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Absorption Spectra of Ethyl Orange in Presence of Non-ionic Surfactant Solutions

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Spectrophotometric studies of ethyl orange—an azo dye in aqueous solutions containing various types of nonionic surfactants such as Triton x-114, Triton x-100, Triton x-102, Tween-20 and Tween-80—has been done below and above their critical micelle concentration. The absorption peak at 474 nm changes with the increase in concentration of the tritons above their critical micelle concentration and shift towards lower wavelength. The new peaks observed have been explained due to the formation of mixed micelles.

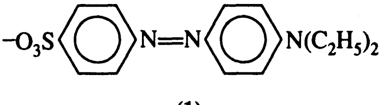
Key words: Spectrophotometric, Ethyl orange, Nonionic surfactants, Micelles.

INTRODUCTION

The amphiphilic character of surfactant molecules determines the specific physicochemical properties of organic dyes in dilute aqueous solutions. The surface properties of this solution change suddenly in the region of critical micelle concentration. The change in spectral shifts has been attributed to the formation of intermolecular complexes between some acid dyes. The colour changes of ionic dyes in the presence of oppositely charged ionic surfactants in aqueous solution have been observed by many workers[1–4]. These changes have been explained by proposing dimmer and multimer formation of dye molecules in the surfactant micelles. Investigations[5–7] show that the complex formation can occur between ionic dyes and nonionic surfactants, but it is still a matter of discussion from the point of view of micelle formation[8–10]. The interaction of congo red dye with cetyltrimethyl ammonium bromide (C_{16}TAB) and Triton X-100 was studied by Hayashi[11] and interpreted in terms of formation of a 1 : 2 dye-surfactant complex. The results of spectrophotometric studies on phenosafranin dye in aqueous solution containing different types of ionic and nonionic surfactants were reported by Rohatgi-Mukarjee *et al.*[12] while the formation of 1 : 1 dye-Triton x-100/sodium dodecyl sulfate was observed and there was no interaction of phenosafranin with C_{16} TAB. Since the interaction of Triton x-100, a good electron donor[13, 14] with cationic dye is charge transfer in nature; it is therefore interesting to see if anionic dye will also form change transfer complexes with various nonionic surfactants. In this paper, the results of the absorption spectra of an ionic dye (*i.e.*, ethyl orange) in aqueous solutions of several non-ionic surfactants (*viz.*, TX-114, TX-100, TX-102, Tween-20 and Tween-18) are presented.

EXPERIMENTAL

Ethyl orange (**1**) (sigma AR) was crystallized from ethanol.



(**1**)

Triton X-114 (TX-114), Triton X-100 (TX-100), Triton X-102 (TX-102), Tween-20 and Tween-80 (Sigma) were used as such. PEG-200 was purchased from E. Merck). Double distilled water from pyrex glass apparatus was always used.

Absorption spectra were recorded on a Shimadzu (UV-160 A) UV-Visible spectophotometer with matched pair of stoppered fused silica cells of 1 cm optical path length.

RESULTS AND DISCUSSION

The absorption spectra of ethyl orange (an anionic azo dye) in aqueous medium in the presence of various tritons and tweens below and above the CMC are shown in Figs. 1–3.

