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# Sonolytic Degradation of Acid Blue 80 Dye

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***Abstract - In the present study, degradation of Acid Blue 80 (AB80) has been carried out by using Ultrasound Cavitation. The effect of various operating parameters such as effect of amplitude, effect of initial pH of solution, operating volume and effect of temperature on the degradation rates were studied. The 34.94% degradation of AB80 was found at the optimized conditions of amplitude, pH, temperature and volume of 75%, 2.5, 30 $^0$C and 200 mL respectively.***
***Keywords - Ultrasound Cavitation, Acid Blue 80, Hydroxyl radicals, waste water treatment, Degradation of dye***

## I. INTRODUCTION

Waste water from the paper and textile industry containing dyes causes environmental problem due to their strong colour and toxicity. These are the largest water consuming and water polluting industries [1, 2]. Main pollution in textile waste water came from dyeing and finishing processes. Major pollutants in textile waste waters are colour, high concentration of organic matters, non-biodegradable matter, toxic substances and other soluble solids. So these waste waters need to be treated before discharge in to the environment. In earlier years, carbon bed adsorption, chemical oxidation treatments, biological methods, electrochemical methods and other oxidation techniques were used for degradation of dyes. But these waste waters are not readily degraded by the conventional physical, chemical and biological effluent treatment methods [3].

Now a days cavitation has been extensively used by many researchers for waste water treatment because this technique is energy efficient and have the potential to degrade the new toxic chemicals, dyes, bio-refractory compounds in wastewater [3, 4]. Cavitation is the phenomena of the formation of nuclei, growth and subsequent collapse of microbubbles in extremely small interval of time i.e. in milliseconds, releasing large magnitude of energy. Based on mode of generation of cavity, there are four principle types of cavitation viz. acoustic cavitation, hydrodynamic cavitation, optic cavitation and particle cavitation . The present study includes acoustic cavitation based technique and the effect of different parameters such as variation of amplitude, initial pH of solution, temperature and volume of solution on percent degradation of AB80. A schematic of acoustic cavitation has been shown in Fig. 1. In the case of acoustic cavitation, cavitation occurs by using sound waves of high frequency i.e. ultrasound, whose frequency ranges from 16 kHz – 100 MHz. It occurs by alternate compression and rarefaction cycles of the sound waves which results in the formation of the bubbly cavity. These bubble grows to a particular size and then collapse in which large amount of energy is released. Due to cavitational bubble collapse, water undergoes thermal dissociation to give hydroxyl radical and hydrogen atoms. These hydroxyl radicals react with organic pollutant and oxidise them.

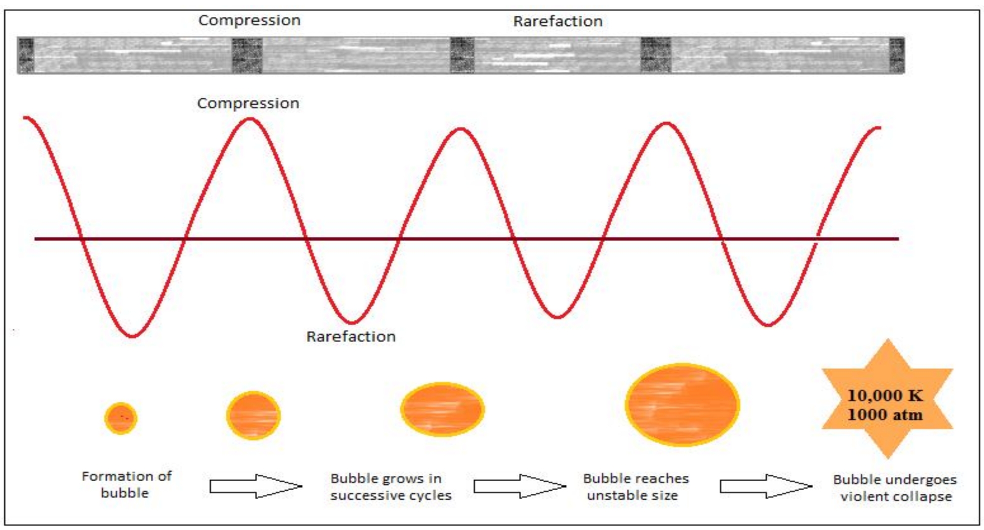


Fig.1 Schematic of acoustic cavitation

## II. MATERIALS AND METHODS

### A. Materials

Acid Blue 80 dye was purchased from Oswal Udhyog, Andheri, Mumbai. Chemical structure of AB80 is as shown in Fig.2. $H_2SO_4$ and NaOH were used for adjustment of pH. All solutions were prepared with distilled water. All chemicals were used as received from the supplier.

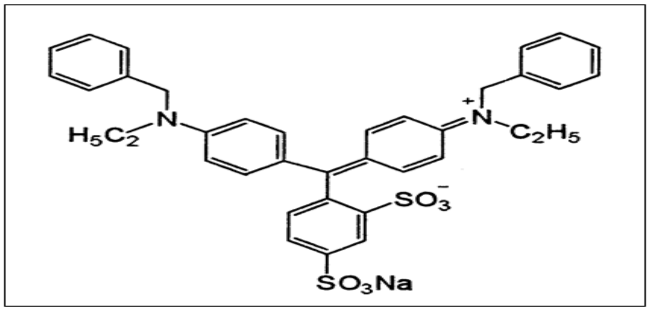


Fig.2 Structure of Acid Blue 80

### B. Experimental Methodology for Acid Blue 80

All the experiments were carried out using 25 ppm concentration of aqueous solution of AB80 dye of required concentration for optimization of the various operating parameters such as amplitude, initial pH of solution, operating temperature and volume of solution. The effect of amplitude on the rate of degradation of AB80 was studied by changing the amplitudes such as 25%, 50%, 75% and 100%. The effect of solution pH on degradation of AB80 was studied by changing pH from 2.5-6.6 (2.5, 4, 6.6). The effect of temperature was also investigated by varying temperature viz 20, 25 and 30$^0$C. The effect of volume of solution on the degradation of AB80 was also investigated by varying volume in the range of 200-300 mL (200, 250 and 300).

