Treatment of Chemical Industry Effluent by FACCO Treatment

Bala Venkata Praveen Inala [1], Prof. Kalpana Saini[2]
*Department of Environment Engineering, Swarrnim Startup & Innovation University,
Gandhinagar, Gujarat

Abstract

The effects of operating thecondition on Fenton oxidation processes is such as hydrogen peroxide and iron concentration were investigated. FACCO process as a treatment can be a good option for to be increase biodegradability of the chemical industrial wastewater. The optimum dosage ratio of the [Fe2+] & [H2O2] will be finalize the based on experiment while the optimum pH was from 2.4 to 3.4, a treatment technique , known as the Fenton Activated Carbon Catalytic Oxidation (FACCO) ,consisting of the coagulation-flocculation using alum, lowering of pH was from 2.4 to 3.4 using the sulphuric acid, chemical dosed with hydrogen peroxide and the Ferrous sulphate (Fenton reagent), The lab scale model suggested to be that the rate of reaction was highly affected by the concentration of the hydrogen peroxide. Treatment of such waste had always been difficult because of the presence of refractory organic pollutants such as different types of organic dye. In this study, treatment of chemical effluent was carried out using combined system of Fenton oxidation process followed by adsorption on granular activated carbon (GAC). In addition, the lab-scale study of the adsorption process was elaborated. The lab scale model is suggested that the rate of reaction was the highly affected by the concentration of hydrogen peroxide. Moreover, the results indicated that the treatment module was very efficient in removing the organic pollutant.

Keywords: FACCO, Ferous sulphate, Fenton, H_2O_2, Effluent treatment, Chemical industry, Advamced Oxidation

I. Introduction

Chemical industrial wastewater the can be treated by some biological oxidation methods are such as trickling filters, rotating biological contactor (RBC), activated sludge, or lagoons (Nemerow, and Dasgupta, 1991; Jobbagy et al., 2000). Pollutants are with a molecular size larger than 10,000- 20,000, can be treated by coagulation followed by sedimentation or flotation (Hu et al., 1999).Waste minimization in the production of the process in chemical industry is the first and most important step to avoid waste formation during the production (Carini, 1999; Alvarez et al., 2004). Surfactants, emulsifiers and petroleum hydrocarbons that are being used in chemical industry reduce performance efficiency of many treatment unit operations (EPA, 1998). The aim of this study is to assess the treatment of wastewater coming from one of a Chemical Industry using a Heterogeneous catalytical oxidation system called FACCO (Fenton activated carbon catalytical oxidation) system.The objective of this study are to be determine characteristics of the chemical effluent, to prepare a lab scale model of FACCO reactor & other experimental setups& to determine optimum dose of ferric Sulphate & hydrogen peroxide for Fenton reactions, to carry out Experiment based study for FACCO-CACCO treatment and to treat chemical.

The best strategy to the cleaner highly contaminated and toxic industrial wastewater is in the general to treat them at the source (Peringer, 1997) and sometimes by applying onsite treatment within the production lines with recycling of treated effluent (Hu et al., 1999). The chemical industry is of the importance in terms of its impact on the environment. The wastewater from this industry are generally strong and may contain the toxic pollutants. Chemical industrial wastes usually contain organic and inorganic matters in the varying degrees of of concentration. It contains acids, bases, toxic materials, and matter high in biological oxygen demand, color, and low in suspended solids. Since these wastes differnt from domestic sewage in general characteristics, pretreatment is required to produce an equivalent effluent (Meric et al., 1999). In thechemical industry, the high variability, stringent effluent permits& and extreme operating conditions define the practice of wastewater treatment (Bury et al., 2002). Hu et al. 1999 proposed to concept to select the appropriate treatment process for chemical industrial wastewater based on molecular size and biodegradability of the water pollutants.

