A STUDY ON PESTICIDE WASTEWATER TREATMENT BY UV/H_2O_2/TiO_2 PROCESS

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Abstract : Pesticide wastewater contains some highly complex organic compounds that make it very difficult to treat by conventional treatment processes. In this paper photo-catalytic degradation (Colour & COD removal) of wastewater from pesticide industry has been studied at laboratory scale. Pesticide wastewater was obtained from an industry in Vadodara district. A laboratory scale reactor was designed consisting of two UV lamps of 6W each. Some parameters like initial pH, dosage of H_2O_2, dosage of TiO_2 and irradiation time were studied and optimum condition for degradation of wastewater was derived. Colour removal was found to be in the range of 74% to 96% and COD removal was found upto 87%. Optimum pH was found out to be 3.5.

***IndexTerms* – Advanced Oxidation Process, Pesticide wastewater.**

1 INTRODUCTION

Advance oxidation processes are efficient for treating various toxic, complex organic pollutants and complete destruction of contaminants occurring from various industries. AOPs are a set of oxidative water treatments that treats effluents at industrial level and wastewater treatment plants. AOPs include UV/O_3, UV/H_2O_2, UV/TiO_2, fenton, photo-fenton, sonolysis, radiolysis, cavitation, supercritical water oxidation processes, etc. AOPs are the processes which include generation of hydroxyl radical and it will react rapidly with almost all organic compounds. Various publications have observed different advanced oxidation processes and their comparison. In this study combination of UV/H_2O_2/TiO_2 process has been observed for removal of COD and colour from pesticide industry wastewater. The wastewater was obtained from an industry in Vadodara district. Initial colour was found out to be 596 on Pt-Co scale and initial COD was 1600 mg/L. Fig 1 shows the mechanism of advance oxidation process. It includes three steps. i) Formation of hydroxyl ions. ii) Reaction of these ions with complex organic compounds converting them into biodegradable compounds. iii) Further oxidation of these biodegradable compounds and complete mineralization of the same. Advance oxidation process has the advantage of high reaction rate and non selective pathways for oxidation as hydroxyl radical can react very fast. This will be helpful in treatment of more than one organic compound at a time.

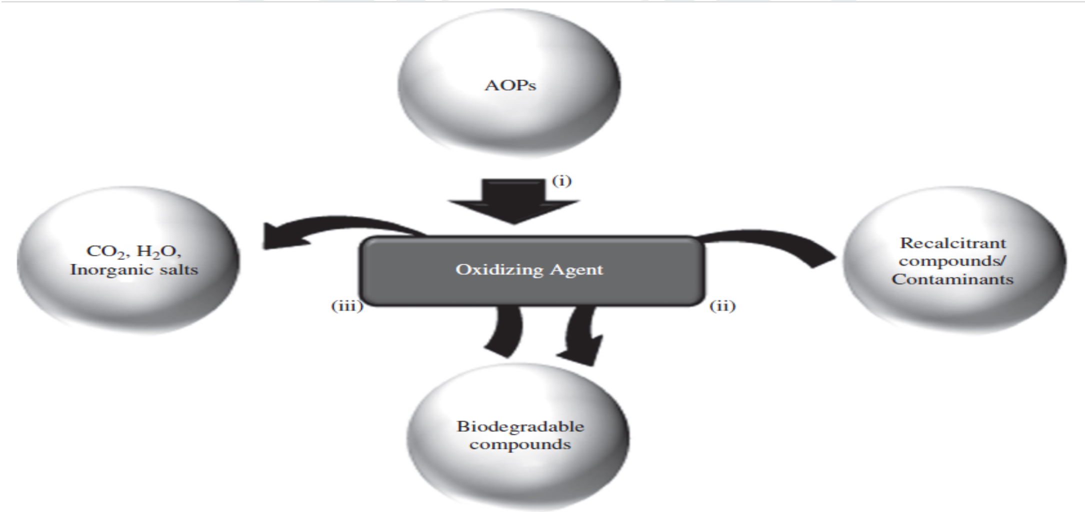

Fig 1. Mechanism of AOP
Source : Ameta, Suresh, and Rakshit Ameta, eds. Advanced Oxidation Processes for Wastewater Treatment: Emerging Green Chemical Technology. Academic Press, 2018.