### C. Experimental procedure for sonolytic degradation of dye

Initially 1000 ppm stock solution of AB80 was prepared using distilled water and used for the preparation of 25 ppm solution. The pH of solution was adjusted using 2M $H_2SO_4$ and 2M NaOH solution. Then the solution was taken into glass reactor and placed in the sonication setup in such a way that the tip of the ultrasonic probe was immersed 2 cm into the solution. The experiments were performed for 120 min of treatment time and the ultrasonic horn was kept on for 6 seconds and off for 4 seconds. After every 15 min of treatment time, 5 mL sample was collected from glass reactor in the sample bottles and analyzed using UV-VIS Spectrophotometer. The percentage degradation of AB80 was calculated using following equation (Eq. (1)).

$$\% \text{ Degradation of AB80 dye} = \left(\frac{Co-C}{Co}\right)x100 \qquad \rightarrow \text{Eq. (1)}$$

Where, $Co$ = Initial concentration of AB80 dye (mg/L), $C$ = Concentration of AB80 with time (mg/L).

## III. RESULTS AND DISCUSSIONS

### A. Effect of amplitude on the sonolytic degradation of Acid Blue 80 dye

The effect of ultrasonic power on the degradation of AB80 dye was studied by varying the amplitude of ultrasonic processor (25%, 50%, 75% and 100%) keeping operating temperature and initial concentration of AB80 dye as 30$^0$C and 25 ppm respectively. The maximum power dissipation at 100% amplitude is 500W. Sonolytic degradation of AB80 dye was carried out for 120 min of total treatment time. Effect of amplitude on the extent of degradation has been shown in Fig. 3. Also the effect of amplitude on the rate of degradation of AB80 dye has been shown in Fig.4. It can be seen from Table 1 that as the amplitude increases from 25% to 75%, extent of degradation increases from 23.88% to 32.06%, but a further increase in amplitude result in decrease in the extent of degradation to 25.55%. The increase in the degradation of AB80 dye with increase in power from 125W to 375W can be due to increase in production of hydroxyl radicals. Further increase in power to 500W results in formation of cavity clouds, resulting in a decrease in degradation efficiency. Gogate and Bhosale [1] have studied the degradation of brilliant green and reported that the extent of degradation increases with an increase in operating power till an optimum value of 80 W and then decreases with a further increase in the power dissipation.

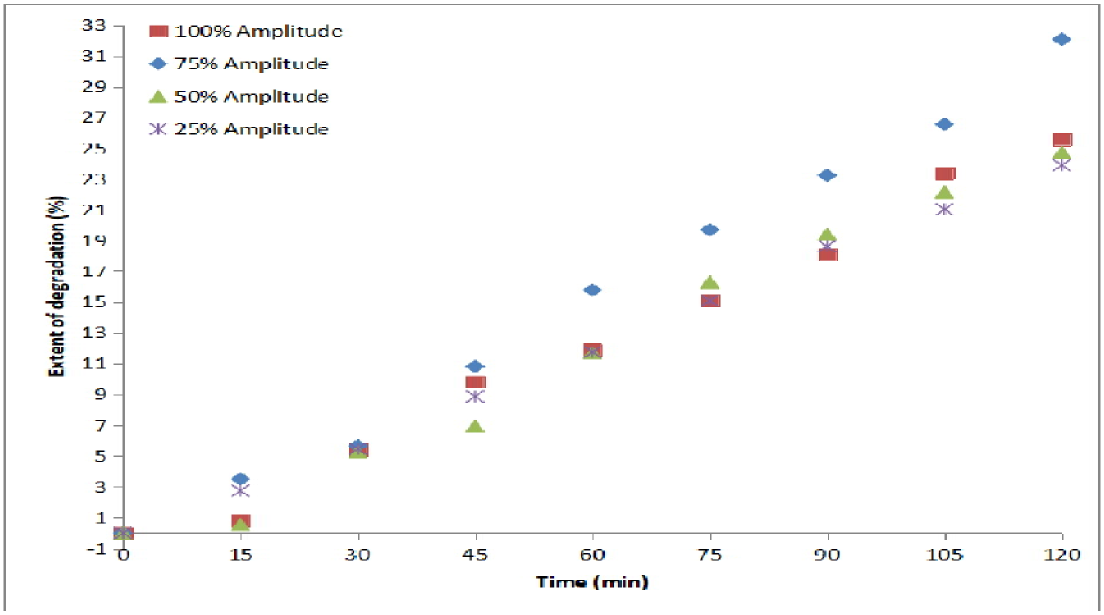


Fig.3. Effect of amplitude on extent of degradation. (Conditions: operating volume: 250 ml, initial concentration: 25 ppm, Temperature: 30°C, pH: 2.5)

