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Catalytic Peroxide Oxidation for Detoxification Of Organic Waste

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Abstract- **The release and accumulation of organic and inorganic pollutants in the environment by the natural and anthropogenic sources have led to serious environmental problems; this subsequently results to adverse effects on human health. Therefore, to prevent the harmful effects of environmental contaminants, the development of newer technologies for the remediation of contaminated water has been of great importance. Water is an irreplaceable basic component of life. Protecting the integrity of our water resources is one of the most essential issues of the 21st century. Advanced oxidation processes were expected to decompose that typically stable product into carbon dioxide, water, and inorganics into harmless compounds. Advanced oxidation processes, based on very strong oxidizing free radicle which destroy the pollutants often leading to their mineralization. Advanced Oxidation Processes (AOPs) is an efficient alternative for the complete removal and detoxification of toxic organic pollutants because the process will not cause any kind of secondary pollution to the environment.Catalytic Wet Peroxide Oxidation process is a very broad area under AOPs for the complete degradation and removal of toxic organic compounds from aqueous streams at mild reaction conditions.**

Keywords- **Advanced oxidation processes (AOPs), Catalytic wet peroxide oxidation**

I. INTRODUCTION

Water is an irreplaceable basic principle of life and is being polluted by different anthropogenic activities. Environmental pollution originates from various sources such as production, application and disposal of wide range of chemicals from agricultural, pharmaceutical, industrial fields etc. which badly affect the balance of hydrosphere. Chlorinated derivatives of aromatic compounds are considered as the major intermediates of many synthetic pesticides and herbicides. Because of their high toxicity and non-biodegradability and hence are listed by both the US-EPA Clean Water Act and the European Union Decision. In people, several adverse effects have also been linked with these compounds including developmental, behavioral, neurologic, endocrinal, reproductive and immunologic adverse health effects.

Environmental concerns have led to an extensive research on the safe and effective removal of hazardous organic compounds from aqueous streams. An ideal waste treatment process must completely mineralize toxic species without leaving behind any hazardous residues in a cost-effective manner.Advanced Oxidation Processes (AOPs) is an efficient alternative for the complete removal and detoxification of toxic organic pollutants because the process will not cause any kind of secondary pollution to the environment.

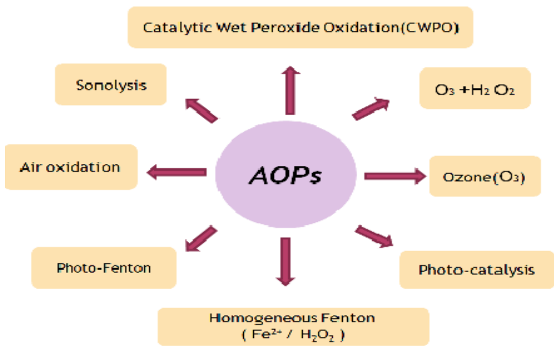

Fig 1. Advanced oxidation processes

II. METHODOLOGY

1. Materials used

4-chlorophenol, Chromic nitrate, Ferrous sulphate, Hydrogen peroxide, Potassium dichromate, Ethylene glycol, Sulphuric acid, Ammonia

2. Experimental methodology

For the present study final structured Iron chromite ($FeCr_2O_4$) was selected as catalyst for the oxidative removal of 4-CP because of its amazing structural and chemical properties. Preparation of iron chromite nano composite: Sol gel method was selected for the preparation of iron chromite. In the sol gel method, a sol is prepared by dissolving metal nitrate precursors in their appropriate ratio in minimum amount of ethylene glycol. On heating this sol at 60-70^{0}C, the sol slowly changed to viscous gel. On further heating, the viscous gel was auto ignited to a powder and it was calcined at 300^{0}C, 400^{0}C and 600^{0}C in the muffle furnace according to stoichiometric equations.