The advantage of the Fenton process reagent are that no energy to input is necessary to activate the hydrogen peroxide.Therefore, this method offers a cost-effective sources of hydroxyl radicals, using easy-to-handle reagents. However, disadvantages in using the Fenton reagent include the production of a substantial amount of Fe (OH)3 precipitate and additional water pollution caused by the homogeneous catalyst that added as an iron salt, cannot be retained in the process [03]. To solve these problems, the application of alternative iron sources as catalysts in oxidizing organic contaminants has been studied extensively. A number of researchers have investigated the application of the iron oxides such as hematite, ferrihydrite. With Fenton processes, COD reduction of wastewater can be achieved successfully. It is suggested that Fenton processes are viable techniques for the degradation of Atenolol from the waste water stream with relatively low toxic by-products in the effluent which can be easily biodegraded in the activated sludge process. Hence, the Fenton process with H2O2/Fe+2 is considered as suitable pretreatment method to degrade the active pharmaceutical molecules and to improve the biodegradability of waste water. After the treatment 66 % COD removal can be achieved.[02] Also the removal of COD from industrial effluent by EC using Al and stainless steel electrode material was investigated in this paper. Several working parameters, such as current density, initial concentration of solution and operating time were studied in an attempt to achieve a higher removal capacity. Al and stainless steel electrodes were found to be effective in the reduction of the COD.

II. FACCO TREATMENT

The Fenton reaction was discovered by Fenton in 1984. 40 year later Harber-Weiss mechanism is found which say that the hydroxyl radical is the effective oxidative reagent in the Fenton reaction. The HO· radical mostly attack all the organic compound, the most accepted scheme is described in the following equation.

Equation 1-1 $Fe^{3+} + H_2O_2 \rightarrow Fe^{3+} + HO\bullet$ (1)

Equation 1-2 $Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + HO_2\bullet + H+$ (2)

Equation 1-3 $Fe2+ + HO\bullet \rightarrow Fe^{3+} + HO\bullet-$ (3)

Equation 1-4 $HO\bullet + H_2O_2 \rightarrow HO_2\bullet + H_2O$ (4)

Equation 1-5 $Fe^{3+} + HO\bullet \rightarrow Fe^{2+} + H+ + O_2$ (5)

Equation 1-6 $Fe^{3+} + O_2\bullet- \rightarrow Fe^{2+} + O_2$ (6)

Equation 1-7 $Fe^{2+} + HO^{2\bullet} \rightarrow Fe^{3+} + HO^{2\bullet-}$ (7)

By following the above method for Soak liquor having the characteristics as BOD - 757 mg/l, COD - 2178 mg/l , TOC - 553 mg/l, Dissolved solids - 20801 mg/l, Dissolved Protein - 1011 mg/l . This pollution load is removed using Fenton Activated Carbon Catalytic Oxidation (FACCO).First Pre-treatment coagulation & flocculation using Alum is given to wastewater after then pH of waste water is reduced to 3 and hydrogen peroxide(0.01ml/L) & Ferrous sulphate(0.1g/L) are added in wastewater after then the coagulated-flocculated and Fenton reagent added soak liquor was applied at a surface loading rate of 1.46m3/m2/day and volumetric loading rate 0f 0.83 m3/m3/hr to the reactor packed with mesoporous activated carbon this wastewater containing Fenton's reagents is passed over a meso porous activated carbon supported over sand & gravels for catalytic oxidation.

In addition, the concentration of the hydrogen peroxide at the 8 ppm was the mostly suitable. The optimum conditions of amount of the catalyst was 5 g/L. In conclusion, the iron/GAC catalyst was successfully synthesized and applied to dye treatment using heterogeneous Fenton reaction. The catalyst showed high efficiency of removal and could be reused the many times.[05] Siyong Zhang in this work showed that a heterogeneous catalytic wet peroxide oxidation process combined activated carbon (AC) and hydrogen peroxide (H2O2) was applied for the removal of organic matter from the salicylaldehyde industry wastewater with high organics content, strong acid and ultrahigh salinity. In the year 2015, Settle showed iron catalyst dispersed on granular activated carbon (GAC) was prepared by impregnating Fe(NO3)3 solution on GAC. The investigation of optimum conditions suggested that initial pH at 3 provided the highest efficiency of MO removal. The optimal operating conditions established through the experiments were as follows: reaction temperature 60'C, initial pH of 3, H2O2 concentration of 21.7 g/L, AC dose of 15 g/ L and reaction time of 1 h. Under such operation conditions, the removal efficiency of TOC, COD, phenol and formaldehyde were 91.21%, 88.52%, 99.54% and 97.18%, respectively. Furthermore, the catalytic stability of AC was evaluated through the continuous reuse experiments.[06]

