ISSN: 0975 -8542

Journal of Global Pharma Technology

Available Online at: www.jgpt.co.in

RESEARCH ARTICLE

Application of Some Effects on the Degradation of the Aqueous Solution of Fuchsine Dye by Photolysis

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Abstract

This manuscript was focused on to how can utilize from UV-A light in order to decolorize the basic fuchsine dye from the aqueous solution at pH 6.4. The produced results from this study were indicated that the acidic medium is favor to decolorize this dye at pH equal to 4.6 and the efficiency of photoreaction increases from 73.75 % to 89.63 % at 70 min. The effect of temperature was done in ranged from (288.15 -333.15) K and occurred that the photoreaction of basic fuchsine dye increases with the increasing the temperature. The activation energy was calculated by depending on Arrihnes equation and found to be 10.286 kJ mol^{-1}. Moreover, the thermodynamics parameters such as $\Delta H^{\#}$, $\Delta S^{\#}$ and $\Delta G^{\#}$ were measured and given values equal to 7.714 kJ mol^{-1}, -0.00362 kJ mol^{-1} and 8.923 kJ mol^{-1} respectively. The positive value of $\Delta H^{\#}$ enhances the photoreaction of photo-decolorization of this dye. A statistic study was performed by using t-test and F-test, and noticed that there was no significant difference between these methods.

Keywords: *Basic Fuchsine dye, Photolysis, Rosaniline hydrochloride dye, PDE and Decolonization.*

Introduction

The common cause for environmental pollution is polluted by dyes; which deem as one of the factors that led to pollute the natural water, sewage water and soil [1, 2]. These dyes are utilized from them in the coloring processes of a number of industrial materials such as textiles, fibers, leather, paper and synthetic [3]. Hence, via the one year, approximately 10-15% of the produced wastes for environment are found as aqueous solutions of dyes and additives to the coloring process [1].

The exposure of a high concentration of dye causes many health symptoms, which affected on eyes, skin, blood flow, liver and irritation in the respiratory tract. From other hand, nausea, vomiting and diarrhea are can be occurred also [4]. In this manner, many paths of removing or destroying of dyes such as Biodegradation [5, 6], photodecolorization [7, 8], adsorption [9, 10] etc.

In spirt of these disadvantages of dyes, but dyes can be applied in positive side such as extraction of toxic metals as complexes [11] and used to measure of irradiation doses for some foods by using visual radiation [12]. This study included one of the methods that used to destroy the basic fuschin dye with determines some conditions and factors that accelerate the destruction process. A comparison study between the different values for the same variable studied via the using of t-test and F-test was done.

Materials and Method

Materials

All the raw chemicals employed in these photocatalytic experiments were supplied in the highest purity available and of analytical grade. Zinc oxide (99.5% purity) was supplied by Merck. Basic Fuchsine dye (BFD) was provided by fluka, the physic

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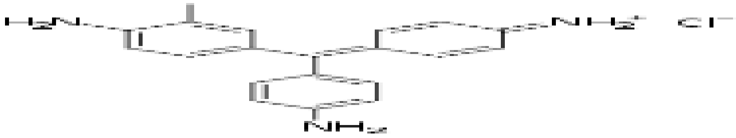
and chemical characteristics of this dye was explained in Table 1.

Table 1: Physico-chemical characteristics of the basic Fuchsine dye [11, 13, 14]

Parameters	Values
Molecular structure	
Molecular Weight	337.86
Molecular formula	$C_{20}H_{20}N_3 \cdot HCl$
Synonym	Rosaniline hydrochloride dye
IUPAC name	(4-[(4-Aminophenyl)-(4-imino-1-cyclohexa-2, 5dienylidene) methyl] aniline hydrochloride
Dyestuff(class)	Tri phenyl methane dyes
Nature	Basic dye
commonly employed	textile industries
λ_{max}	(540 -555) nm

Method of Photo-decoloeization

The most photo experiments were performed without the using of ZnO this called photolysis; which depended on using 100 mL of certain concentration of basic Fuchsine dye, and irradiation under stirring in series of sequence times. The residue concentration of dye was measured at 415 nm through the UV-visible spectro-photometer type Optima. The photocatalytic reaction was done after dark reaction, with using ZnO as a catalyst in 100 mL of basic Fuchsine dye employing a Labtech magnetic stirrer. At a regular intervals; about 3 mL of the suspension solution was collected and double centrifuged at 4000 rpm and 15 minutes by using a Hettich centrifuge to remove the fine ZnO particles. The concentrations of residual basic Fuchsine dye were depressed with irradiation and determined at 540 nm also. The rate constant and photodecolorization efficiency PDE were found by depended on the following equations [15, 17].

$$\ln\left(\frac{C_o}{C_t}\right) = k_{app} .t \qquad (1)$$

Here: C_o and C_t are an initial concentration of basic Fuchsine dye in dark reaction (irradiation time = 0 min) and a concentration of the this dye at t time of irradiation.

