

Recovery of Reactive Dyes from Textile Effluents Using Aliquat 336 as Carrier

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Abstract—Dyes are usually toxic and they are highly soluble in water hence they contaminated in aquatic system. The recovery of two reactive dyes namely Gold Yellow HE-R (GYHE-R) and Reactive Green HE-4BD (RGHE-4BD) from aqueous solutions using Aliquat 336 has been investigated. These dyes were collected from textile industries. The UV absorbance of GYHE-R and RGHE-4BD are 405nm and 630nm respectively. The extraction of dye increases with increasing Aliquat 336 concentration in organic phase. The other influencing parameters were also examined; effect of carrier concentration in organic phase, effect of diluents, effect of inorganic salts, effect of time, dye concentration, A/O ratio, stripping reagent concentration and O/A ratio. The maximum percentage of extraction (96.0% for GYHE-R and 97.5% for RGHE-4BD) obtained in 3×10^{-4} mol/L Aliquat 336 at neutral medium (pH 6.5-7.0). Real effluent was also extracted and found to give satisfactory result.

Key words— Aliquat 336; stripping; extraction; organic phase; gold yellow HE-R.

I. INTRODUCTION

Reactive dyes are widely used to colour cellulosic fibers such as cotton and dyeing with reactive dyes causes serious environmental problems [1]. They have low rates of fixation for dyeing process results the highest loss upto 50% of colour discharged in the effluent. Even the presence of very low concentrations of dyes (less than 5mg/L) in the effluent is highly visible and affects the aesthetic merit, water transparency, lakes, rivers and other water bodies.

When a new dye is made that is stable under all conditions (exposure to sunlight, water, soap, soil etc.), it becomes more difficult to treat it in wastewater. The removal of dyes is, therefore, a challenge to both the textile industry and wastewater treatment facility for treating this wastewater [2]. Dye wastewaters are usually treated by conventional methods such as biological oxidation [3], adsorption [4], or coagulation by aluminium or iron salts [5].

Solvent extraction method is used for the purification, enrichment, separation and analysis of various compounds in mixtures. These are based on the principle that a solute can distribute itself in a certain ratio between immiscible solvents. Therefore, the selection of both a diluent and an extractant determines the equilibrium for a given system and efficiency of the extraction process depends on its mass transfer rate [6]. The advantage of solvent extraction includes high throughput, ease of automatic operation and of scale up, and high purification [7].

In the present study the extraction of reactive dyes from aqueous solution using Aliquat 336 has been investigated. The affecting parameters such as effect of diluent, extractant concentration, dye concentration, time, A/O ratio and stripping reagent concentration also studied.

II. MATERIALS AND METHODS

A. Materials

The reactive dyes GYHE-R [C.I. Reactive Yellow-84] and RGHE-4BD [C.I. Reactive Green-19] were obtained from local dyeing industry, Thiruvallur district, Tamil Nadu. It was used 'as received' without further purification. The structure of the dyes are presented in Figure (1). Aliquat 336 (88%, Merck), dichloromethane (98.5%, Merck), sodium nitrate (99.0%, Qualigens) were purchased and used without purification. A stock solution of GYHE-R and RGHE-4BD (1000 mgL^{-1}) were prepared and suitably diluted to the required initial concentration. A calibration curve of absorbance vs. concentration was constructed using a UV spectrophotometer (Shanghai mapada Instruments Co.Ltd., Model: UV 1100) at maximum wavelength of 405 nm and 630 nm for GYHE-R and RGHE-4BD respectively.

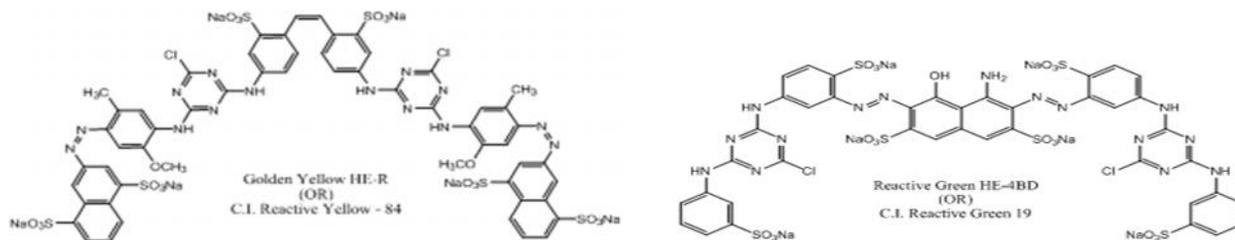


Figure. (1): Structure of Reactive Green HE-4BD ($\lambda_{max} = 630 \text{ nm}$) & Gold Yellow HE-R ($\lambda_{max} = 405 \text{ nm}$).

