Modern Techniques in Decolourization of Dyes using Advanced Oxidation Process combined with Membrane Technology

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Abstract

Conventional and traditional textile wastewater and effluent treatment procedures have of late become a major concern especially in the context of our current environmental issues. Dyes cannot be destroyed by primary and/or secondary treatments. Primary treatment encompasses coagulation and flocculation while secondary treatment involves the activated sludge process. Neither of these treatments successfully degrades textile dyes and also the dyes are resistant to these treatments. Hence there arises a need for a tertiary treatment process – advanced oxidation process such as Fenton's method. The textile industry is very diverse, heterogeneous, and characterized by high consumption of water, fuel and chemicals. Environmental problems are mainly associated with wastewater. Wastewater treatment and recycling possibilites are now global priorities in view of scarcity of water and a host of other problems. Dyes have obtained notoriety as hazardous substances, because most of them are toxic and non biodegradable. Acid Orange 7 and Acid Blue 113 were decolorized as part of this research project using two oxidation processes (H_2O_2/UV and H_2O_2/Fe^{2+}). The efficiency of decolorization was measured by decolorization time and absorbance.

Keywords: *Advanced Oxidation process, Decolourization, Dyes*

1. Introduction

Our environment is being polluted continuously, by domestic and industrial wastes. The water, air and land which are essential for living beings should be in their pure state. Modern civilization, increasing population and growth of industries have altered the natural environment. The air we breathe, the water we drink and the places where we live are contaminated with toxic substances resulting in air, water and land pollution. These results in health hazards too. Pollution may be defined as the excessive discharge of undesirable substances into the environment adversely altering the natural quality of the environment and causing damage to humans, plants and animals. Pollution is the introduction of pollutants (chemical substances, noise, heat, light, energy and others) into the environment which result in deleterious effects of such nature as endanger human health, harm living resources and ecosystems, and impair or interfere with amenities and other legitimate uses of the environment. There are different types of pollutants, Biodegradable pollutants (the pollutants are said to be bio-degradable which decompose rapidly by natural processes) and Non biodegradable pollutants (the pollutants are said to be non-biodegradable which do not decompose rapidly in the environment).Water is of prime importance for all human activities and so its management and conservation is most essential. In this present age, when every man is aware of the importance of sustainable environment, training the masses in environment management is the need of the hour. When toxic substances enter lakes, streams, rivers, oceans, and other water bodies, they get dissolved or lie suspended in water or get deposited on the bed. This results in detergents and washing powders containing phosphates, which soften water among other things. These and others chemicals contained in washing powders affect the health of all forms of life in the water. Waste water from manufacturing or chemical processes in industries contributes to water pollution. Industrial waste water usually contains specific and readily identifiable chemical compounds. During the last fifty years**,** the number of industries in India has grown rapidly. But water pollution is concentrated within a few sub sectors, mainly in the form of toxic wastes and organic pollutants.

A dye can generally be described as a colored substance that has an affinity to the substrate to which it is applied. The dye is generally applied in an aqueous solution, and many require a mordant to improve the fastness of the dye on the fiber. Both dyes and pigments appear to be colored because they absorb some wavelengths of light preferentially, in contrast with a dye, a pigment generally is insoluble, and has no affinity for the substrate. Some dyes can be precipitated with an inert salt to produce a pigment. In Azo dyes, Azo compounds refer to chemical compounds bearing the functional group R-N=N-R', in which R and R' can be either aryl or alkyl. The N=N group is called an azo or di imides. Many of the more stable derivatives contain two aryl groups due to the electron delocalization. Because of this delocalization, many azo compounds are colored and in fact many are used as dyes.

The concentration of dye is significant at lower parts per million and it remains visible even at that concentration. The strong color and turbidity of waste water effluents have a negative impact because dyes absorb sunlight and plants in sewage may perish. Thus the ecosystem of trees could be seriously affected. The release of this waste water in natural environment causes problems to aquatic lives and mutagenic to human's prolonged exposure to some of the color and is associated with allergy. Some azo dyes, dye precursors and the degradation process such as aromatic amines were known to be carcinogenic. Direct discharge of dye waste water may contaminate the soil as well as ground water. Therefore it is necessary to treat waste water before being discharged into the environment. Azo dyes constitute the most important class of commercial dyes in waste water. They are mostly non-biodegradable and resistant to destruction by conventional waste water treatment. Recent studies indicate that toxic and refractory organic compounds including dyes and waste water could be destroyed by the most advanced oxidation process. Since water pollution is caused by domestic sewage and industrial waste any abatement of water pollution depends mainly on the efficiency of waste water treatment.

