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Studies on aggregation of AOT and NaDEHP via the energy transfer between AO and RB molecules

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Abstract

The aggregation behaviours of sodium bis(2-ethylhexyl)sulfosuccinate (AOT) and sodium bis(2-ethylhexyl)phosphate (NaDEHP) solutions are studied via the energy transfer of acridine orange (AO) and rhodamine B(RB) molecules. The approximate apparent energy transfer efficiency (ϕ_a) of the dye molecules reaches its maximum value when the concentrations of AOT and NaDEHP are far lower than their cmc. This might be caused by the formation of surfactant–dye mixtures. The anionic surfactants (SDS, AS, AOT and NaDHEP), cationic surfactant (CTAB) and nonionic surfactant (Triton-X-100) are chosen to investigate the effect of the structure of surfactant on the ϕ_a between AO and RB molecules. The results indicate that the effective energy transfer may occur in the anionic surfactant systems and it is not obvious in the nonionic and cationic surfactant systems.

Keywords: AOT; NaDEHP; AO; RB; Energy transfer

1. Introduction

The surfactant system is a good model for simulating the biological system [1]. Different kinds of aggregates, such as the regular micelle, the reversed micelle, the microemulsion, the liquid crystal and so on can be formed due to the special characters of the surfactants. The aggregate state of the molecules at the interface of the lipid–water in the cell membrane of the simulation system can be obtained with the aid of the dye molecules. The micelle formed by ionic surfactants, as a particle with charges, can work in the separation charges, which plays a key role in the transition of photo-energy to electro-energy [2]. The energy transfer between different dye molecules in the surfactant solutions has attracted much attention in the recent years [3–8]. The investigation on the energy transfer of the dye molecules in the micelle system provides much useful information on the structure of the micelle.

At present the studies about the energy transfer between two dye molecules in the single-chain surfactants and polymer/surfactants have been carried out [7,9,10], while the effect of the double-chain surfactants on the energy transfer of the dye molecules has not been observed until now. Sodium bis(2-ethylhexyl)phosphate (NaDEHP) and sodium bis(2-ethylhexyl)sulfosuccinate (AOT) are important surfactants used in studies on chemical reaction and enzyme activity, liquid–liquid extraction of proteins, sol–gel preparation, nanoparticle preparation, hydrometallurgy and the nuclear industry [11–16]. They contain the same hydrophobic chains but the different polar headgroups. The aggregation behaviours of them in the apolar solution are violently different, even reverse [17–19]. The aggregation behaviours of the two surfactants have been studied by the surface tension measurement, computer simulations, the fluorescence

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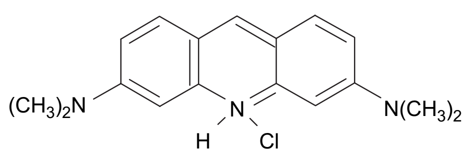
spectroscopy and the dynamic light scattering (DLS) and the results suggest that small aggregates are more readily formed by NaDEHP molecules than AOT molecules and the interaction between AOT and poly(vinylpyrrolydone) (PVP) is stronger than that between NaDEHP and PVP molecules [20–22]. The present paper aims to further investigate the differences of aggregation behaviours between AOT and NaDEHP in the aqueous solution via the energy transfer from AO molecule to RB molecule in the double-chain surfactants.

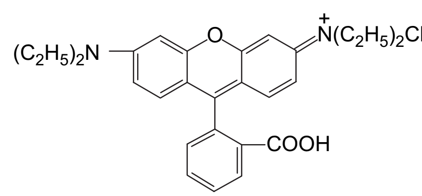
2. Experimental section

2.1. Materials

AOT was purchased from Fluka Corp. AO, RB, bis(2-ethylhexyl)phosphate (HDEHP, C.R.), sodium dodecyl sulfate (SDS), sodium alkyl sulfonate (AS), cetyltrimethyl ammonium bromide (CTAB) and Triton-X-100 were bought from Shanghai Chemical Corp. (China). The preparation of NaDEHP was described in previous paper [20].



AO



RB

2.2. Sample preparations

The solutions of AOT (0.03 M) and NaDEHP (0.1 M) are prepared and have been diluted to the required concentration in the experiment. AO and RB solutions (10^{-4} M) are prepared. The solution is obtained by putting suitable amount of surfactant, dye and water into the tube and shake to clear.

2.3. Fluorescence spectra measurements

Fluorescence spectra were recorded on F-4500 FL Spectrophotometer. The optimal excitation and the maximum emission spectra of AO and RB molecules obtained by continuously scanning the excitation and the emission spectra are 493/529.2 nm, and 556/575 nm, respectively. The excitation wavelength is 450 nm for the AO–RB mixed systems. The experiments are carried out at the room temperature. The water used in this experiment is distilled for three times.

3. Results and discussion

3.1. The excitation and emission spectra of AO and RB molecules

The fluorescence technique is very important in the study of the physico-chemical properties, such as the micropolarity, the microviscosity and the aggregation number of the aggregates formed by surfactants. AO and RB are common dye molecules (the protonated molecular structures are shown in the following scheme). The excitation and emission spectra of the AO and RB molecules in aqueous solution are shown in Fig. 1. It is known that the emission of the donor overlaps the excitation of the acceptor is necessary for the occurrence of Förster resonance energy transfer (FRET). It can be seen from the figure that the emission spectra of AO overlapped with the excitation spectra of RB molecule. So the energy can be transferred from AO molecule to RB molecule in the suitable condition.

3.2. The fluorescence spectra of AO and RB in different surfactant concentrations

The fluorescence spectra of AO and RB in the AOT and NaDEHP solutions are given in Fig. 2. It can be seen that there are two fluorescence peaks centered around 498 nm and 530 nm for AO molecule, respectively. According to Ref. [23] the first peak is the fluorescence

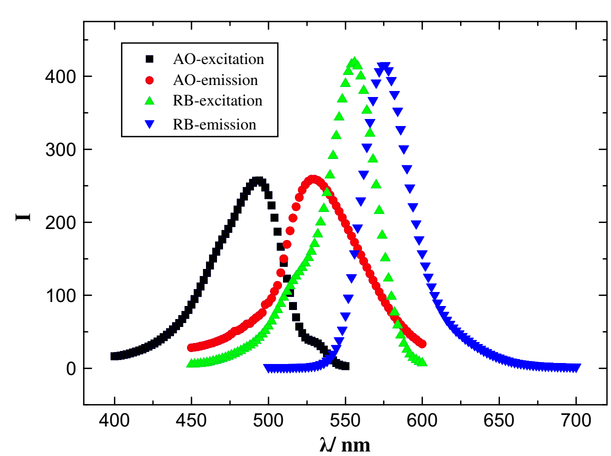


Fig. 1. The excitation and emission spectra of AO and RB molecules.