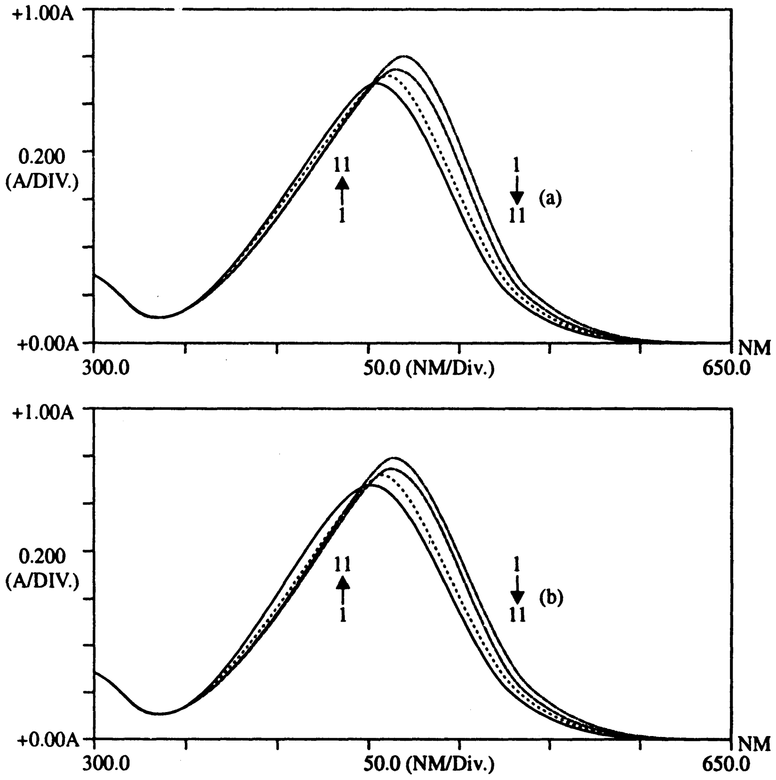


Fig. 1. Visible and UV spectra of ethyl orange with TX-114 and TX-100 at 27°C:

(a) in water (ethyl orange) 3×10^{-5} M and [TX-114]: (i) 0.0, (ii) 1×10^{-4}, (iii) 2×10^{-4}, (iv) 3×10^{-4}, (v) 4×10^{-4}, (vi) 5×10^{-4}, (vii) 6×10^{-4}, (viii) 7×10^{-4}, (ix) 8×10^{-4}, (x) 9×10^{-4}, (xi) 10×10^{-4} M;

