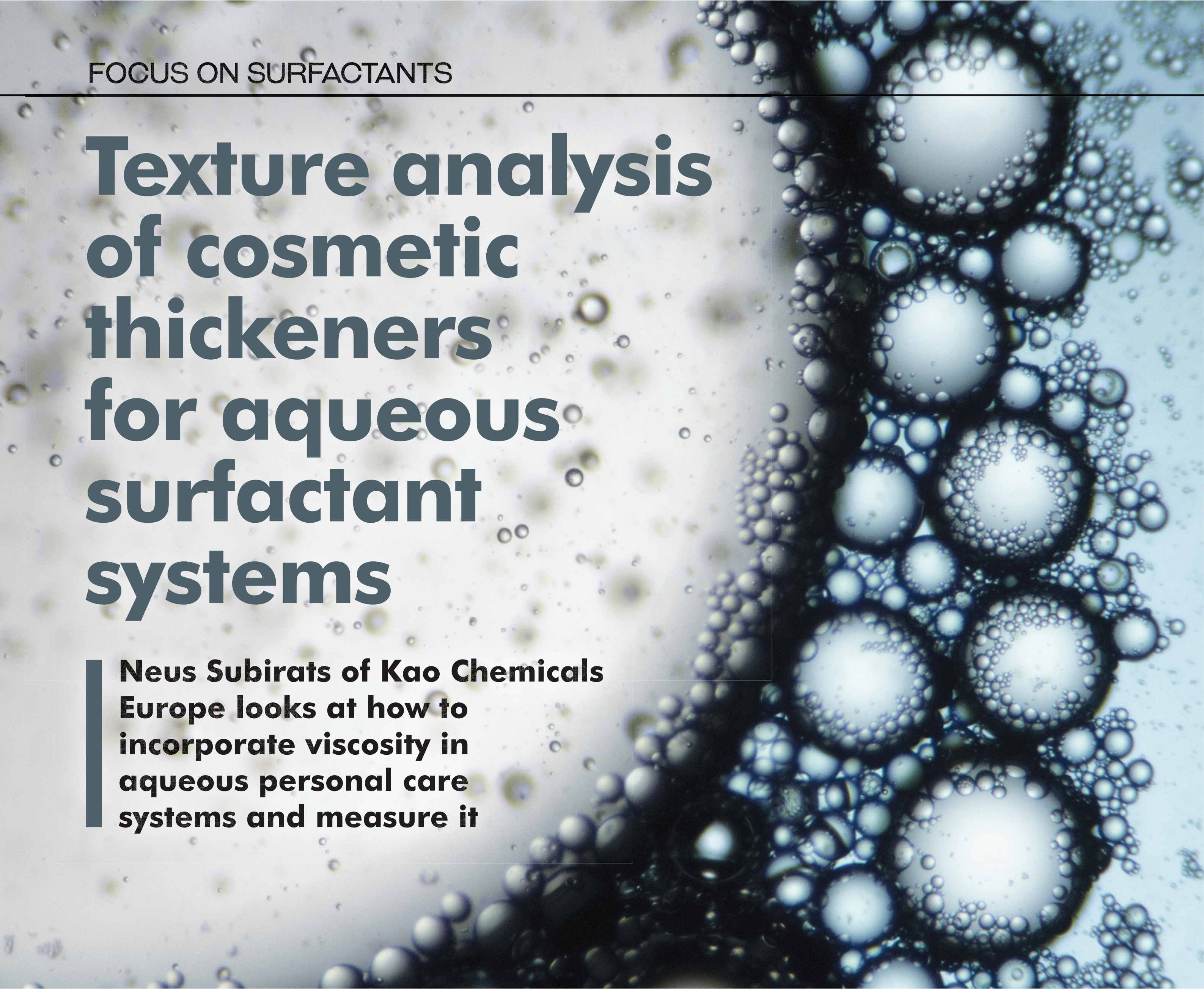


Texture analysis of cosmetic thickeners for aqueous surfactant systems

Neus Subirats of Kao Chemicals Europe looks at how to incorporate viscosity in aqueous personal care systems and measure it

THERE ARE BOTH marketing and technical reasons for enhancing the viscosity of aqueous surfactant systems. In formulation development and optimisation, having a thickened formulation can make it possible to keep heterogeneous solutions in a stable equilibrium and this simplifies the design of suitable packaging.

