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FIELD EVALUATION OF SULFOLANE DEGRADATION IN GROUNDWATER USING UV/H₂O₂

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1. Background

Sulfolane (C₄H₈SO₂) is a highly polar, water miscible and colorless organic solvent. It is used extensively in natural gas processing plants to remove H₂S and other polar compounds from natural gas and petroleum refining operations for aromatics extraction. Leachates from disposal areas and leaks during processes and maintenance activities have led to extensive sulfolane contaminated soil and groundwater around gas processing plants and refineries. Sulfolane has been identified as an emerging contaminant with a potential hazard to human health and environmental receptors. A recognition of this problem by industry, coupled with more attention from regulators, has pushed sulfolane contamination issues to forefront in some regions of North America. Recent studies have indicated that sulfolane can be degraded using advanced oxidation processes (AOPs) (Yu et al, 2016; Mehrabani et al. 2016). Yu et al. (2016) found that a combination of UV and H₂O₂ was a promising method to degrade sulfolane in aqueous media; however, the study was conducted at laboratory scale and prior to application at commercial scale, field pilot scale studies are needed. In this project, we evaluated a pilot scale AOP system on sulfolane degradation at a sulfolane contaminated site using sulfolane contaminated groundwater. The impact of different hydrogen peroxide dosages on sulfolane degradation was investigated.

2. Contaminated site and pilot UV/H₂O₂ unit

A sulfolane contaminated site in Alberta, Canada was selected for this field pilot test. The field test was conducted from May to August, 2016. A sour gas plant has been operating on the site since 1978. The plant processed sour gas and produced sweet natural gas and liquid condensate until 2015 when the sour processing units were decommissioned. Recently, sulfolane contamination has been observed in both groundwater and soil on the site. In this field test, a pilot scale UV/H₂O₂ system was evaluated for treatment of sulfolane contaminated ground waters. The UV/H₂O₂ pilot testing system was setup on site. The testing system consisted of one reservoir, several water pumps, one H₂O₂ peristaltic pump, one H₂O₂ storage tank and one UV Unit (UV LOGIC 8AL20, Trojan Technologies). The reservoir, UV unit and water pumps were integrated through flexible PVC pipes. The power consumption of the UV unit is approximately 2140 W, and is equipped with eight germicidal lamps. The reservoir is made of high density polyethylene with a volume of 5.6 m³. The water in the reservoir was pumped into the UV unit by using a variable controllable valve. Hydrogen peroxide was introduced through a peristaltic pump. Water was mixed with H₂O₂ by a motionless mixer and then passed through the UV unit.

3. Testing procedure

For each test, three cubic meters of groundwater was pumped into the reservoir. The UV Trojan unit was turned on and warmed up for 30 minutes before each test. The H₂O₂ dosage was adjusted based on the ratio of H₂O₂ delivered to the water flow rate. There are three water sampling ports: (#1) before adding

H₂O₂; (#2) after adding H₂O₂ but before UV chamber and (#3) after UV chamber. Samples were collected at varying time intervals and immediately placed in ice. Sulfolane in the water samples was then extracted with dichloromethane and analyzed with gas chromatography-flame ionization detector.

4. Findings

Our field testing results (Figure 1. a) show that sulfolane in groundwater can be successfully treated using UV/H₂O₂. With 8 hours of retention time, sulfolane decreased from 12.6 ppm to less than 0.5 ppm. Electrical energy per order reduction (EEO) of sulfolane was used to evaluate the energy efficiency of the system. As shown in Figure 1.b, higher H₂O₂ dosages resulted in a smaller EEO values. EEO decreased from 12 KWH to 2KWH as H₂O₂ increased from 10 ppm to 240 ppm; however, the chemical expense is increased with H₂O₂ dosage. The trade-off between energy consumption and chemical expense led to an optimal H₂O₂ concentration, which was determined to be 40 ppm in this project. The required EEO for treating sulfolane in water is 2.3 KWH. The one order sulfolane reduction operational cost including electricity consumption, chemical expense and UV lamps replacement cost was estimated to be 0.35 \$/m³. The success of this field demonstration has provided useful and practical information for system scale-up and full application of the technology.

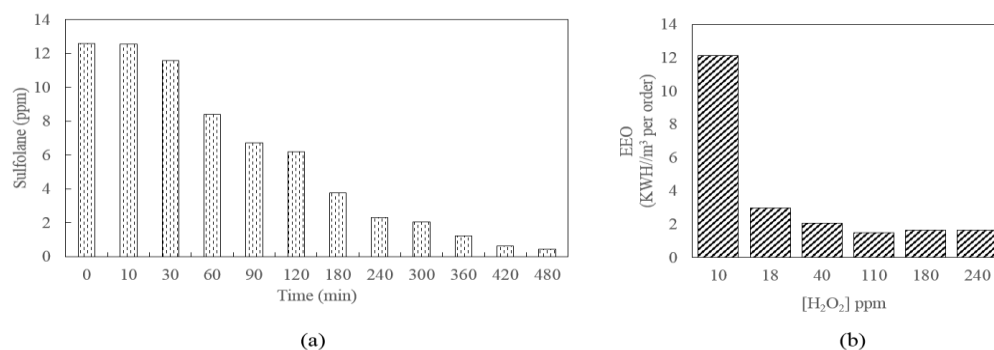


Figure 1. (a) Degradation of sulfolane in two different groundwater with 30 ppm of H₂O₂; (b) The impact of H₂O₂ dosage on EEO.

5. Challenges

It was observed that some groundwater turned yellow and became turbid after it was brought to the surface. This might be due to the oxidative environment of ambient condition that led to iron precipitation. The precipitates can decrease UV transmittance and cause fouling problem on the protection sleeves of UV lamps. In order to achieve a higher treatment efficiency, a pre-treatment step might be required for full-scale application.

Acknowledgement

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References

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