

# Interaction between Cationic Gemini/Conventional Surfactant with Polyethylene oxide: Surface Tension Measurement

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**Abstract**—The interaction between bishexadecylammonium pentane (16-5-16, G5) and its conventional counterpart cetyltrimethylammonium bromide (CTAB) with polyethylene oxide (PEO) was investigated using the surface tension measurements by the help of tensiometer. The driving force which is responsible for the interaction is supposed to be the minimization of interfacial force between the non-polar polymer parts and solvent water by association. It is observed that CMC value of G5 is very small as compared to CTAB. The result shows that the interaction of gemini surfactant is much higher than the conventional surfactant.

**Keywords:** gemini, conventional, interfacial, non-polar.

## 1. INTRODUCTION

Interaction between polymers and surfactants in aqueous solutions have attracted significant interests and have been the subject of review papers because of their widespread applications and relatively complex behaviors. Mixtures of surfactants have improved characteristics as compared to the single component systems. These mixtures are used in fields such as water treatment, pharmaceuticals, cosmetics, detergency and oil recovery. The interaction of water-soluble polymers with the ionic surfactants in aqueous medium are of great interest for polymer-surfactant association and can be used in the process of enhance oil recovery. The driving force which is responsible for the interaction is supposed to be the minimization of interfacial force between the nonpolar polymer parts and solvent water by association.

In the past few years, a novel class of surfactants called gemini (dimeric), consisting of two hydrophobic chains and two hydrophilic head groups united by a short (rigid or flexible) spacer, has emerged. These gemini surfactants impart better surface properties as compared to their single head, single-tail counterparts. The geminis have much smaller cmc values, much greater efficiency in reducing surface tension than expected, better wetting properties, and other unusual behaviors.

Polyethylene oxide (PEO) is an amphiphilic polymer and is soluble in water. It was suggested that the PEO chain is

wrapped around the micelles with a fraction of the ethylene oxide units directly adsorbed on the hydrocarbon/water interface, with the major part of the polymer chain forming loops in the surrounding water.

The purpose of this study is to investigate the interaction between cationic gemini surfactant and non ionic polymer, PEO, and its effect on critical micellisation concentration of both surfactants.

## 2. EXPERIMENTAL METHOD

### 2.1 Materials

Cetyltrimethylammonium bromide, CTAB ( $\geq 99.0\%$ , Merck, Germany), polyethylene oxide (PEO) were used as received. The gemini surfactant  $\alpha,\omega$ -bis(hexadecylammonium) pentane dibromide (16-5-16) was prepared and purified by crystallization. The molecular structures of CTAB and 16-5-16 are shown Fig. 1.

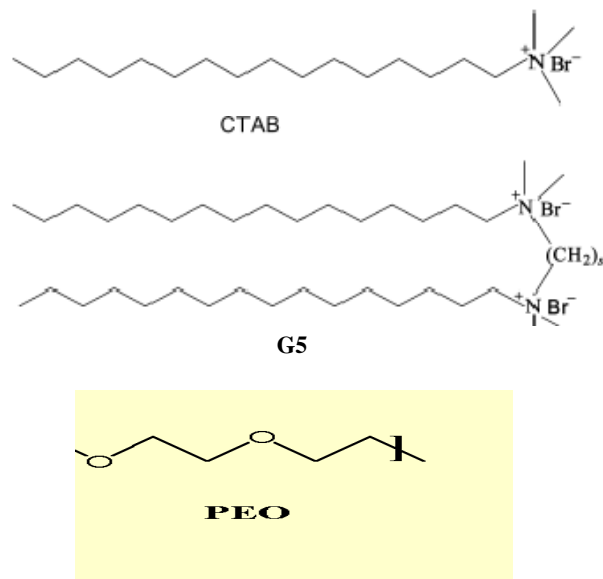


Fig. 1: Structure of CTAB, G5 and PEO

## 2.2 Sample preparation

All samples were macroscopically homogenous and were equalibrated at various temperatures in thermostatic bath. Sample composition is given by the total surfactant weight percentage, or when more convenient in terms of total surfactant molar concentration,  $C_t = C_i + C_{PEO}$  and by mole fraction of surfactant in the surfactant mixture  $X_i = C_i / C_i + C_{PEO}$  ( $I = CTAB$ ). Polymer concentration was constant in all the solutions (0.1wt%).

