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EFFICACY OF FLUIDIZED BED FENTON PROCESS FOR REMOVING COD AND COLOUR FROM SYNTHETIC TEXTILE WASTE WATER

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Abstract

In the world, different types of industrial activities are fastly growing day to day and it produced various kinds of wastes and wastewater. Among these fast growing industries most dangerous and needful industry is textile industry. But its effluents are damaged the environment and ecosystem. So its treatment is very essential for maintain the good environment and healthy atmosphere to all creatures in to the earth. The present study mainly focussed on the treatment of synthetic textile wastewater by fluidized bed Fenton process and investigated the efficiency of this Advanced Oxidation process for removing COD and colour. Synthetic textile wastewater prepared by Reactive ultra-red dye. In this study used various parameters such as pH of solution,Fe^{2+} concentration and H_2O_2 concentration. The fluidization conducted with different carriers like Silicon dioxide and Aluminium Oxide .The comparative study of COD and Dye removal efficiency by two carriers also carried out in this experiment. The study proved that both carriers are effective for achieved the target .But the Al_2O_3 experimental result shows that maximum COD removal efficiency of 79% obtained at pH-3, Fe^{2+}-3mg/l and H_2O_2- 200mg/l and maximum Dye removal efficiency of 90.1% attained at pH-3, Fe^{2+}-4 mg/l and H_2O_2- 200mg/l.The SiO_2 experimental results shows that maximum COD removal efficiency of 89% obtained at pH-3, Fe^{2+}-3mg/l and H_2O_2- 200mg/l and maximum Dye removal efficiency of 96.8% attained at pH-3, Fe^{2+}-3mg/l and H_2O_2- 200mg/l. So the present study proved that carrier silicon dioxide is very effective for removing colour and COD from textile wastewater by Fluidized Bed Fenton process .

Keywords: *- Textile effluent, Fluidized bed Fenton process, Silicon dioxide, and Aluminum oxide etc…*

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1. INTRODUCTION

Water is an essential and very important for all types of activities on the earth. It is included human activities and industrial or productive activities such as farming different types of industrial activities, tourism, cattle raising etc. Due to the sudden growth of population, the consumption of water is increasing in tremendously. And as a result, there is a large amount of wastewater with different types of degradable and non-degradable materials. .The various production processes included in the textile industries are sizing of fibres, scouring, bleaching, washing, mercerization, dyeing and finishing etc. So textile industry consumes more water for its processes.

The mainly used treatment process of dye-contaminated effluents is coagulation, flocculation, precipitation, oxidation, irradiation, incineration, and membrane adsorption.The treatment process of textile wastewater mainly depends on the quality and quantity of textile effluents discharged from the industry. Textile effluents are contained different types of surfactants, dyes, oils, grease, starches, detergents, alkaline and acidic substances etc. All are very harmful to environment and also ecosystem.

Advanced Oxidation Process (AOP) is the best method for treating textile wastewater which is based on the free hydroxyl radicals production (*OH) as a strong oxidant for organic compounds. Advanced Oxidation Process is that makes use of free Hydroxyl radicles in aqueous solution, produced by different chemical, photochemical or electrochemical reactions, to increase the oxidation of organic compounds present in wastewater. Hydroxyl radicals (•OH) are promote radical chain reactions leading to the destruction of aromatic compounds, adsorbable organic halogen (AOX), detergents, pesticides, azo dyes, and phenols [16] . One of the most important processes among AOPs is the Fe^{3+}/ H_2O_2 system,the homogeneous Fenton reaction which generates hydroxyl radicals.

This reaction is very easy and does not generate any sludge. So, it has been widely used to degrade pollutants. The OH* is a powerful oxidant that can rapidly oxidizes organic contaminants into CO_2 and H_2O, so it is able to eliminate the pollutants effectively. The most important AOP is the Fenton's system,the reaction between H_2O_2 and Fe^{2+}in an acidic solution to produce free Hydroxyl radicals.

$$Fe^{2+} + H_2O_2 \longrightarrow Fe(OH)^{2+} + \bullet OH$$

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Hydrogen peroxide can be activated by various methods and it decomposes into hydroxyl radical and hydroxyl ion [1].Hydrogen peroxide is highly affected the decolourisation process because it variously activated to form hydroxyl radicals, which are the strongest existing oxidizing agents [6]. Fenton's reagent ($Fe2+$ ions and $Fe3+$ ions) commonly in to the Fenton's oxidation process used as catalyst for the decomposition of under acidic pH ranging from 2 to 5[1].The main advantage of the Fenton's reagent are readily available, store easily and handle safely [7].This study demonstrates the efficiency of the fluidized bed Fenton reactor in synthetic textile wastewater with different carriers and various parameters. And also compare the efficiency for removing COD and colour from the textile wastewater by the FBF process with two carriers.

