Color Removal from Textile Effluent using Emulsion System

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Abstract

India's domestic clothing and textile sector produce 5% of the country's GDP, 7% of industry output in value terms, and 12% of the country's export revenues. The primary threat faced by the textile industry is the color of the water that is left after dyeing. In the present study, water in oil nanoemulsion was used to remove the color from textile effluent. Nano-emulsion based on cyclohexanol was prepared using a high-speed homogenizer followed by ultrasonication. The emulsion, in general, was prepared using dye effluent water as the aqueous phase and cyclohexanol as the oil phase, and Beisol DEP as an emulsifier. The prepared emulsion was used to treat Reactive Blue 21 and Reactive Black 5. The treatment ratio of 1:1, 1:3,1:5, 1:7, 1:10 were tried. The treated effluent was tested for color removal efficiency, Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD). Also, this study investigated the reusability of emulsion and solvent recovery. Emulsion characterization such as particle size and zeta potential was also carried out. It was found that there was about 95% decolourisation dye in effluent and the reusability of the solvent decreased by 7-10% after each cycle.

Key words:

Dye removal; Effluent treatment; Emulsion system; Reactive Dye; Reusability

Citation

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1.0 Introduction

The textile industry stood as the largest in all amongst industries in the Indian economy for several decades. Even today, the textile industry is a significant contributor to India's export business, around 13 percent of all exports. The textile business employs more than 65 million people directly and indirectly. Total India's export in textiles from 2016-2017 was around 40 billion USD [1] . The textile business in India exports the most considerable textile material and is also responsible for producing a large amount of effluent, which is quite challenging to treat and not cost-effective.

The effluent generated by the textile industry, which consumes a very high amount of dyes and pigments, causes high coloration to the effluent. The dyes and pigments have complex chemical structures, large molecule sizes, and toxic nature. These pigments and dyes are responsible for the dangerous effect on human and aquatic life [2] . The high concentrations of dyes cause mutagenic effects on the marine ecosystem. The colors and pigments mostly have complex aromatic structures. These aromatic structures are difficult to degrade and require significant chemical oxygen demand (COD) [3].

During dyeing, some amount of dye remains in the dye bath, and also unfixed dyes come out from the fabric during the washing operation. This unfixed dye is high in concentration. When mixed with the effluent causes high coloration, which has highly complex structures and is challenging to remove through conventional biological water treatment processes is also resilient to microorganisms when present in a mixture with various auxiliaries [4]. This effluent consists of highly concentrated dyes and auxiliaries used in various processing stages of textile material. The effluent contains few metal traces such as Cu, Zn, Cr, and As are capable of causing several health issues like nausea, irritation to the skin, dermatitis, hemorrhage, and ulceration of human skin [5].

Several treatments are employed to treat effluent, which follow primary, secondary, and tertiary treatments. These treatments include flocculation, coagulation, sedimentation, aerobic activated sludge, aerated lagoons, reverse osmosis (RO), trickling filter, electrodialysis, and nanofiltration [6][7] . But no single method can be used to remove more than one class of dye or complete removal of a particular dye from effluent. Also, most methods are too costly and hence are not feasible to be used in the current scenario, or the sludge generated is high [8].

In this work, we have developed a simple emulsion using cyclohexanol as the oil phase and water as the aqueous phase and made water in the oil emulsion using an emulsifier, which can remove the color from effluent and then it can be taken up for further treatment. The emulsion technique is an

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easy way the removal of dyes from wastewaters. It transports them into desired phases, where the pollutants can be concentrated 10 to 100 times. There are no sludge generation less operational and energy costs than conventional effluent treatment. The emulsion separation technique has been regarded as membrane technology with considerable potential for various applications.

2.0 Materials and Method

2.1 Materials

Cyclohexanol was procured from Amrut Chemicals, Mumbai, and CHT Chemicals supplied surfactant (Beisol DPH). Colourtex industries, Mumbai, provided various dyes. All chemicals were used without any further purification.