The Photo decolorization Efficiency PDE of basic Fuchsine dye was expressed by the following equation [16, 18]

$$PDE = \left(\frac{C_o - C_t}{C_o}\right) x100 \qquad (2)$$

Statistical Analysis

The F -test was determined if the variances of two data sets (a and b) are the same. Based on the results of the F -test, the t-test, which can be employed to determine if the means of two data sets are the same. Alternatively, the F-test can be employed to find the significance of individual parameters in a model (non-linear curve fitting) [11].

Results and Discussion

Preliminary Experiments

This part involved series of preliminary experiments. Firstly, the photolysis of this dye at natural pH equal to 6.4 under UV-A light was performed, and then the photocatalysis of the same dye with using ZnO was done also. The photocatalysis is very fast compared with photolysis, so, in this work, the photolysis was chosen by us to improve and find the necessary conditions for decolorization of this dye.

BFD + light→ slight decolorization (3)

BFD + ZnO+ light→ fast decolorization (4)

Effect of Initial pH

The initial pH of aqueous solution is played vital role in the production of hydroxyl

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radicals and decolorized of the studied dye. The pH of 2 ppm of the basic Fuchsine dye solution was fixed from 3.23 to 10.1 by adding HCl solution or NaOH solution with using pH meter type Benchtop 3001- Germany. By depended on figures 1 and 2, the dye is affected by altering the initial pH of dye solution, and that leaded to change the structure of dye or increase the chance of destroying it, that performed under UV-A-light which have wavelength equal to 365nm with temperature equal to 288.15K.

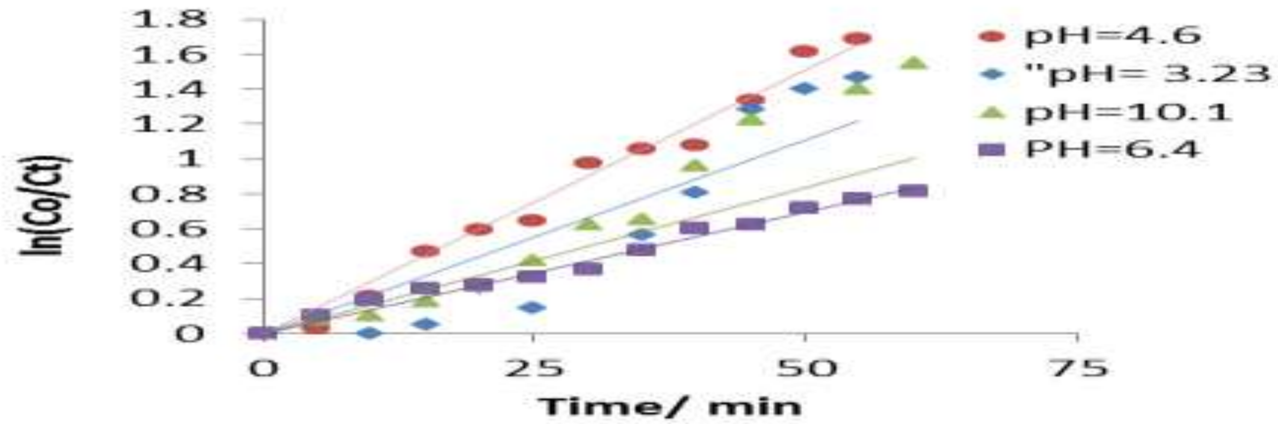


Figure1: Effect of pH of solution on the time of reaction. At conditions: fuchsine dye conc.= 2 ppm, pH of solution between (3-11) and T=288.15K