2. METHODOLOGY

The different types of methodologies adopted for the removal of COD and colour from synthetic textile wastewater. But in this study, used Fluidised Bed Fenton process for treating the synthetic wastewater .The wastewater is prepared by Ultra Red 3D dye. For the crystallisation process, the fluidised bed filled with carriers, they are Silicon Dioxide ($SiO_{2)}$ and Aluminium Oxide (Al_2O_3)

Preparation of Synthetic Wastewater

The reactive Ultra Red 3D dye was used for preparing the stock solution.100mg Chemifix Ultra red 3D dye powder were mixed with 1000ml of distilled water for synthetic sample preparation. Then it prepared different concentrations such as 10 to 100mg/l for the experiment. After the preparation of synthetic sample ,the characteristics of the wastewater analysed in to the chemical laboratory .The characteristics such as, Chemical Oxygen Demand (COD) , Biological Oxygen Demand (BOD) ,Turbidity,alkalinity,hardness etc.

Experimental Setup

Fluidised –Bed Fenton Reactor Set up

The fluidized bed Fenton process is carried out in a fluidized bed reactor. Its dimensions are 1.35L height, 5.2 cm diameter and 133 cm height. The main parts of the Fluidised Bed reactor are inlet, outlet, and recirculation compartments. Inside of this reactor consists Glass Beads of size 2 mm are used to support the carrier material. In this study, Quartz ($SiO2$) and Aluminium Dioxide with diameters in the range of 0.5-2 mm, were used as carriers.

Fluidized Bed Fenton Experiment

In this experiment, the glass beads of 2 mm diameters are first added to the acrylic tube . It is followed by the addition of 100 g/l of $SiO2$ carriers or Aluminium Dioxide carrier. About 500ml of the Reactive dye Sample whose pH is adjusted by adding sulphuric acidIn this experiment, the glass beads of 2 mm diameters are first added to the acrylic tube . It is followed by the addition of 100 g/l of $SiO2$ carriers or Aluminium Dioxide carrier. About 500ml of the Reactive dye Sample whose pH is adjusted by adding sulphuric acidor Sodium Hydroxide is then introduced into the reactor. The pump was switched on to suspend the carriers and mix the solution. Carriers were fluidized by adjusting the internal circulation at 50% bed expansion. The reaction began when the $H2O2$ and $Fe2+$ solution was added.

Result and Discussion

The chemical oxygen demand (COD) of dye solution was analysed by the standard methods of closed reflux methods of water and wastewater.Thecolour concentration of dye was determined from the Spectrophotometer with calibration graph of different absorbance characteristics.. An UV–Vis Systonics 106 spectrophotometer was used. The maximum absorption measured at the wavelength (λmax=600 nm) of dye was determined. The absorbance at different known concentration of dye is shown in table below.

