International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)
Journal Home page:www.iscientific.org/Journal.html

Degradation of Reactive Black B dye in wastewater using oxidation process

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Abstract

$KMnO_4$ oxidation was tested to degrade the reactive black B dye present in water effluent. Effect of pH, time, temperature and $KMnO_4$ concentration on decolorization efficiency was studied. 99.95% decolorization and 74.99% decrease in COD were observed at optimum conditions which were pH = 1, Time = 50 min, Temperature = 60ºC and KMnO4 dose was 108.5 ppm Mineralization took 8 h in which 83.89% decrease in COD was observed. $KMnO_4$ oxidation is best for the decolorization of reactive black B dye in water effluent but mineralization was insufficient.

Key words:$KMnO_4$,oxidation, decolorization, wastewater, reactive black B.

Full length article Received:14-01-2013 Accepted: 01-07-2013 Available online: 31-07-2013
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1. Introduction

Effluents from textile, food, dye, cosmetics, paper, plastic and lather industries contains dyes and other organic toxic compounds which are hazardous to aquatic life [1]. The effluents from textile industries are characterized by strong color, high pH, high temperature, high COD value and low biodegradability [2]. Other parameters include turbidity, odor, bacteria, viruses, heavy metals and total suspended solids [3]. Annual production of dye stuff is more than 7× 105 tons [4] 1 – 15% of which is wasted during processes and pollute the water bodies [5]. A little negligence to treat water can result in the spread of many diseases [6].The compounds are stable to aerobic decomposition and other oxidizing agents and make it difficult to treat such effluents with conventional methods of water treatment [7]. Efficient, easy and cheap method to treat textile effluents is highly demanded. Potassium is a strong oxidizing agent. It can oxidize ferrous, manganese and organics [8-10] it can work in acidic and alkaline conditions [11]. $KMnO_4$ decolorization of waste water containing dyes was proposed [12]. Advantages of $KMnO_4$ on other oxidizing agents are easier to handle [13], highly efficient for soil and water treatment [14] and it can oxidize trichloroetylene [15,16], methyl ter-butyle ether [17] and toluene [18].

In this work synthetic effluent of reactive black B dye was degraded by $KMnO_4$. Effects of $KMnO_4$ concentration, pH, temperature and reaction time on degradation of dye were examined.

2. Materials and Methods

All the chemicals were purchased from Merck and Reactive Black B dye was obtained from Sandal dyestuff Faisalabad Pakistan. Waste water was prepared by the following method reactive black B (1504 mg), hydrolyzed starch (13.9 mg) and sodium sulphate (27.8 mg) were dissolved in 1000 ml of deionized water and hydrolyzed at 80ºC for 1.5 h and stored at 4ºC. [19] 20 ml of synthetic effluent was decomposed using different amounts of 0.5M $KMnO_4$. The decomposition efficiency was checked by taking absorption of treated solution with spectrophotometer (PG-60) and COD value was tested by Lovi bond COD analyzer. To optimize reaction conditions experiments were performed at pH = 1,3,5,7,9 and 11, time intervals 5,10,20,30,40 and 60 min and temperature = 30, 40, 50, 60, 70 and 80ºC with 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5 and 5 ml 0.5M $KMnO_4$.Mineralization of dye solution at optimum conditions was noted after 2, 4, 6 and 8 h by determining the COD values. At the end other water quality parameters were evaluated [12].

3. Results and discussion

3.1. Optimization of pH for decolorization and COD value of colored effluent:Reactive Black B was taken as model pollutant in this work pH value from 1 to 11 was used to decolorize the dye solution and COD values were also

determined. The results are shown in fig.1 pH has significant effect on decolorization. At pH = 1, 99.91% decolorization was achieved and COD value was decreased to 66.05%. Mn (VII) is reduced to various oxidation states depending on acidic, alkaline and neutral medium. pH is an important variable in redox reactions as it can affect the redox potential and overall redox potential of the reaction increase with the decrease of pH there the oxidation of ability of potassium permanganate is grater in more acidic media and best color removal can be obtained[4,20]. During the treatment of water above pH 3 there is formation of colloidal particles of MnO2 which may also decrease the degradation efficiency [12].

