ION DECONTAMINATION WITH A MIXTURE OF CATIONIC AND ANIONIC SURFACTANTS

N. FILIPOVIĆ-VINCEKOVIĆ

Rudjer Bošković Institute, Zagreb (Yugoslavia)

(Received June 3, 1985)

The composition of mixed micelles and mixed micelle - solution interfaces changes with the concentration and molar ratio of the cationic and anionic surfactants present. The micelle - solution interface includes besides the headgroups of both surfactants, the counterions of the surfactant in excess. The finding of an enhanced binding of counterions to mixed micelles may be of some practical importance in decontamination.

Introduction

The removal of radioactive contaminants by liquid decontamination involves contacting of the contaminant with a suitable reagent and dissolving them into the reagent solution. The decontamination of firmly attached contaminants by commercial detergents can be studied as a special case of detergency. Commercial detergents usually contain, in addition to other components, a mixture of surfactants of the anionic and nonionic type. Because of the interaction of these different surfactant species significant changes occur in their bulk association and adsorption at interfaces and a combination of properties difficult to achieve with a single surfactant is obtained. Therefore investigations of the effects of surfactant mixtures on the mechanisms of surfactant adsorption on the interfaces and the binding of contaminants as counterions to associative surfactant species in bulk solution play an important role in decontamination. As the interactions of surfactants are particularly strong in the case of oppositely charged headgroups of surfactant ions, mixtures of cationic/anionic surfactants were investigated in an attempt to suggest new and better modes of decontamination.

The relation of the physico-chemical properties of aqueous cationic/anionic surfactant solutions to their abilities to remove radioactive contaminants were studied over a wide range of cationic surfactant concentrations and at a constant concentration of the anionic surfactant.
Experimental

Because of the complexity of the decontamination process, the contaminated surface (a stainless steel disc), the contaminants (Na\(^{131}\)I, \(^{110}\)AgNO\(_3\), obtained from the Boris Kidrić Institute, Beograd, Yugoslavia) and the mechanical and geometrical factors were held constant,\(^{14}\) while the decontamination solutions were varied with respect to their cationic to anionic surfactant ratio. The anionic surfactant chosen for the experiments was sodium tetradecylsulfate, STS (Henkel and Cie Gmbh) and the cationic surfactant tetradecylpyridinium chloride, TDPC (British Drug Houses). Both surfactants were purified several times by recrystallization. The critical micelle concentrations, cmc, determined from surface tension isotherms corresponded to literature data (cmc\(_{TDPC}\) = 0.0004 mol dm\(^{-3}\), cmc\(_{STS}\) = 0.0019 mol dm\(^{-3}\)).\(^{15-17}\)

Surface tension, \(\sigma/\text{Nm}^{-1}\), was determined with a du Noüy tensiometer (Krüss, Hamburg).

Relative system turbidity, \(\tau\), was measured by a Pulfrich photometer equipped with a turbidimetric extension (Carl Zeiss, Jena). Electrophoretic mobility, \(u\varepsilon/cm^2V^{-1}s^{-1}\), and particle charge were determined using an apparatus for particle microelectrophoresis (Rank Brothers, Aparatus II).

The binding of chloride ions was measured using a chloride specific electrode relating the observed cell potential to a calibration curve (emf vs. concentration of free chloride ions, \(c_f\)).\(^{18,19}\) The results are presented as changes in the concentrations of \(c_f\) (chloride ions not bound to micelles) or fractions of chloride ions bound to micelles, \(f\) (\(f = c_t - c_f/c_t\), where \(c_t\) denotes the total concentration of chloride ions originally added with TDPC) vs. TDPC concentration.

The decontamination experiments were performed as described previously.\(^{14}\) The results are expressed as changes in the decontamination factor, DF (DF is the ratio of the original contamination of the surface to the residual contamination after decontamination) vs. TDPC concentration.

Results and discussion

The interactions of TDPC and STS in aqueous solutions were studied by adding different volumes of concentrated TDPC solution to a constant volume of the STS solution. The results show the effect of changes in the molar ratio of the surfactants in the bulk solution on the measured physico-chemical properties. The changes in turbidity and particle charge vs. the molar concentration of TDPC at constant STS concentration are shown in Fig. 1. The various regions of the interactions may be initially qualitatively designated as first a clear region then a turbid region and