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Micelle-mediated extraction as tool for separation blue RGL 42 in waste samples

M.Fathimadabadi, M.Daroon, F.Ahmadi*

Department of Chemistry, Azad Islamic University, Gachsaran, (IRAN)

Tel : (098)-742-3333923; Fax : (098)-742-3333533

E-mail : ahmadi@iaug.ac.ir

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ABSTRACT

An attempt has been made to remove color from waste water containing Blue RGL 42 (a cationic dye) by surfactant mediated cloud point extraction (CPE) in batch mode using Triton X-114 as non-ionic surfactant. Most of the dye molecules get solubilized in the coacervate phase leaving a dye free dilute phase. The effects of different operating parameters such as concentration of surfactant, salt, temperature and pH on the removal of dye were studied in details and a set of optimum conditions were obtained. It has been observed that 94.5-91.02 percent Blue RGL 42 is possible for the feed dye concentration of up to 500 ppm using pH 9, 0.015(M) of TX-114 and 0.1(M) of salt (KCl) at 65^0C.

KEYWORDS

Blue RGL 42;
Triton X-114;
Cloud point extraction.

1. INTRODUCTION

Color removal from effluent is one of the most difficult requirements faced by textile finishing, dye manufacturing, paper industries. Among the various types of dye, Blue RGL 42 dye is used in textile, wood and leather. The effluents containing dyes are highly colored resulting in major environmental problems. So these colored wastes need to be treated before disposal.

At certain temperature, aqueous solution of a nonionic surfactant separates into two phases. The first one is a surfactant-rich phase containing a high concentration of surfactant, which has small volume compared to the solution and the second one is the aqueous phase containing a low concentration of surfactant. This temperature is known as cloud point temperature (CPT) of the surfactant[1]. The solute molecule present in aqueous solution of non-ionic surfactant is distributed between the two phases above the cloud point temperature[2]. This phenomenon is known as cloud point extraction (CPE).

Many investigators have studied different techniques for the removal of colored dye from wastewater, e.g.,(a) different membrane separation processes like reverse osmosis (RO)[3], nanofiltration (NF)[4] micellar enhanced ultra filtration (MEUF)[5,6] and membrane-wet oxidation[7]: (b) adsorption on to (i) agricultural solid waste[8], (ii) different bentonites[9], (iii) various types of activated carbon[10] and (iv) surfactant impregnated montmorillonite[11], etc.: (c) several oxidation processes[12]: (d) ozonations[13]. Cloud point extraction (CPE) may be an effective method for removing dye from aqueous solution[14,15].

In the present work, cloud point extraction has been adopted to remove cationic dye (Blue RGL 42) from waste water using TX-114 as nonionic surfactant. The effect of pH, temperature, concentrations of surfactant and salt on extraction of dye has been studied.

2. EXPERIMENTAL

2.1. Instruments

The absorption of Blue RGL 42 was performed with a 160A shimadzu spectrophotometric UV-VIS. The instrumental parameters were those recommended by the manufacturer. A Metrohm 691pH/Ion meter with a combined glass. Calomel electrode was used for adjustment of test solution pH.

2.2. Reagents

All Chemicals used water of analytical grade and double distilled water was used throughout. A solution of Triton X-114 (0.5mol L^{-1}) was prepared by dissolving 27.94 g of Triton X-114(Merck) in Water and diluting to 100 mL in a volumetric flask. A stock solution of 500 mg L^{-1} of Blue RGL 42 was prepared by dissolving.05 g of the Blue RGL 42 (Maxilon) in water and diluting to 100 mL in a volumetric flask, More diluted were prepared daily using this stock solution. A solution of potassium chloride (KCl) 2.0 mol L^{-1} was prepared by dissolving 14.91 g of KCl (Merck) in water and diluting to 100 mL in a volumetric flask. Doubly distilled water was used to prepare all the solutions.

2.2. General procedure

An aliquot of the Blue RGL 42, 1.5 mL of 0.5mol L^{-1} Trion X-114, 2.5 mL of 2 mol L^{-1} KCl were added to a 50 mL volumetric flask and diluted to the mark with water. The resultant solution was transferred to a 50 mL tube and equilibrated at 65^{0}C in a thermostat bath for 25 min. After complete phase separation, the tube was removed from the temperature bath and cooled to room temperature. The concentration of Blue RGL 42 in the dilute phase was measured by spectrophotometeric method.

3. RESULTS AND DISCUSSION

The absorption of Blue RGL 42 in aqueous solution showed a maximum absorption band at 606 nm. Therefore, all the measurements were carried out at this wavelength.