3.2. Optimization of reaction time for decolorization and COD value:Reactive Black B dye was decolorize by $KMnO_4$ and the results are shown in fig.2 Degradation experiment was performed for 5–60 min best decolorization efficiency (99.28%) and maximum decrease in COD was obtained after 50 min and remain constant upto 60min. [4,17]. Reactive dyes are consisting of aromatic rings and have conjugated double bond system specially chromophoric group these double bond does not required significant amount of energy hence degradation of reactive black B dye by $KMnO_4$ is fastest than other organics because about 90% of dye decomposed in 5 min of reaction time.

3.3. Optimization of temperature for decolorization and decrease in COD:Decolorization of reactive black B dye was performed at 30 – 80ºC and results are shown in fig.3 Best decolorization and maximum decreace in COD was obtained at 60ºC and more increase in temperature has no significant effect on decolourization and COD. Effect of temperature on decolorization of dye solution is significant like other reactions and color is completely removed at 60ºC [12].

3.4. Optimization of concentration of $KMnO_4$ for decolorization and decrease in COD:Decolorization was performed with Different concentrations (39.5 – 395 ppm) of KMnO4 and results are presented in fig. 4. The concentration of $KMnO_4$ has dominant effect on decolorization of dye solution and decrease in COD. 99.91% decolorization was obtained with 108.5 ppm and remained constant with further increase in concentration. Decrease in COD was 74% at this concentration of $KMnO_4$. Over dose of $KMnO_4$ should be avoided otherwise it will cause toxic effect due the presence of Mn ions.

3.5. Mineralization of Dye:For the mineralization of Reactive Black B dye long time treatment was performed fig.5 shows the decrease in COD from 2 to 8 h treatment. 83.89% decrease was achieved in 8 h.

