Treatment of Ethanolamine and Hydrazine in CPP Regeneration Wastewater Using Zero-valent Iron Nanoparticle and Hydrogen Peroxide

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1. Introduction

Ethanolamine is a main substance of wastewater produced from regeneration process of the condensate polishing plant (CPP). Ethanolamine (ETA) is an alkali pH controller in order to sustain pH to prevent metal piping from corrosion in the secondary cooling system within power plants. It is known as refractory by physicochemical and biological treatment process. Furthermore, the wastewater also contains hydrazine, a dissolved oxygen scavenger to prevent pipe corrosion, and is toxic to human health and environment. Best available technology (BAT) to treat ETA has not been yet fully established. This research poster shows complete degradation of ETA and hydrazine by oxidation reaction using nano-particulate zero valent iron (nZVI) and hydrogen peroxide. And a biological treatment process, PPFBR (pseudo plug flow bioreactor), was employed as a post-treatment to down the level of COD and total nitrogen to legal discharge limit.

2. Background

2.1 Characteristics of wastewater from CPP regeneration

The major pollutants in the wastewater are ETA, Hydrazine, and sulfate ion. The concentration of ETA (C_2H_7ON) ranges from 5,000 to 9,000 mg/L which results in elevated COD level, 6,000 to 13,500 mg/L. ETA is highly stable substance both chemically and biologically. The ratio of COD_{Cr} to COD_{Mn} was more than 7. Degradation of ETA produces high total nitrogen concentration, mainly ammonia.

Hydrazine (N_2H_4) also induces high ammonia concentration after degradation. The total nitrogen concentration of the wastewater ranges from 2,000 to 3,500 mg/L and ammonia 500 to 1,500 mg/L.

Huge amount of sulfuric acid is used to regenerate cation exchange resin resulting in sulfate ion concentration as high as 60,000 mg/L. Extremely low pH requires huge chemicals for neutralization.

2.2 Previous Researches

One of the most effective technique for ETA removal is Fenton oxidation(1) using ferrous salt. Dutta et al (1) reported that as high as 55% of ETA was removed using ferrous iron ($FeSO_4$) and hydrogen peroxide. This most highest removal rate achieved at high initial ETA concentration, 13,000 mg/L as COD, at extreme high chemical dose such as 8,100 mg/L $FeSO_4 \cdot 7H_2O$ and 212 mL of 35% H_2O_2. However, as the initial ETA concentration decreases, removal rate decreased.

3. Oxidation using nZVI and Peroxide

3.1 ETA Degradation using nZVI

nZVI and hydrogen peroxide was employed to

degrade ETA in this research. 1 g/L of nZVI and 150 mL/L of 35% H_2O_2 was removed ETA from 9814 mg/L to 290 mg/L for 24 hours reaction. Removal rate was 97%. Fig. 1 shows ETA removal by reaction time as COD.

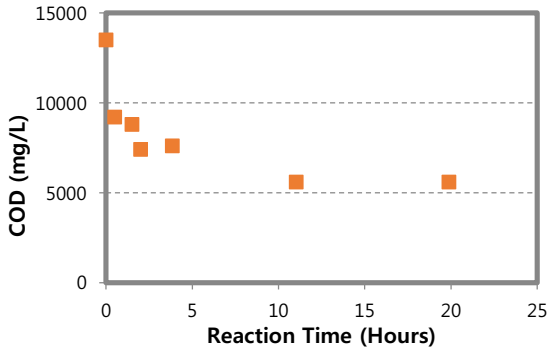

Fig. 1. The effect of reaction time of ETA removal using 1 g/L nZVI and 150 mL/L 35% H_2O_2.

The effect of dose of hydrogen peroxide was examined from 10 to 150 mL/L, and showed proportional relationship. The optimum dose was identified at 50 mL/L dose in the economical aspect. The effect of nZVI was also tested from 10 mg/L to 1,000 mg/L. At 10 mg/L of nZVI also showed 60% COD removal. Optimum pH was observed at pH 3.

Hydrazine was removed 99.8% from 1520 mg/L to 3.2 mg/L with 10 mg/L of nZVI and 50 mL/L H_2O_2.

4. Biological Treatment using PPFBR process

Pseudo Plug Flow Bioreactor (PPFBR) is a patented bioreactor designed for advanced fast nitrification. Fig. 2 shows COD and ammonia removal by PPFBR. After oxidation of ETA wastewater, COD and ammonia were 3,800 and 1,720 mg/L, respectively. After 200 hours of retention time COD and ammonia was 90 and 1.7 mg/L, respectively.

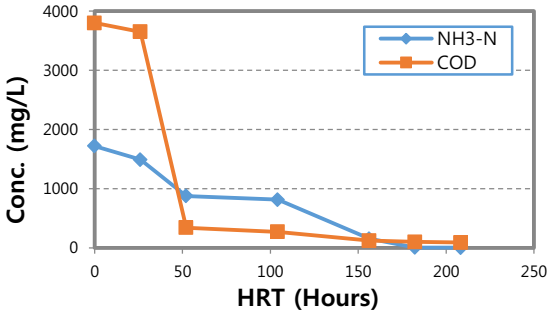

Fig. 2. COD and ammonia removal by Pseudo Plug Flow Bioreactor (PPFBR).

5. Conclusion

Zero-valent iron nano-particulate (nZVI) and hydrogen peroxide effectively degrades ethanolamine. After 97% degradation of ETA and 99.8% degradation of hydrazine by nZVI oxidation, the remaining COD and total nitrogen were effectively degraded by biological treatment to below of legal discharge limit.

ACKNOWLEDGEMENT

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