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STUDIES ON REMOVAL OF ACID ORANGE 7 BY ADVANCED OXIDATION PROCESS USING UV AND HYDROGEN PEROXIDE (H_2O_2)

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ABSTRACT

Advanced Oxidation Processes could be a good option to treat and eliminate textile dyes. The main advantage of AOP is its simplicity in usage and there is no sludge problem. In the present study, Synthetic dye Acid Orange 7(AO7), an anionic dye is used and its characterization is done by measuring pH, and Color. Decolourization studies of AO7dye is carried out with H_2O_2& UV in specially designed SS reaction vessel equipped with UV tube. Experiments were performed for UV and H_2O_2 alone and combination of both at optimized condition. Various process parameters like pH, dosage of H_2O_2, Contact time of UV & H_2O_2 is varied and their effect have been analysed. As a result, dosage of 20-30ml H_2O_2 /100ml at neutral pH and contact time of 30mins were found to be optimized condition for the colour removal with H_2O_2 and Colour removal of about 100% is obtained at neutral pH withcombination of H_2O_2 dosage of 30ml and UV contact time of 90minutes during batch study.100% removal of colour achieved after 4 hours of contact time of UV and 30ml/1000ml dosage of H_2O_2 during continuous flow experiment maintained at a flow rate of 11.0ml/min.Experiment on Industrial effluent is also performed and 100% removal is obtained for 30ml dosage of H_2O_2in combination with UV after a contact time of 24hours.

Keywords: Advanced oxidation Process (AOP), AO7, H_2O_2 Textile wastewater, and UV.

INTRODUCTION

Water is an integral component in industry. Water is not only needed as an input in the industrial process, but also for discharging the effluents generated. Industries like the pulp and paper industry, thermal power plants, textiles, and the iron and steel industry are highly water intensive. Industries in India have also been criticised for taking inadequate steps to comply with existing environmental standards.It is implicit that an unchecked rise in industrial demand will eventually prove to be harmful for India's water resources. Indian

Textile Industry has earned a unique place in our country. It is among one of the industries which were earliest to come into existence in India. This industry provides one of the most basic needs of people and holds importance; maintaining sustained growth for improving quality of life. The main environmental problems associated with textile industry are typically those associated with water body pollution caused by the discharge of untreated effluents. The large volumes of wastewater generated also contain a wide variety of chemicals, used throughout processing. These can cause damage if not properly treated before being discharged into the environment. Several physical, chemical and biological decolourization methods such as coagulation/flocculation treatment, biodegradation processes, oxidation methods, membrane filtration and adsorption have been investigated for the removal of dyes from industrial effluents. In addition, there are other methods including ozonation, irradiation, ion exchange and photo degradation. Some of these techniques may have some limitation, including excess amount of chemical usage, accumulation of concentrated sludge with disposal problems, expensive plant requirements and operational costs, lack of effective colour reduction and sensitivity to a variable wastewater.The objective of AOP is catalytic conversion of a strong oxidizing agent to hydroxyl free radicals which are more effective oxidizing agents in presence of UV or ultrasound. AOP with H_2O_2 as oxidizing agent has gained considerable interest due to its highly oxidative nature.
Hence treatment of textile effluent by AOP is taken for study.

MATERIALS & METHODOLOGY

The materials and methods used during this research, includes H_2O_2, chemicals, glassware's, UV photo reactor, pH adjustment and analysis by colorimeter, and procedures used to dose the dye and effluent solutions with H_2O_2 and UV. The compilation of the varying H_2O_2 dosages and the varying UV contact times for the Acid red dyes with varying concentrations and effluents make up the experimental matrix.