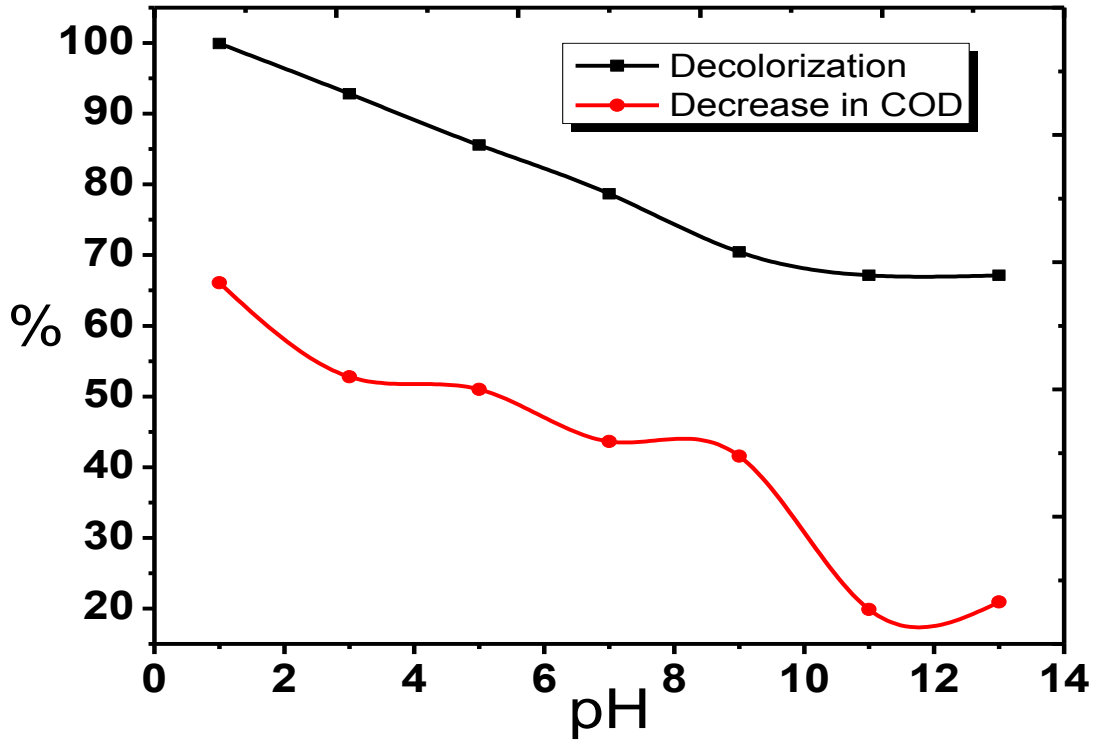

Fig. 1. Effect of pH on decolorization and COD

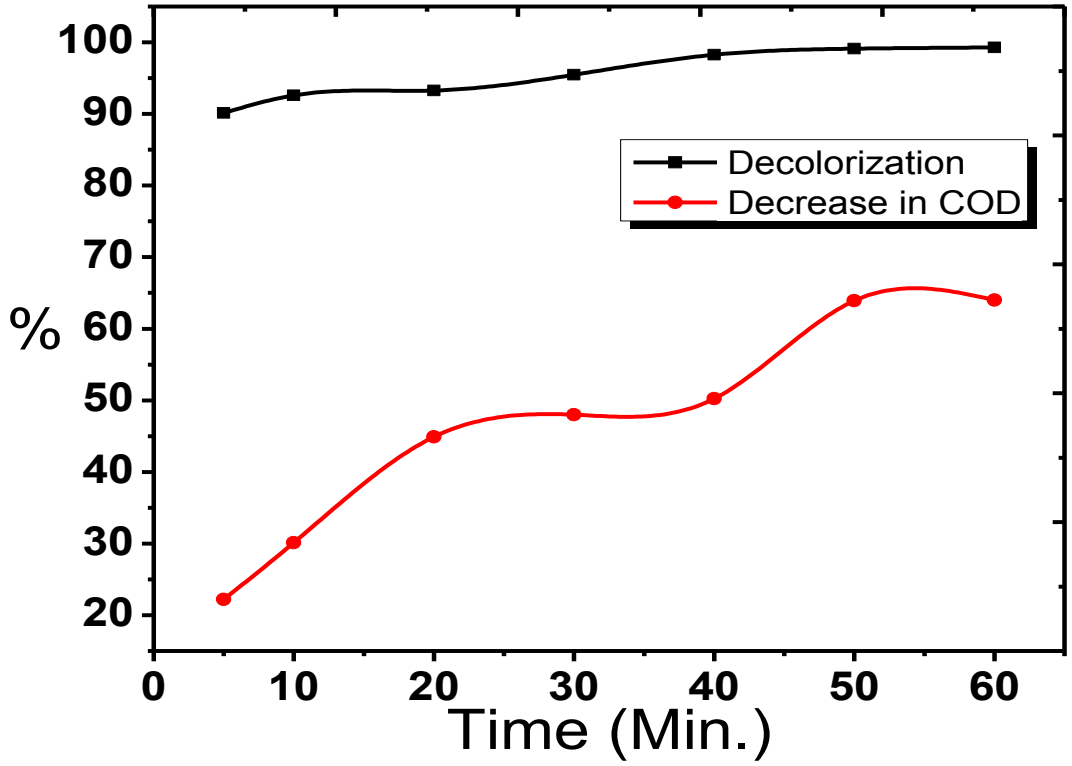

Fig. 2. Effect of Reaction time on decolorization and COD

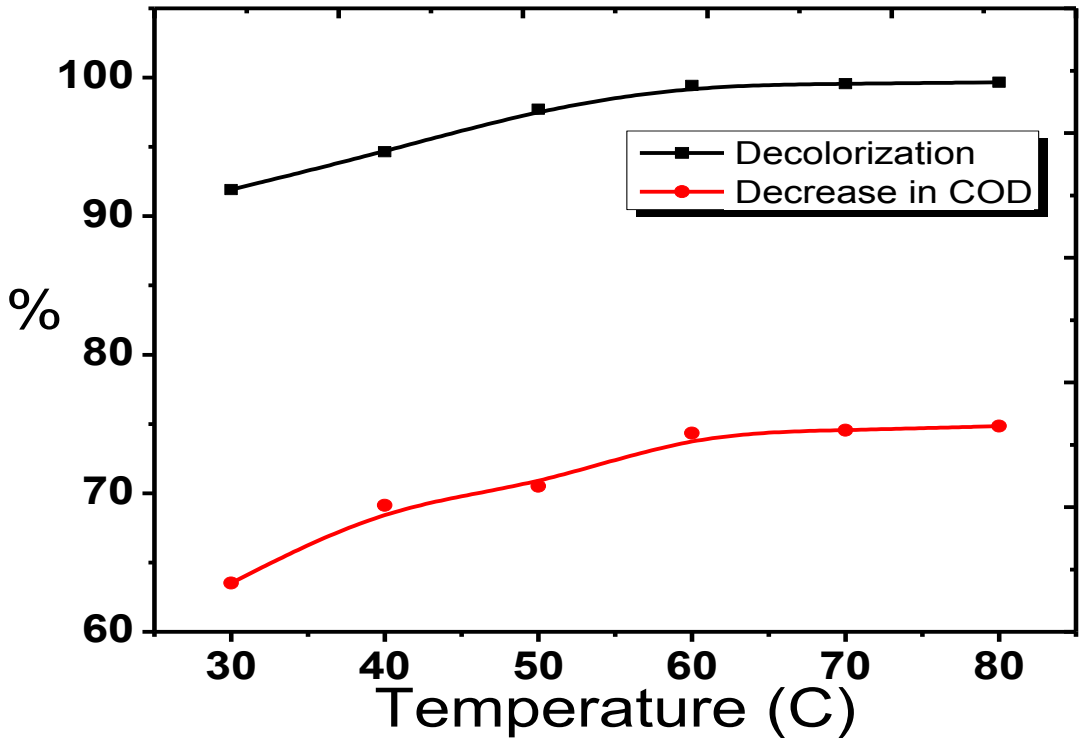

Fig. 3. Effect of Temperature on decolorization and COD

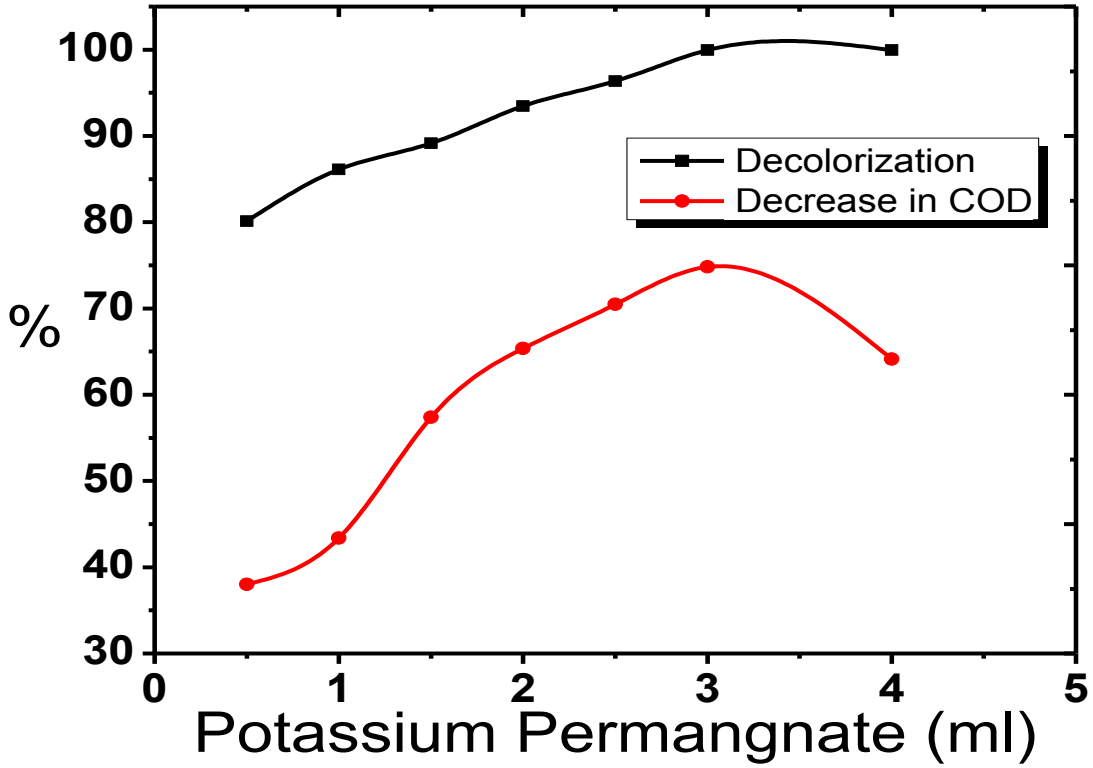

