

Sonophotocatalysis for the degradation of azo dye (C.I. Reactive Black 5)

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1. Introduction

Reactive dye amounts to large part of textile industry. When 1kg of cotton fiber is dyed, it needs 80-100 L of water and it goes to wastewater. Reactive dye is hydrophilic, so it is hard to remove using adsorption with activated carbon. And dyes are commonly large molecules, so it needs long time to degrade in conventional process. Therefore, Advanced Oxidation Process (AOP) has applied to degrade of dyes [1].

Ultrasonic irradiation has received attention because of rapid degradation. Especially, photocatalytic process with ultrasound has a positive effect which overcomes UV-screening of catalysts. So the degradation rates are improved by combined process.

The inorganic ions exist in waste water which was used for dyeing. Increasing of the ionic strength of solution, occurring of driving force from aqueous phase to bubble surface, and changing surface tension of bubble are advantages of adding the inorganic anions. But the results are different according to a kind of anions and initial concentration of organics [2,3].

In this study, the effects of salt and three processes (photocatalytic, sonocatalytic and sonophotocatalytic) on the degradation of azo dye solution were investigated.

2. Materials and method

The sonolysis equipment was a Flexonic (Mirae Ultrasonic Tech.) with frequency 35 kHz and 3 W energy input. Energy in the reactor was measured by the calorimetric method. The UVC light manufactured by a commercial halogen lamp (10.5 W, 18.5 cm). Four lamps were used.

The UV-spectra of dye solution was measured using a UV-spectrophotometer Specord 40 from Analytik Jena. The maximum absorbance wavelength (λ_{\max}) of C.I. Reactive Black 5 could be found at 598 nm from spectra. The concentration of the dye solution in the reaction at different reaction times were decided by measuring the absorption intensity at $\lambda_{\max} = 598$ nm and from a calibration curve.

C.I. Reactive Black 5 (Remazol Black B; MW = 991.8 g mol⁻¹; RB5) was obtained from DyStar. Initial concentration of dye was 50 mg L⁻¹. TiO₂ powder (rutile form, 99%) and NaCl (99.5%) were obtained from Junsei chemical co. The catalyst concentration was fixed at 0.5 g/L. A reactor was made of Pyrex, and volume was 500mL. Temperature was maintained at 20-25 °C. During the experiments, the sample was mixed well using stirrer (100rpm). All samples were filtrated using Syringe filter (0.45 μm) from Whatman. A specially designed ultrasonic machine is presented Fig. 1.

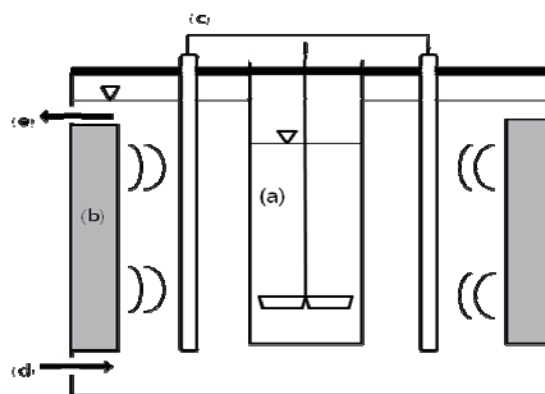


Fig. 1 Experimental set up. (a) Reactor, (b) Sonicator, (c) UV lamp, (d) Cooling water inlet, (e) Cooling water outlet.

3. Results and discussion

The decolorization of C.I. Reactive Black 5 (RB5) was carried out using sonocatalytic and photocatalytic process. Fig. 2 shows the decolorization of RB5 that was observed during the processes. Over 60% decolorization could be achieved after 120min of reaction in the sonocatalytic process. In the photocatalytic process with ultrasound, RB5 was decolorized more around 10%. The enhanced effect of combine photocatalysis with ultrasound may be ascribed to several reasons [4] which are increasing of hydroxyl radicals, improvement of mass transfer between the liquid phase and the catalyst surface, and increasing catalytic activity. Among these reasons, Chen et al. [2] suggested that deagglomeration and surface cleaning of catalyst were mainly supportive functions in the combine photocatalysis with ultrasound.

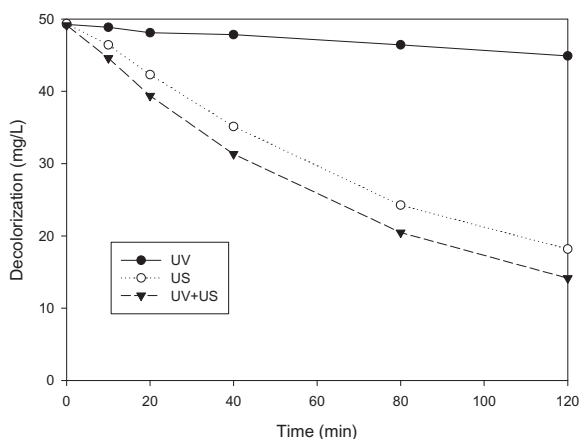


Fig. 2 The decolorization of RB5 with whole processes (initial concentration = 50 mg/L, frequency = 35 kHz, power = 3 W, $\text{TiO}_2 = 0.5$ g/L.)

The influence of inorganic materials on the processes has been investigated [3]. In industrial and natural water, there are inorganic materials such as NaCl, and NaHCO_3 . Also, the dyeing process requires salts. For achieving improved bonding onto the fiber, salts are needed. Adding NaCl increases the ionic strength of aqueous phase, and can accumulate of organic compounds to cavitation interface in ultrasound process [5,6]. However, the NaCl may act radical scavenger or inhibitor by TiO_2 [7].

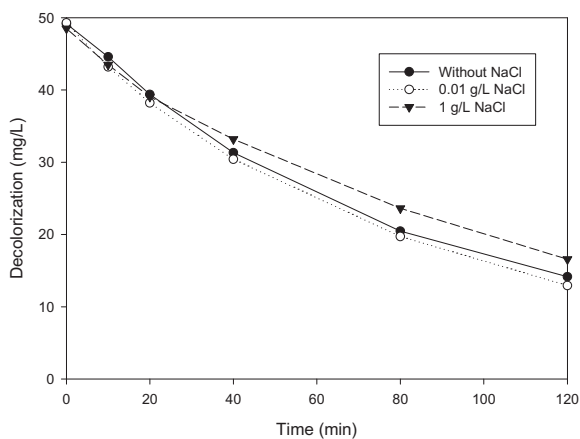


Fig. 3 The decolorization of RB5 with NaCl using sonophotocatalytic process (initial concentration = 50 mg/L, frequency = 35 kHz, power = 3 W, $\text{TiO}_2 = 0.5$ g/L.)

Fig. 3 shows the effect of salt in photocatalytic process with ultrasound. As it can be seen from Fig. 3, addition of 0.01 g/L NaCl can obtain to enhance the decolorization a little when compared with the absence of salt. However, the result of addition 1 g/L NaCl was not effective more than without NaCl. M. Dukkanci et al. [8] studied the ultrasonic degradation of oxalic acid in aqueous

solutions. Little amount of salt affect positive, but excessive amount of salt may adversely affect to decolorization of RB5. Otherwise, in the photocatalytic process, Cl⁻ anions could disturb the degradation according to pH [2]. So there may be the appropriate range of concentration of salt and pH.

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