DYE: ACID ORANGE 7

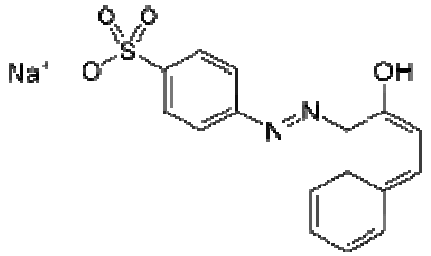

Fig 1: ACID ORANGE 7 STRUCTURE

IUPAC name of AO7	Sodium 4-[(2E)-2-(2-oxonaphthalen-1-ylidene) hydrazinyl] benzene sulfonate
Other names	2-naphthol orange, Orange II, CI 15510, D&C Orange 4, COLIPA C015
Molecular formula	$C_{16}H_{11}N_2NaO_4S$ (sodium salt)
Molar mass	350.32 g/mol
UV absorption	λmax 490nm

Physical & Chemical Properties of AO7:

Physical state and appearance:	Solid andOrange Powder
Odor:	Odorless
Melting Point:	>300°C (572°F)
Dispersion Properties:	Very slightly dispersed in cold water
Solubility:	Very slightly soluble in cold water
Stability:	The product is stable
Incompatibility with various substances**:**	Reactive with oxidizing agents

UV reactor is made up of SS304 having dimensions of 493mm x 101mm used is equipped with 27W UV tube attached having wavelength of 254 nm and intensity 30000 µw-s/cm^2 alongwith control panel. Inlet and outlet size of the reactor is 3/4"BSP.

Preparation of Dye solution

For most of the experiments, dye solutions of 500 ppm concentration were prepared by dissolving 0.5g in deionized water and make the solution quantity to1 L.

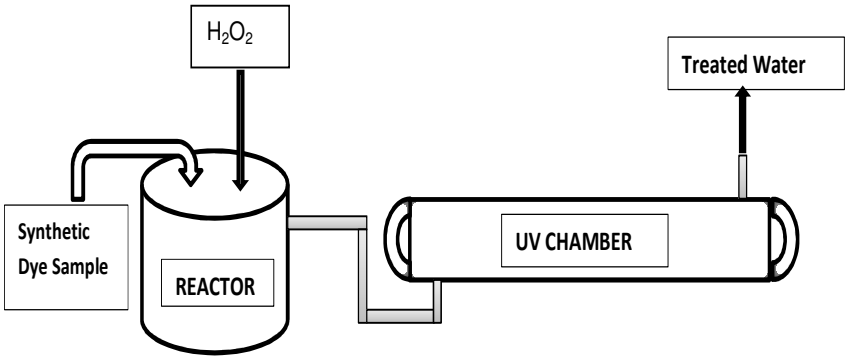

Fig 2: EXPERIMENTAL SET-UP

RESULTS AND DISCUSSIONS

Effect of pH Alone

A series of experiments were conducted at different pH value of 2.0, 4.0, 6.0, 8.0, and 10without addition of H_2O_2 dose with initial concentration of 500PPM. It is observed that there is no much influence of pH on percentage colour removal. Without addition of H_2O_2 highest decolourization was observed at pH 10 (35%) as shown in Fig 3.

Effect of H_2O_2 Dosage Alone

To investigate the effect of H_2O_2 Dosage for colour removal experiments were carried out with initial dye concentration of 500PPM and varying contact time 10, 20, 30, 40, 50 and 60 minutes and at a constant stirring speed of 150 rpm for different H_2O_2 dosages from 5, 10, 15, 20, 25, 30 and 35ml.

Fig.4 shows the relationship between the decolourization of dye by H2O2 dosage alone. The objective was to select the best operational dosage of H2O2 in oxidation process. The result indicates that decolourization efficiency increases to 19 % with increase in H2O2 dose from 10 ml to 35 ml/100ml after 20 min of reaction time.
Increasing H2O2 dosage increases dye removal to some extent but at higher H2O2 dosage dye removal efficiency does not increase. Thus, the presence of excess hydrogen peroxide (H2O2) can lower the treatment efficiency of AOPs.