2.2 Methods

2.2.1 Preparation of Emulsion

Sets of the experiment were performed to obtain a stable emulsion using cyclohexanol and effluent water and an emulsifier. The cyclohexanol to water ratio was tried from 90:10, 80:20, 70:30, 60:40, and 50:50, and surfactant concentration was varied from 5, 10, and 20%. The ratio of O/W 90:10 and surfactant concentration of 20% gives excellent stability compared to other O/W ratios and surfactant concentrations. This stable emulsion was utilized to treat reactive dye effluent.

A known amount of Beisol DEP was added to cyclohexanol using a magnetic stirrer at 500 rpm at room temperature. The aqueous phase water was added dropwise by using a high-speed homogenizer at a speed of 12000 rpm for 15 to 20 min, followed by ultrasonication for 15 min. The oil to water ratio was kept at 90:10.

2.2.2 Use of Emulsion in Effluent Treatment

The prepared emulsions were added to Reactive Blue 21 (RB 21) and Reactive Black 5 (RB 5) effluent in the ratio of 1:1, 1:3, 1:5, 1:7, 1:10 and three different concentrations of effluent dye solution, i.e., 125, 250, and 500 mg/L were used for treatment. The selection of both dyes is that they are most widely used and are difficult to degrade by bacterial or oxidative methods [9] .

The physical properties of emulsion like partice size and zeta potential were characterized by using SHIMADZU SALD 7500 Nano, Japan, and Zetasizer Ver. 7.11, Malvern, UK. To check the dye concentration after treatment the absorbance of treated effluent was measured by using a UV-vis spectrophotometer (SHIMADZU 1800 UV vis, Japan). The optimized treated dye effluent of RB 21 and RB 5 of concentration 250 mgL and treatment ratio 1:10 was tested for COD and BOD using Hatch DRB 200 and Hatch BOD Track II., USA, respectively. The cyclohexanol emulsion was reused to treat the effluent of Reactive Black 5 dye having a concentration of 250 mg multiple times.

3.0 Result and Discussion

3.1 Characterization of emulsion

The colorless emulsion obtained showed a particle size of about 30nm. It is said that the lower the particle size higher is the stability of the emulsion [10]. The Zeta potential values between -25 mV and -35 mV are sufficient to avoid the separation of nanoemulsion into different phases, leading to good stability [10]. The zeta potential was found to be -32.2 mv for emulsion after preparation.

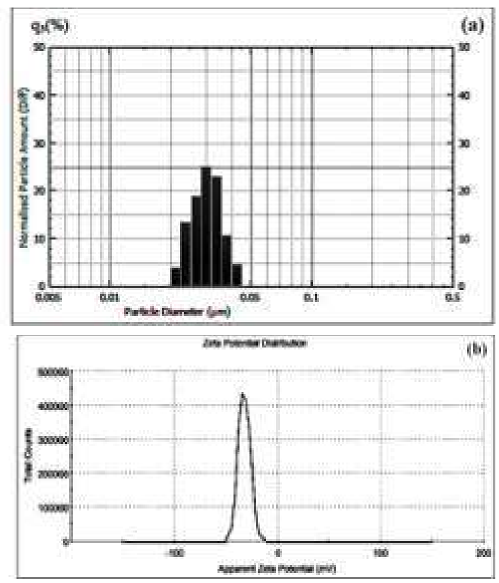

Figure 1 -The particle size (a) and zeta potential (b) graph of the emulsion

3.2 The absorbance of treated effluent by using UV-vis spectrophotometer

Fig 2. shows the results of % decolorization for RB 21 and RB 5 at different concentrations treated with cyclohexanol emulsion. The effluent was decolorized by more than 95% for a ratio of 1:10 in a span of 6 h.