## 2.3 Method

### 2.3.1 Surface tension measurements

Surface tension measurements were carried out by Hardson Tensiometer under atmospheric pressure by ring detachment method. The platinum ring was thoroughly cleaned and flamed before each measurement. To measure the surface tension, the vertically hung ring was dipped into a liquid and subsequently it is pulled out. The maximum force required to pull the ring through the interface was taken as the surface tension,  $\gamma$  (mN/m). Measurement of surface tension of pure water at room temperature were used to calibrate the tensiometer and to check the cleanliness of glassware. The standard deviation did not exceed  $\pm 0.1$  mN/m. The temperature was controlled by circulating water through a jacketed bath cell. Sample solution was continuously stirred using magnetic stirrer.

## 3. RESULT AND DISCUSSION

Only single cut is observed in case of pure surfactant. As the concentration of surfactant increases, surface tension decreases due to interfacial tension between the boundaries because hydrophobic group may distort the structure of water increasing free energy of the surface. The cmc of in water is 0.986 and for G5 it is 0.035. We observed that CMC value of G5 is very small as compared to CTAB as gemini surfactant has two hydrophobic, two hydrophilic groups and one linkage and they can self-assemble at much lower concentrations with superior surface activity and reduces the intermolecular repulsion between head group which leads to micelle formation at low CMC. The higher value of cmc of CTAB than G5 suggest its weaker association with hydrophobic group.

The surfactant monomer starts to adsorb on the surface and when the surface is fully covered they get adsorbed on the polymer chain in solution where the interaction starts, that concentration is called CAC.

Surfactant monomer is adsorbed on the chain of polymer until it gets saturated with surfactant monomer and after that it again get saturated when we increase the concentration of surfactant in solution and cmc is obtained. The cac for CTAB is 0.704mM and cmc is 1.267 and for G5 is 0.012 and cmc is 0.041.

The value of cmc is increased in presence of polymer as is obtained in case of absence of polymer and it is higher in case of anionic surfactants in comparison with gemini.

The surface tension is reduced more rapidly in case of G5 with polymer PEO than CTAB with polymer PEO. It suggests stronger interaction of Gemini surfactant than anionic surfactants.