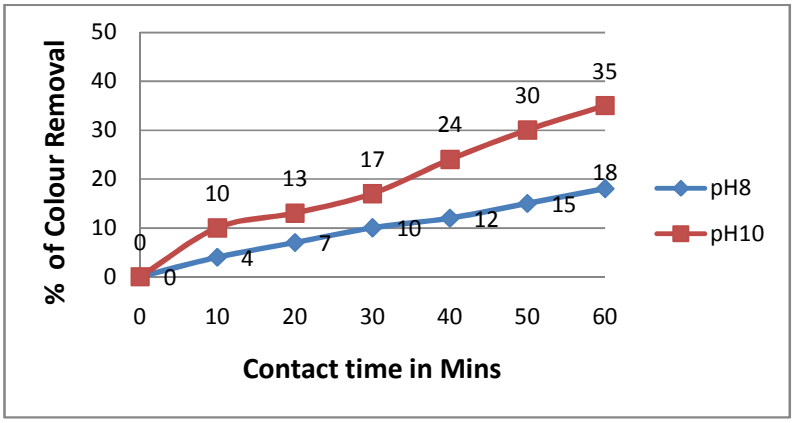

Fig 3: Effect of pH alone on decolourization of AO7-500PPM

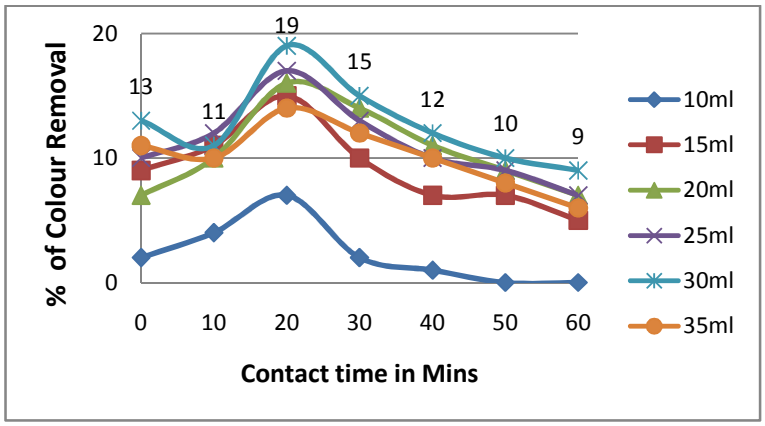

Fig 4: Effect of H_2O_2 alone on decolourization of AO7-500PPM

EFFECT OF pH ON H_2O_2 DOSAGE

The optimum pH has been observed tobe 2 in the majority of the cases in which $H_2O_2$was used and hence isrecommended as the operating pH. With addition of H_2O_2 highest decolourization was observed at pH 2 (100%). Colour removal efficiency is higher in acidic range. Keeping in mind the effluent pH from textile industry and to correlate the removal process, the optimum pH is chosen as 8 for further oxidation process studies. Fig 5 shows the effect of H_2O_2 Dosage @ pH-2

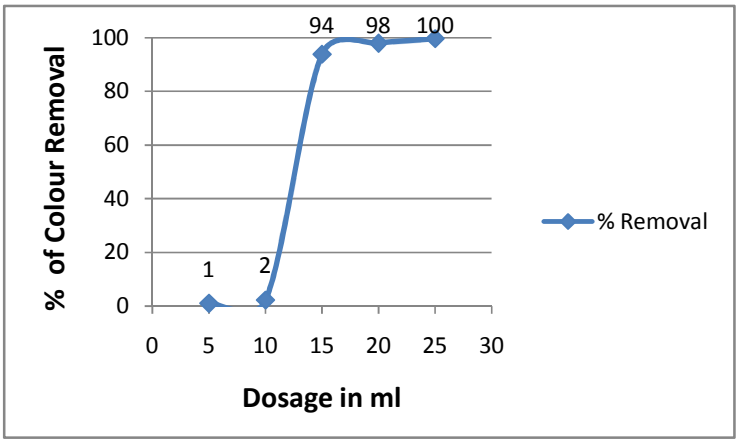

Fig 5: Effect of H_2O_2 dosage on decolourization of AO7-500PPM at pH-2

Effect of UV Alone

After optimizing pH and H_2O_2 dose, presence of irradiation source i.e. UV light was tested, it was observed that disappearance of color was fast in presence of light compared to H_2O_2 alone. This improvement in the reaction yields may be due to the production of extra hydroxyl radicals.