According to Vijayalakshmi Gosu in the present study, the treatment of chemical wastewater in terms of organic content (COD, TOC) has been investigated using advanced catalytic per-oxidation with granular activated carbon supported nano zero valent iron (Fe/GAC). At optimum conditions, 81% COD and 76% TOC removal was attained. Moreover, advanced catalytic per-oxidation process was more favourable to the complete oxidation. The two-step kinetics can be attributed primarily to the oxidation of organic compound first to short chain molecular structures (organic acids) followed by their complete oxidation to produce carbon dioxide and water. Moreover, the average oxidation state (AOS) got raised from 1.8 to 2.1, which represents the strong mineralization and the generation of highly oxidized intermediates.

Thus, the treatment of pharmaceutical wastewater using Fe/GAC + H2O2 could be considered to be an effective alternative treatment option.[01]

III. MATERIALS AND METHOD

- **Wastewater collection from chemical industry**

Wastewater sample was collected after the primary treatment of Effluent treatment plant (ETP) of a chemical industry located near Dahej, Gujarat, India. The sampling container was cleaned perfectly and rinsed with carefully with distilled water, filled and seal air tightly.

Fig. 1: Wastewater collection

- **Chemicals used in Characterization of Wastewater are:**

Borate buffer, Sodium hydroxide solutions, Standard potassium dichromate, Mercuric Sulphate, Silver Sulphate, Concentrated H_2SO_4, Ferroin indicator solution, Standard ferrous ammonium Sulphate, Dechlorinating agent and different catalysts.

- **Apparatus used for Analysis of Waste Water:**

Jar test apparatus , pH meter, Chemical oxygen demand (COD) apparatus, , Kjeldahl analytical setup, Magnetic stirrer, Gas chromatograph (GC), Batch reactor, Pump, Air compressor, Heater, Catalytic Bed.

- **Experimental Procedure:**

1) pH meter:
pH meter is consist of the potentiometer, a glass electrode, a reference electrode, and the temperature compensating device the range of instrument is pH 0.0 to 14.0 equipped with temperature compensation adjustment range 0 C to 100 C is used to find pH value.

Fig.2 pH meter

Fig.3 Analytical sampling of NH4-N

2) Analytical sampling of NH_4-N:
The standard of the method is to be carried for the detection of NH_4-N is Kjeldahl method though other method can be used like nessler`s reagent method. Standard Method by APHA Ed.22nd .2012,4500 NH3-B& C was followed for this research study.

3) Analytical sampling of COD:
Standard Method provided by the APHA Ed.22nd .2012,5220 – B was carried out for COD analysis of wastewater

Fig. 4: COD Digestion Apparatus

IV. RESULTS AND DISCUSSION

- **Initial Characteristic of Waste Water:**

Sampling of the wastewater was carried out at different days and their characteristics are as shown in below tables.

Table – 1

Initial Characteristic of Waste Water

Sr no	Para-meter	Method specification	Permissible limit	Unit	Result at different sampling days				
					SAMPLE: A	SAMPLE: B	SAMPLE: C	SAMPLE: D	SAMPLE: E
1	pH	Standard Method by APHA Ed.22nd .2012,4500 - H+B	6.5-8.5	-	6.65	6.70	7.17	6.93	7.23
2	TDS	Standard Method by APHA Ed.22nd .2012,2540 – C	2100	Mg/l	19890	18804	29698	17952	25569
3	COD	Standard Method by APHA Ed.22nd .2012,5220 – B	250	Mg/l	2354	2354	2260	2668	2354
4	NH_4-N	Standard Method by APHA Ed.22nd .2012,4500 NH_3-B& C	50 mg/L	Mg/l	9	13	9	10	13

From above table it is clear that the range of the pH exists between the 6.65 to 7.3, TDS from 17952 to 29698, COD between 2260 to 2668, and Ammonical Nitrogen from to 9 to 13. Thus further studies were carried out to the determine the optimum dose of Ferrous Sulphate ($FeSO_4$) By Keeping Hydrogen Peroxide (H_2O_2) Constant & Optimum Dose keeping Hydrogen Peroxide (H_2O_2) varying & Ferrous Sulphate ($FeSO_4$) constant.