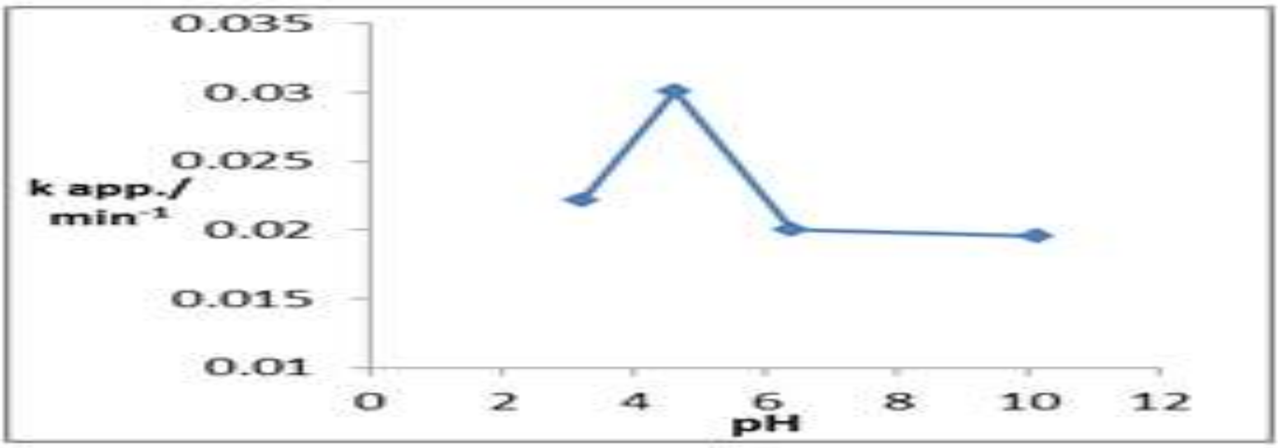
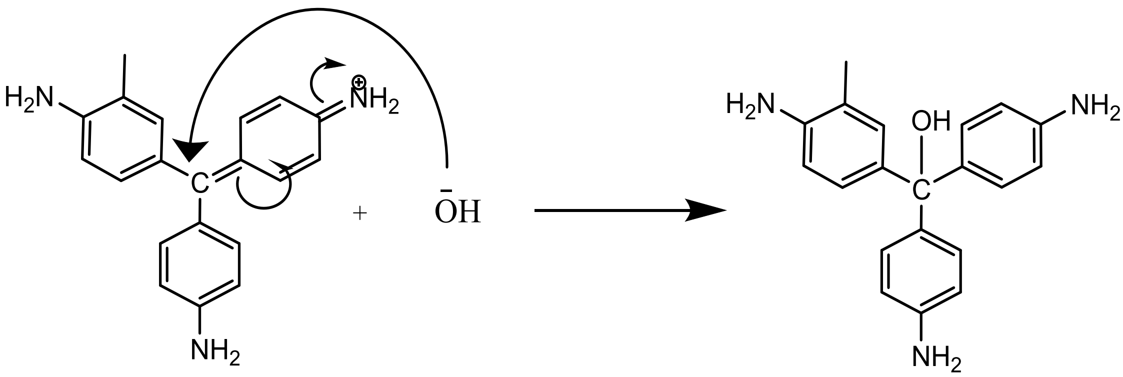


Figure 2: Effect of initial pH of solution on the apparent rate constant of reaction. At conditions: fuchsine dye conc.= 2 ppm, initial pH of solution and T=288.15K

The highest value of rate constant was observed at pH equal to 4.6 and then the values of the rate constant were reduced because the basic fuchsine dye was changed in the basic medium to another compound as in the following equation [19]



(5)

Effect of Temperature

In these experiments used different temperature the range from 313.15K to 333.15 K with light intensity equal to 1.90 x 10^{-7} enisien.s^{-1}, initial basic Fuchsine dye concentration of 2 ppm, pH solution equal to 6.4. It is found that the decolorization rate of basic Fuchsine dye is raised with increasing the temperature. The results in table 2 which

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plotted in Figures 3 showed the Arrhenius relationship[18] that gives low value of activation energy which equal to 10.286 kJ mol^{-1} for photocatalytic decolorization of basic Fuchsine dye.

The raised of temperature is enhanced the photolysis reaction of BFD and leads to fast, endothermic, less random and non-spontaneous reaction in Figures 3 and 4. The PDE % at 60 ^{o}C is reached to 80% at at50 min.

