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Solubilization of two organic dyes by anionic, cationic and nonionic surfactants

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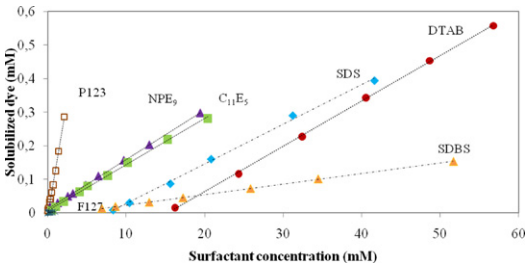
HIGHLIGHTS

- The type of head group was not crucial for the solubilization efficiency.
- Straight chain surfactants were better solubilizers than alkylaryl surfactants.
- Solubilization was enhanced at high pH for a cationic surfactant.
- Solubilization increased with the temperature.

GRAPHICAL ABSTRACT



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ABSTRACT

In this study, the solubilization of two organic dyes, Sudan I (1-phenylazo-2-naphtol) and Quinizarin (1,4-dihydroxyanthraquinone), was studied in the presence of different types of surfactants (nonionic, anionic, cationic, and nonionic block copolymers) using UV–vis spectroscopy. The effects of temperature, pH and electrolyte on dye solubilization were investigated for single surfactants and for binary surfactant mixtures. The results showed that the solubilization of both dyes in the surfactant micelles increased with the temperature and with addition of salt and that there was no synergy when a mixture of surfactants was used. A straight chain alkyl tail seemed to be better than an alkylaryl tail, as judged from the comparison of solubilization power for the pairs sodium dodecyl sulphate (SDS)/sodium dodecyl benzene sulphonate (SDBS) and penta(ethylene glycol)monoundecyl ether ($C_{11}E_5$)/nona(ethylene glycol)monononylphenyl ether (NPE_9). While the solubilization of both dyes in the presence of SDS and $C_{11}E_5$ remained almost the same within the pH interval 3–12, the solubilization of the dyes was much higher above pH 8.2 in the presence of the cationic surfactant dodecyltrimethylammonium bromide. This was attributed to an attractive interaction between the ionized form of the dye and the positively charged head group of the micellized surfactant.

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1. Introduction

Solubilization of hydrophobic substances into surfactant micelles is of considerable importance for applications such as detergency, textile dyeing, pharmaceutical formulations, etc. The solubility of a water-insoluble substance, such as a dye, in an aqueous surfactant solution normally starts at the CMC and increases almost linearly with the surfactant concentration [1]. Such a solution of an apolar substance in a micellar solution is thermodynamically stable [2]. There are several possible locations for a solubilizate in a surfactant micelle: the very hydrophobic inner core, the less hydrophobic environment just below the head group region, the head group palisade layer, and the surface of the micelles. The optimal position depends mainly on the polarity of the substance but specific interactions between the solubilizate and the surfactant head group can also play a role. The solubilization capacity depends on factors such as chemical structure of both the solubilizate and the surfactant, temperature, pH, and ionic strength [3].

The use of a combination of surfactants instead of a single one is very common in many applications and often results in improved

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