More than 500 cosmetic thickeners are available to enhance the viscosity of aqueous personal care systems, ranging from classical hydrocolloids to polymeric high molecular weight (MW) surfactants and low MW nonionics or alkanolamides. Viscosity and thickening agents are an important element of cosmetic formulation, offering the opportunity to change viscosity, improve rheological properties and modify the product aesthetics linked to consumer perception. Therefore, the selection of a thickener is a critical decision.[1]

The first part of this article gives an overview of the possible methods of incorporating viscosity in aqueous personal care systems, including an explanation of the different mechanisms involved. The second part looks at the quantification of textural properties influenced by different thickening agents.

Mechanism of thickeners

Nowadays, the wide selection of ingredients on the market for final formulations requires a greater understanding of the interplay between ingredients. An accurate description of the product's microstructure and its rheological and dispersion properties is essential. Thus, understanding the general mechanism of thickeners in aqueous surfactant systems can help to understand and explain how thickening agents regulate the viscosity and rheological properties of formulations.

The viscosity of surfactant solutions normally depends on the size of the surfactant micelles, the concentration of surfactants, the type and ratio of the surfactant used, the temperature and the micelle charge density. Most thickeners work by an associative mechanism, based on modifying the micellar structure by reducing charge density, or by a non-associative mechanism, where the thickener does not interact with surfactant structures and forms cross-linked micro-gel structures.

The most common way to thicken a surfactant system is to use sodium chloride. Salt thickens by reducing micelle charge density, helping to promote the conversion of spherical micelles to rod shapes.[2] The transition from micelles to worm-like micelles has been well characterised by small angle X-ray scattering (SAXS), a non-destructive technique that can be used to determine the size, shape, organisation and structural parameters of surfactant aggregates.

The viscosity of salt-thickened formulations decreases with increasing temperature and will not stabilise suspended particles. Using too much salt can also impact the clarity and cloud point of the formulation. Therefore, other types of thickeners are necessary. By means of SAXS, the structure of surfactant aggregates thickened by different mechanism has been rationalised.

Lauryl lactate, which Kao Chemicals markets as Excepearl LM-LC, is a natural liquid thickener that is derived from renewable sources. SAXS studies on surfactant systems thickened by it provide useful information concerning phenomena, such as micellar growth. Adding lauryl lactate to a surfactant system consisting of a 3:1 ratio of sodium laureth sulfate (SLS) and cocamidopropyl betaine produces a reduction of electrostatic repulsion. This leads to an increase in the packing parameter, making the aggregates bigger and increasing viscosity, due to their subsequent interaction.

Figure 1 compares the general mechanism of NaCl against that of Excepearl LM-LC in a surfactant system. The latter interacts internally with surfactant mixtures, which are normally organised in solution in isometric spherical micelles. This generates a structural change that can result in a transformation to anisometric rod-like micelles.

In the case of NaCl, an increase in the ionic strength of the bulk phase is observed. This produces a reduction of the surface charge of aggregates resulting in the formation of larger micelles and thus having a positive influence on the viscosity.

Additionally, lauryl lactate is a mild product with some emollient and conditioning properties for skin and hair, due to its hydrophobic characteristics. It has no detrimental effect on the foaming behaviour of the formulations.

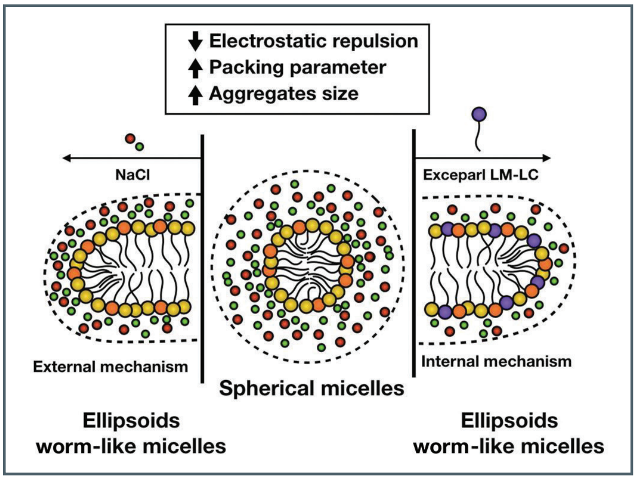


Figure 1 – Proposed general mechanism of NaCl & Excepearl LM-LC in a surfactant system

Textural analysis

Texture is defined as a combination of the mechanical, geometrical and surface attributes of a product, as perceived by means of mechanical, tactile and visual receptors. Mechanical texture analysis is widely used for product characterisation in the food, cosmetic and pharmaceutical industries, where it provides information on some highly important analysis parameters, such as hardness, firmness and work of shear.