2. Methodology

All the chemicals used were of commercial grade and they were used without further purification. The experimental procedure was carried out using the dye sample solution containing different concentrations of Acid Orange 7 and Acid Blue 113. The solution was taken in a clean, dry conical flask. pH was adjusted to a desired pH using sulphuric acid and sodium hydroxide. The reagents namely hydrogen peroxide, ferrioxalate were added to the solution. Then 5mL of aliquot sample was taken as a reference. The remaining solution was kept in the solar light in the case of solar method and kept in the photo reactor in the case of UV method. For every 15 minutes interval the sample was taken and analyzed using UV-visible spectrophotometer

(Shimadzu model 160 A). The UV visible spectra of the sample were recorded in the wavelength range of 200nm to 800nm. The absorption maximum is observed at 485nm for Acid Orange 7 and at 565nm for Acid Blue 113. The difference in absorbance of the reference and sample gives the percentage of decolourization of the dyes.

3. Result

3.1. Effect of dye concentration

It is evident from the Fig 1 and 2 that the concentration of Acid Orange 7 and Acid Blue 113 decreased with increase in concentration. The concentration of Ferrioxalate and H_2O_2 were kept constant for all the experiments .Hence the same quantity of hydroxyl radicals were generated in all the experiments. When the concentration of dye is low sufficient decolourization was obtained. However when the concentration of the dye was increased to 100ppm the hydroxyl radicals were insufficient to decolorize the dyes in the desired time of one hour. The high color of dye concentration makes the penetration of photons difficult, thereby decreasing the hydroxyl concentration (1, 2).