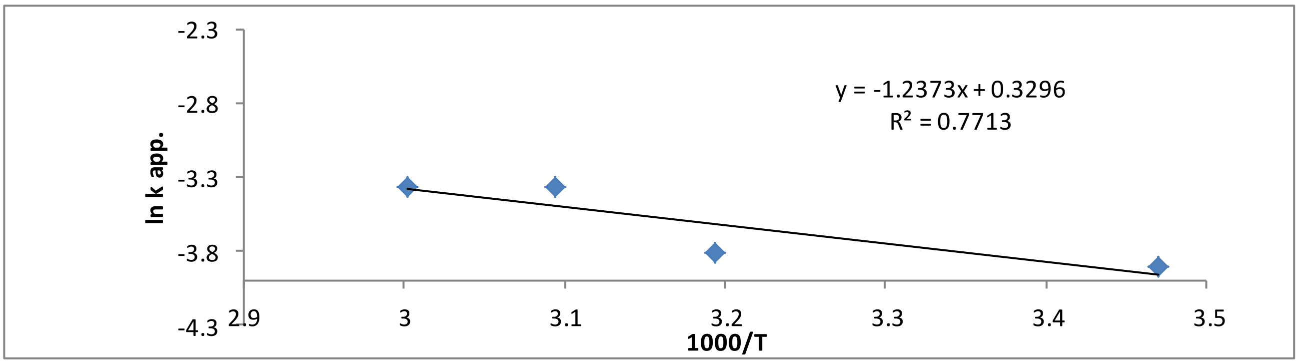

Figure 3: Arrhenius equation plotted at varying temperature at (288.15 - 333.15) K. At conductions: dye conc. 2 ppm, and normal pH= 6

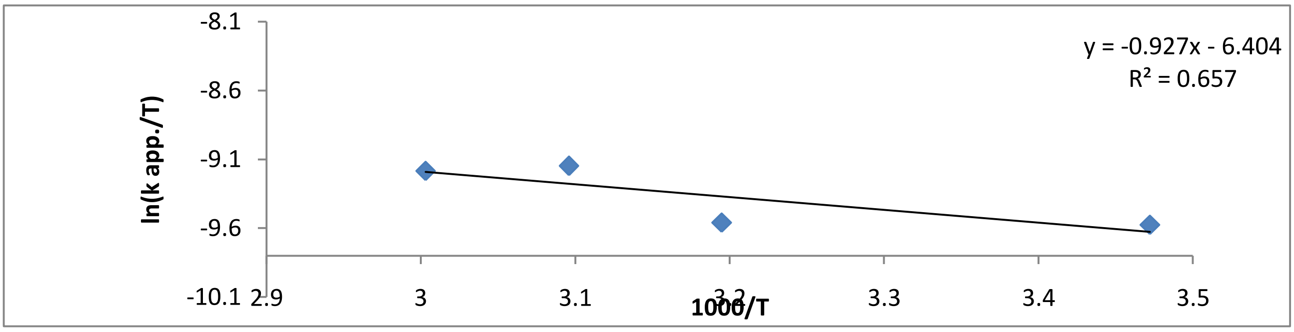

Figure 4: Eyring plot of (ln(kapp./T) vs. 1000/T. At conductions: dye conc. 2 ppm and normal pH=6

The activation energy of photolysis of this dye was calculated by using Arrhenius equation [20, 21],the thermodynamics parameters were measured with using Eyring equation and Gibbs equation [22, 23] As shown in Table 2.

Table 2: The kinetic and thermodynamic factors for the photolysis of BFD under UV-A

E_a kJ mol^{-1}	$\Delta H^{\#}$ kJ mol^{-1}	$\Delta S^{\#}$ J mol^{-1} K^{-1}	$\Delta G^{\#}_{333.15}$ kJ mol^{-1}
10.286	7.715	-3.628	8.923

According to the results of in above table, the photolysis of this dye under 2 ppm concentration with pH 6.4, the reaction was found was fast (activation energy equal to 10.286 kJ/mol), endothermic (positive enthalpy), less random(negative entropy) and non- spontaneous (positive free energy).This results are inagreement with the reported in references [7, 8, 16, 22, 25].

