Decolorization of dye compounds in aqueous solution by VUV-based advanced oxidation processes

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ABSTRACT

The purpose of this study is to investigate the reaction behaviors of the decomposition of dye-containing wastewaters by VUV-based advanced oxidation processes (AOPs). The effects of pH value, VUV intensity, initial dye concentration, initial H2O2 concentration, and TiO2 loading dose on the degradation of three azo dyes: acid Orange 8, acid Blue 29, and acid Blue 113 were studied to explore and compare the treatment efficiencies among the adopted AOPs. The degradation of three azo dyes was observed during VUV irradiation, while they were not oxidized by H2O2 alone and TiO2 alone. It was found that pH represented as an important role which affected strongly on the degradation of three dyes. For VUV/H2O2, VUV/TiO2, and VUV/TiO2/H2O2 processes, the decoloration rates of three azo dyes were always decomposed more efficiently at acidic condition than those at alkaline condition except VUV only process. Especially, three azo dyes were considered to disappear in a short time at acidic condition by VUV/TiO2 and VUV/TiO2/H2O2 process because of their absorption on positively charged TiO2 surface. The effect of VUV intensity on the degradation efficiency of dyes was negligible. On the other hand, the degradation rates of dyes increased with increasing of H2O2 concentration, but the reaction rates would be retarded while H2O2 concentration was too high because it acted as a scavenger of hydroxyl radical. The results also indicated that the degradation rate decrease with increasing of azo dye concentration. The optimal concentration of TiO2 applied in this study was 0.5 g/L, some degradation rates of dyes would decrease if exceeding this optimal dose because of the blocking effect on VUV of TiO2. The decomposition rates of mono-azo dye (i.e. acid Orange 8) were found to be larger than those of di-azo dye (i.e. acid Blue 29), and amino-azo benzene of diazo dye (i.e. acid Blue 113). The experimental results were explained based on the differences among their molecular structure. The effect of VUV direct photolysis among the VUV-based AOPs can not be negligible because three azo dyes can be decomposed efficiently by VUV irradiation. The treatment efficiency of dyes by VUV/TiO2/H2O2 process was the worst one possibly due to the excess effects of TiO2 and H2O2 dose to retard the generation of hydroxyl radicals. A pseudo-first order kinetic was established for the four VUV-base AOPs. However, kinetic for direct photolysis reaction acted as zero-order that was better well fitted than the first order reaction. The K absorption behaviors of three azo dyes on TiO2 surface were determined based on the Langmui-Hinshelwood kinetic model. In addition, a kinetic model with pseudo-steady state assumption (PSSA) was established according to the generally accepted elementary reaction in VUV/H2O2 process. The rate constant for the reaction between dyes and hydroxyl radicals was found by fitting the experimental data to the PSSA kinetic model.

Keywords : advanced oxidation processes ; VUV irradiation ; azo dyes ; wastewater treatment ; VUV/TiO2 ; VUV/H2O2 ; VUV/TiO2/H2O2

Table of Contents

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