Effect of Perfumes on the Viscosity of Surfactant Systems

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It is well-known that perfumes can affect the viscosity of bubble bath or shampoo formulations. Usually they have a thinning effect, but they can also cause a viscosity increase. The effect and its magnitude will vary with perfume type and also with the product formulation. Small changes in the latter can cause large changes in a perfume's effect on the viscosity.

This behaviour of perfumes as viscosity modifiers tends to be overlooked by formulators of surfactant systems. Usually a product’s formulation is established and then a perfume selected and the viscosity adjusted.

It is, however, not uncommon for the effect of the perfume to be of sufficient magnitude to make it impossible to achieve the desired viscosity.

The studies in this article were prompted by a project to perfume a typical marketed shampoo based on sodium lauryl ether sulphate. While most perfumes caused a viscosity reduction in a product, one caused an unacceptable increase. The main raw materials used in the perfume formulations were tested for their effect and the material causing the largest increase in viscosity was used for further study.

Materials and Methods

The shampoo contained about 10% sodium lauryl ether sulphate, plus a small amount of a secondary detergent and other minor additives. Sodium chloride was added as a viscosity modifier. The investigations were carried out using Empicol ESB3 supplied by Albright & Wilson, UK. This is 27% active sodium lauryl ether sulphate (2 mol).

All viscosities were measured at 25°C using a Brookfield viscometer, model LVT with spindles 1, 2 or 3 and speed settings of 3 to 60 rpm. 500ml samples in a 600ml beaker were used for each measurement.

Results

The main materials used in the perfume gave viscosities as detailed in Table I when made up in the finished shampoo formulation. Citronellol, which was the main material in the perfume, clearly caused the greatest changes in viscosity.

The perfume was subsequently made up with lower levels of citronellol. Mix A (a blend of proprietary perfumery materials) was used to replace the citronellol. The results were surprising in that the viscosity increased.

Mix A gave a lower viscosity than the test perfume, so this was unlikely to be the cause. It was, therefore, decided to start from basic principles and look at the effect of citronellol on the main surfactant used in the shampoo, sodium lauryl ether sulphate.

Because the shampoo contained sodium
Table I. Viscosities of various materials in the test shampoo. All materials at 0.5%.

<table>
<thead>
<tr>
<th>Material</th>
<th>Viscosity in mPa.s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenyl ethyl alcohol</td>
<td>1,240</td>
</tr>
<tr>
<td>Lilial</td>
<td>6,650</td>
</tr>
<tr>
<td>Citronellol</td>
<td>8,300</td>
</tr>
<tr>
<td>Hexyl cinnamic aldehyde</td>
<td>6,300</td>
</tr>
<tr>
<td>Methyl dihydrojasmonate</td>
<td>1,840</td>
</tr>
<tr>
<td>Lixetone Coeur</td>
<td>3,120</td>
</tr>
<tr>
<td>Test perfume</td>
<td>3,060</td>
</tr>
<tr>
<td>Unperfumed shampoo</td>
<td>1,010</td>
</tr>
<tr>
<td>Mix A</td>
<td>2,080</td>
</tr>
</tbody>
</table>

chloride, a simple base was made comprising 37% Empicol ESB3 and 2% sodium chloride. The viscosity of this was measured after adding increasing levels of citronellol. Increasing levels of citronellol increased the viscosity up to a peak of about 4,250 mPa.s at just over 1% citronellol. Past this peak, increasing the level of citronellol decreased the viscosity.

In practice, this would mean that a product made up with, for example, 1.2% citronellol, would exhibit an increase in viscosity if the citronellol content was reduced to 1.1%. This would explain the results obtained in which the use of less citronellol gave higher viscosities.

The levels of citronellol necessary to reach the peak were very high and the viscosities were lower than expected. Therefore a further set of measurements was made with higher levels of sodium chloride. The effect of increasing sodium chloride is to lower the level of citronellol required to produce a peak in the viscosity.

These results are interesting because they demonstrate that citronellol increases the viscosity building effect of sodium chloride when the latter is used below a level of somewhere between 5% and 6%.

It is more usual to perfume a shampoo and then add the viscosity adjuster. A separate set of measurements was made starting off with different levels of citronellol and increasing the sodium chloride content. The results of these are shown in Figure 1. These curves more clearly demonstrate the comments made above. The highest viscosity is obtained when no citronellol is present. However, citronellol does increase the viscosity building effect of sodium chloride up to a peak. This peak decreases in magnitude with increasing citronellol content.

From these results, it is evident that citronellol can increase or decrease viscosity depending on the relative level with sodium chloride. However, the higher the level of citronellol, the lower the maximum viscosity that can be achieved.

**Discussion**

When sodium chloride is used to thicken a surfactant system, the viscosity usually increases with increasing sodium chloride content to a peak and then decreases sharply. This behaviour is still obtained when perfumes are present but it is clear that the peak value and the amount of sodium chloride necessary to reach it will be altered. This could cause problems if the desired viscosity has been fixed prior to selecting a perfume or establishing the required perfume level.

For example, from Figure 1 it can be seen that if citronellol were added at 0.5%, it would not be possible to achieve a viscosity of over about 7,500 mPa.s whatever the level of sodium chloride. However, other results have shown that citronellol increased viscosity. This could be somewhat confusing unless a complete set of viscosity measurements is made.

Other misleading results could be obtained if the level of perfume in a product is changed sometime after formulating the product. For example, in the case of Figure 1, changing from 0.1% to 0.2% citronellol could result in a viscosity increase or decrease depending on the level of sodium chloride used and the initial viscosity. With about 6% sodium chloride there will be a large decrease. But at about 4.5% sodium chloride, there will be an increase. If the viscosity peak had been exceeded at higher sodium chloride levels, then the viscosity change would be even greater.

For example, at around 6.5% salt the change from 0.1% to 0.2% citronellol would more than cut the viscosity in half. As the upward curves
become closer with increasing levels of citronellol, the viscosity differences obtained by changing the citronellol level decrease.

Looking at Figure 1 from another viewpoint, it is evident that, for a given level of citronellol, the same viscosity can be achieved with two different levels of sodium chloride. It is also clear that the effect of changing the sodium chloride content will give opposite results depending on which side of the peak the original level falls.

Conclusions

The behavior of citronellol can be assumed to be typical of a group of perfumes that contain this or similar materials. This being the case, it is evident that there are dangers in formulating a surfactant system, based on the commonly used sodium lauryl ether sulphate, and adding such a perfume afterwards.

The perfume should be considered as an ingredient in the formulation and that plays a major role in the viscosity of the product. Selecting the optimum level of sodium chloride and perfume to give the desired viscosity could result in less sodium chloride being used, giving a less aggressive product with lower eye irritation.

If it is not possible to select a perfume during the formulation stage, as is often the case, then the effect of the perfume on viscosity should be investigated by a series of viscosity measurements similar to those explained here.

This work has been limited to the effect of only one material on sodium lauryl ether sulphate. The results in the first experiment indicate that different effects may be obtained with a range of perfumes, depending on which materials they contain. It also would be expected that other surfactant systems may behave differently.

Thus, a formulator of a range of shampoos or bubble baths should consider the perfume not only as an additive but as part of the formulation and pay particular attention to the effect of the perfume on viscosity. This could avoid problems at the time or at a future date if a perfume is changed.

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References

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