3. Experimental set up- CWPO of 4-CP was carried out in a 250 ml two necked round bottomed flask immersed in a water bath with magnetic stirring. The flask was equipped with a running water condenser to maintain the reactor content inside the flask. A thermometer immersed in the water bath ensures the specified temperature. In a typical run, the amount of 4-CP and catalyst was fixed 25ml of pollutant stock solution (1 g/L 4-CP) and 0.5 g catalystin powder form along with 4 ml hydrogen peroxide (30%, v/v) with continuous stirring. The reaction mixture was heated up to 70^{o}C for one hour by changing reaction variables.

III. RESULT AND FINDINGS

1. Effect of temperature

Table 1 COD removal efficiencies by varying temperature (10µg/l 4-CP,0.5g catalyst,4ml H_2O_2)

S.N.	Temperature(^{0}c)	Cod (Mg/L)	Efficiency (%)
1	40	334.6	17.54
2	50	291.9	28.07
3	60	185.12	54.36
4	70	35.6	91.89
5	80	64.08	84.21
6	90	92.56	77.12

The efficiency increases from 17.54 to 91.89% up to ambient temperature and then it decreases. With increase in temperature the residual amount of hydrogen peroxide decreases. Increase in temperature cause the degradation of hydrogen peroxide.

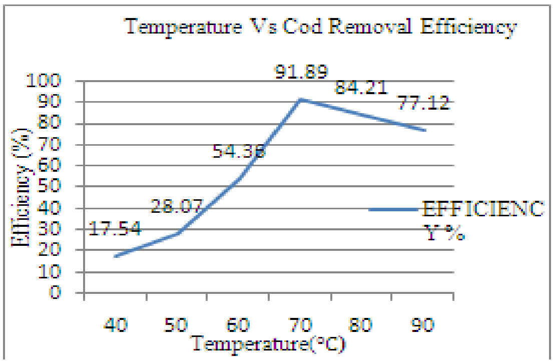

Fig.2 Temperature Vs COD Removal efficiency.

2. Effect of hydrogen peroxide concentration-

Table 2 COD removal efficiencies by changing concentration of H_2O_2 (10µg/l 4-CP, 0.5g catalyst, 70^{0}C).

S.N.	Concentration of H_2o_2(Ml)	Cod (Mg/L)	Efficiency (%)
1	1	327.52	19.29
2	2	270.56	33.3
3	3	178	56.14
4	4	36.6	91.59
5	5	99.7	75.43
6	6	199	50.87

Concentration of hydrogen peroxide plays a crucial role in deciding the overall efficiency of the catalyst in the degradation of 4-CP. Different oxidant dosages have been tested in order to find the lowest amount of the oxidant needed for an efficient oxidation treatment. However, at higher oxidant dosage can decrease the oxidation rate due to auto scavenging mechanism according to the following equation. $HOO^*/O_2^* + HOO^*/O_2^*$ H_2O_2 $HO^* + HO^*$ H_2O_2.

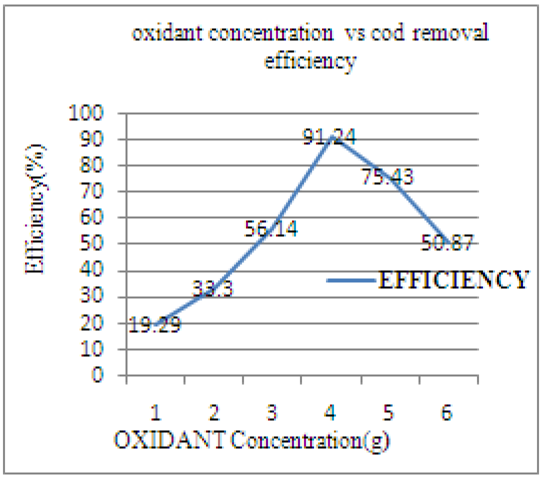

Fig.3 Oxidant concentration Vs COD Removal Efficiency.