B. Procedure

Solvent extraction experiments were carried out at $30 \pm 0.5^\circ \text{C}$. The pH of the dye solution was adjusted by using acid (hydrochloric acid) and base (sodium hydroxide). A feed phase containing dye (100mg/L, $V=25\text{mL}$) and the organic phase ($V=25\text{mL}$) were introduced in a separating funnel. The two phases were immiscible with each other. The two phases were mixed gently for known time and then left to separate. The raffinate was collected for measurement of the remaining dyes is calculated as per the following equations.

$$E = 1 - [\text{Dye}]_{\text{aq}} / [\text{Dye}]_{\text{aq}0} \times 100 \quad \text{----- (1)}$$

Where $[\text{dye}]_{\text{aq}}$ = dye concentration (mg/L) in the aqueous phase after extraction, $[\text{dye}]_{\text{aq}0}$ = initial dye concentration (mg/L) in the aqueous phase, E = percentage of extracted dye.

In the stripping, the loaded organic dye ($V=25\text{mL}$) and the stripping solution ($V=25\text{mL}$) were added together into a separating funnel and shaken at 200rpm. The aqueous strippant was taken for measurements of absorbance. From this value, the percentage of stripped dye was calculated by the following equation.

$$R = [\text{Feed}]_s / [\text{feed}]_{\text{aq}0} \times 100 \quad \text{----- (2)}$$

Where R = percentage of stripped dye, $[\text{feed}]_s$ = concentration of stripped feed phase and $[\text{Feed}]_{\text{aq}0}$ = initial concentration of feed phase [8].

C. RESULT AND DISCUSSION

A. Effect of diluent in organic phase

Diluent plays a vital role in solvent extraction. Therefore various low density and high density solvents used were; hexane, toluene, xylene, benzene, carbon tetra chloride, chloroform and dichloromethane. Among them high density solvent like dichloromethane extract the dye very well. It might be because dichloromethane has high polarity as interact well with Aliquat 336. The results were presented in Table I. The maximum percentage of extraction (96.0% for GYHE-R and 97.5% for RGHE-4BD) achieved using dichloromethane used as diluent.

TABLE I. EFFECT OF DILUENT

Diluents	Percentage of extraction	
	Golden Yellow HE-R	Reactive Green HE-4BD
<i>Low Density Solvents</i>		
Benzene	73.5	78.0
Toluene	62.5	70.0
Xylene	65.0	71.0
Hexane	-	-
<i>High Density Solvents</i>		
Dichloromethane	96.0	97.5
Chloroform	92.5	91.0
Carbon tetra chloride	68.0	74.5

B. Effect of extractant concentration

The effect of Aliquat 336 concentrations on the extraction of reactive dyes was studied with varying extractant concentration from 0.9×10^{-4} to 4×10^{-4} mol/L. The percentage of extraction of dye increased with increase in extractant concentration from 0.9×10^{-4} to 4×10^{-4} mol/L at neutral medium (pH 6.5-7.0) was shown in Fig. 2. It reveals that 3×10^{-3} mol/L Aliquat 336 is effectively extracting (96.0% for GYHE-R and 97.5% for RGHE-4BD) these dyes from aqueous solutions.

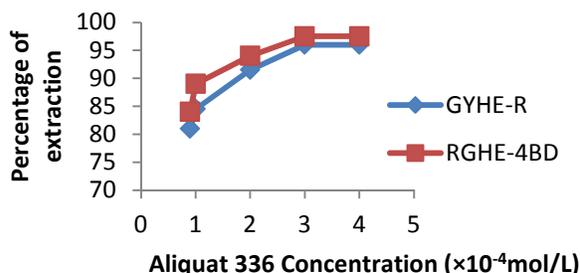


Figure (2): Effect of Aliquat 336 concentration: Experimental conditions (Experimental conditions: volume of feed phase = 25 mL, volume of organic phase = 25 mL, pH = 6.5-7.0 and equilibrium time = 5 min).