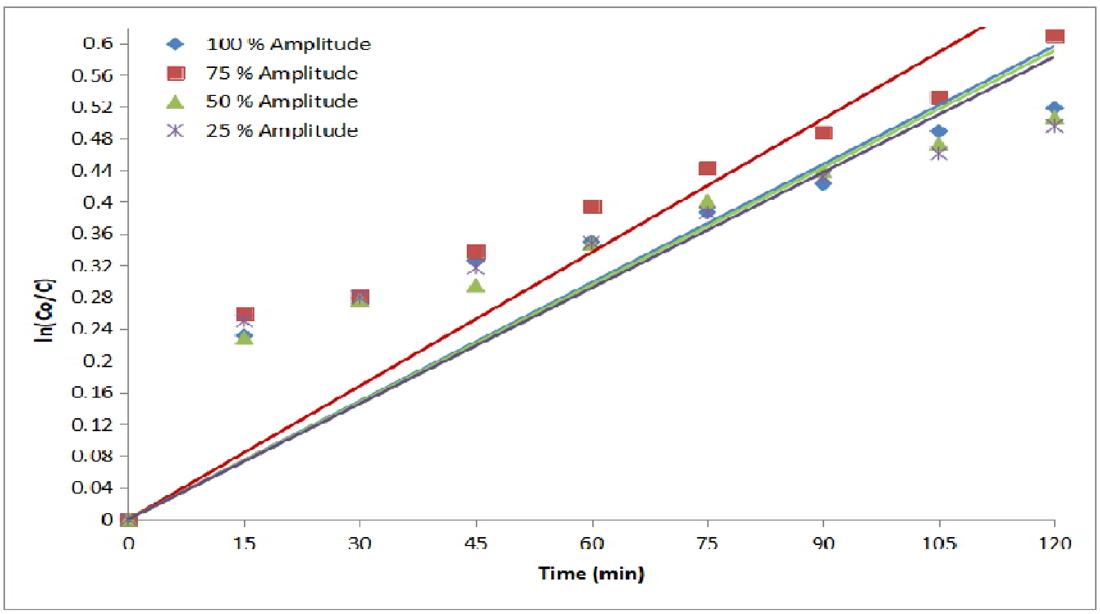


Fig.4. Estimation of kinetic rate constant at different amplitudes. (Conditions: operating volume: 250 ml, initial concentration: 25 ppm, Temperature: 30°C, pH: 2.5)

Table 1. Extent of degradation and kinetic rate constant for degradation of AB80 dye.

| Amplitude (%) | Power (Watt) | Extent of degradation (%) | First order rate constants k x $10^3$ ($min^{-1}$) |
|---|---|---|---|
| 25 | 125 | 23.88 | 4.9 |
| 50 | 250 | 24.70 | 4.9 |
| 75 | 375 | 32.06 | 5.6 |
| 100 | 500 | 25.55 | 5 |

*B. Effect of pH on the sonolytic degradation of Acid Blue 80 dye*

The initial pH of solution is one of the most important parameter, which affects the rate of degradation of dyes. In present study, in order to investigate the effects of pH on sonolytic degradation of Acid Blue 80 dye, experiments were conducted at different pH such as 2.5, 4, and 6.6. The effect of pH on degradation of Acid Blue 80 dye was studied at initial concentration of 25 ppm and operating temperature of $30^0$C. Fig.5 shows the effect of pH on extent on degradation of AB80 dye. Fig.6 shows the effect of pH on the rate of degradation of Acid Blue 80 dye. It has been observed that the rate of degradation of AB 80 dye increases with decrease in the pH. The maximum rate of degradation was observed at pH of 2.5 and minimum rate of degradation of Acid Blue 80 dye was observed at pH of 6.6. Table 2. shows the effect of pH on the extent of degradation and the first order reaction rate constant of AB 80 dye. It has been observed that the extent of degradation was increased from 23.33% to 32.06% as the pH was lowered from 6.6 to 2.5. Similar results have been reported for the degradation efficiency of orange acid II [1], reactive red 120 [2], rhodamine B dye [5], methomyl [6], acid orange 7 [7], reactive red 2 [11] , acid blue 92 [16] increases at acidic pH.

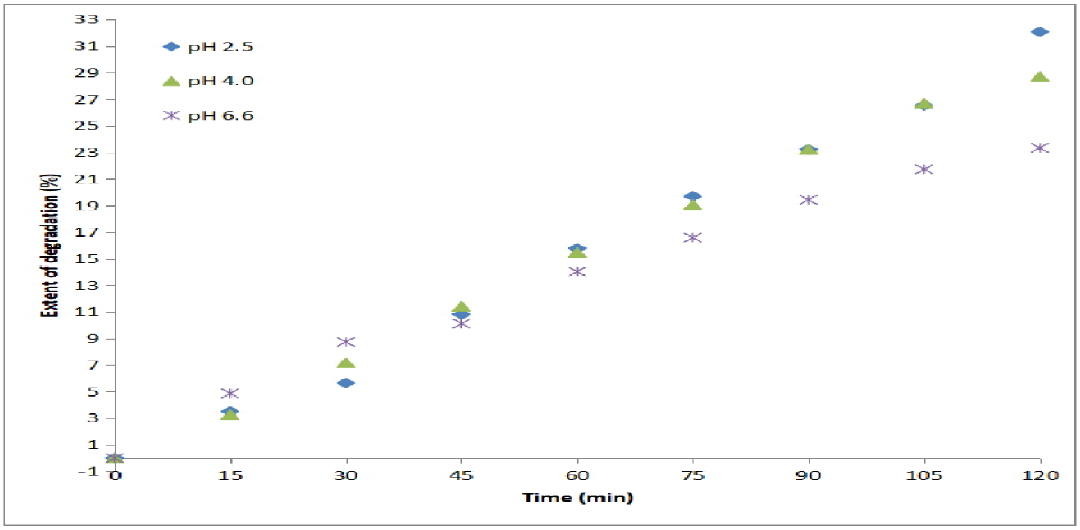


Fig.5. Effect of initial pH on extent of degradation. (Conditions: operating volume: 250 ml, initial concentration: 25 ppm, Temperature: 30°C, Amplitude: 75%)

