

Oral presentation report on the 2nd IWA Malaysia Young Water Professionals Conference, 2015

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1. Preface

I presented an oral presentation on the topic of “Effects of Operational Parameters on Electrochemical Nitrate Removal Using an Electrochemical Flow Cell” in the Vivatel, Kuala Lumpur Malaysia from 17th to 20th March, 2015.

2. Summary of Presentation

2.1 Introduction

The World Health Organization (WHO), United States Environmental Protection Agency (USEPA), and European Community (EC) set the maximum contaminant level (MCL) in drinking water to be 50 mg nitrate (NO_3^- /L), 0.5 mg nitrite (NO_2^- /L) and 0.5 mg ammonium (NH_4^+ /L). Due to elimination of nitrogenous compounds from different sources of water, many researchers have focused on the electrochemical reduction of NO_3^- , because it shows comparatively high treatment efficiency, negligible amount of sludge production, small area consumption and overall, relatively low investment costs (Duarte *et al.*, 1998). However, during electrochemical reduction of NO_3^- at a constant potential it has been demonstrated that the simultaneous electrochemical oxidation of NH_3 to nitrogen (N_2) seems to be difficult (Li *et al.*, 2009). Therefore, it is challenging to find out the appropriate conditions to perform both cathodic reduction of NO_3^- and anodic oxidation of the produced NH_3 . The aim of this research work was to demonstrate the NO_3^- removal by using a two-compartment electrochemical flow cell and to evaluate the NO_3^- removal performances.

2.2 Materials and Methods

Figure 1 shows the experimental setup. The laboratory scale experimental system was composed of a hand-made electrolytic flow cell, a feed pump (RP-1000, EYELA, Japan), and a DC power supply (PW 18-3 AD, Kenwood, Japan). The flow cell was divided into two compartments, namely cathodic and anodic by inserting a flat sheet cation exchange membrane (Nafion NE-1110, DuPont, USA) between two com-

partments. Ten sheets of copper meshes (#40/36, 0.28 mm in the diameter of Cu wire) with the configuration of 50 cm^2 constituted the cathode by stacking them in the cathodic chamber. The effective cathode area amounted to 2892 cm^2 . The anodic compartment was equipped with a Ti/Pt electrode at the outside of the compartment and was filled with a fluorocarbon mesh sheet.

Accordingly, the empty volume of cathodic and anodic compartment was 20 cm^3 and 5.0 cm^3 , respectively.

2.3 Results and Discussion

Figure 2 (a), (b), (c) and (d) shows the variation of TN, NO_3^- , NO_2^- , NH_3 and chloramines concentration after electrolysis with the presence of different dozes of NaCl. Here, total nitrogen (TN) indicates the sum of NO_3^- , NO_2^- , NH_3 and chloramines nitrogen concentration. All of these experiments were performed at the flow rate of 20 mL/min with 1 mM K_2SO_4 , 1.42 mM KNO_3 and varied Cl^- concentration of 100, 200, 400 and 800 mg/L, respectively. From Figure 2 (a) and (b) it is observable that NO_3^- was transformed into NO_2^- and NH_3 in the similar trend, where NO_3^- was transformed into NO_2^- nonlinearly and into NH_3 linearly. The R^2 values observed were 0.990 for Figure 2 (a) and 0.929 for Figure 2 (b). Moreover, another linear relationship was observed in the formation of chloramines with respect to the increase in volumetric electric charge at the R^2 value of 0.910 for Figure 2 (a) and 0.951 for Figure 2 (b). However, addition of small amount of Cl^- (100 mg/L and 200 mg/L) did not show any significance decrease in TN. From Figure 2 (c) it is observable that NH_3 was enhanced with the increase in volumetric electric charge within the range of 300 to 2,700 C/L and it gradually decreased over 2,700 C/L.

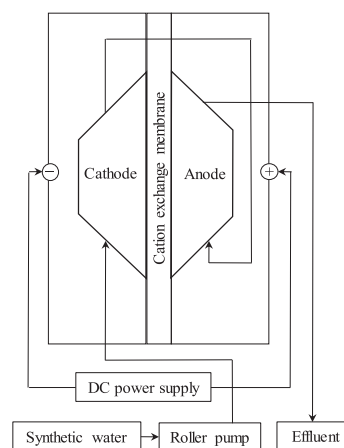


Figure 1 Experimental setup

The chloramines concentration were increased gradually within the volumetric electric charge of 300 to 7,500 C/L but it decreased at the volumetric electric charge of 8,700 C/L, which indicates that chloramines were oxidized at 8,700 C/L. Here, it could be considered that the reaction rate of Cl_2 with NH_3 over 2,700 C/L exceeded the production rate of chloramines. Then the chloramines produced was removed by the break-point chlorination mechanism and TN gradually decreased.