- **Determining of Optimum Dosage keeping Hydrogen Peroxide (H_2O_2) varying & Ferrous Sulphate ($FeSO_4$) constant**

Dosage of H_2O_2:- Varying, Dose of $FeSO_4$ (Fixed):-200 mg/L, pH (Fixed):- 3 and Temperature (Room temperature):- 25°C

Table – 2

Determination of Optimum Dose keeping Hydrogen Peroxide (H_2O_2) varying & Ferrous Sulphate ($FeSO_4$) constant

Sr.No	Dose of H_2O_2 (mg/L)	COD before treatment(mg/L)	COD after treatment(mg/L)	% COD removal
1	0 (Initial)	2592.9(Initial)	2592.9(Initial)	0(Initial)
2	450	2592.1	1723.2	33.52
3	550	2592.1	1644.3	36.53
4	650	2592.1	1613.7	37.78
5	750	2592.1	1488.8	42.67
6	850	2592.1	1550.9	40.26

From above table it is clear that when dose of $FeSO_4$ is taken as 200 ml/L, the reduction in COD is Maximum. i.e 42.61%, keeping the dose of H_2O_2 as 700 mg/L.Thus, from above experiments it is clear that the dosing of H_2O_2 as 700 mg/L and FeSO4 as 200 mg/L gives maximum reduction. So the further experiment will be carried out keeping this values for conducting experimental procedures for FAACO treatment.

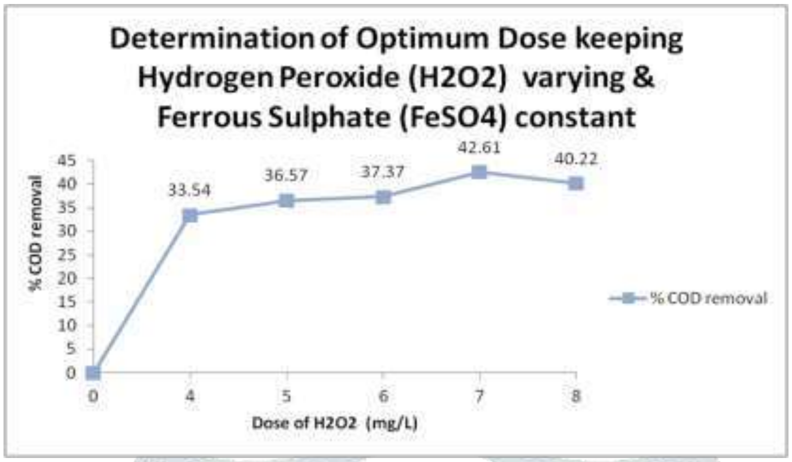

Fig. 5: Graphical representation of Determining of Optimum Dose of Hydrogen Peroxide (H_2O_2) varying and Ferrous Sulphate ($FeSO_4$) Constant at above said condition.

- ***Determining of Optimum Dose keeping Hydrogen Peroxide (H_2O_2) varying & Ferrous Sulphate ($FeSO_4$) constant:-***

Dose of H2O2 $_{(30\%\ Concentrated)}$:- Varying (5.5 to 7.5) mg/L, Dose of FeSO4 (Fixed):-0.1 g/L, pH (Fixed):- 2, Temperature (Room temperature):- 25°C

Table – 3
Determining Of Optimum Dose Of Hydrogen Peroxide (H_2O_2) by Keeping Ferrous Sulphate ($FeSO_4$) Constant