The results obtained for decolourization of AO7 dye under UV is shown in Fig.6. It shows percentage color removal increases with contact time of UV.

Effect of UV+H_2O_2

The best results were obtained under UV light conditions, because UV light has the largest fraction of photons with the energy needed to drive photochemical reactions involved in the present reactive system.According to these studies, the use of H_2O_2/UV process seems to show a satisfactory colour (80-100%) removal performance.Fig.7shows percentage of colour removal with UV and 30ml dosage of H_2O_2 at different contact time.

Continuous Study

In continuous study, the use of H_2O_2/UV process seems to show a satisfactory colour (80-100%) removal performance.Fig.8 shows 100% removal of colour achieved after 4 hours of contact time of UV and 30ml/1000ml dosage of H_2O_2 during continuous flow experiment maintained at a flow rate of 11.0ml/min.

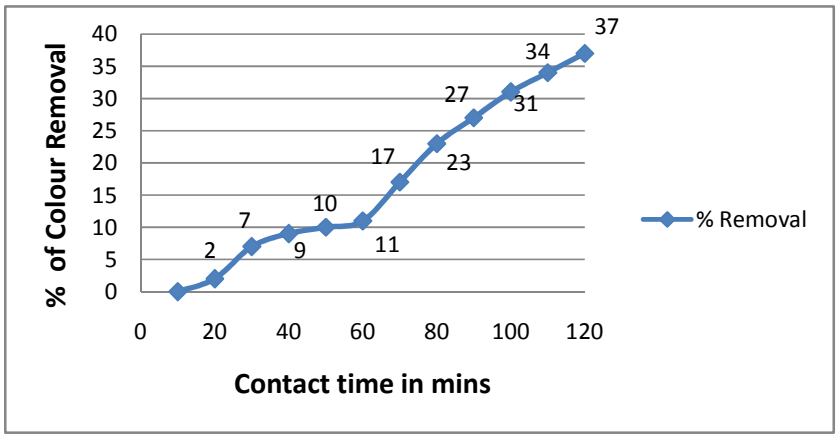

Fig 6: Effect of UV alone on decolourization of AO7-500PPM

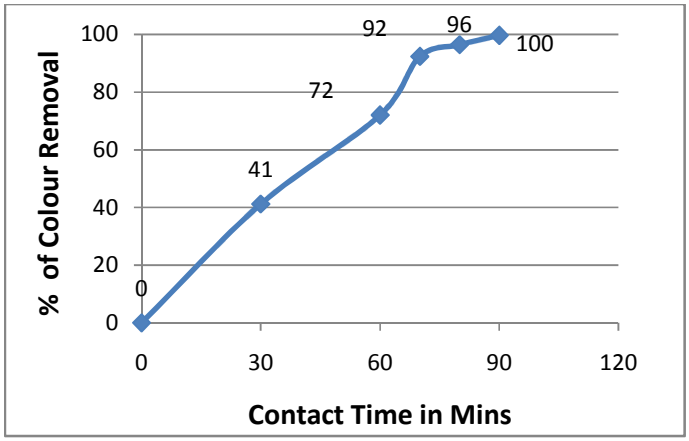

Fig 7:- Effect of UV: 30ml H_2O_2 on decolourization of AO7-500PPM

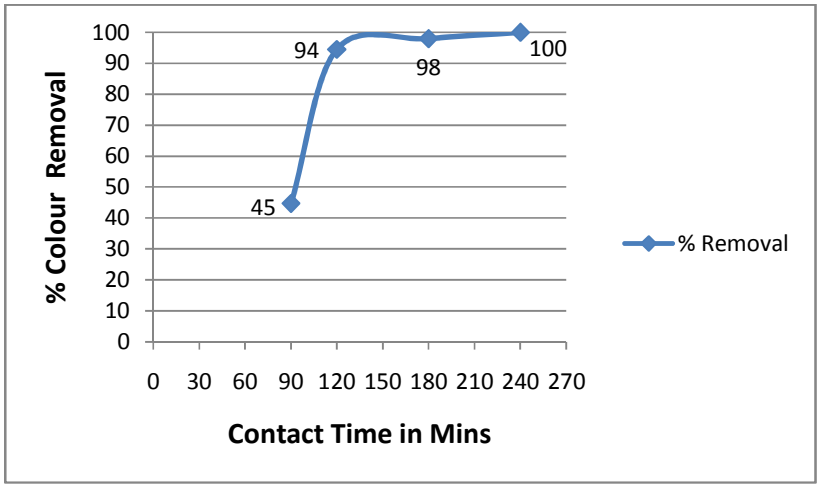

Fig 8:- Continuous study- UV: 30ml H_2O_2 on decolourization of AO7-500PPM