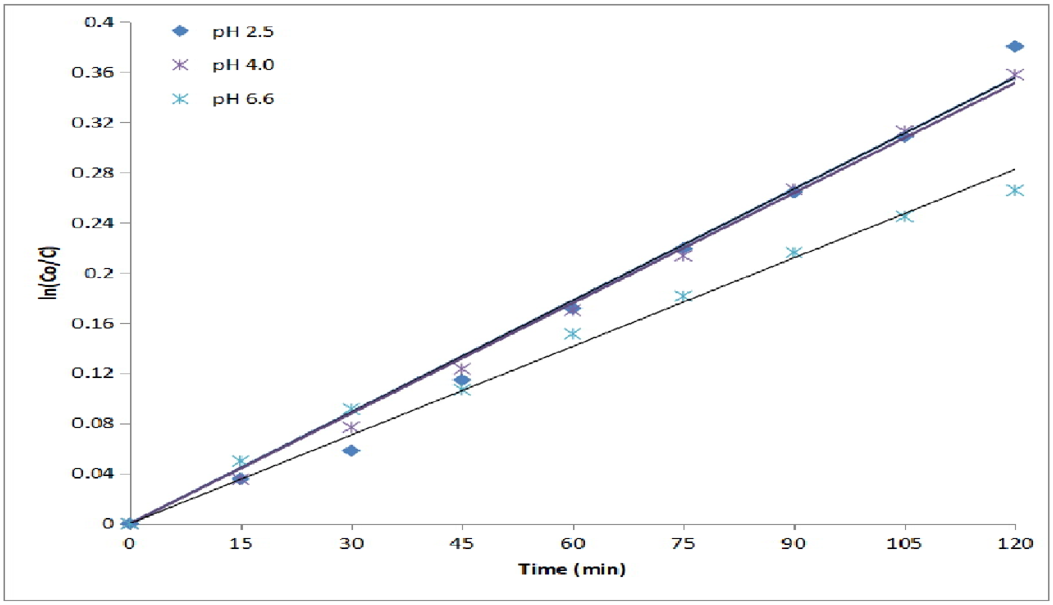


Fig.6. Estimation of kinetic rate constant at different pH. (Conditions: operating volume: 250 ml, initial concentration: 25 ppm, Temperature: 30°C, Amplitude: 75%)

Table.2 Extent of degradation and kinetic rate constant for degradation of AB80 dye.

| Initial pH of solution | Extent of degradation (%) | First order rate constants $k \times 10^3$ ($min^{-1}$) |
|---|---|---|
| 2.5 | 32.06 | 3 |
| 4 | 29.86 | 2.9 |
| 6 | 23.33 | 2.4 |

*C. Effect of temperature on the sonolytic degradation of Acid Blue 80 dye*

The effect of temperature on the degradation of Acid Blue 80 dye was studied at three different operating temperatures such as 20, 25 and 30$^0$C at 25 ppm initial dye concentration and initial pH of 2.5. Sonolytic degradation was carried out for 120 minutes of total treatment time. Fig.7 shows the effect of temperature on sonolytic degradation with respect to extent of degradation. Fig.8 Shows the effect of temperature on the rate of degradation of Acid Blue 80 dye at different operating temperatures.. It has been observed that the rate of degradation of Acid Blue 80 dye increases with an increase in the temperature upto 30$^0$C. The maximum rate of degradation of Acid Blue 80 dye was observed at temperature of 30$^0$C. Table.3 shows the effect of temperature on the extent of degradation and the first order reaction rate constant of Acid Blue 80 dye. The rate of degradation increases with increase in temperature because as temperature increases, the number density of cavitation bubbles increases. When this bubble collapse on surface, they leads to increase in hole and pores and thus, more hydroxyl radicals are formed on the surface. It has been observed that as temperature is increased from 20$^0$C to 30$^0$C, the extent of degradation of dye increases from 23.93% to 32.06%.