C. Effect of extraction time

Extraction of dyes from aqueous to organic phase at different time intervals 1 to 6min was studied and the results were presented in Figure (3). It shows that the extraction efficiency of dyes increased with increasing time. The maximum extraction of GYHE-R was 96% and RGHE-4BD was 97.5% obtained at 5 min. Beyond 5 min, the extraction efficiency did not change. For further studies, the equilibration time was fixed at 5 min.

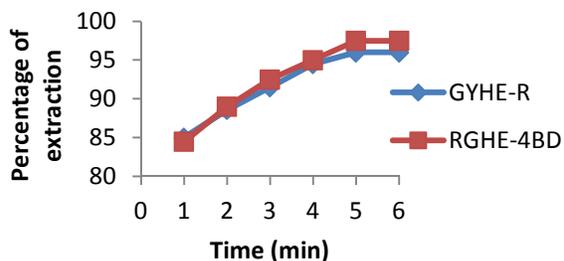


Figure (3): Effect of equilibration time (Experimental conditions: volume of feed phase = 25 mL, volume of organic phase = 25 mL, extractant concentration = 3×10^{-3} mol/L and pH 6.5-7.0).

D. Effect of A/O ratio

The effect of the organic to aqueous volume ratio (O/A) was investigated by varying the (O/A) ratio from 1/1 to 8/1 keeping the volume (25mL) of organic phase constant. The results were presented in Figure (4). It shows that the extraction efficiency decreases from 96% to 78.5% for GYHE-R and from 97.5% to 81.0% for RGHE-4BD with increasing A/O ratio. This could be due to the higher free concentration of organic phase when the aqueous to organic phase ratio (A/O) is lower [9]. The lower ratio 1/1 yielded high percent (96% for GYHE-R and 97.5% for RGHE-4BD) due to better interaction of dye with organic phase.

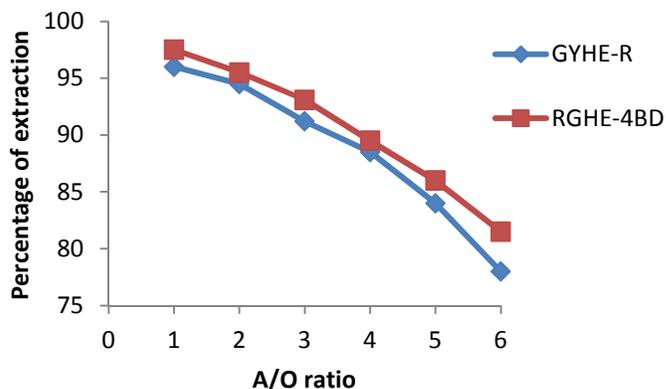


Figure (4): Effect of aqueous to organic phase ratio (Experimental conditions: volume of aqueous phase = 25 mL, extractant concentration = 3×10^{-3} mol/L, pH 6.5-7.0 and equilibrium time = 5 min).

E. Effect of stripping reagent and its concentration

It is an important to back extract the dye from loaded organic phase, which is reused. Various inorganic acids and bases were tried as stripping agents in this experiment. Sodium nitrate was found to be the best to strip the dye from loaded organic phase. Table. 3 indicate that the stripping efficiency increases with increasing concentration of sodium nitrate from 0.05 to 0.3mol/L. The maximum stripping efficiency (98% for GYHE-R and RGHE-4BD) was obtained at 0.2mol/L of sodium nitrate.

TABLE II EFFECT OF SODIUM NITRATE CONCENTRATION

Sodium Nitrate Concentration (mg/L)	Percentage of extraction	
	Golden Yellow HE-R	Reactive Green HE-4BD
0.07	76.5	80.0
0.08	84	86.5
0.09	90.2	91.5
0.1	95.5	96.2
0.2	98.0	98.0
0.3	98.0	98.0

IV. CONCLUSION

The removal and recovery of reactive dyes such as Gold yellow HE-R (GYHE-R) and Reactive green HE-4BD (RGHE-4BD) from aqueous solutions has been investigated. Aliquat 336 is able to extract 96% for GYHE-R and 97.5% for RGHE-4BD from aqueous solutions in a short time of 5 min. Extraction efficiency of dyes decreased with increasing aqueous to organic ratio. The extracted dyes were successfully stripped (98%) into 0.2mol/L sodium nitrate solution from loaded organic phase. Stripping efficiency increased with increasing sodium nitrate concentration.

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