Fig. 4. Effect of $KMnO_4$ concentration on decolorization and COD

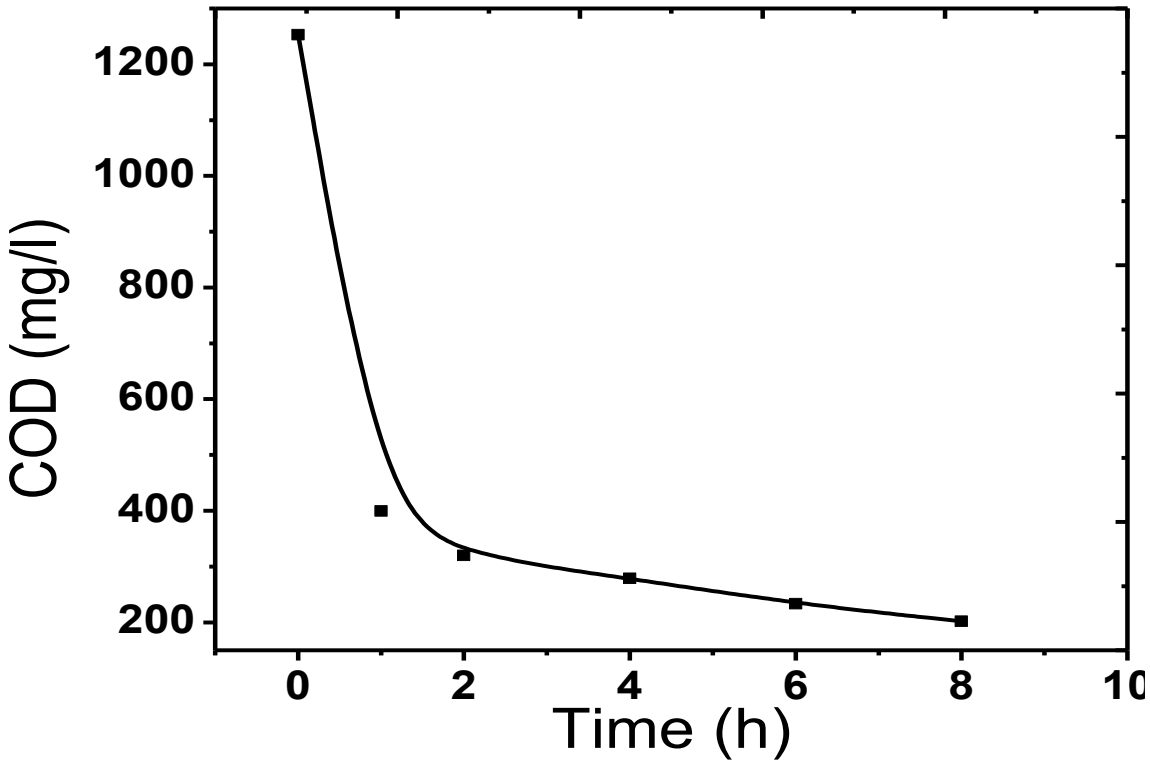

Fig. 5. Mineralization of Dye in 8 h

Conclusion:

The degradation of reactive black B dye in aqueous solution by $KMnO_4$ was dependent on concentration of $KMnO_4$, pH, temperature and reaction time. Optimum parameters of these values were pH = 1, $KMnO_4$ concentration = 108 ppm, temperature = 60 ℃ and reaction time = 50 min for decolorization and 8h for mineralization. 99.95% decolorization and 83.89% mineralization was obtained. Results of the study showed that this method can be recommended to treat the textile waste water.

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