3. Effect of catalyst dosage

Table3 COD removal efficiencies by varying concentration of catalyst (10µg/l 4-CP, 4ml H_2O_2, 70^{0}C).

S. N.	Concentration of Catalyst(G)	Cod (Mg/L)	Efficiency (%)
1	0.2	135.28	66.6
2	0.3	113.92	71.9
3	0.4	99.68	75.43
4	0.5	35.6	91.22
5	0.6	92.56	77.19
6	0.7	106.8	73.68

The concentration of catalyst used for wet peroxide oxidation is an important parameter to check the efficiency of the catalyst.4-CP degraded with 0.2 g catalyst itself and it signifies the importance of the nanoferrite catalyst used in the degradation of 4-CP.

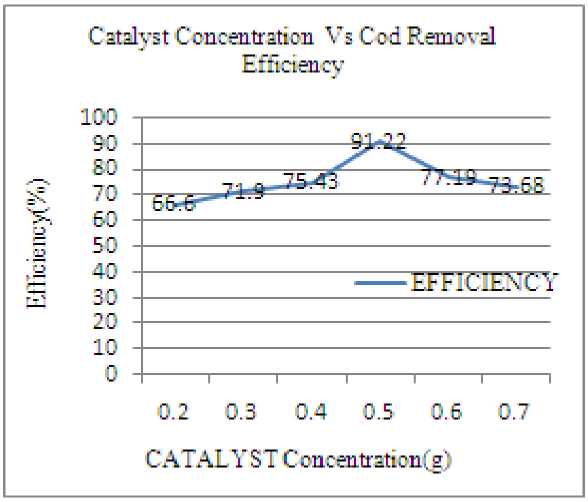

Fig.4 Catalyst concentration Vs COD Removal Efficiency.

4. Effect of change in concentration of 4-CP

Table 4. COD removal efficiencies by varying concentration of 4-CP (0.5g catalyst, 4ml H_2O_2, 70^0C)

S.N.	Concentration of 4-Cp(μg/L)	Cod (Mg/L)	Efficiency (%)
1	5	64.08	84.21
2	10	42.72	89.5
3	15	185.12	54.38
4	20	213.6	47.36
5	25	270.56	33.3

Complete degradation of pollutant occurs at lower concentrations with significant reduction in the COD.

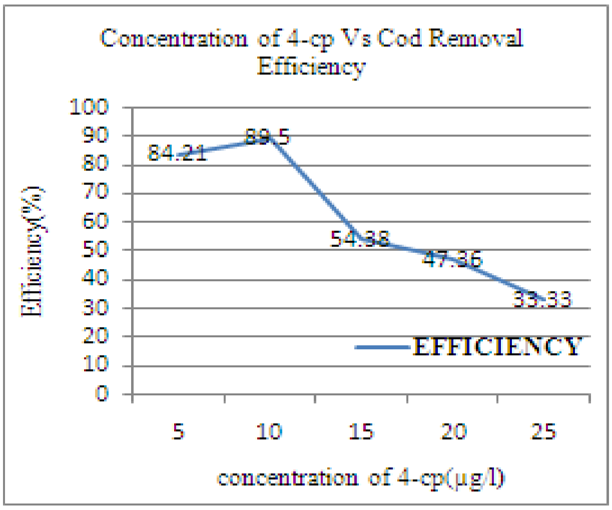

Fig.5 Concentration of 4-CP Vs COD Removal Efficiency.

IV. CONCLUSIONS

Wastewater treatment and its reuse is a very challenging task related not only to a number of benefits in regard to water management and but related to its sustainable maintenance also. Iron chromite catalyst was synthesized by sol gel method. The catalytic activity of iron chromite nano composite towards the oxidative removal of 4-CP using hydrogen peroxide was studied under optimized reaction conditions. The complete removal of 4-CP was observed within 60 minutes over 0.5 g catalyst at 70^oC. Thus iron chromite nano composite could be applied as a good alternative for the pre-treatment and detoxification of organic waste.

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