

Removal of Eosin B from Water Samples by Cloud Point Extraction Using Triton X-100 as Nonionic Surfactant

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Abstract

A surfactant mediated cloud point extraction (CPE) procedure has been developed to remove color from wastewater containing Eosin B, using triton x-100 as nonionic surfactant. The effects of the concentration of the surfactant, pH, temperature and salt concentration on the different concentration of dye have been studied and optimum conditions were obtained for the removal of Eosin B. The concentration of Eosin B in the dilute phase was measured using UV-Vis spectrophotometer. It was found that the separation of phases was complete and the recovery of Eosin B was very effective in the presence of NaCl as an electrolyte.

Keywords: Eosin B dye, Triton x-100, Cloud point extraction, Removal, Water samples

Introduction

Color removal from effluent is one of the most difficult requirements faced by the textile finishing, dye manufacturing, pulp and paper industries. Among the various types of dye, congo red (CR) dye is used in wool and silk to give red color with a yellow fluorescence. The effluents containing dyes are highly colored resulting in major environmental problems. So these colored wastes need to be treated before disposal. Many investigators have studied different techniques for removal of colored dye from wastewater, e.g., micellarenhanced ultrafiltration [1], several oxidation processes [2–4], ozonations [5], nanofiltration [6] and adsorption onto (i) agricultural solid waste [7] (ii) different bentonites [8] (iii) various types of activated carbon [9] and (iv) surfactant impregnated montmorillonite [10], etc. Ultrafiltration (UF) and nanofiltration (NF) can be used for complete removal of all classes of dye, but care is needed to avoid membrane fouling which decreases the flux. Due to low biodegradability of dyes, a conventional biological wastewater treatment process is not very efficient in treating dye wastewater [11]. Physical or chemical treatment processes are generally used to treat it [12].

Adsorption is a common treatment process. Previous investigators have studied the adsorption of dyestuffs using a variety of natural adsorbents, but yet these adsorbents are impractical for the effluent treatment of modern textile industries. Activated carbon can effectively be used to remove color although it is ineffective for dispersed and vat dye [13]. Many investigators have found that depending on the type of adsorbent and adsorbate, the adsorption capacity is greatly influenced by changing the pH of solution. Experimentally it has been found that some dyes change their color with change in pH. For example, crystal violet: purple at pH w6, green at pH w4 and yellow at pH w2; chrysoidine: red in acidic pH and changes its color from red to yellow at strong alkaline pH. This change in color is due to the shifting of absorption band to the longer and shorter wavelengths because of bathochromic and hypsochromic effects, respectively. Therefore, for pH sensitive dyes, it is better to think about a suitable process where pH change is not a process parameter. In the last decade, increasing interest on the use of aqueous micellar solution has been found in the field of separation science [14,15]. At certain temperature, aqueous solution of a non-ionic surfactant becomes turbid. With further increase of temperature, solution separates in two phases: first, surfactant rich phase, which has small volume compared to the solution and is called coacervate phase and the other is bulk aqueous solution containing surfactant concentration slightly above the critical micelle concentration(CMC) [16]. This temperature is known as cloud point temperature (CPT) of the surfactant. The cloud point is strictly defined at a particular surfactant concentration (e.g., 1 wt%), but because the phase boundary between the two phases is fairly independent of concentration, the cloud point is generally quite close to the lower consolute solution temperature [17]. The solute present in aqueous solution of non-ionic surfactant is distributed between the two phases at the cloud point temperature [18]. This phenomenon is known as cloud point extraction (CPE). surfactant, precipitation method is not applicable for non-ionic surfactant. For volatile solute, it is easy to recover surfactant from coacervate phase by vacuum, steam, or gas stripping [19]. But problem arises for non-volatile solute like dye, which is used in the present case. Although regeneration of surfactant from coacervate phase is not studied here, an experimental investigation has been performed to observe the potential of solvent extraction to recover surfactant from dilute phase. The same process may be applicable to separate surfactant from coacervate phase. Once, the surfactant is transferred to the extracting medium (non aqueous medium: hexane, heptanes etc.), it is recovered by evaporating the solvent. In the present work, CPE has been adopted to remove cationic dye (congo red) from wastewater using TX-100 as non-ionic surfactant. The effects of temperature, concentrations of surfactant, dye and salt on extraction of both dye and TX-100 have been studied. Heptane is used to extract surfactant from dilute phase. The efficiency of solvent extraction for surfactant recovery from dilute phase has also been studied with different surfactant concentration and the volume of extracting medium.

Experimental

A UV-Vis spectrophotometer was used for recording absorption spectra and absorbance measurements using 1cm glass cells. A metrohm digital pH meter model 691 with a combined glass electrode measured the pH. A thermostat bath model colora maintained at the desired temperature was used for the cloud point temperature (CPT) experiments. A 30 E 148 Sheme fan or Hettich centrifuge was used to accelerate the phase separation process. All chemical used were of analytical grade and doubled distilled water was used throughout.

Results and Discussion

Effect of initial pH

For this study, the effect of a pH range of 1-8 on the CPE of 20 mg L⁻¹ of Eosin B, was investigated. As can be seen in Figure 1, maximum efficiency was obtained at pH 2.5. Therefore, this pH was chosen for further work. Different buffer systems with pH 2.5 such as citrate, acetate, phthalate and Britton-Robinson were examined and Britton-Robinson buffer was selected as the optimum for subsequent experiments because it did not change the extraction efficiency of the solution after CPE.

Effect of electrolyte concentration

It has been shown that the presence of electrolytes can change the cloud point (CP) in different ways. Salting-out electrolytes such as NaCl and KCl decrease the cloud point temperature, even by 30 oC. They can promote the dehydration of the ethoxy groups on the outer surface of the micelles, enhancing the micellar concentration leading to solubilization of more dye and resulting in a more efficient extraction. Thus, the separation of the surfactant-rich phase can be obtained at lower temperatures, which is very important from practical point of view. Therefore, the effect of both potassium chloride and sodium chloride as electrolytes was studied. The results showed that when concentration of KCl or NaCl is increased, the extraction efficiency of Eosin B was increased only by few percent but both electrolytes decreased the cloud point temperature and our further experiments showed that less triton x-100 is consumed when using NaCl as electrolyte. Thus, for this reason and because NaCl is more economical it was chosen as an electrolyte for further studies.

Conclusion

Cloud point extraction was successfully applied to remove Eosin B from wastewater using triton x-100 as a nonionic surfactant. The extraction efficiency increased with temperature, surfactant and salt concentrations. From the experimental results, it was observed that for dye concentrations 10-40 mg L⁻¹, quantitative recoveries (>90%) is obtained in a single extraction. triton x-100 is environmental friendly, only small amounts is used and can be recovered from the system by a simple extraction. The experimental requirements (time and preparation of material) are better than some of the previously reported methods for the removal of Eosin B.

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