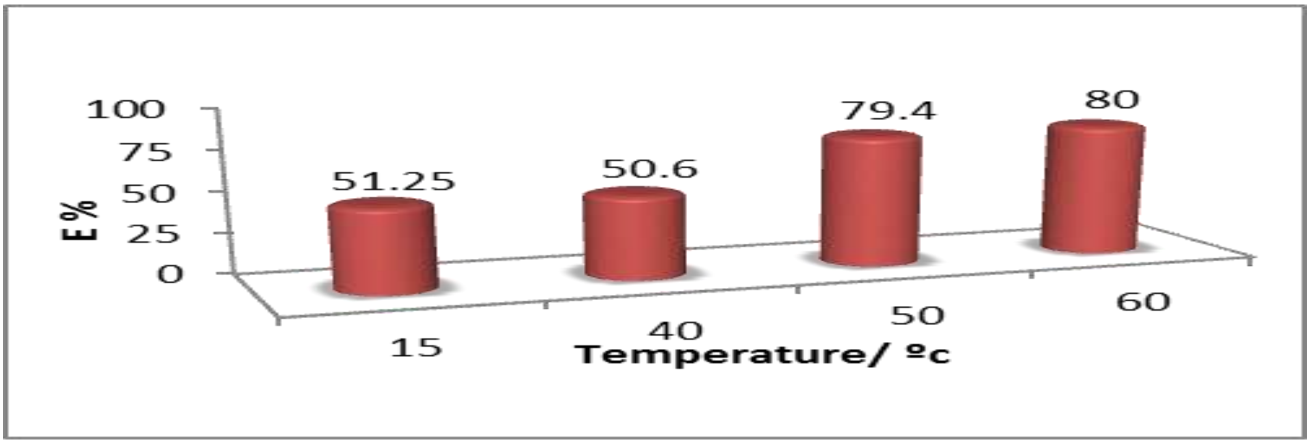

Figure 5: % Efficiency of decolourization of dye by using different temperature at standard initial pH of solution= (6). At conditions: fuchsine dye conc.= 2 ppm and time = 50 min

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Statistical Analysis

Based on the T-test and f-test for decolorization of basic fuchsin dye at pH = 6.4 with compared it with other mediums at pH 3.4, 4.4 and 10.1 in Table (3), the results noted that the decolorized of this dye at pH 4.4 and 10.1 was possible, that due to the calculated T-test is less than that value mentioned in table 3, so, no observed any altering between the standard pH of dye's solution (6.4) and each other studied pH at 4.4 and 10.1. While, the t-test and F-test for decolorized this dye at pH equal to 3.4 is more than both calculated values in table 3, and is not favor values. From the other hand, the statistical study of temperature effect was done and found no observed any altering in calculated T-test and f-test that mentioned in table 3, So, all the calculated values are less than that calculated values in table 3, that deduced the ability of decolorized this dye in these studied temperature values.

Table 3: Statistical treatments for comparison the decolorization of basic fuchsin dye at pH = 6.4 and different acidic medium, and then comparison the decolorization of basic fuchsin dye at room temperature (20 °C) and different temperatures

Affecting factor	Pooled Variance	T-test	T/ Critical one-tail 90%	T/ Critical two-tail 95%	F-test	F Critical one-tail	Df
pH(6.4,3.2)	0.00563	2.960351	1.69552	2.03951	3.4236	2.6709	31
pH(6.4,4.6)	0.56965	-1.04458	1.690924	2.032245	1.12406	2.4000	34
pH(6.4,10.1)	2.76101	-1.15922	1.690924	2.032245	0.20864	0.4433	34
Temperature(15,40)	0.00217	0.18588	1.699127	2.04523	0.78355	0.42053	29
Temperature(15,50)	0.0019	1.218513	1.710882	2.063899	1.4478	4.56782	24
Temperature(15,60)	0.0021	0.400096	1.708141	2.059539	0.7624	0.380471	25

Mechanism of Decolorization of Basic Fuchsin Dye

The most acceptance mechanism for photolysis of Basic fuchsin dye was proposed as follows figure 6. This mechanism depends on formed hydroxyl radical which acts as power force to start any photolysis or photocatalysis [24,27].