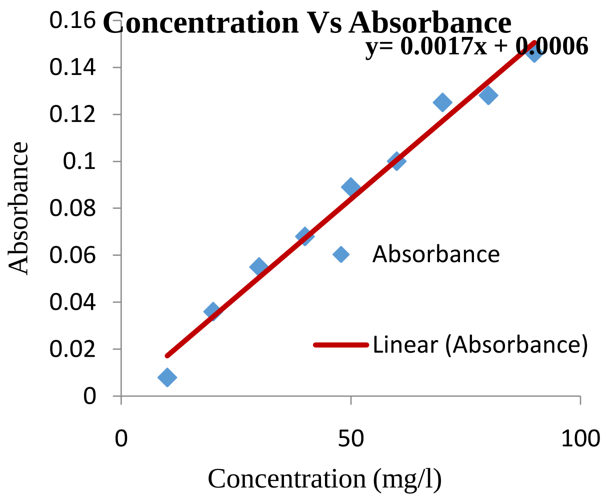

Fig 1: Calibration graph for absorbance

Aluminium Oxide (Al_2o_3) as a Carrier

The Effect of pH on Removal of COD and Colour

The pH values vary from one sample to other, so pH values always strongly affected the removal efficiency of the synthetic sample or wastewater. The change in pH of the solution directly affects the mechanism of oxidation dye, because it involves a variation of the concentration of Fe^{2+}.So the rate of production of OH radicals responsible for oxidation dyes, will be restricted (NeseErtugey et al, 2012). In this investigation, the pH values changed as 1to 8. As per this study the maximum COD removal and at pH 3 under the conditions of Fe^{2+} 2 mg/l and H_2O_2 concentration was 200mg/l.The removal efficiency was higher in the range of pH 3-4 after that, the increasing of pH, the removal efficiency was decreased. The reaction rate slowly happened in alkaline medium compared to acidic medium (NeseErtugey et al, 2012).At the low pH ,the decrease in

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removal of COD was very speedy process because of the formation of $FeOOH^{2+}$ and it is competed with iron 2+ to react with hydrogen peroxide(Chia-Chi Su et al ,2011).

Dye removal efficiency also depends on the pH of the solution. In this study, the maximum dye removal efficiency at acidic pH 3 and the maximum removal is 76% under the conditions of Fe(II) 2mg/l and H_2O_2 concentration was 200mg/l as per From the maximum dye removal pH 3 to 4,further increasing of the pH removal efficiency became decreasing. In this investigation the optimum condition was observed at pH 3 for removal of COD and colour.Fig.4.3 showed that the pH was strongly affected the removal of COD upto 3 then removal efficiency decreased gradually. This proved that acidic range of solution was mostly depends on COD removal.

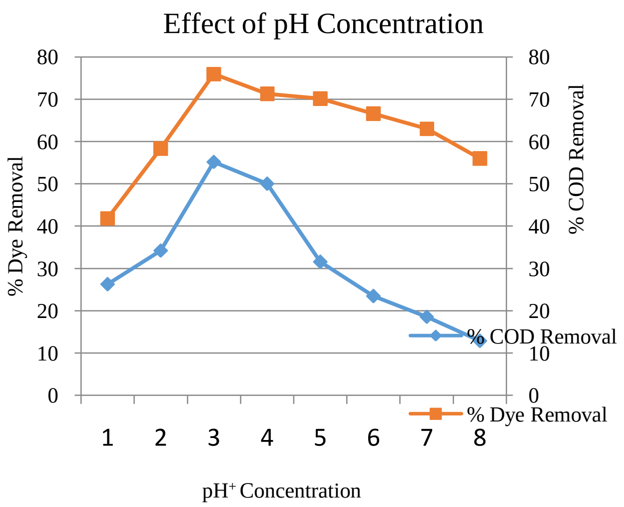

Fig-2: Effect of pH concentration in COD and Dye removal

The Effect of Fe^{2+} on Removal of COD and Colour

In this stage, the dosage of $Fe^{2+}$was varied from 1mg/l to 8mg/l at a constant H_2O_2 dosage of 125 mg/l and pH of 3. Under these conditions, the removal efficiency of COD and colour varied from 50% to 76% and 56% to 78% respectively shown in fig 3. It is increasing Fe^{2+} from 2 to 4mg/l has a more effective on the efficiency of the degradation of wastewater in fluidised bed fenton process. Increasing the Fe^{2+} concentration resulted that decreasing the removal efficiency on COD and slightly affect the colour removal efficiency.The overdoses of Fe^{2+} affect the scavenging effect on OH radicals. Because in higher dosages of Fe2+, OH radicals may be scavenged by participating in reactions with Fe2+as in reaction 4 (the formation of orange-brown iron precipitate (Fe(OH)3 flocs), consequently, the COD removal could decrease .

