Removal of Cytostatic Drugs by UV, UV/H_2O_2 and UV/Persulfate: Process Optimization and Cost Comparison

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Abstract
Treatment of eight cytostatic drugs (CSDs) commonly found in hospital wastewater effluent with UV direct photolysis, UV/H_2O_2 and UV/persulfate was investigated. UV photolysis is ineffective but with addition of small doses of H_2O_2 or persulfate the CSDs removal can be enhanced significantly. The factors affecting the treatment efficiency such as pH, water matrix species and TOC were evaluated. Economic analysis shows that UV/PS is the most cost-effective process due to the high selectivity of sulfate radical towards the micropollutants.

Keywords:
Cytostatic drugs; oxidation; photolysis, degradation; hospital effluent

INTRODUCTION

Cytostatic drugs (CSDs) have been increasingly used in cancer therapies due to population growth and aging. Many of them have been categorized as carcinogenic, mutagenic and teratogenic compounds, triggering widespread concerns about occupational exposure and their release into the environment (Zhang et al., 2013). Once released, these compounds pose potential risks to the ecosystem and human health. In addition, conventional water treatment processes have been proved ineffective to remove these emerging micropollutants (Lin et al., 2013).

UV-based advanced oxidation processes (AOPs), on the other hand, have shown their effectiveness towards a large number of recalcitrant pollutants. Due to the production of highly reactive radicals, simple operation and low capital and operation cost, UV-based AOPs have been widely applied for organic pollutant removal in small and medium water and wastewater treatment plants. This paper focuses on (1) investigating the efficiency of direct photolysis, UV/H_2O_2 and UV/persulfate (PS) systems in removal of eight CSDs in water; (2) evaluating the factors affecting the treatment efficiency and the optimal operating condition, and (3) comparing the treatment cost of the three systems.

RESULTS AND DISCUSSION

Experiments with different operating conditions and water quality were carried out to evaluate the effects of oxidant dose, pH, and matric species on CSDs degradation. The CSDs degradation generally follows the pseudo-first-order kinetics in the UV, UV/H_2O_2, and UV/PS systems. Direct photolysis is ineffective to degrade CSDs, while UV/PS is more effective than UV/H_2O_2 (Fig. 1) because of the selective attack on the CSDs by the generated sulfate radical and also its two-order magnitude longer lifetime than HO•.

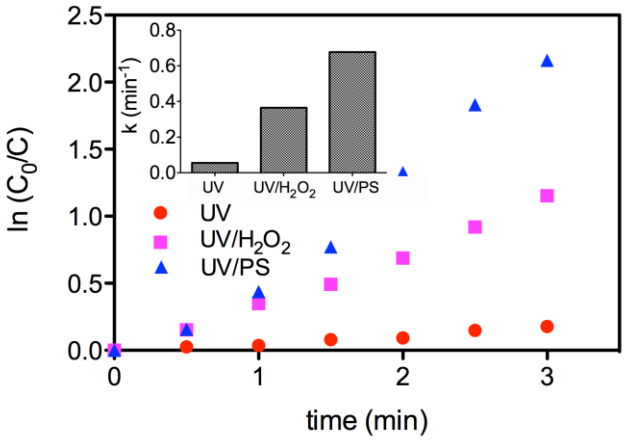

Figure 1 Comparison of UV, UV/H_2O_2 and UV/PS for Aza degradation.

Fig. 2 shows that adding the oxidant at small doses could significantly increase the CSDs degradation rates. However, excessive doses could inhibit the process efficiency due to self-scavenging of the generated radicals by the excess oxidants, especially in the UV/H_2O_2 system.

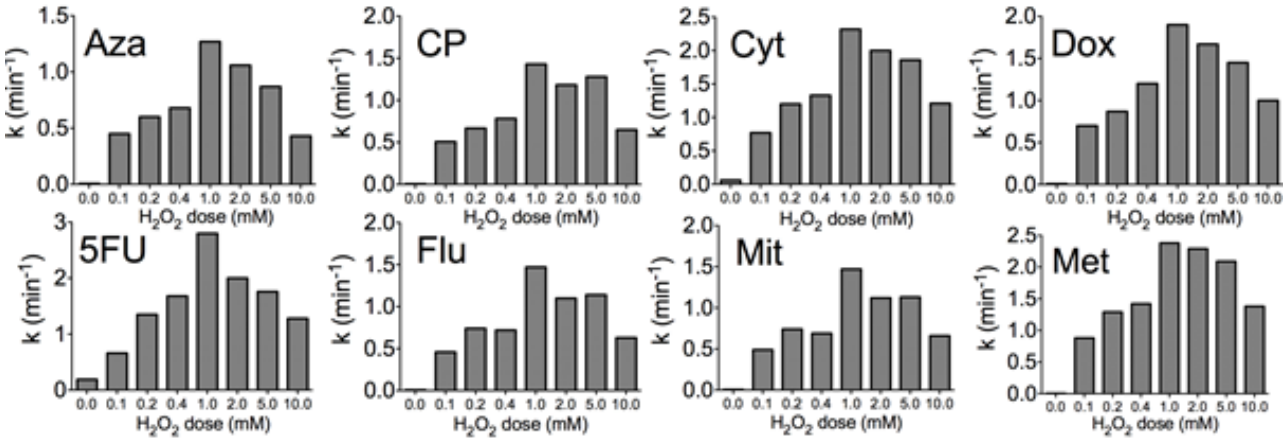

Figure 2 Effect of H_2O_2 dose on the degradation rate of cytostatic drugs in UV/H_2O_2 system.

Economic analysis of UV, UV/H_2O_2 and UV/PS systems is performed taking into account electrical energy per order (EE/O) and chemical cost per order (Cost/O). At a small oxidant dose, UV/PS is the most cost-effective. At a higher oxidant dose, due to the higher cost of PS compared to H_2O_2, UV/H_2O_2 could be the more economic option.

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