Surface and interfacial tensions of systems involving lyotropic liquid crystals*)

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With 13 figures and 1 table

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Introduction

There are some experimental data for the surface tension of thermotropic liquid crystals (1), but only few are known concerning the surface or interfacial tension of the systems involving lyotropic liquid crystals (2).

This paper gives the data of surface and interfacial tensions obtained with the ternary systems: 1) cetyltrimethylammonium bromide (CTAB) + water + n-hexanol and 2) sodium dodecyl sulfate (SDS) + water + n-hexanol, in whose phase diagrams lyotropic liquid crystalline phases exist at ordinary temperatures. The experimental results will be described with a discussion.

Experimental

Phase diagrams: The above systems are of the type of ternary systems of ionic surfactant + water + cosurfactant, which have been studied by many investigators from various points of view. The system: CTAB + water + hexanol was particularly studied by Ekwall and his co-workers (3) intensively, with regard to its phase equilibria and the relation between chemical composition and structure of liquid crystals appearing in the system.

The phase diagram of the system: SDS + water + hexanol obtained in our laboratory is given in figure 1. The similar phase diagram for the system: CTAB + water + hexanol has been obtained by the above mentioned investigators as well as in our laboratory.

In figure 1 notations L₁ means aqueous micellar solution in which hexanol being solubilized; L₂ nonaqueous micellar solution or microemulsion in which water being solubilized, 2L two liquid mixture or emulsion, LC liquid crystal, LC + L liquid crystal in equilibrium with solution, (L) + LC + S mixture of liquid crystal with solid crystal or solution. The marks:

Table 1. Surface tension of pure solvents

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Surface tension (dyn/cm)</th>
<th>Temperature (°C)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>70.8</td>
<td>25.5</td>
<td>Wilhelmy's</td>
</tr>
<tr>
<td></td>
<td>72.4</td>
<td>20.0</td>
<td>du Noüy's</td>
</tr>
<tr>
<td>Hexanol</td>
<td>24.6</td>
<td>25.5</td>
<td>Wilhelmy's</td>
</tr>
<tr>
<td></td>
<td>25.6</td>
<td>20.0</td>
<td>du Noüy's</td>
</tr>
</tbody>
</table>

**Experimental result:** Table 1 shows the result for the surface tension of water or hexanol as a pure solvent determined by the above two methods.

Figure 2 indicates the result for the surface tensions of two component systems: water + CTAB and hexanol + CTAB, while figure 3 gives the corresponding result for systems: water + SDS and hexanol + SDS.

These two figures illustrate the surface tension vs. concentration relations for the above four systems, respectively, where it is noticed that both surfactants CTAB and SDS are, as well known, distinctly surface active in aqueous solutions, whereas they are practically surface inactive in hexanol solutions. From figure 2 we find the critical micelle concentration for CTAB about 1.6 mM at 25 °C, while from figure 3 the critical micelle concentration for SDS is about 6.9 mM at 20 °C.

Figure 4 shows how the surface tension of water changes with the concentration of hexanol or CTAB, both being surface active. In the former case the change is slower than that of the latter but the final values are almost the same, nearly 31 dyn/cm in both cases.

We measured the interfacial tension of hexanol/water and its change by the addition of CTAB. As figure 5 indicates, the interfacial tension for hexanol/water was found 6.2 dyn/cm at 25 °C, both solvents being saturated by mutual solubilities with each other, which however decreases rapidly with the addition of the surfactant and reaches nearly zero when the surfactant concentration becomes about 6 mM where a homogeneous stable emulsion appears.

We then measured the surface tension in the domain of L2 i.e. microemulsion in the phase...