DEGRADATION OF POTASSIUM PERMANGANATE USING ACOUSTIC CAVITATION

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ABSTRACT

In the present investigation, degradation of potassium permanganate ($KMnO_4$) has been studied using acoustic cavitation. The effect initial concentration and acoustic frequency on the extent of degradation have been studied. The maximum degradation was found to be 48.98% at 100 kHz frequency and 15 ppm initial concentration. Further, first order degradation model has been fitted for experimental data. The first order degradation constant was found to be 0.011 min^{-1}.

Keywords: Acoustic Cavitation, Degradation

I. INTRODUCTION

Advance oxidation processes (AOPs) such as photolysis, ozonation, Fenton oxidation, heterogeneous photocatalyis, electrochemical oxidation, etc are commonly used for degradation of organic/inorganic pollutant from waste water. Cavitation, one of the AOPs, has shown to be promising for degradation of persistent organic/inorganic pollutants in waste water. Cavitation using ultrasound **(**acoustic cavitation) has some important advantages that it does not require addition of oxidants or catalyst and that it does not generate additional waste. Acoustic cavitation is the formation, growth, and implosive collapse of small bubbles in a liquid blasted with sound. The collapse of these bubbles leads to surprisingly high local temperature and pressure. These localized hot spots were estimated to have temperature of roughly 5000K and pressure of about 500 atm and life time of few microseconds [1]. The mechanism of sono-chemical degradation can be found elsewhere [2]. Literature review reveals that there is scanty information available on the degradation of $KMnO_4$. Therefore, in the present work, we have studied degradation of $KMnO_4$ using acoustic cavitation to elucidate the effect of initial concentration and acoustic frequency on the extent of degradation. Further, we have also proposed a first order degradation model which fits the experimental data well.

II. EXPERIMENTAL

2.1. Chemical

$KMnO_4$ was purchased from S. D. Fine Chemical Ltd, Mumbai. Distilled water, used for all the experimental runs, was obtained from water- distillation set up available in our laboratory.

2.2. Analysis

Analysis of sample was carried out using UV single beam spectrophotometer.

2.3. Set up

A schematic of experimental set up is shown in Figure 1. A glass water jacked reactor of 70 mm i. d. and 300 mm length was used. The transducer connected to ultrasound multi frequency generator and placed in a glass reactor 15 mm above the bottom.

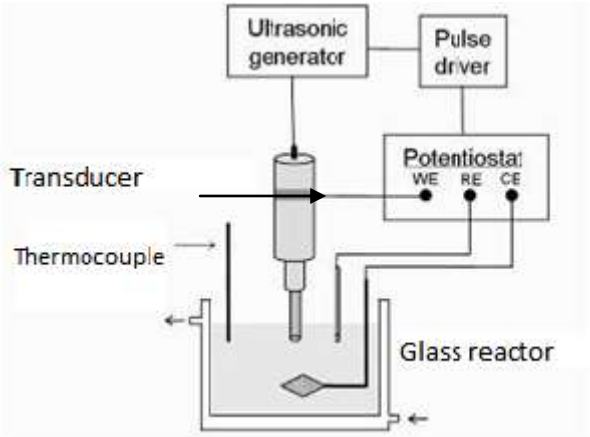

Figure 1 Experimental Set-Up

2.4. Methodology

An artificially prepared samples of $KMnO_4$ (initial concentration in the range of 10- 25 ppm) were subjected for acoustic cavitation for 1 hour at a 50 kHz to study the effect of initial concentration. The effect of frequency was studied by ranging the frequency in the range of 25 kHz– 100 kHz for a 15 ppm solution. The extent of degradation was estimated by analyzing a sample and using a calibration chart.

III. RESULTS AND DISCUSSION

3.1. Effect of Initial Concentration

Experiments were carried by ranging initial concentration in the range of 10-25 ppm at 50 kHz frequency for 1 hour. Figure 2 shown that degradation of $KMnO_4$ decreases with an increase in initial concentration. The maximum degradation was found to be 45.32% for 10 ppm initial concentration.

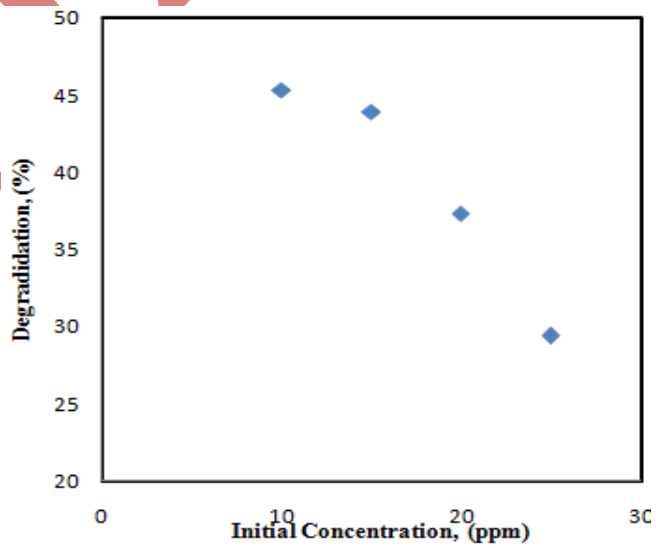

Figure 2. Effect of initial concentration

The half life of free •OH radicals generated by cavitation is in the order of microseconds. Therefore, it is worthwhile to assume that degradation reaction take place at the bubble- liquid interface [3, 4]. In that case, $KMnO_4$ degradation at higher initial concentration may be limited by available interfacial area.