1.1 UV/H_2O_2 process

This process includes addition of hydrogen peroxide (H_2O_2) in the presence of ultraviolet rays. After irradiating with UV light H_2O_2 will generate hydroxyl radical (•OH) and it will oxidize complex organic compounds. Irradiation of H_2O_2 will be as follows.

$$H_2O_2 \xrightarrow{hv} 2\ \bullet OH$$

1.2 UV/TiO_2 process

This process involves following euations;

$$TiO_2 \xrightarrow{hv} e^- + p^+$$

$$e^- + O_2 \longrightarrow O_2^-$$

$$p^+ + organic \longrightarrow CO_2$$

$$p^+ + H_2O \longrightarrow \bullet OH + H^+$$

$$\bullet OH + organic \longrightarrow CO_2$$

2 EXPERIMENTAL

For this study a reactor was made consisting 2 UV lamps of 6W each. A magnetic stirrer was used for agitation. Speed was set to 500 rpm. Before starting the process the pH of the wastewater was reduced to 2.5, 3, 3.5 and 4 by adding 0.5 M H_2SO_4 as H_2O_2 can work efficiently in acidic pH. Then dosage of H_2O_2 was selected assuming complete oxidation of COD as described below:
1g COD = 1g O_2 = 0.03125 mol O_2 = 0.0625 mol H_2O_2 = 2.125g H_2O_2.
This lead to set the COD:H_2O_2 ratio equals to 1:2.2, 1:3.3, 1:4.4 for the optimization of the H_2O_2 dosage. Initial COD was 1600 mg/L so the dose of H_2O_2 was decided to be 3520 mg/L, 5280 mg/L and 7040 mg/L respectively 30% w/w solution of H_2O_2 was used and the density of H_2O_2 is 1.11 g/L, so the actual dose of H_2O_2 was decided to be 10.57 ml/L, 15.85 ml/L and 21.14 ml/L respectively. Then for the execution of the experiment first the pH of wastewater sample was adjusted to 2.5 and H_2O_2 dose of 10.57 ml/L was fixed. For this combination of pH and H_2O_2 dose, TiO_2 varying from 0.5 g/L to 2.0 g/L was tested. 500 ml of sample was taken and described dosages of H_2O_2 and TiO_2 were added. Treated samples were taken after every 15 minutes and then COD and colour was measured. Likewise the experiments were carried out at 3, 3.5 and 4 pH. pH was optimized and fixed at 3.5. After that different H_2O_2 doses were tested and optimum dosage was found out to be 15.85 ml/L. Detailed results are shown in the next part of the paper.

3 RESULT AND DISCUSSION

Different sets described above were tested and the following results were found. Colour removal was found to be in the range of 74% to 96% and COD removal was found upto 87%. Here are shown the results of the optimum condition of COD:H_2O_2, TiO_2 dose, pH and time.

Table 1 Results at COD: H_2O_2 = 1:3.3; pH = 3.5

Time	Colour	% colour reduction	COD	% COD reduction
		TiO_2 = 0.5 g/L		
0	596	0	1600	0
15	43	92.7852349	1000	37.5
30	48	91.94630872	600	62.5
45	33	94.46308725	600	62.5
60	44	92.61744966	1000	37.5
75	36	93.95973154	800	50
90	44	92.61744966	550	65.625
		TiO_2 = 1.0 g/L		
0	596	0	1600	0
15	39	93.45637584	600	62.5
30	44	92.61744966	400	75
45	43	92.7852349	200	87.5
60	31	94.79865772	500	68.75
75	18	96.97986577	450	71.875
90	31	94.79865772	500	68.75

TiO_2 = 1.5 g/L				
0	596	0	1600	0
15	65	89.09395973	600	62.5
30	74	87.58389262	200	87.5
45	69	88.42281879	500	68.75
60	69	88.42281879	400	75
75	69	88.42281879	600	62.5
90	69	88.42281879	600	62.5
TiO_2 = 2.0 g/L				
0	596	0	1600	0
15	60	89.93288591	700	56.25
30	54	90.93959732	400	75
45	57	90.43624161	600	62.5
60	61	89.76510067	400	75
75	53	91.10738255	400	75
90	58	90.26845638	200	87.5

Optimum results were observed at COD:H_2O_2 = 1:3.3; pH = 3.5 and TiO_2 = 1.0 g/L. After that increasing dose of H_2O_2 showed decline in COD and Colour removal.