Experiment on Industrial Effluent

Fig 9 shows the percentage removal of colour for industrial textile wastewater. From the figure it shows that 100% removal is achieved after 24 hours of UV contact time with 30ml optimum dosage of H_2O_2 which is obtained during batch study.

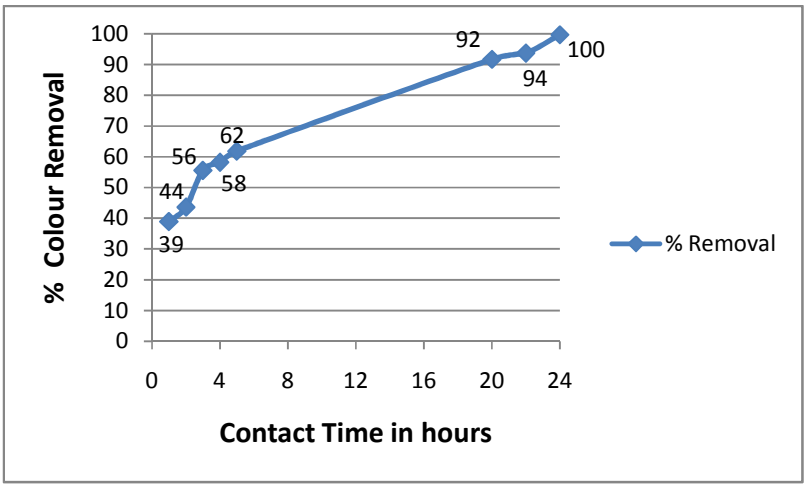

Fig 8:- Decolourization of Industrial Textile Wastewater

CONCLUSIONS

This work was conducted for the effective removal of Acid Orange7 dye from aqueous solution by UV and H_2O_2. Theresults concluded are as follows:

- ✓ Advanced oxidation process using UV and H_2O_2 for AO7 depends on initial pH, H_2O_2 dosage, and contact time of UV.
- ✓ Colour removal efficiency with addition of H_2O_2 is higher in acidic range (pH-2).Keeping in mind the effluent pH from textile industry and to correlate the removal process, the optimum pH is chosen as 8 for further oxidation process studies.
- ✓ Removal capacity was increased by increasing the UV contact time.
- ✓ From the batch studies it was concluded that at pH of 7, dosage of 30ml H_2O_2/1000ml of dye solution and contact time of 90 minutes with UV were found to be optimum conditions for the removal of acid orange 7 dye by AOP.

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