(b) in water (ethyl orange) 3×10^{-5} M and [TX-100]: (i) 0.0, (ii) 1×10^{-4},

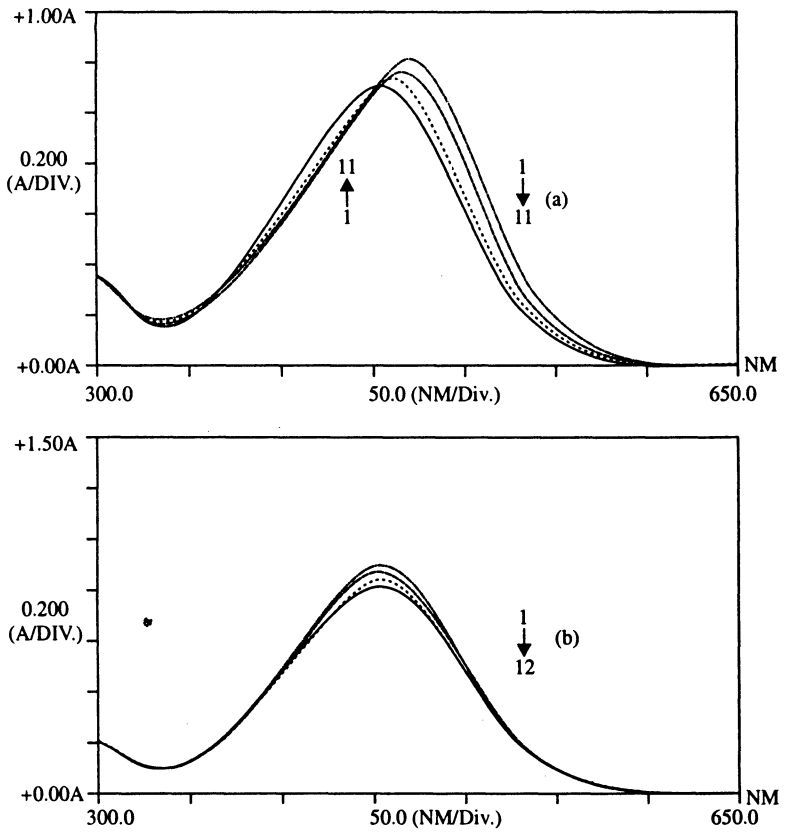


Fig. 2. Visible and UV spectra of ethyl orange with TX-102 and Tween-20 at 27°C:
(a) in water (ethyl orange) 3×10^{-5} M and [TX-102]: (i) 0.0, (ii) 1×10^{-4}, (iii) 2×10^{-4}, (iv) 3×10^{-4}, (v) 4×10^{-4}, (vi) 5×10^{-4}, (vii) 6×10^{-4}, (viii) 7×10^{-4}, (ix) 8×10^{-4}, (x) 9×10^{-4}, (xi) 10×10^{-4} M;
(b) in water (ethyl orange) 0.3×10^{-5} M and [Tween-20]: (i) 0.0, (ii) 0.1×10^{-4}, (iii) 0.2×10^{-4}, (iv) 0.3×10^{-4}, (v) 0.4×10^{-4}, (vi) 0.6×10^{-4}, (vii) 0.8×10^{-4}, (viii) 1×10^{-4}, (ix) 2×10^{-4}, (x) 3×10^{-4}, (xi) 4×10^{-4} M.

A dilute aqueous solution of ethylorange (EO) and nonionic surfactant has an absorption peak at 474 nm. Figs. 1 (a), (b) and 2 (a) show the absorption spectra of ethyl orange in aqueous media in presence of TX-114, TX-100 and TX-102, respectively. The results show that the spectra of EO solutions vary markedly with increasing concentration of Tritons. The figures present some typical data to illustrate the effects observed when the nonionic surfactant concentration is progressively increased in 3×10^{-5} M ethylorange solution. It is observed that in the absence of Tritons, ethylorange has an absorption peak at 474 nm in water. As the Triton concentration is increased (1×10^{-3} M) the absorbance gradually decreases and absorption wavelength shifts toward lower wavelength (for TX-