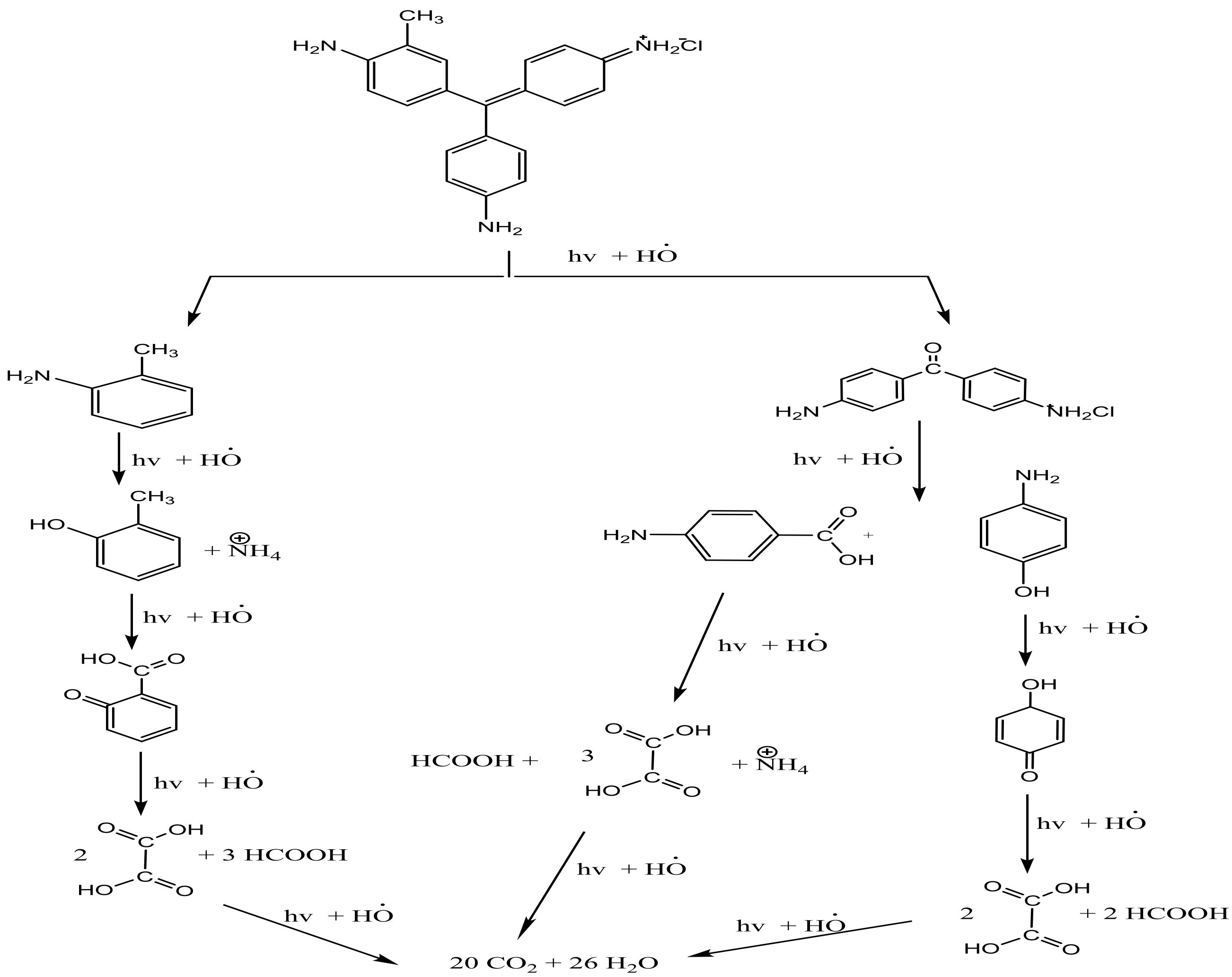

Figure 6: Schematic diagram for photolysis of Basic fuchsin dye

Conclusions

In this work the Preliminary experiments were performed and found the photolysis is slight reaction compared with photocatalysis with using ZnO, and the best conditions for improving the photolysis of BFD were done, and found to be the reaction is fast, endothermic, less random and non-spontaneous. The efficiency percentage for photolysis was maximum at 60 °C equal to 80%. The best initial pH for photolysis reaction was 4.6, and that most statistical treatments do not contain a difference in the credibility between comparative circumstances.

Acknowledgement

Authors would like to introduce the acknowledge to any people that support this work either theory or in practically parts (physical chemistry lab and analytical chemistry lab) in the University of Kerbala, College of Science in the Department of Chemistry in Iraq.

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