Sr.No	Dose of H_2O_2 (mg/L)	COD before treatment(mg/L)	COD after treatment(mg/L)	% COD removal
1	0 (Initial)	3604 (Initial)	3604(Initial)	0(Initial)
2	550	3604	3234	10.26
3	600	3604	3485	03.30
4	650	3604	3589	00.42
5	700	3604	2785	22.72
6	750	3604	3031	15.89

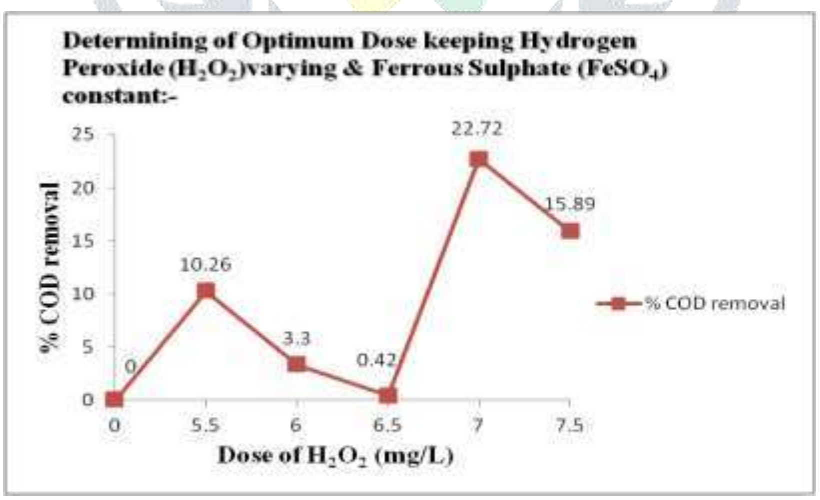

Fig. 6: Graphical representation of the Determining of Optimum Dosage of the Hydrogen Peroxide (H_2O_2) by Keeping Ferrous Sulphate ($FeSO_4$) Constant

- ***Determining of Optimum Dose keeping Hydrogen Peroxide (H_2O_2) varying & Ferrous Sulphate ($FeSO_4$) constant:-***

Dose of H2O2 $_{(30\%\ Concentrated)}$:- Varying (0 to 3) mg/L, Dose of $FeSO_4$ (Fixed):- 0.1 g/L, pH (Fixed):- 3, and Temperature (Room temperature):- 25°C

Table – 4

Determining Of Optimum Dose Of Hydrogen Peroxide (H_2O_2) by Keeping Ferrous Sulphate ($FeSO_4$) Constant

Sr.No	Dose of H_2O_2 (mg/L)	COD before treatment(mg/L)	COD after treatment(mg/L)	% COD removal
1	0 (Initial)	3604(Initial)	3604(Initial)	0(Initial)
2	1.0	3604	2008	44.21
3	1.5	3604	2329	35.34
4	2.0	3604	2128	40.92
5	2.5	3604	2503	30.59
6	3.0	3604	2610	27.58

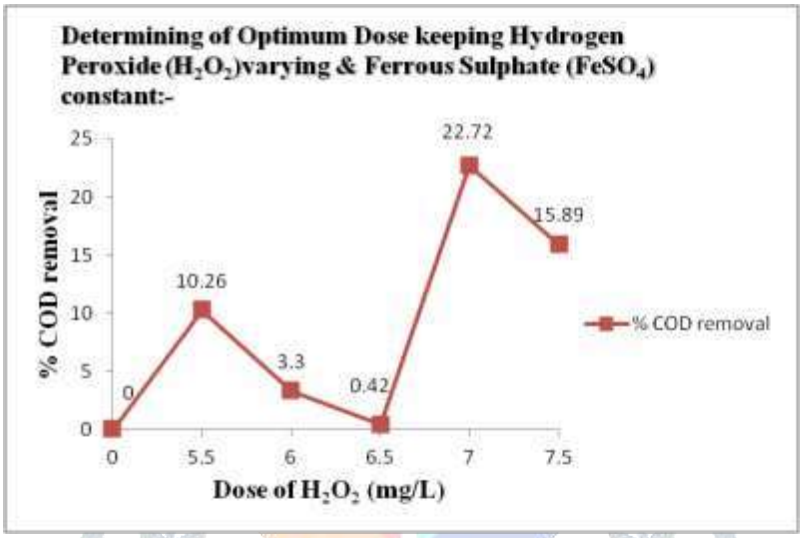

Fig 7: Graphical representation of Determining of Optimum Dose of Ferrous Sulphate ($FeSO_4$) by Keeping Hydrogen Peroxide (H_2O_2) Constant.