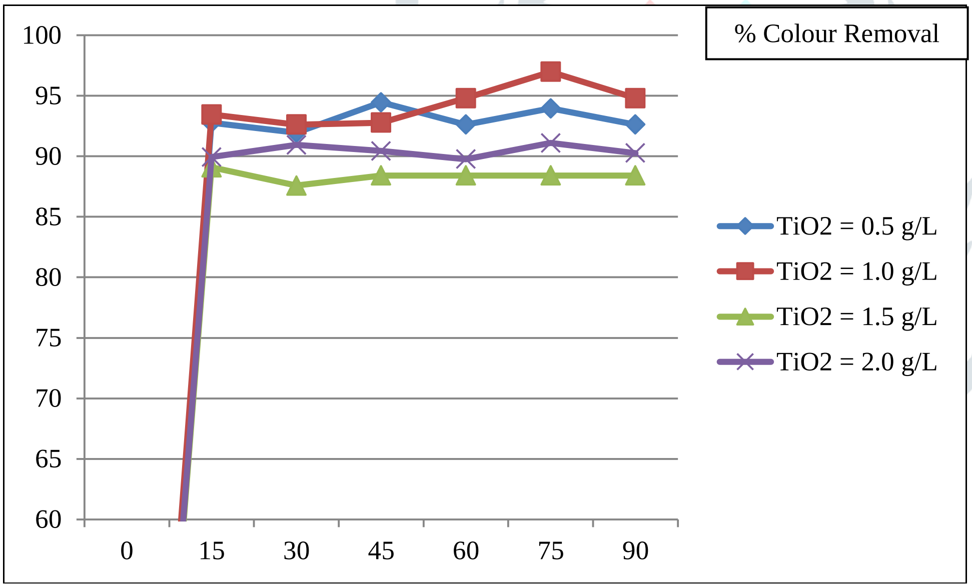

Fig.2 COD:H_2O_2 = 1:3.3; pH = 3.5

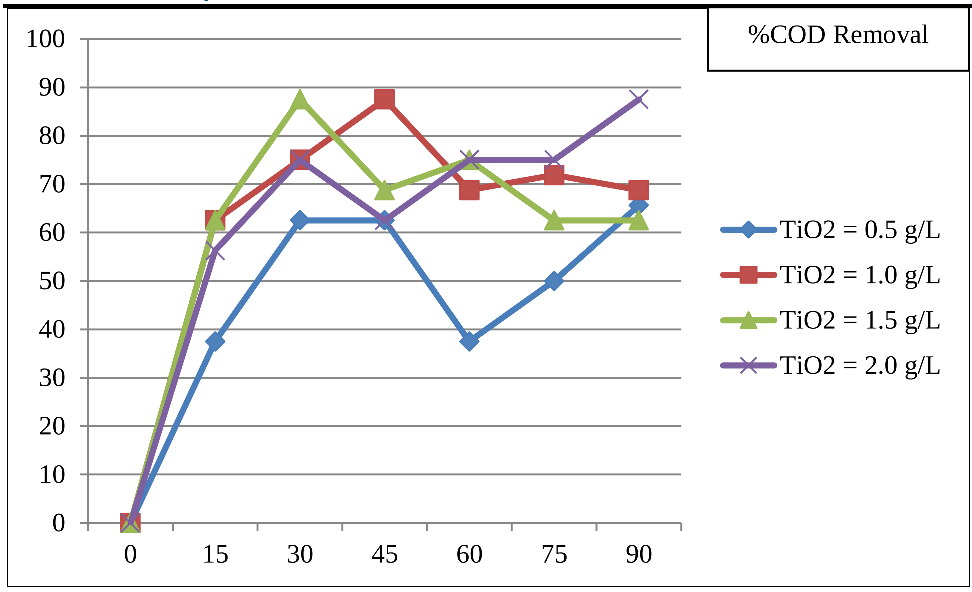

Fig.3 COD:H_2O_2 = 1:3.3; pH = 3.5

4 CONCLUSION

After all sets of experiment it is concluded that the maximum colour removal was found out to be 97% and maximum COD removal was 87.5% at COD:H_2O_2 = 1:3.3; TiO_2 = 1.0 g/L; pH = 3.5. Optimum time was 45 minutes and 75 minutes respectively.

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