3.1. Effect of pH

The effects of the pH of the solution on the extent of Blue RGL 42 extraction are shown in figure 1. for different concentration of Blue RGL 42 (5, 8 mg L^{-1}), 0.025 mol L^{-1} and 75^{0}C. Extraction of Blue RGL 42 is less in acidic pH. Hence, pH 9 was chosen as adequate pH value for further studies.

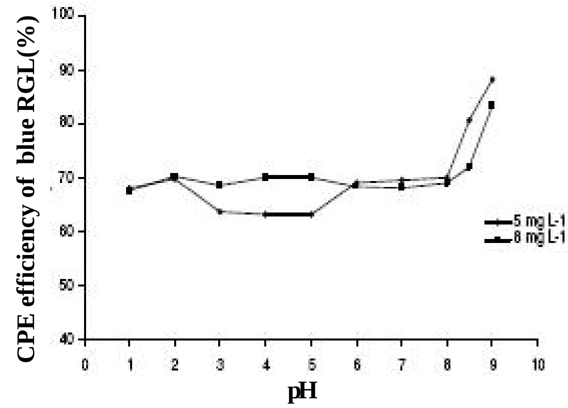

Figure 1 : Effect of pH on extraction of dye using TX-114.Conditions: 50 mL of solution containing different concentration of Blue RGL 42 (5, 8 mg L^{-1}), 0.025 mol L^{-1} of TX-114, Temp 75^0 C and time 30 min

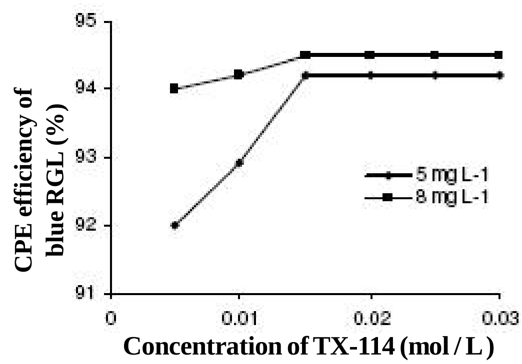

Figure 2: Effect of TX-114 concentration on the CPE efficiency of Blue RGL 42. Conditions: 50 ml of solution containing different concentration of blue RGL 42 (5, 8 mg L^{-1}), pH 9, Temp 75^{0}C and time 30 min

3.2. Effect of triton X-114 concentration

The effect of the Triton X-114 concentration on CPE efficiency of Blue RGL 42 is shown in figure 2. for successful cloud point extraction of dye, it is desirable to use minimum amount of surfactant maximum extraction of dye. Therefore, the effect of the surfactant concentration was investigated in order to ensure maximum extraction efficiency. It has been observed from the figure that extraction of the dye increase sharply when TX-114 concentration increases from 0.005 to 0.015M. Beyond 0.015M, the extraction efficiency is

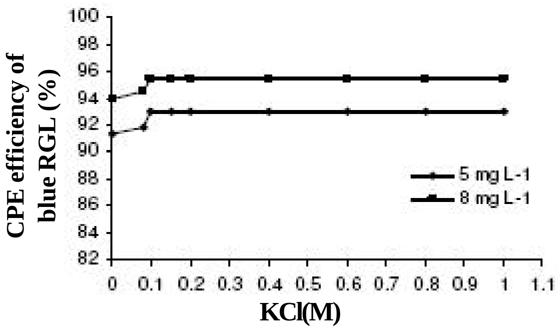

Figure 3: Effect of KCl concentration on the CPE efficiency of Blue RGL 42. Conditions: 50 mL of solution containing different concentration of blue RGL 42 (5, 8 mg L^{-1}), 0.015 mol L^{-1} TX-14, pH 9, Temp 75^{0}C and time 30 min

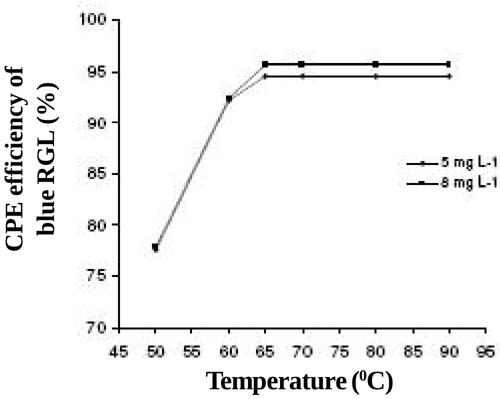

Figure 4: Effect of temperature on the CPE efficiency of Blue RGL 42. Conditions: 50 mL of solution containing different of Blue RGL 42(5, 8 mg L^{-1}), 0.1 mol L^{-1} of KCl, 0.015 mol L^{-1} of TX-114, pH 9 and time 30 min