$$Fe^{2+} + HO^* \longrightarrow HO^- + Fe^{3+}$$

Table-2: Optimization of Fe^{2+}on COD removal and Dye Removal

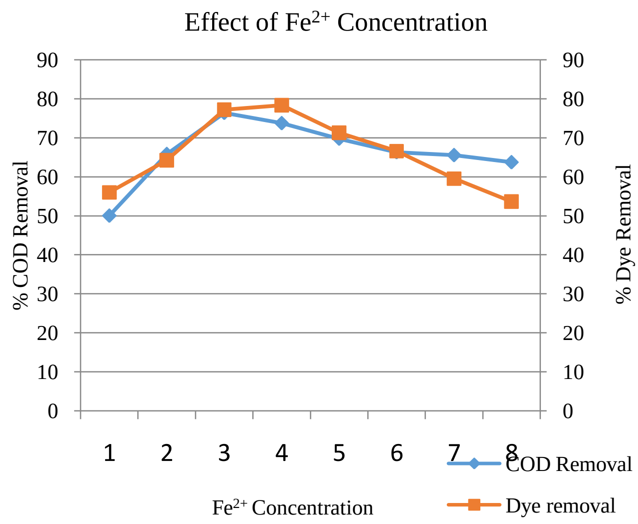

Fig -3: Effect of Fe^{2+} concentration in COD and Dye removal

The Effect of H_2O_2 on Removal of COD and Colour

H_2O_2 concentration is very important factor in Advanced Oxidation Process.It greatly affect the removal of COD and colour from the wastewater by fluidized bed Fenton process. The results from this study shown in fig 4.6. As per the results of degradation of COD and colour, maximum COD removal 79% at 200mg/l of H_2O_2 and maximum colour removal 90% at same conditions ,that is 200 mg/l H_2O_2 ,Fe dosage and pH was fixed at 3mg/l and 3 respectively.

In the optimum concentration of H_2O_2, ferrous ions completely oxidized; consequently, the generation of hydroxyl radicals increased. Therefore, H_2O_2 dosage of 200mg/l with a COD removal efficiency of 79% and colour removal efficiency of 90% as the optimum dosage. The excess H_2O_2 interferes with the measurement of COD, because the residual amounts of H_2O_2 consume K2Cr2O7.

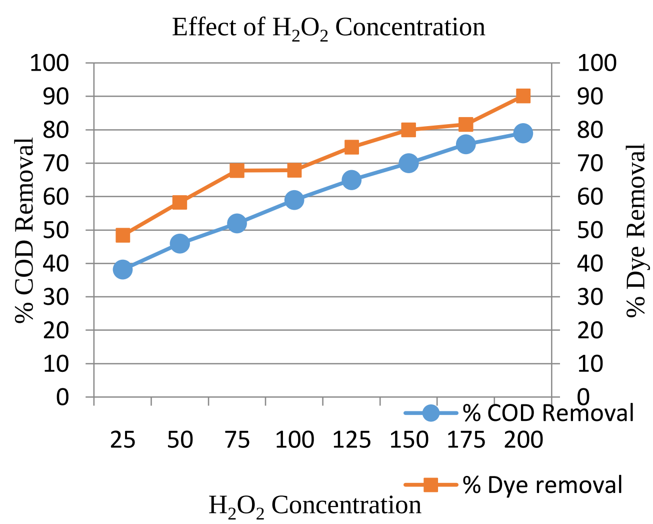

Fig-4: Effect of H_2O_2 concentration in COD and Dye removal

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Silicondioxide (SiO_2) as a Carrier

The Effect of pH on Removal of COD and Colour

COD removal efficiency increased with the increasing initial pH from 3 to 4, but further increase of pH reduced the removal efficiency. The same trend was also found in the decolourization (Fig. 4.4). Table 4.4 showed that the removals of COD and colour from the textile wastewater. The highest initial rate of COD obtained at pH 3 and colour also at the conditions fixed at Fe =2mg/l and H_2O_2 =200mg/l.The obtained removal efficiency of COD and colour was 58.42 % and 78.35% respectively (chia chi su et al 2011)

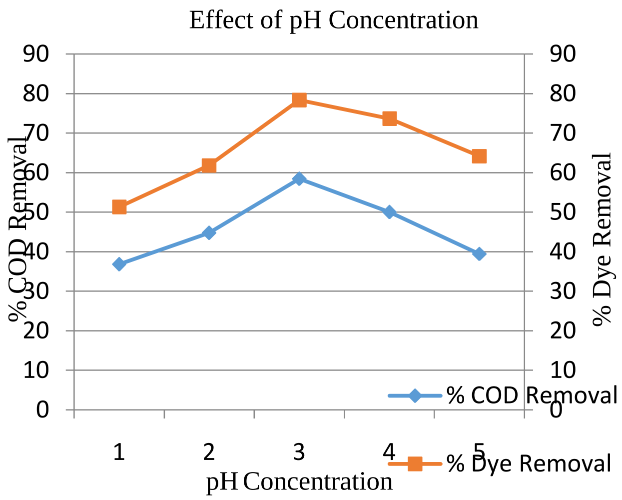

Fig-5: Effect of pH concentration in COD and Dye removal

The Effect of Fe^{2+} on Removal of COD and Colour

The Ferrous ions catalyse the rapid decomposition of H_2O_2 to form hydroxyl radicals; The maximum COD removal efficiency obtained at the Fe ions concentration at 3mg/l and constant parameters pH =3, H_2O_2 =200mg/l.