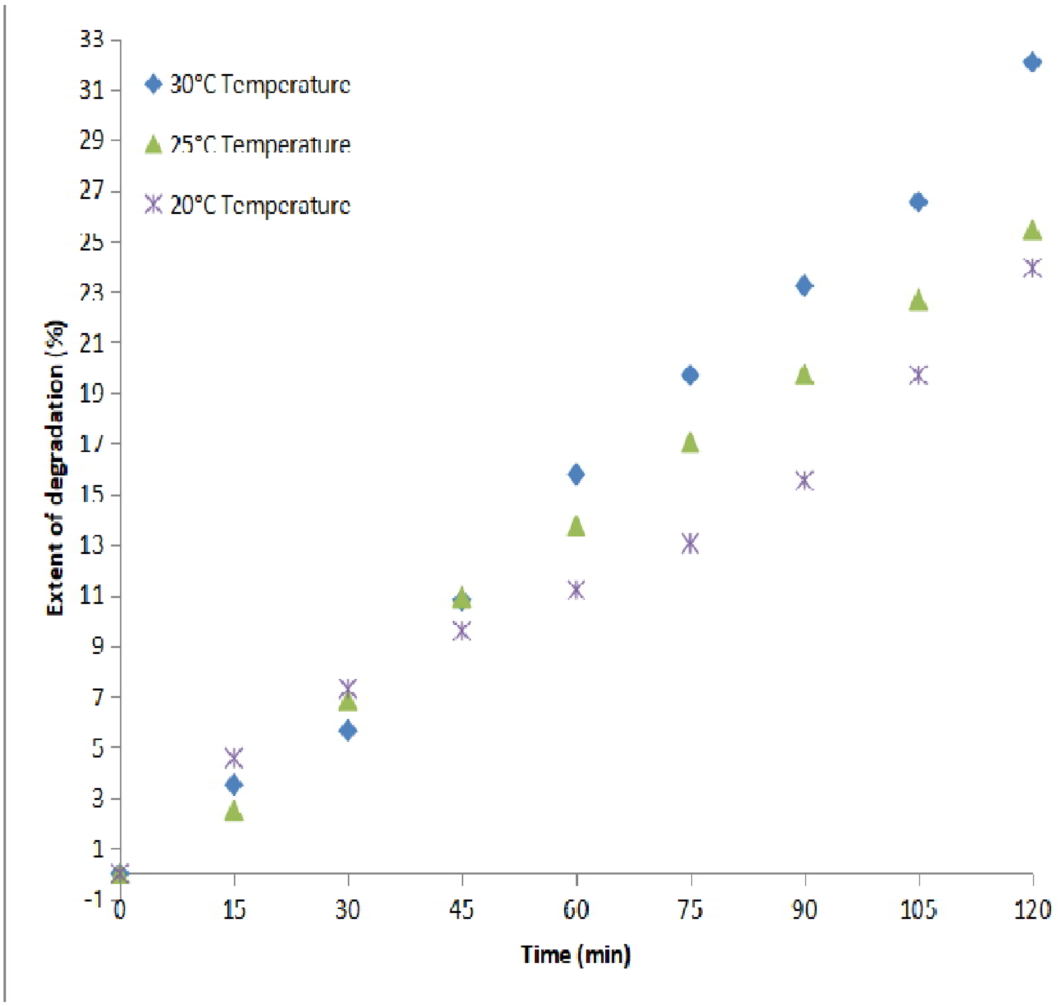


Fig.7. Effect of operating temperature on extent of degradation. (Conditions: operating volume: 250 ml, initial concentration: 25 ppm, pH:2.5, Amplitude: 75%)

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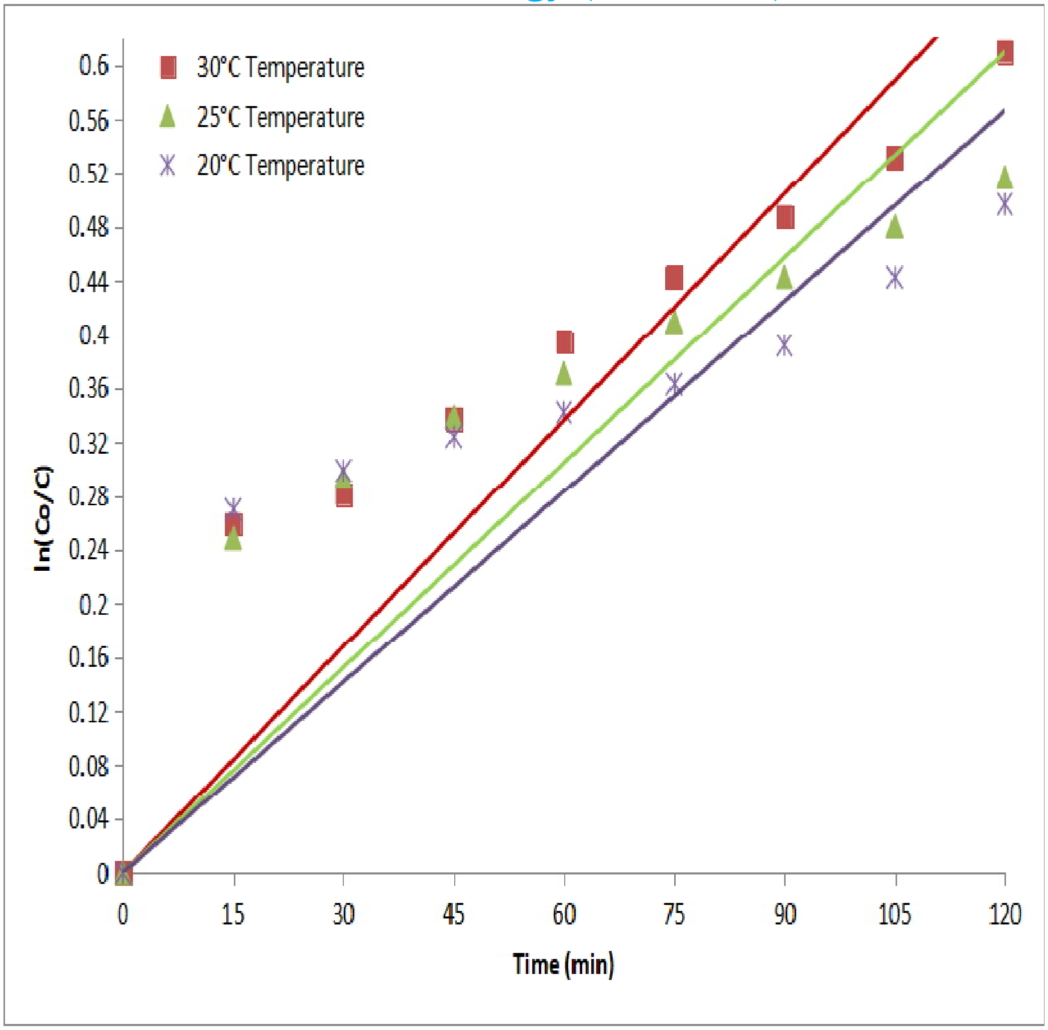