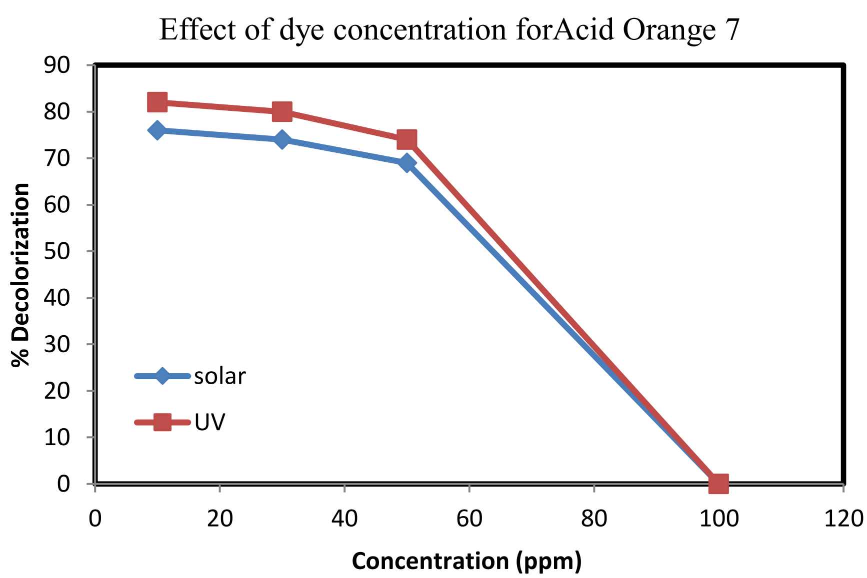


Fig 1.Effect of dye concentration for Acid Orange 7

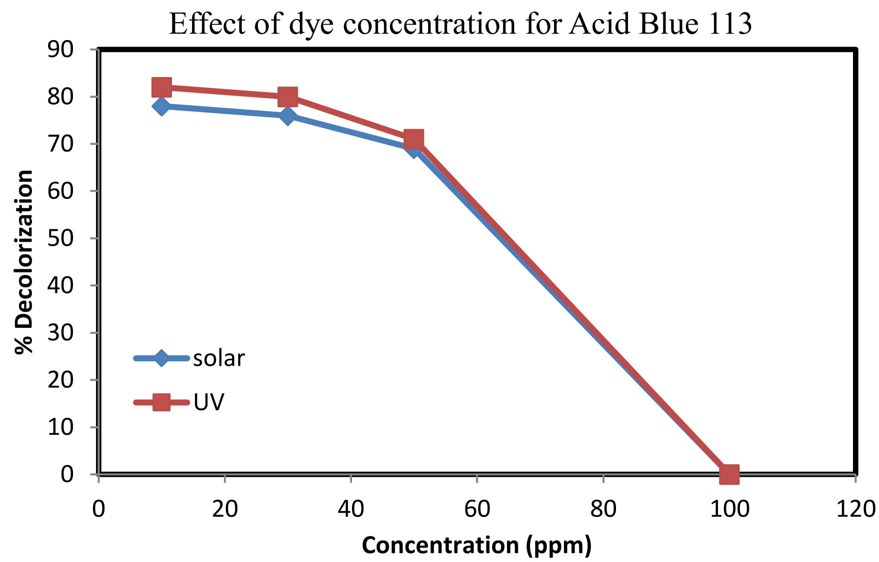


Fig 2.Effect of dye concentration for Acid Blue 113

3.2 Effect of pH

The experiments were carried out at different pH ranges 3,5 and 10 for the dye concentration of 30ppm,Hydrogen peroxide dosage 30%(V/V) of 1.5mM and Iron dosage of 1.5mM.At low pH of 3 very low decolourization was obtained .At pH 5, the highest value for decolourization was achieved. Above pH 5 the color removal capacity decreased. This is due to the formation of ferric hydroxo complexes during the reaction, which blocks the decomposition of hydrogen peroxide catalyzed by the ferrous ion (3).

Table 1.Effect of pH for Acid Orange 7

pH	Solar (% decolorization)	UV (% decolorization)
3	82	86
5	92	98
10	86	89

Table 2.Effect of pH for Acid Blue 113

pH	Solar (% decolorization)	UV (% decolorization)
3	83	87
5	90	98
10	87	89

3.3 Effect of Peroxide dosages

The objective of this method is to select the best operational dosage of H2O2 for the decolourization of dyes. The addition of H2O2 between 1mM and 2mM decolourization increases and maximum decolourization was obtained at 1.5mM concentration. However an increase in the peroxide dosage, decolourization decreases. This is probably due to the scavenging of hydroxyl radical (4).

Table 3.Effect of peroxide dosage for Acid Orange 7

Concentration of Peroxide (mM)	Solar (% decolorization)	UV (% decolorization)
1	72	76
1.5	85	97
2	73	85

Table 4.Effect of peroxide dosage for Acid Blue 113

Concentration of Peroxide (mM)	Solar (% decolorization)	UV (% decolorization)
1	70	74
1.5	87	94
2	74	85

3.4 Effect of Iron dosages

The results indicate that the extent of decolourization increases with higher iron concentration.

Table 5. Effect of Iron dosage for Acid Orange 7

Concentration of Fe^{3+} (mM)	Solar (% decolorization)	UV (% decolorization)
0.1	62	66
0.15	85	92
0.2	81	87

Table 6.Effect of Iron dosage for Acid Blue 113

Concentration of Fe^{3+} (mM)	Solar (% decolorization)	UV (% decolorization)
0.1	64	68
0.15	87	95
0.2	81	85

3.5 Effect of Time

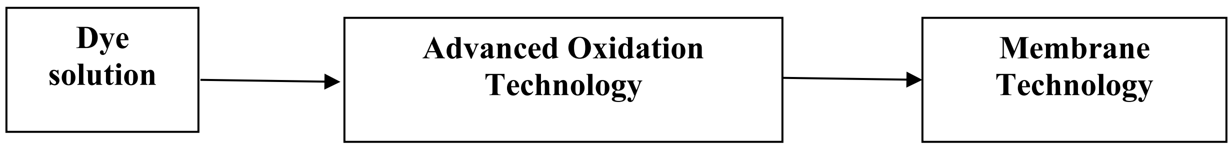
It is evident from all the above graphs and tables that the reaction time is very important in decolourization. As the reaction time increases decolourization also increases.

4. Conclusions

The decolourization of dyes is studied by Solar and UV methods using Ferrioxalate/H_2O_2. From the study it can be concluded that these methods are highly efficient for the decolourization of dyes. These act as effective oxidizing agents by generating hydroxyl radical which plays an active role in decolorization. The extent of decolourization as a function of various parameters such as dye concentration, pH, Peroxide dosage and Iron dosage were investigated. The objective of the present work is the degradation of dye and its removal by the advanced oxidation process.

5. Future Work

In future studies aiming to combine advanced oxidation process with membrane separation process.



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