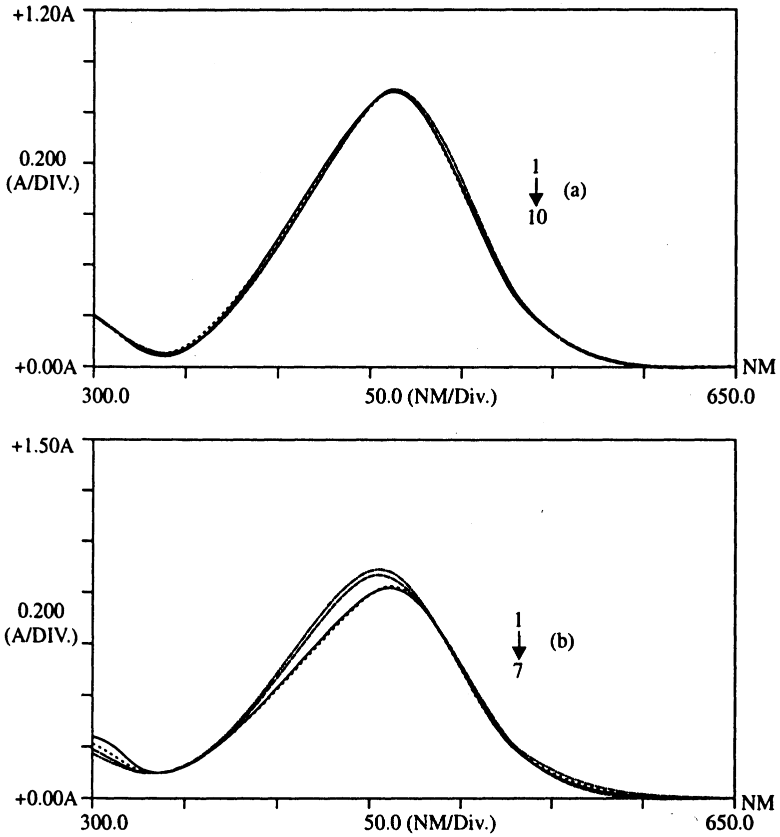


Fig. 3. Visible and UV spectra of ethyl orange with Tween-80 and PEG-200 at 27°C:
(a) in water (ethyl orange) 3×10^{-5} M and [Tween-80]: (i) 0.0, (ii) 0.05×10^{-4}, (iii) 0.07×10^{-4}, (iv) 0.09×10^{-4}, (v) 0.1×10^{-4}, (vi) 0.2×10^{-4}, (vii) 0.4×10^{-4}, (viii) 0.6×10^{-4}, (ix) 0.8×10^{-4}, (x) 9×10^{-4}, (xi) 1×10^{-4} M;
(b) in water (ethyl orange) 0.3×10^{-5} M and [PEG-200]: (i) 0.0, (ii) 0.0005, (iii) 0.0001, (iv) 0.005, (v) 0.01, (vi) 0.025, (vii) 0.05%.

114, 463 nm; TX-100, 458 nm and TX-102, 457 nm)[15]. However, it may be pointed out that at higher concentrations of cationic surfactant the absorption maxima shift to higher wavelengths[15]. Such a behaviour has not been observed with nonionic surfactants with ethylorange.

The absorption peak near 474 nm is characteristic of the micro-crystallites and the shifting of peak toward lower wavelength on addition of Tritons can be interpreted in terms of formation of mixed micelles between ethylorange and Tritons. It seems that as the hydrophilic nature (*i.e.*, as polyoxyethylene chain) of Tritons increases, the absorption peak shifts toward lower wavelength. It indicates that the polyoxyethylene chain may play an important role in the formation of mixed micelles between ethylorange and Tritons. The mixed micelle

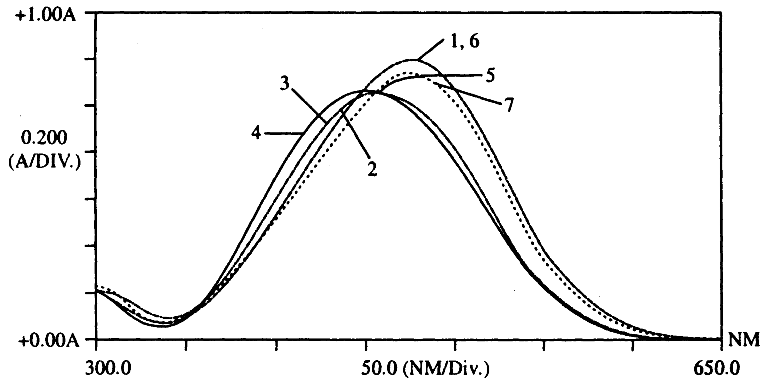


Fig. 4. Visible and UV spectra of ethyl orange and various non-ionic surfactants in water at 27°C: (a) [ethyl orange] = 3×10^{-5} M, (i) in water, (ii) [TX-114] = 1×10^{-3} M, (iii) [TX-100] = 1×10^{-3} M, (iv) [TX-102] = 1×10^{-3} M, (v) [Tween-20] = 1×10^{-4} M, (vi) [Tween-80] = 1×10^{-4} M, (vii) [PEC-200] = 0.025%

is formed at concentrations far below the critical micelle concentration (CMC) for the nonionic surfactant.

Similarly, the absorption spectra of ethylorange in aqueous medium in the presence of Tween-20 and Tween-80, below and above the CMC are shown in Figs. 2 (b) and 3 (a). As we compare the results of Tweens and Tritons, tweens show decrease in absorbance above CMC without any shifting of peak. It indicates that tween does not form mixed micelles with ethylorange, but may be solubilized in tween micelles. Similar behaviour is observed for ethylorange in PEG-200 in aqueous media [Fig. 3 (b)].

To compare the effect of various nonionic surfactants (TX-114, TX-100, TX-102, tween-20, Tween-80 and PEG 200) on the absorption spectra of ethylorange in aqueous media (Fig. 4), it shows that TX-102 is more effective in forming mixed micelles with ethylorange compared to TX-114, while no mixed micelle formation is observed in Tweens and PEG solutions.

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