Fig.8. Estimation of kinetic rate constant at different operating temperature. (Conditions: operating volume: 250 ml, initial concentration: 25 ppm, pH: 2.5, Amplitude: 75%)

Table.3. Extent of degradation and kinetic rate constant for degradation of AB80 dye.

| Operating Temperature ($^0$C) | Extent of degradation (%) | First order rate constants k x $10^3$ (min$^{-1}$) |
|---|---|---|
| 20 | 23.93 | 4.7 |
| 25 | 25.45 | 5.1 |
| 30 | 32.06 | 5.6 |

*D. Effect of volume on the sonolytic degradation of Acid Blue 80 dye*

The effect of operating volume on sonolytic degradation of Acid Blue 80 dye was studied at different operating volumes such as 200 mL, 250 mL and 300 mL. Sonolytic degradation was carried out for 120 minutes of total treatment time. Fig.9 shows the effect of volume on sonolytic degradation with respect to extent of degradation. Fig.10 shows the effect of volume on the rate of degradation of Acid Blue 80 dye at different operating volumes. It has been observed that the rate of degradation of Acid Blue 80 dye increases with decrease in volume. The maximum rate of degradation was observed at volume of 200 mL and minimum rate of degradation of Acid Blue 80 dye was observed at volume of 300 mL. Table.4 shows the effect of volume on the extent of degradation and the first order reaction rate constant of Acid Blue 80 dye. It has been observed that as volume is decreased from 300 mL to 200 mL, the extent of degradation of dye increases from 29.40% to 34.94%.

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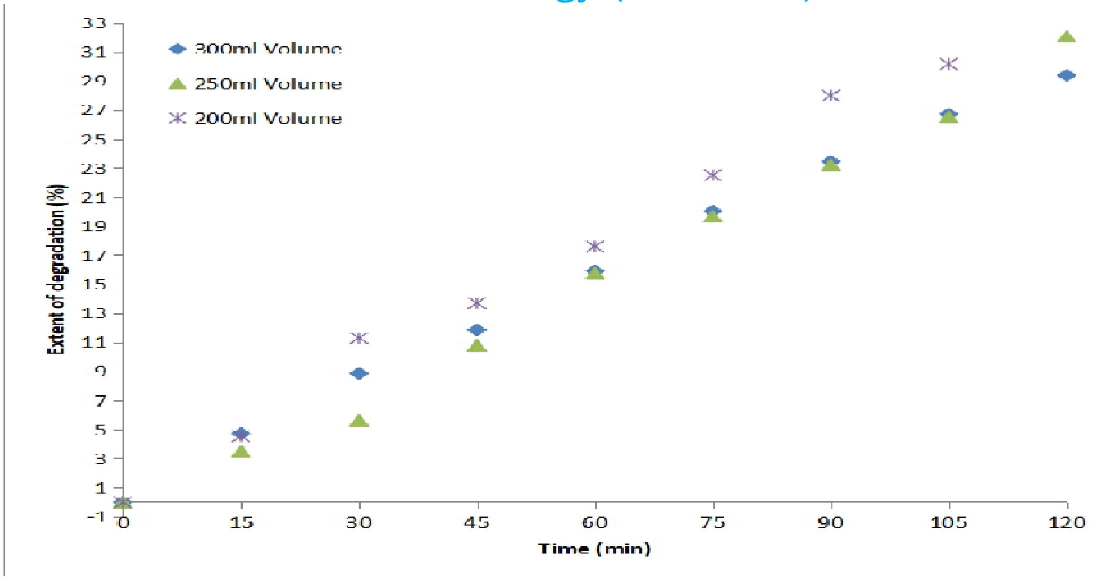



Fig.9 Effect of operating temperature on extent of degradation. (Conditions: initial concentration: 25 ppm, pH:2.5, Temperature: 30°C, Amplitude: 75%)