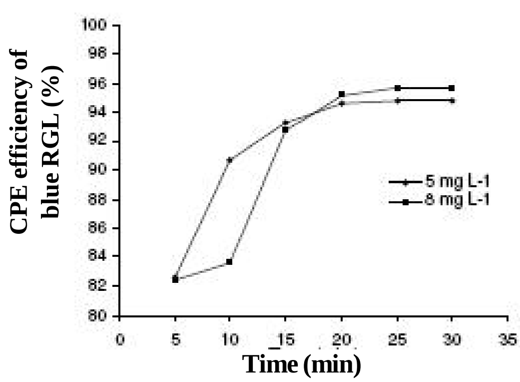

Figure 5 : Effect of equilibration time on the CPE efficiency of Blue RGL 42. Conditions: 50 mL of solution containing different concentration of Blue RGL 42 (5,8 mg L^{-1}), pH 9, 0.1 mol L^{-1} of KCl, 0.015 mol L^{-1} of TX-114 and Temp 65^{0}C

almost constant.

Quantitative CPE efficiency was observed when the Triton X-114 concentration was above 0.015 mol L^{-1}.The surfactant concentration of 0.015 mol L^{-1} was chosen as optimum.

3.3. Effect of electrolyte

It has been reported that due to electrolyte salting-out effect, salts decrease the cloud point of the surfactant and it is promotes the dehydration of the ethoxy group on the outer surface of the micells. The salting-out phenomena is directly related to the desorption of ions from the hydrophilic parts of the micelles, increasing inter-attraction between micelles and consequently leading to the precipitation of surfactant molecules[16]. Therefore, addition of electrolyte increases phase separation enhancing the micellar concentration in the coacerate phase, leading to solubilization of more dye. However, the effect of potassium chloride is important because the cost of the eventual process depends on the amount of heat needed to obtain the separation of phases.

The effect of potassium chloride as an electrolyte was studied. It is observed from figure 3, the extraction efficiency of Blue RGL 42 was slightly increased in the presence of KCl and it was almost constant above 0.1 mol L^{-1} of KCl. Thus a 0.1 mol L^{-1} of KCl was selected for further studies.

3.4. Effect of equilibration temperature

The effect of the equilibration temperature (50-90^{0}C) on the cloud point extraction was also investigated. The critical micelle concentration (CMC) of non-ionic surfactant decreases with temperature[17]. Moreover, non-ionic surfactant appear relatively more hydrophobic at higher temperatures, due to an equilibrium shift that favors dehydration of the ether oxygens. This leads to an increase in the number concentration of micells. Therefore, the solubilization capability of the micellar solution increases with temperature leading to an increase in the dye extraction. The effects of the operating temperature on the extraction of Blue RGL 42 are clear from figure 4. the extraction efficiency of dye increases with temperature. Quantitative CPE efficiency for Blue RGL 42 were temperature above when minimum 65^{0}C were used. Thus a temperature of 65^{0}C was selected.

3.5. Effect of equilibration time

Optimal equilibration time are necessary to com-

TABLE 1: Effect of initial dye concentration on the CPE efficiency of blue RGL 42

Concentration (mg L^{-1})	CPE efficiency (%)
5.0	94.5
8.0	95.6
15.0	96.7
20.0	96.6
35.0	97.7
50.0	95.8
100.0	97.3
150.0	94.5
200.0	94.6
500.0	91.02

plete reaction, and achieve easy phase separation as efficient as possible. The dependence of extraction efficiency upon equilibration time was studied for a time interval of 5-30 min (Figure 5). An equilibration time of 25 min was chosen as an optimum value.

3.5. Effect of initial dye concentration

The effect of initial dye concentration on the extraction efficiency using above optimum concentration was investigated. The results presented in TABLE 1. show that up to 500 mg L^{-1} of Blue RGL 42 be removed (>91 %) by CPE procedure. from Table observed that the extraction efficiency of dye decreases with the feed dye concentration. At a particular operating temperature and surfactant concentration, the surfactant concentration in both the dilute and coacervate phase remains constant. Hence, the dye solubilization capacity of the surfactant micelles remains almost invariant in the coacervate phase. Therefore, with the further increase in feed dye concentration, excess dye remains unsolubilized in the dilute phase, resulting in a decrease of the extraction efficien.

4. CONCLUSIONS

Cloud point extraction of Blue RGL 42 can be successfully used to remove color wastewater using TX-114 as non-ionic surfactant. The effects of pH, temperature, and time, concentration of KCl, TX-114 and Blue RGL 42 on the extraction efficiency have been studied in detail. It is observed that the extraction efficiency increases with temperature, TX-114 and KCl concentration. From the experimental, it is observed that for dye concentration up to 500 mg L^{-1}, >91 percent of Blue RGL 42 dye is removed. Separated aqueous phase still contains some of dye, probably solubilized in the micelle of the surfactant.

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