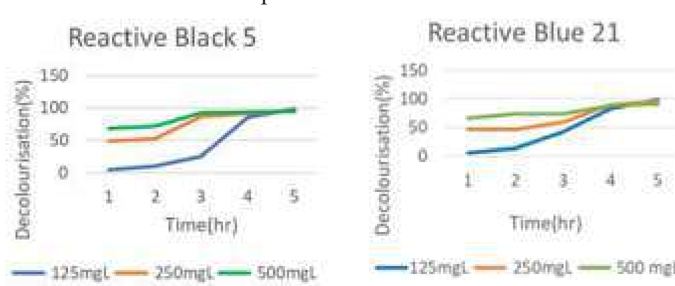

Figure 2 - % Decolourisation of RB 5 and RB 21 after about 5 h of treatment

3.3 COD and BOD analysis

It showed 167 mg/L and 139 mg/L values compared to BOD values of 4 mg/L and 8 mg/L of standard untreated dye effluent of RB 21 and RB 5. It showed 229 mg/L and 258 mg/L values compared to COD values of 150 and 158 mg/L of RB 21 and RB 5. There was a considerable increase in BOD and COD values in both dyes. The increased values were due to cyclohexanol and a high amount of surfactant.

3.4 Visual analysis of the treated samples

As can be seen from fig. 3a and 3b all the ratios of RB 21 and RB 5 give almost complete decolorization in 6 h. Different ratios of emulsion and effluent were tried. It can be seen that even with minimum usage of emulsion, i.e., 1ml for 10 ml of effluent, a complete decolorization is there for both the dyes.

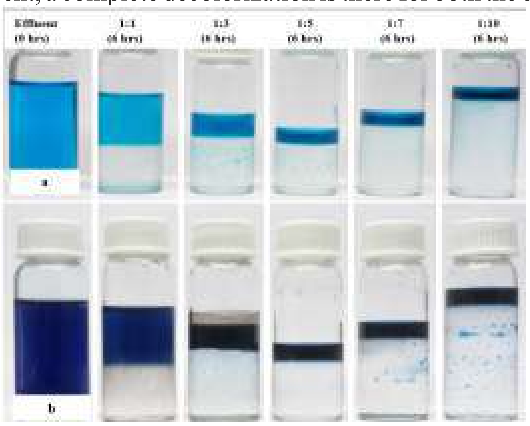

Figure 3 - visual confirmation of dyes a. RB 21 and b. RB 5 removal from the effluent in all concentrations

3.5 Recovery and reusability of cyclohexanol

The cyclohexanol emulsion was reused to treat the effluent of Reactive Black 5 dye with 250 mg multiple times, as can be seen in fig 4. The color removal percentage reduced to 62% after being used 4 times. The efficiency decreases may be due to the saturation of water present in the emulsion with the dye particles. After each use, the reactivity of the emulsion decreased by 8-10%.

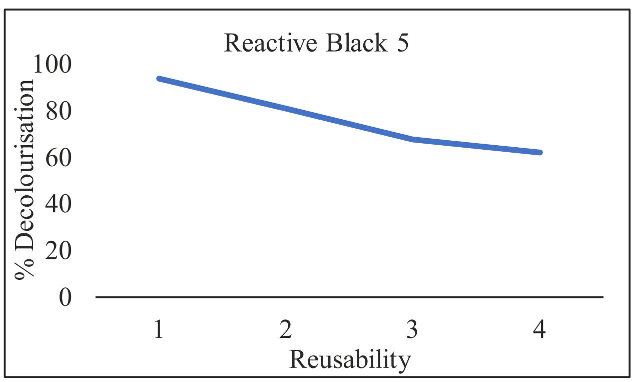

Figure 4 - Reusability of cyclohexanol emulsion

3.6 A trail on Industrial Effluent

An unknown effluent supplied by Atul Industries (Valsad, India) was treated with cyclohexanol emulsion in the ratio of 1:5 for 12 h and 48 h. The results are shown in figure 5, and it is clear that after 12 h, slight traces of dyes were present in the water in both effluent while the 48 h treatment showed the complete removal of color from the effluent.

Figure 5 - Treatment of industrial effluent

4. Conclusion

Water in oil emulsion was successfully carried out using cyclohexanol as an oil phase, effluent as an aqueous phase, and Beisol DEP as a surfactant. The zeta potential was -32.2, indicating that the emulsion was stable. Also from UV-vis spectroscopy, we can see that more than 95% decolorization is there. There was an increase in COD and BOD values due to the cyclohexanol used, but it can be reduced in the subsequent stages of effluent treatment. Also, if the emulsion is recovered, the value will go down. The decolorization was more than 95% after 6 h of treatment. It can be implemented in the industrial process after the primary treatment of effluent.

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