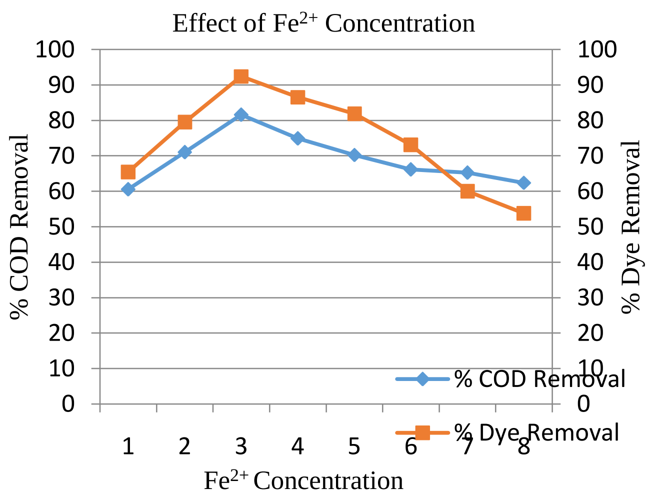

Fig -6: Effect of Fe^{2+} concentration in COD and Dye removal

The Effect of H_2O_2 on Removal of COD and Colour

The Hydrogen peroxide greatly affects the colour and COD removal from the textile wastewater with the use of carrier Silicon Dioxide in Fluidized Bed Fenton process. In this study ,Hydrogen peroxide dosage as 25,50,75,100,125,150,175 & 200 mg/l .Maximum removal achieved in 200 mg/l at the conditions of pH 3 in both COD removal and Dye removal. But the ferrous ions concentrations were changed in to the maximum removal efficiency of COD and Colour. The maximum COD removal at Fe^{2+} concentration on 3mg/l and 4 mg/l used for the maximum removal of colour.The maximum removal of COD and Colour under these conditions was 89% and 96.8% respectively.

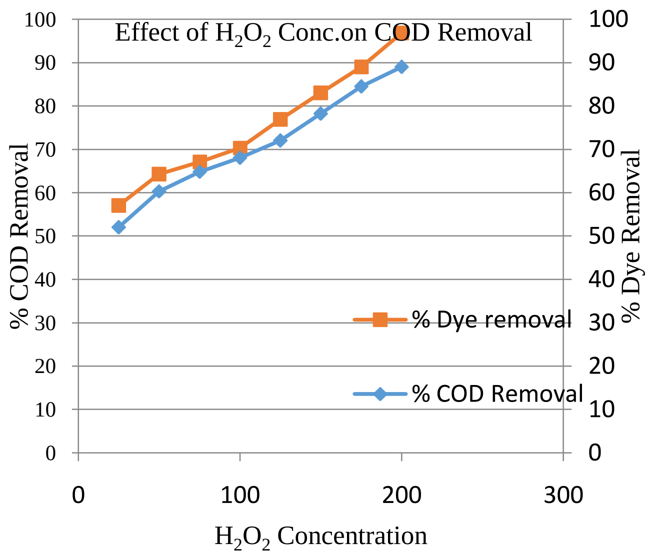

Fig-7: Effect of H_2O_2 concentration in COD and Dye removal

Comparative Study of Cod and Dye Removal By Two Carriers

The comparative study conducted for showing the efficiency of different carriers such as Silicon Dioxide and Aluminium Oxide in the treatment of textile wastewater by Fluidized Bed Fenton Process.

Different variables or parameters were analysed, they are pH of the solution, ferrous ions dosage and Hydrogen peroxide concentration. After the study, it proved that Silicon dioxide was effective carrier for treating the textile waste water rather than aluminium oxide because silicon dioxide removal efficiency was very higher compared to aluminium oxide with same concentration of pH and H_2O_2.

