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Case Study

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COMPARISON OF NITRILOTRIACETIC ACID AND [S,S]-ETHYLENEDIAMINE-N,N'-DISUCCINIC ACID IN UV-FENTON FOR THE TREATMENT OF OIL SANDS PROCESS-AFFECTED WATER AT NATURAL PH

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1 Introduction

Naphthenic acids (NAs) are a group of aliphatic and alicyclic carboxylic acids, which are primarily responsible for the toxicity of oil sands process-affected water (OSPW) generated in the bitumen extraction from oil sands and subsequent froth treatment process. Modified Fenton process at neutral pH with the addition of chelating agents or UV-Fenton have not been used for the treatment of OSPW yet. Therefore, the application of UV-Fenton processes with two chelating agents, nitrilotriacetic acid (NTA) and [S,S]-ethylenediamine-N,N'-disuccinic acid ([S,S]-EDDS), for the treatment of oil sands process-affected water (OSPW) at natural pH was investigated in this study. The efficiency of the UV-NTA/EDDS-Fenton processes was examined on the removal of acid extractable organic fraction (AEF), aromatics and the overall toxicity of OSPW towards *Vibrio fischeri*. The removals of classical naphthenic acid (c-NAs) and oxidized NAs (oxy-NAs) in the UV-NTA-Fenton, UV-H_2O_2 and NTA-Fenton processes were also compared.

2 Objectives

The objectives of this study were: (1) to explore the reduction mechanism of Fe(III)NTA/EDDS to Fe(II)NTA/EDDS; (2) to study the decomposition of Fe(III)NTA and Fe(III)EDDS under UV irradiation; (3) to compare the efficiency of the UV-NTA/EDDS-Fenton processes on the removal of acid extractable organic fraction (AEF), aromatics and the overall toxicity of OSPW towards *Vibrio fischeri*; (4) to investigate the toxicity of NTA, EDDS, Fe(III)NTA/EDDS and their degradation products towards *Vibrio fischeri*; and (5) to compare the removals of c-NAs and oxy-NAs in the UV-NTA-Fenton, UV-H_2O_2 and NTA-Fenton processes.

3 Methodology

UV irradiation experiments were conducted by placing a 100-mL beaker (5.4-cm diameter) with an 80 mL sample solution on a magnetic stirrer under a collimated beam UV apparatus equipped with a 1-kw medium-pressure (MP) Hg-lamp. H_2O_2, Fe, NTA, EDDS, metal ions in OSPW, Fourier transform infrared (FT-IR) spectra, synchronous fluorescence spectra (SFS), 1H nuclear magnetic resonance (NMR) analysis, NAs, toxicity toward Vibrio fischeri were analyzed by following standard analytical methods.

4 Results

The results indicate that UV-NTA-Fenton is more efficient in the reduction of acid extractable organic fraction (AEF) in OSPW compared with UV-EDDS-Fenton, primarily due to the lower scavenging effect of NTA on $^{\bullet}OH$ than that of EDDS. Both ^{1}H NMR and SFS spectra showed very high removal of aromatics in the UV-NTA-Fenton process, indicating high capability of this process to degrade aromatics. The toxicity test also showed that NTA is a much better chelating agent than EDDS due to its lower toxicity risk of the agent towards aquatic organisms. Figure 1 indicated that NA removal in the UV-NTA-Fenton process was much higher compared to the UV-H_2O_2 and NTA-Fenton processes.

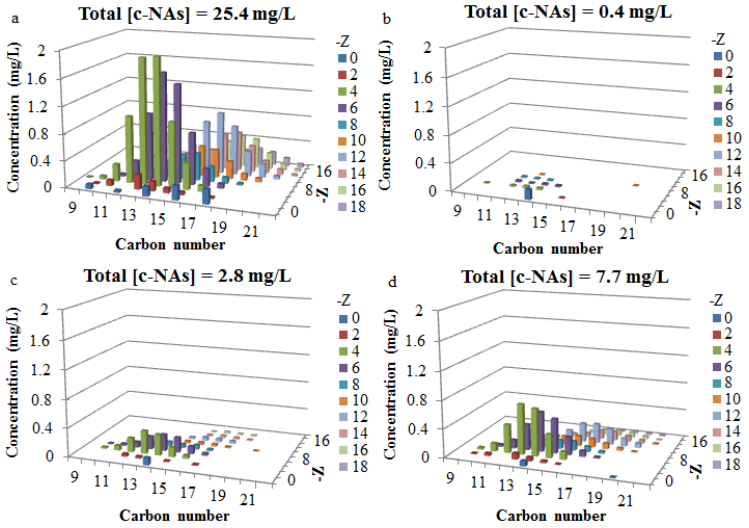

Figure 1. NA distribution in a) raw OSPW, and OSPW treated with b) UV-NTA-Fenton, c) UV-H_2O_2, and d) NTA-Fenton ($[H_2O_2]_0$ = 5.88 mM for all three processes. $[Fe]_0$ = 0.089 mM and $[NTA]_0$ = 0.72 mM for UV-NTA-Fenton and NTA-Fenton. 30 min UV irradiation for UV-NTA-Fenton and UV-H_2O_2) (Zhang et al., 2016).

5 Conclusions and Recommendations

Overall, NTA is a much better chelating agent than EDDS for the application of the UV-Fenton process on the treatment of OSPW at natural pH. The findings obtained in this study have significant impact for the further development of this process and OSPW remediation. The combination of UV-NTA-Fenton with biodegradation process might be an economical and efficient approach for the organic and toxicity removal in the OSPW remediation, which deserves more studies to confirm its effectiveness. The total cost should be considered for the application of UV-NTA-Fenton in the treatment of OSPW *in situ*, especially the electricity cost for UV irradiation.

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Reference

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