3.2. Effect of Acoustic Frequency

In order to study the effect of acoustic frequency, experiments were conducted by ranging frequency in the range of 25- 100 kHz and by keeping initial concentration equal to 15 ppm. Figure 3 shows the effects of acoustic frequency on the extent of degradation. It is clear that an increases in acoustic frequency increases degradation of $KMnO_4$. An increase in frequency result into an increase in interfacial area over-which degradation of $KMnO_4$ takes place and as a consequence degradation of $kMnO_4$ increases.

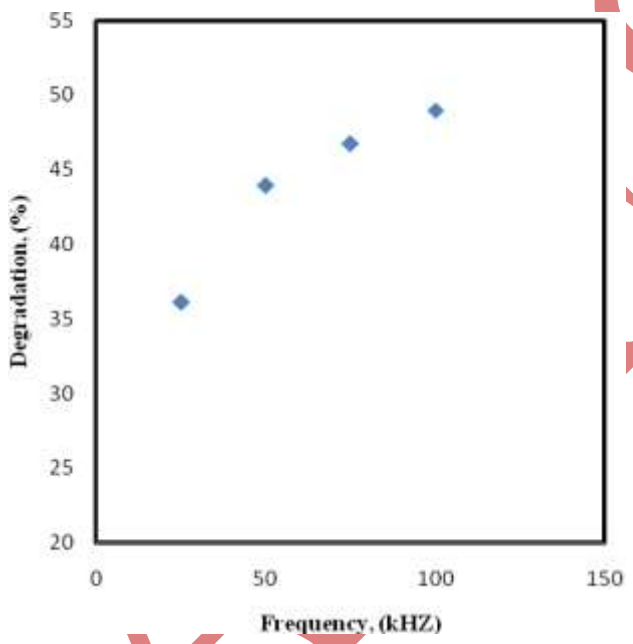

Figure 2 Effect of acoustic frequency

3.3. Kinetics of Degradation

Kinetics of degradation of $KMnO_4$ has been studied using 15 ppm solution subjected to 75 KHz frequency. The samples were taken at regular interval for analysis. Using initial method of analysis, following rate model can be obtained:

$$ln\frac{(KMnO_4)_{t=0}}{(KMnO_4)_{t=t}} = kt$$

The plot of $ln\frac{(KMnO_4)_{t=0}}{(KMnO_4)_{t=t}}$ vs time gives a straight line wherein slope of the line is a first order rate constant. Figure 3 shows the same. The slope of the line was found to be 0.011 min^{-1}. Therefore, following rate model can be used to determined degradation of $KMnO_4$ with respect the time:

$$ln\frac{(KMnO_4)_{t=0}}{(KMnO_4)_{t=t}} = 0.011t$$

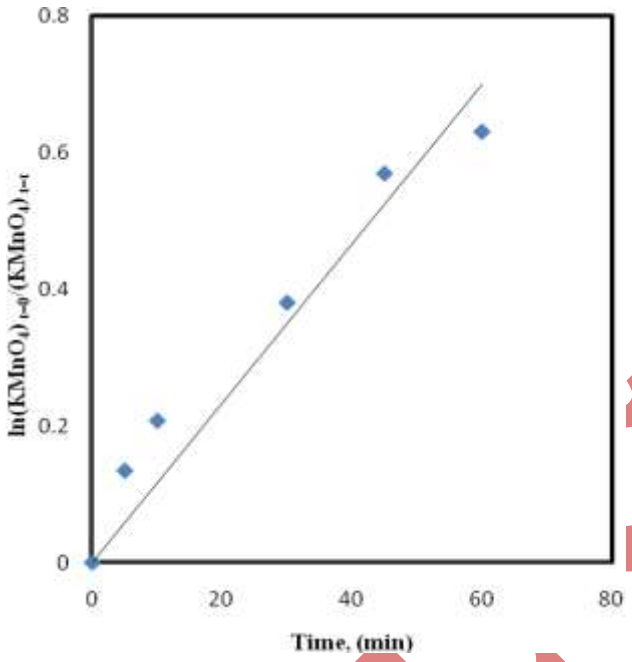

Figure 4 Kinetic of degradation

IV. CONCLUSION

Following conclusions can be drawn from the present investigation:

1) For a given acoustic frequency, an increase in initial concentration decreases degradation of $KMnO_4$.
2) For a given initial concentration, an increase in acoustic frequency increase degradation of $KMnO_4$.
3) The maximum degradation was found to be 48.98% at 100 kHz frequency and 15 ppm initial concentration
4) The first order reaction model fits the experimental data. The value of constant was found to be 0.011 min^{-1}

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