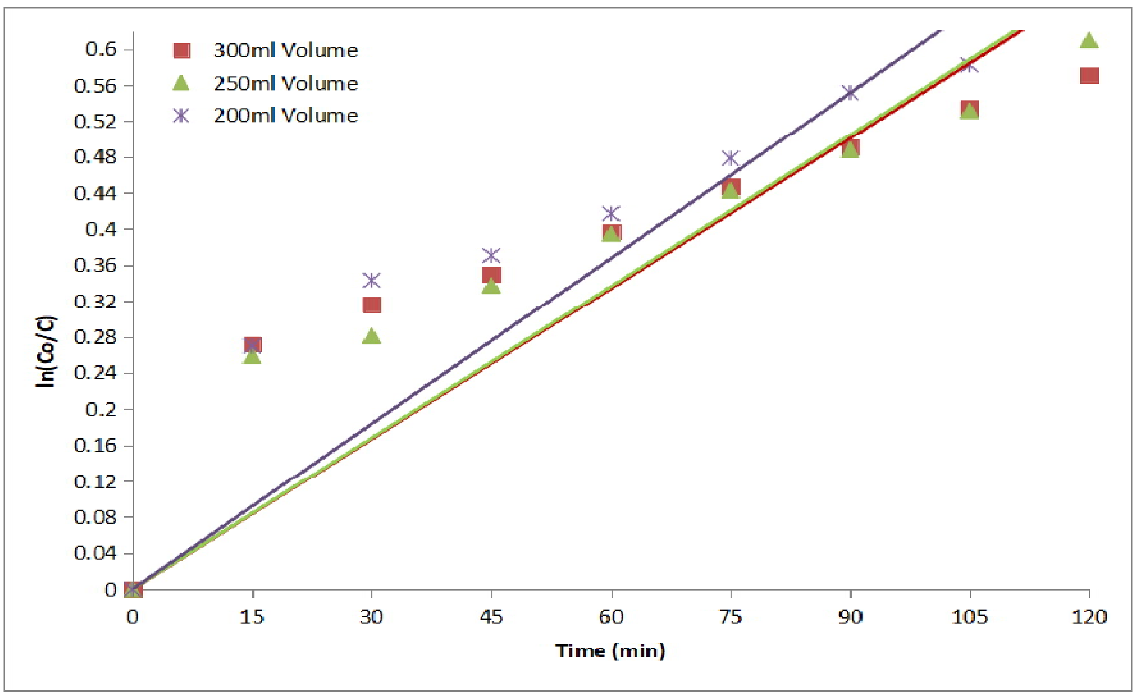



Fig.10. Estimation of kinetic rate constant at different operating volume. (Conditions: initial concentration: 25 ppm, pH:2.5, Temperature: 30°C, Amplitude: 75%)

Table.4. Extent of degradation and kinetic rate constant for degradation of AB80 dye.

| Operating volume (mL) | Extent of degradation (%) | First order rate constants $k \times 10^3$ ($min^{-1}$) |
|---|---|---|
| 200 | 34.94 | 6.1 |
| 250 | 32.06 | 5.6 |
| 300 | 29.40 | 5.6 |

## IV. CONCLUSIONS

In the present study, the effect of the different operating parameters on the rate of degradation of Acid Blue 80 dye has established the following important conclusions:

*A.* Rate of sonolytic degradation of AB 80 dye increases with an increase in the amplitude till an optimal value of 75% (i.e. power dissipation of 375W), beyond which the reduction in the rate of degradation of AB 80 dye was observed.

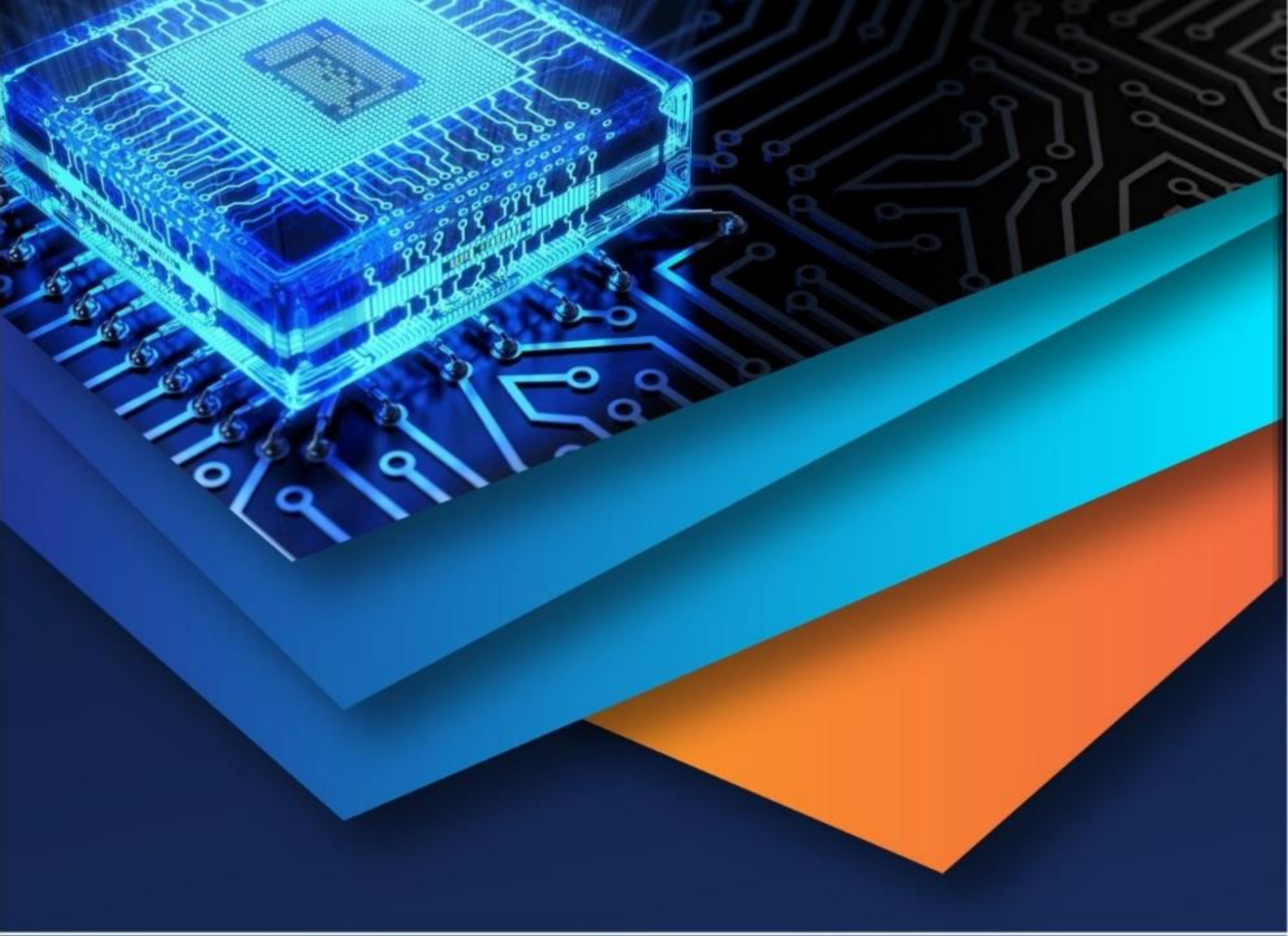
*B.* Acidic conditions are found to be better for the degradation of AB 80 dye and operating pH of 2.5 has been found to be the optimal with a maximum degradation of 34.94%.