- ***Determining of Optimum Dose keeping Hydrogen Peroxide (H_2O_2) varying & Ferrous Sulphate ($FeSO_4$) constant:-***

Dose of H_2O_2 $_{(30\%\ Concentrated)}$:- Varying (0 to 3) mg/L, Dose of $FeSO_4$ (Fixed):- 0.1 g/L, pH (Fixed):- 3, Temperature (Room temperature):- 25°C

Table – 5

Determining Of Optimum Dose Of Hydrogen Peroxide (H_2O_2) by Keeping Ferrous Sulphate ($FeSO_4$) Constant

Sr.No	Dose of H_2O_2 (mg/L)	COD before treatment(mg/L)	COD after treatment(mg/L)	% COD removal
1	0 (Initial)	3604(Initial)	3604(Initial)	0(Initial)
2	1.0	3604	2008	44.28
3	1.5	3604	2329	35.37
4	2.0	3604	2128	40.95
5	2.5	3604	2503	30.54
6	3.0	3604	2610	27.58

It is clear from the above table that by keeping $FeSO_4$ is constant at 0.1 mg/L, the maximum reduction at which COD is reduced upto 44.28 % is 1 mg/L. Thus, it is clear from all the above sets of experiments that about 45% of reduction can be obtained or achieved by Fanton Process on this particular chemical wastewater.

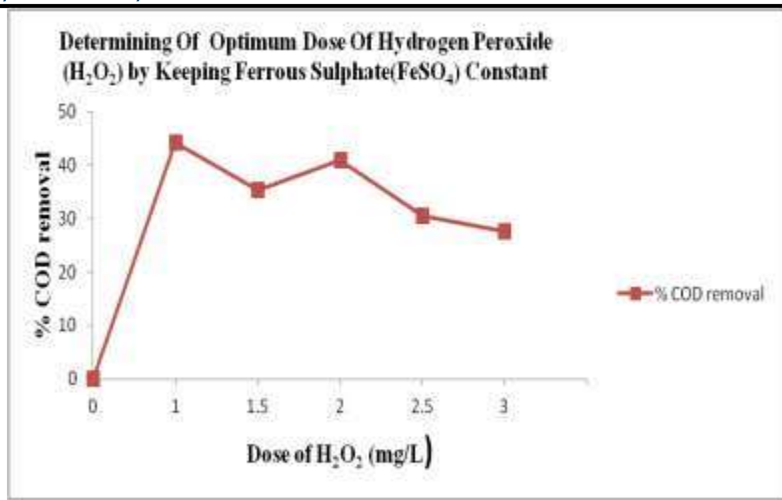

Fig. 8: Graphical representation of Determining of Optimum Dose of Ferrous Sulphate ($FeSO_4$) by Keeping Hydrogen Peroxide (H_2O_2) Constant.

V. Conclusions

The present investigation draws the following conclusion:-

1) Primary clarification of the wastewater removes the suspended solids and less of dissolved organics from wastewater.
2) Wastewater generated from chemical industries are less amendable to biological treatment which is due to the presence of dyes and other non-biodegradable chemicals.
3) Fenton's reagent, a mixture of hydrogen peroxide and the ferrous iron, is capable of releasing hydroxyl radicals which may take part in oxidation of dissolved organics in wastewater.
4) The oxidation of the dissolved organics by Fenton's reagent and adsorption on granular activated carbon (GAC)resulted in the percentage removal of COD,TDS, NH_4-N were find out respective.
5) Fenton' process's reagent added to the salt laden wastewater was further catalytically oxidized in meso porous activated yhe carbon packed column.

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