When aluminium oxide was used as carrier the removal efficiency of COD obtained at maximum as 55.2% under the conditions of pH 3 and 58.42% removal efficiency shown by the use of Silicon Dioxide carrier at same condition of pH 3.

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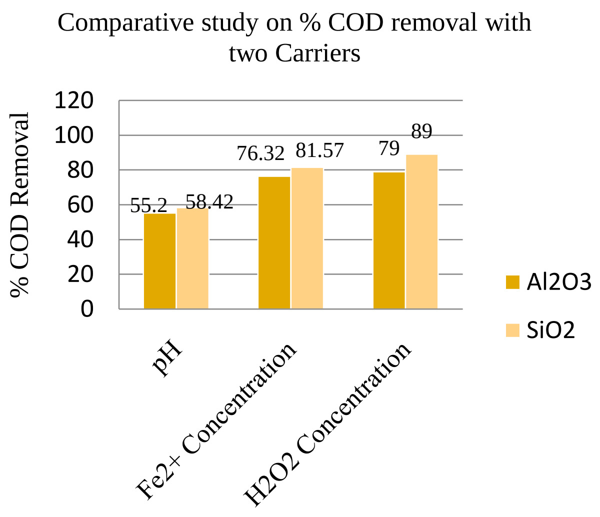

Chart-1: Comparative study on COD removal with two carriers

As per chart-1., the COD removal efficiency of Al_2O_3 and SiO_2 were 76.32% and 81.57% respectively under the conditions of ferrous ions dosage as 3mg/l in Al_2O_3 carrier and 4mg/l in SiO_2 carrier. And Hydrogen peroxide at 200mg/l, the COD removal efficiency became 79% and 89% in to the use of Al_2O_3 and SiO_2.

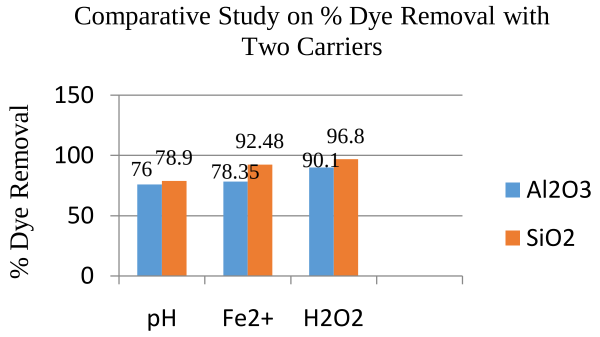

Chart-1: Comparative study on Dye removal with two carriers

Chart-2 shows that, both carriers were obtained maximum dye removal at pH 3 and dye removal efficiency was 76% and 78.4% in Al_2O_3 and SiO_2 respectively. But in the case of ferrous ions with SiO_2 and Al_2O_3 carriers were maximum at 4mg/l of $Fe2^{+}$ of removal efficiency was 80.3% and 92.8% respectively. Same as the maximum removal efficiency was obtained at 200mg/l of H_2O_2 and its dye removal efficiency was 90% and 96.8% with the use of Al_2O_3 and SiO_2 respectively.

3. CONCLUSION

This study investigated the decolourization and cod removal from the synthetic textile wastewater by the use of fluidized bed Fenton process. This study proved that all type of degradation efficiency depended upon the variables like that pH, concentration of H_2O_2 and Fe^{2+} .COD analyser and spectrophotometer were used for monitoring the COD and colour.

In this study was analysed effectiveness of different parameters on degradation efficiency and it was also conducted comparative study of maximum removal efficiency by the use of different carriers such as Silicon Dioxide and Aluminium oxide.

The maximum COD removal of 79% at pH -3, Fe^{2+}- 3 mg/l and H_2O_2- 200 mg/l and maximum dye removal of 90.1% under the optimum conditions such as pH -3, Fe^{2+}- 4 mg/l and H_2O_2- 200 mg/l by the use of aluminium oxide as the carrier. But in the case of silicon dioxide ,the maximum COD removal efficiency of 89% and dye removal efficiency of 96.8%.The optimum conditions of COD removal efficiency was pH -3, Fe^{2+}- 3 mg/l and H_2O_2- 200 mg/l and same optimum conditions of dye removal efficiency also.

So it can be concluded that, Silicon dioxide is the best carrier for removing colour and COD from the textile wastewater by Fluidized bed Fenton process. Silicon dioxide can reacted with Fenton's reagent in faster and effective manner and it affected crystallization during the fluidization time.

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