CHAPTER 5

CONCLUSION AND SCOPE FOR FUTURE WORK

5.1 CONCLUSION

The degradation of RR 11 and RY 16, using Fenton and Electro-Fenton process and hybrid systems in combination with ultrasound/ultraviolet irradiation sources has been carried out. The observations of these investigations clearly demonstrate the importance of choosing the optimum degradation parameters to obtain a high degradation rate, which is essential for any practical application of hybrid system. The degradation rate was influenced by many factors such as: initial hydrogen peroxide concentrations, initial iron concentrations, pH, current density and initial dye concentration. Optimization Studies by central composite design using Response Surface Methodology were also carried out. The results of the present studies are as summarized below:

i) Fenton’s process could be applied for the degradation of RR 11 and RY 16. Degradation rates of RR dye 11 and RY dye 16 by means of Fenton process can be expressed as a pseudo first-order reaction with respect to dye concentration. The rate of degradation was found to be maximum in acidic medium (pH=3). Optimum $\text{H}_2\text{O}_2$ and $\text{Fe}^{2+}$ concentration for the degradation of RR 11 and RY 16 (100 mg l$^{-1}$) was found to be 0.9 g l$^{-1}$ and 40 mg l$^{-1}$, 25 mg l$^{-1}$ and 0.5 g l$^{-1}$ respectively. Higher initial iron concentrations showed negative effect on
The results obtained for Fenton’s process were not satisfactory for higher dye concentrations. However it would be feasible to use Fenton’s process as pre treatment step in combination with other treatment methods.

The use of ultrasound in Fenton process is a good alternative. The study reveals that further acceleration of RR 11 and RY 16 degradation can be achieved by this hybrid system. This increases the amount of reactive radical species inducing oxidation of the substrate and degradation of intermediates and is mainly responsible for the observed synergy. Mainly ultrasound contributes through cavitation to the scission of \( \text{H}_2\text{O}_2 \) produced by sonolysis. This increases the amount of reactive radical species inducing oxidation of the dye and degradation of intermediates and is mainly responsible for the observed synergy. The amounts of hydrogen peroxide and \( \text{Fe}^{2+} \) used are less than that of Fenton’s process by 12 %, 20 % and 20 %, 50% for RR 11 and RY 16 respectively, without efficacy loses. Degradation rates of RR 11 and RY 16 by means of Sono-Fenton process can be expressed as a pseudo first-order reaction with respect to dye concentration.

The Photo-Fenton hybrid system also turned out to be a good treatment method. The study reveals that further the acceleration of RR 11 and RY 16 degradation can be achieved by ultraviolet irradiation. The amounts of hydrogen peroxide and \( \text{Fe}^{2+} \) used are less than that for Fenton’s process by 20 %, 20 % and 40 %, 75 % for RR 11 and RY
16, respectively, without efficacy loses. The effect is due to hydroxyl radical production from UV light and iron Photoredox process. The photo-Fenton process uses UV for the reduction of Fe (III) back to Fe (II).

v) Photo-Fenton hybrid system showed to be an efficient method to enhance the degradation of dyes and was superior to Fenton and Sono-Fenton process. Degradation rates of both dyes by means of Photo-Fenton process can be expressed as a pseudo first-order reaction with respect to RR 11 and RY 16 concentration. The first order rate constants were found to increase for Photo- Fenton process compared to Fenton and Sono-Fenton process, for both dyes. The average color and COD removal were 96 and 88 % respectively.

vi) The limitation of photofenton process was the influence of initial concentration of the dye solution on the rate of degradation. The photodegradation rate is observed to decrease with increasing initial concentration. The color removal for RY 16 and RR 11 dye concentration of 300 mg$^{-1}$ were to 88 % and 80 % respectively.

vii) Electro Fenton process could be efficiently applied for the degradation of RR 11 and RY 16. Degradation rates of RR 11 and RY 16 by means of Electro-Fenton process can be expressed as a pseudo first-order reaction with respect to dye concentration. The rate of degradation was found to be maximum in acidic medium (pH=3). The color and COD removal were 93 and 76 % respectively.
viii) Sono-Electro-Fenton hybrid system showed an increase in degradation efficiency. This hybrid system increases the amount of reactive radical species inducing oxidation of the substrate and degradation of intermediates. The effect can be due to hydroxyl radical production from Sonolysis, in addition to that produced from Fenton’s process. In this case also, degradation followed pseudo-first order kinetics and the color and COD removal were 94 and 83% respectively.

ix) The study of Photo-Electro-Fenton hybrid system reveals that further the acceleration of RR 11 and RY 16 degradation can be achieved by ultraviolet irradiation. Degradation rates of RR 11 and RY 16 by means of this hybrid system can be expressed as a pseudo first-order reaction with respect to dye concentration. The Photo-Electro-Fenton hybrid system showed a good removal of color and COD even at higher dye concentrations.

tax) The degradation of RR 11 and RY 16 were optimized using statistical tool Minitab 15.0. Response Surface Methodology was applied for batch operation and the results were analyzed and the regression model equation was obtained. From global solution it was found that, the optimum pH and dye concentration were 4.41 and 58.57 mg l⁻¹, 3.27 and 58.57 mg l⁻¹, for 98.6 and 96.8 % color removal, for RY 16 and RR 11 respectively.

xi) The efficiency of the Photo-Electro-Fenton hybrid system was examined with textile industry effluent. The present investigation revealed that the newly developed hybrid system showed better degradation for reactive dyes compared to industrial effluent. This may be due to the fact
that the effluent may contain higher concentration of dyes in the effluent. A higher time was required for industrial effluents than the synthetic dyes studied.

According to the experiments carried out in this study, the decolorisation and degradation of the dyes can be achieved. The hybrid system which combines photolysis and electrofenton process shows a higher degradation of dyes compared to other processes. The insitu electrochemical production of peroxide enhances the efficiency of the process. The addition of Fe$^{2+}$ and H$_2$O$_2$ to the system also promotes the oxidation of the dyes, achieving 98 % decolorisation and 95 % mineralization of reactive yellow 16 and reactive red 11. Based on the results of the hybrid systems used, it may be concluded that Photo-Fenton hybrid technique could be used successfully at lower dye concentrations and Photo-Electro-Fenton hybrid technique could be used as an efficient and eco friendly technique at higher dye concentrations and effluent treatment of textile wastewater.
5.2 SCOPE FOR FUTURE WORK

In the present investigation, attempts were made to compare the efficiency of the various processes and select the best one and apply for the textile industry waste. Since the present investigation has successfully paved ways for the development of hybrid systems for treatment of textile industrial effluent, much light is thrown on to extend the further research on the following:

i) Another possible development of this work would be to go on exploring the efficiency of different Electrodes in Photo-Electro-Fenton process, for more effective treatment of textile dyes.

ii) By properly combining different possibilities, hybrid techniques can be developed for specific problems. Finally, other hybrid systems using advanced oxidation processes could be applied in order to study their efficiency in the degradation enhancement of the textile wastewater.