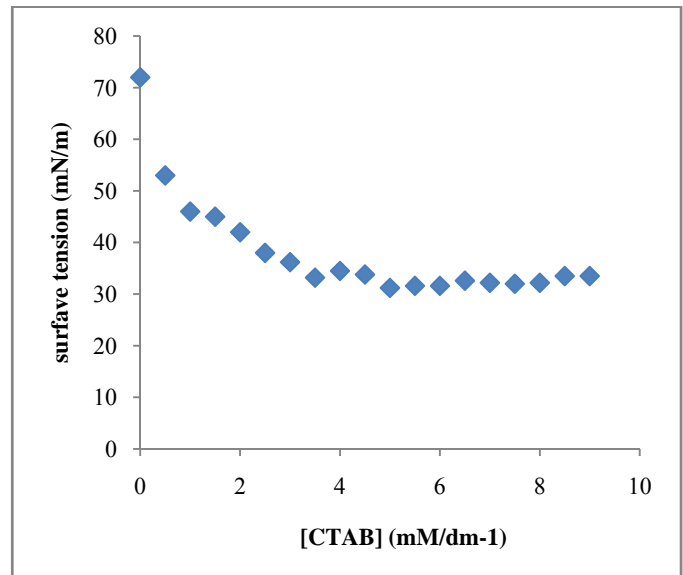


Fig. 2: CTAB in water

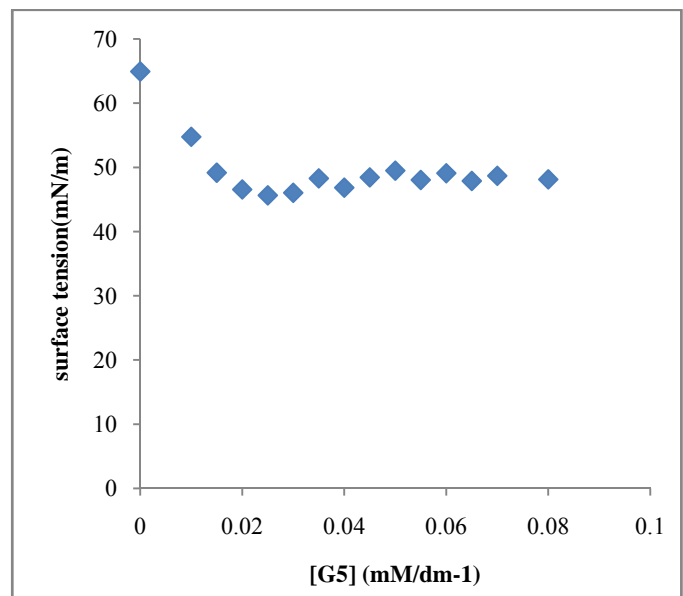


Fig. 3: G5 in water

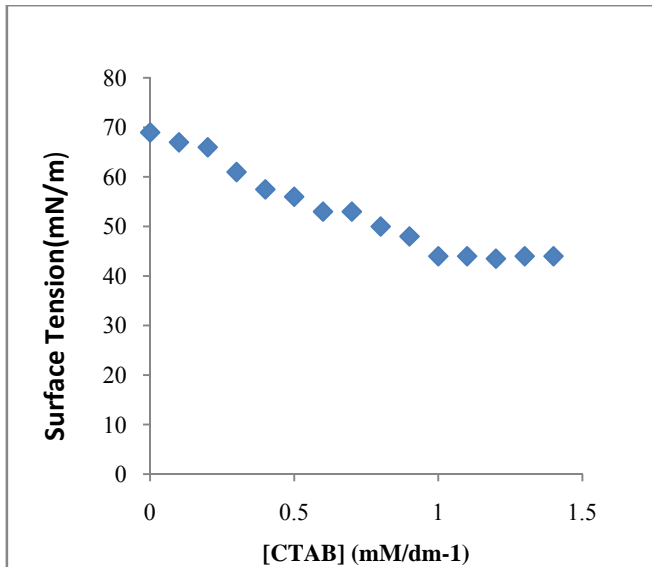


Fig. 3: CTAB in PEO(0.1wt%)

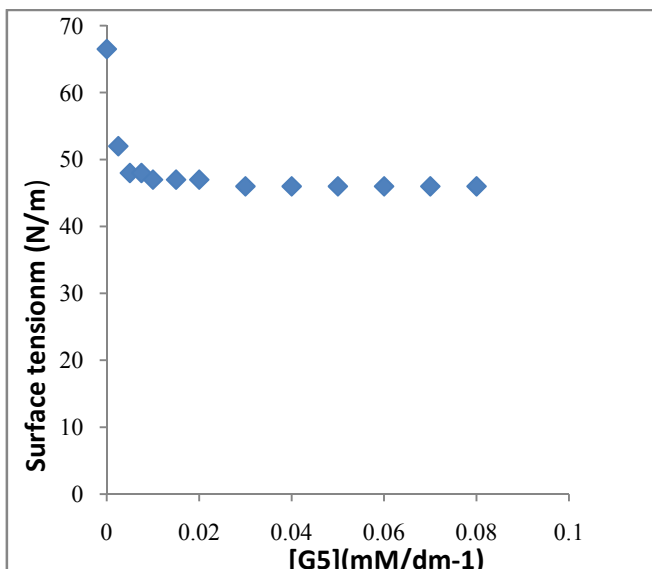


Fig. 3: G5 in PEO(0.1wt%)

#### 4. CONCLUSION

The interaction between cationic gemini surfactant and their corresponding monomeric counterparts with neutral polymer polyethylene oxide have been studied. The lowering of surface tension with increase of concentration of surfactants higher in case of G5 than CTAB and its cmc value is lower than its counterpart due to difference in their head group. It was found that the G5 surfactant interacts more strongly as compared to the conventional one and the maximum interaction occurs between cac and cmc of the surfactant and it is found to be supported by surface tension measurements.

#### 5. ACKNOWLEDGEMENTS

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