From Figure 2 (d) it is also observable that NH_3 accumulation rate was enhanced with the increase in volumetric electric charge within the range of 300 to 1,500 C/L and it gradually decreased with the volumet-

ric electric charge over 1,500 C/L. The complete consumption of NH_3 was observed at the volumetric electric charge of 8,700 C/L. The formation of chloramines were increased from the volumetric electric charge of 300 to 2,700 C/L and it followed the similar trend like NH_3 over 2,700 C/L. Finally, TN decreased linearly with the increase in volumetric electric charge at the R^2 value of 0.978. At the volumetric electric charge of 8,700 C/L the TN was 0.54 mM that was composed of NO_3^- , NO_2^- , NH_4^+ and chloramines with the concentrations of 0.43, 0.09, 0.01 and 0.01 mM, respectively. These results confirm that the appropriate amount of Cl^- lead sufficient amount of HOCl production, which could oxidize the NH_3 and other byproduct presumably into N_2 . An interesting relationship was observed between the quantity of volumetric electric charge and Cl^- concentration to oxidize NH_3 as well as other byproducts.

2.4 Conclusion

In this study, TN removal was accelerated via the break-point chlorination mechanism, in which the N_2 evolution pathway was thought to be main pathway of TN removal of this research. However, the current efficiency remained a low level; only 6.1% at Cl^- concentration of 800 mg/L. Accordingly, further improvement such as an increase in Cl^- concentration and the use of more catalytic electrode material will be required for practical use of this technique. In spite of the low current efficiency, 1.42 mM of initial NO_3^- was decreased to 0.43 mM without NH_3 and NO_2^- accumulation within 1 minute contact time at the volumetric electric charge of 8,700 C/L, flow rate of 20 mL/min and Cl^- concentration 800 mg/L. Thus, the electrochemical technique was thought to be feasible for rapid nitrate removal from water streams.

3. Acknowledgement

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References

- Duarte H. A., Jha K. and Weidner J. W. (1998). *Journal of Applied Electrochemistry*, Volume.28, pp.811–817.
- Li M., Feng C., Zhang Z. and Sugiura N. (2009). *Journal of Electrochimica Acta*, Volume.54, Issue.20, pp.4600–4606.

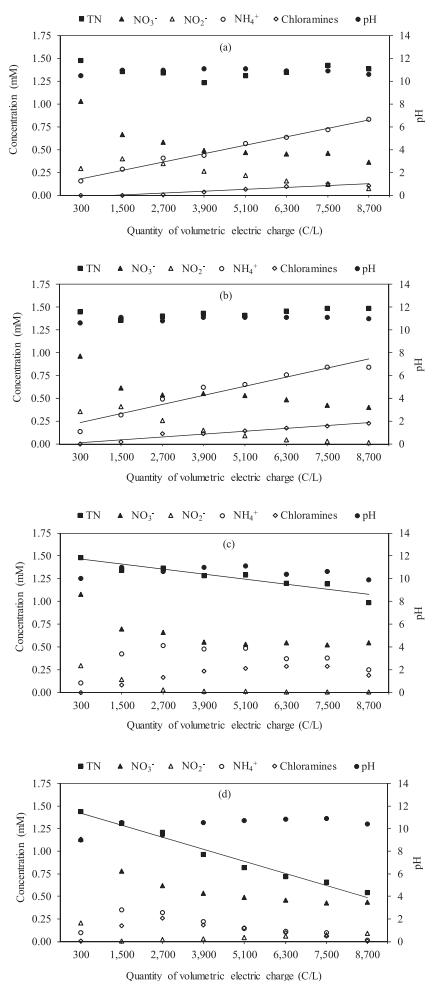


Figure 2 Variation of TN, NO_3^- , NO_2^- , NH_4^+ and chloramines concentration at (a) Cl^- concentration of 100 mg/L, (b) Cl^- concentration of 200 mg/L, (c) Cl^- concentration of 400 mg/L and (d) Cl^- concentration of 800 mg/L.