy (SEM) and Energy Dispersion Spectroscopy (EDS). The electrochemical performance of the electrode will be measured using cyclic voltammetry and galvanostatic polarization techniques. The gases evolved will be characterized using a gas chromatograph.

The optimized design of the electrodes as well as the performance of the electrodes in low ammonia concentrations will be reported. An economics analysis of the technology will be presented.

References

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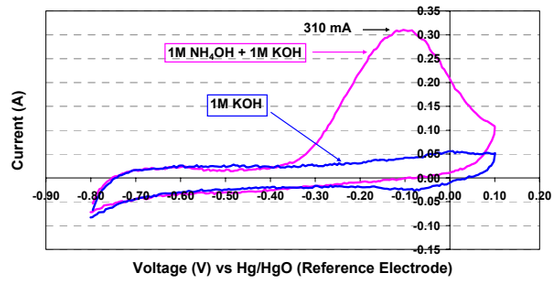

Figure 1. Cyclic Voltammetry for a Raney Nickel-Platinum Electrode in a 1M NH_3 and 1M KOH solution. The peak shown at 310 mA for 1M NH_3 and 1M KOH proves the reactivity performance of the Raney Nickel-Pt electrode. The difference presented between the behavior with 1M KOH alone and with both NH_3OH and KOH indicates a good potential catalyst. The peak suggests that the electro-oxidation of ammonia is occurring.

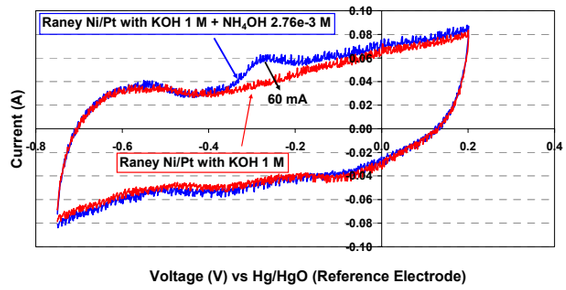

Figure 2. Cyclic Voltammetry for a Raney Nickel-Platinum Electrode in a 2.76×10^{-3} M $NH_3$and 1M KOH solution. A peak of 60 mA is observed showing that the electrode is reactive in the presence of the low ammonia concentrations. Design modifications are being performed on the electrode to increase its reactivity in these conditions.