

## P-1: The Sonochemical Decolorization of Textile Azo Dye Orange II by Using 850 kHz Ultrasonic Reactor

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In this study, the decolorization of Orange II (O-II) from aqueous solution under irradiation at 850 kHz has been studied. The effects of parameters such as of initial dye concentration, initial pH value of Orange II water solution and addition of H<sub>2</sub>O<sub>2</sub> was investigated. The results showed that the degree of decolorization decreased with the increase of initial dye concentration but increased with acidification. Acidification of Orange II from pH=6.5 to pH= 2.0 accelerated the decolorization degree of Orange II from 28.9 % to 45.8 %. Addition of H<sub>2</sub>O<sub>2</sub> into Orange II solution has positive effect on the decolorization degree of Orange II after 2h reaction. The Orange II ultrasonic decolorization was found to follow first order kinetics.

### 1. Introduction

Textile industries generate wastewaters that contain considerable amounts of non-fixed dyes, especially azo-dyes, and a huge amount of inorganic salts. The most common treatment methods, including adsorption, biological treatment, chlorination and coagulation are not efficient enough to remove these compounds from the treated water streams. In view of this, Advanced Oxidation Processes (AOP) seem to be a very promising way of treatment of wastewaters from textile industry. The AOPs are characterized by production of OH (hydroxyl) radical as primary oxidant. The OH radicals are extremely reactive species and are powerful oxidizing agent (Mozia et al., 2005). Sonochemical oxidation has been investigated as viable AOPs for the destruction of various pollutants in water. The chemical effect of sonication is arise from acoustic cavitation, namely the formation, growth and implosive collapse of bubbles in a liquid, which produces unusual chemical and physical phenomenon. The collapse of bubbles generates localized "hot spots" with transient temperature of about 5000 K, pressures of about 1000 atm. Under such extreme conditions water molecules dissociated into OH radical and H atom. The radical species can either recombine each other or react with other molecules to induce sonochemical degradations (Özdemir et al., 2011, Merouani et al., 2010, Ghodbane et al., 2010, Wang et al., 2008).

In this study sonolytic degradation of Orange II (O-II) azo dye in aqueous solution by using ultrasonic equipment at 850 kHz was investigated. The effects of parameters such as of initial dye concentration, initial pH value of Orange II water solution and addition of H<sub>2</sub>O<sub>2</sub> was studied. The Orange II solution degradation was monitored by UV-Vis spectra in a continuous flow-loop system so that the sonicated sample remains always at the same volume.

### 2. Experimental Procedure

The ultrasonic system includes an ultrasonic signal generator (Meinhardt, Type: K80-5, 140 W of max output power) operating at 22.3 W effective power (measured by calorimetry) (Mason, 1999), a piezoelectric transducer emitting ultrasound waves at 850 kHz. Transducer is sited at the bottom of a special design glass reactor. The solution to be sonicated is placed in the reactor having a water cooling jacket to control the reaction temperature. In a typical run, Orange II aqueous solution (always 200 cm<sup>3</sup>) at a known concentration was placed in the reactor and the Orange II solution degradation was monitored by UV-Vis spectrophotometer at 483 nm in a continuous flow-loop system.

### 3. Results, Discussion and Conclusions

In the previous study done by the authors, sonochemical degradation of Orange II in aqueous solution was investigated in a variety of ultrasonic equipment: 20 kHz probe, and ultrasonic baths at 40, 380, 850, 1000 and 1176 kHz. The results showed that, the lower frequencies of ultrasound proved to be ineffective for decolorization of highly soluble Orange II azo dye. The highest decolorization degree (49.0 % in 2 hours) was observed by using 850 kHz ultrasonic bath at a power of 22.07 W. 850 kHz ultrasonic bath was not only highly effective on Orange II decolorization but also had the highest electrical efficiency and the best cost effective equipment (Dükkancı et al.,

2012). According to these results, in this study, the parameters such as initial dye concentration, initial pH value of Orange II water solution and addition of H<sub>2</sub>O<sub>2</sub> that effect the decolorization of Orange II was studied at a frequency of 850 kHz.

Decolorization of Orange II decreased with increasing initial concentration due to the proportion of OH\* generated relative to the higher initial concentration of O-II. Reaction rate constants increased from 6.8x10<sup>-3</sup> min<sup>-1</sup> to 2.3x10<sup>-2</sup> min<sup>-1</sup> with decreasing initial concentrations from 0.140 mMol/dm<sup>3</sup> to 0.0140 mMol/dm<sup>3</sup>, which shows rapid degradation of O-II in that concentration.

Decolorization degree was accelerated by acidification of Orange II due to neutralization of the Orange II by protonation of negatively charged SO<sub>3</sub><sup>-</sup> sites and the hydrophobic enrichment of the molecules to enhance their reactivity under ultrasonic cavitation. Less decolorization degree in alkaline conditions results from enriched hydrophilic character (Ince and Tezcanlı-Güyer, 2004). The obtained highest reaction rate constant, 1.1\*10<sup>-2</sup> min<sup>-1</sup>, at pH=2 showed the faster Orange II decolorisation compared with the alkaline conditions.

As known well H<sub>2</sub>O<sub>2</sub> is a good oxidant. H<sub>2</sub>O<sub>2</sub> decomposes into hydroxyl radicals in ultrasonic environment causing high degradation rates of dyes. Addition of H<sub>2</sub>O<sub>2</sub> into Orange II aqueous solution has positive effect on sonolytic degradation of O-II but it was observed that there was an optimum H<sub>2</sub>O<sub>2</sub> concentration at 10 mM.

### References

Dükkancı M., Vinatoru M., Mason T.J., 2012, Sonochemical treatment of Orange II using ultrasound at a range of frequencies and powers, *Journal of Advanced Oxidation Technologies* (Accepted for publication in January 29, 2012)

Ghodbane H. and Hamdaoui, O., 2010, Decolorisation of antraquinonic dye, C.I. Acid Blue 25, in aqueous solution by direct UV irradiation, UV/H<sub>2</sub>O<sub>2</sub> and UV/Fe(II) processes, *Chemical Engineering Journal* 160, 226-231.

Ince N.H. and Tezcanlı-Güyer, G., 2004, Impacts of pH and molecular structure on ultrasonic degradation of azo dyes, *Ultrasonics* 42, 591-596.

Mason T.J., 1999, *Sonochemistry*, first ed., Oxford University Press.

Merouani S., Hamdaoui O., Saoudi F. and Chiha M., 2010, Sonochemical degradation of Rhodamine B in aqueous phase: Effects of additives, *Chemical Engineering Journal* 158, 550-557.

Mozia S., Tomaszewska M. and Morawski A.W., 2005, Photocatalytic degradation of azo-dye Acid Red 18, *Desalination* 185, 449-456.

Özdemir C., Öden M.K., Şahinkaya S. and Güçlü, D., 2011, The sonochemical decolorisation of textile azo dye CI Reactive Orange 127, *Coloration Technology* 127, 68-273.

Wang X., Yao Z., Wang J., Guo W. and Li G., 2008, Degradation of reactive brilliant red in aqueous solution by ultrasonic cavitation, *Ultrasonics Sonochemistry* 15, 43-48.