*C.* Rate of degradation of Acid Blue 80 dye increases with an increase in the operating temperature and the maximum degradation was observed at temperature of $30^0$C.

*D.* Rate of degradation of Acid Blue 80 dye increases with decrease in volume and the maximum rate of degradation was observed at volume of 200 mLAlthough complete degradation of dye was not achieved using sonolytic degradation, the rate of degradation of Acid Blue 80 dye can further be increased by combining the ultrasonic cavitation with process intensifying additives such as hydrogen peroxide and Fenton reagent.

## REFERENCES

[1] P.R. Gogate and G.S. Bhosale, "Comparison of effectiveness of acoustic and hydrodynamic cavitation in combines treatment schemes for degradation of dye wastewaters" Chem.Engg. and processing: Process Intensification 71, 2013, 59-69.
[2] V.K. Saharan, M.P. Badve, A.B. Pandit, "Degradation of Reactive Red 120 dye using hydrodynamic cavitation," Chemical Engineering Journal, 178, 2011, 100-107.
[3] P.R. Gogate and A.B. Pandit, "A Review of Imperative Technologies for Wastewater Treatment I: Oxidation Technologies at Ambient Conditions," Advances in Environmental Research 8, 2004, 501-551.
[4] M.V. Bagal and P.R. Gogate, "Wastewater Treatment Using Hybrid Treatment Schemes Based on Cavitation and Fenton Chemistry: A review," Ultrasonics Sonochemistry 21, 2014, 1-14.
[5] P.L. Chaudhari, V.G. Joshi, P.B. Patil and K.S. Kulkarni, "Sonochemical Synthesis of Polyacrylicacid Nano $CACO_3$ Nanocomposite for the Adsorption of Rhodamine- B Dye," International Journal of Advanced Technology in Engineering and Science, 03, 2015, 168-176.
[6] S. Raut-Jadhav, D.V. Pinjari, D.R. Saini, S.H. Sonawane and A.B. Pandit, "Intensification of Degradation of Methomyl (Carbamate Group Pesticide) by Using Combination of Ultrasonic Cavitation and Process Intensifying Additives," Ultrasonics Sonochemistry 31, 2016, 135-142.
[7] H. Zhang, J. Zhang, C. Zhang, F. Liu and D. Zhang, "Degradation of C.I. Acid Orange 7 by the Advanced Fenton Process in Combination with Ultrasonic Irradiation," Ultrasonics Sonochemistry 16, 2009, 325-330.
[8] Y. Thakare, S. Jadhav and K. Wani, "Acid Orange 7 Dye Degradation Using Combined Acoustic Cavitation with Fenton and Photo Fenton Processes," International Journal of Engineering Science and Computing, 2016, 3379-3386.
[9] R. Singla, F. Grieser and M. Ashokkumar, "Sonochemical degradation of martius yellow dye in aqueous solution," Ultrasonics Sonochemistry 16, 2009, 28-34.
[10] M.A. Rauf and S.S. Ashraf, "Fundamental Principles and Application of Heterogeneous Photocatalytic Degradation of Dyes in Solution," Chemical Engineering Jornal, 151, 2009, 10-18
[11] CH. Wu and CL. Chang, "Decolorization of Reactive Red 2 by Advanced Oxidation Processes: Comparative Studies of Homogeneous and Heterogeneous Systems," Journal of hazardous materials, 128 (2–3), 2006, 265-272.
[12] P. Riesz, D. Berdahl, and CL. Christman,"Free Radical Generation by Ultrasound in Aqueous and Non-aqueous Solutions," Environmental Health Perspectives, Vol 64, 1985, 233-252.
[13] A. Khataee, R. Darvishi, C. Soltani, A. Karimi and S. Woo Joo, "Sonocatalytic Degradation of a Textile Dye over Gd-doped ZnO Nanoparticles Synthesized through Sonochemical Process," Ultrasonics Sonochemistry 23, 2015, 219-230.
[14] A. Alwash, A. Abdullah, and N. Ismail, "Zeolite Y encapsulated with Fe-TiO 2 for ultrasound-assisted degradation of amaranth dye in water," Journal of Hazardous Materials, 2012, 184– 193.
[15] M.A. Matouq, Z.A. Al-Anber, T. Tagawa, S. Aljbour, M. Al-Shannag, "Degradation of Dissolved Diazinon Pesticide in Water using the High Frequency of Ultrasound Wave," Ultrasonics Sonochemistry 15, 2008, 869-874.
[16] A. Khataee, S. Saadi, B. Vahid, S. Woo Joo and B. Min,"Sonocatalytic Degradation of Acid Blue 92 Using Sonochemically Prepared Samarium Doped Zinc Oxide Nanostructures," Ultrasonics Sonochemistry 29, 2016, 27-38.

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