The texture analysis was performed using a TA.XT plus texture analyser equipped with two probes – a TTC spreadability rig, HDP/SR, and 1" spherical probe, P/1s – at room temperature. The method consists of inserting the analytical probe into the sample, with defined speed and depth, leading to a pre-defined period of recovery, resulting in a force (g) versus time (sec) graph.

The analysis was performed on ten aqueous surfactant cleansing compositions. These were thickened by two different types of thickener: a hydrophobic, oligomeric surfactant and water-soluble organic polymers (synthetic, semi-synthetic and natural). The first test, related to spreadability, evaluated the work of shear of the compositions. This measure is obtained from the area under the positive curve.

From a consistency test, four parameters can be evaluated: index of viscosity, consistency, firmness and cohesiveness. In this test, firmness is obtained from the maximum value of the positive curve, consistency from the area under the positive curve. Cohesiveness is measured from the maximum value of the negative curve and the index of viscosity from the area under the negative curve (Figure 2).

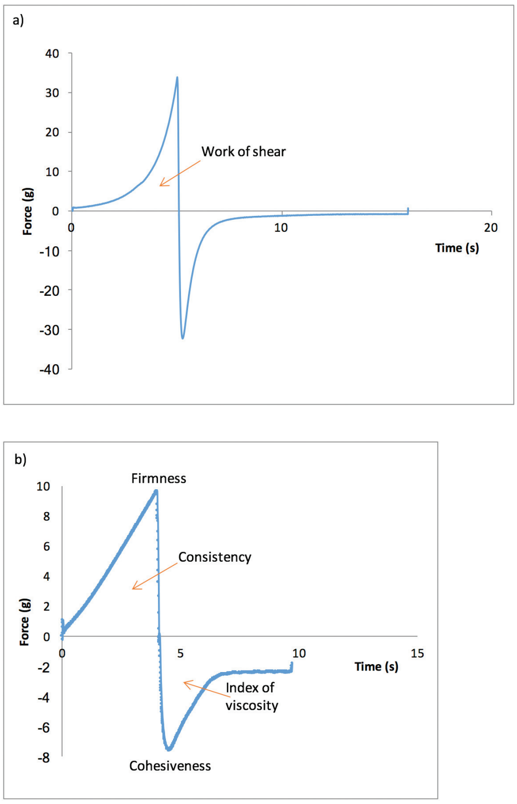
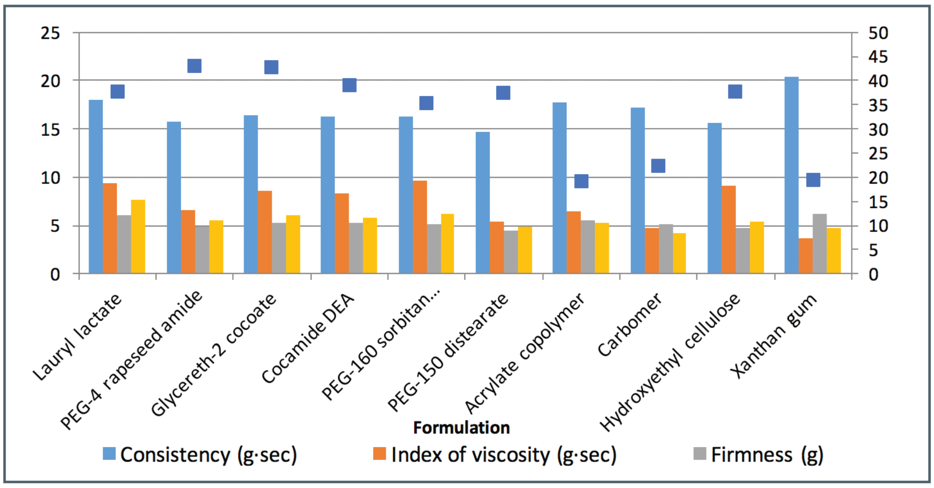


Figure 2 – Typical plots of texture analysis of experimental data of spreadability: Consistency test (a) & interpretations (b)



➊ **Figure 3 – Texture profile characterisation of the formulations at about 5000 cP by different thickeners**

➋ Interpretation of parameters

The interpretation of the mechanical parameters is an important tool that makes it possible to predict the sensorial characteristics of a formulation. The shear work values are highly correlated with the formulation's spreadability. Firmness is a textural property defined as the necessary force to reach a given deformation and can be related to the ease of application to the skin.

Cohesiveness is the work required to overcome the attractive forces between the surface of the formula and the surface of the probe. High cohesiveness describes products that do not extend from the surface of the mass to the fingers but rather make a clean separation between the surfaces. However, low cohesiveness may be a favourable property in a product where considerable extension of the product from its main body of material is accepted.

Consistency is a textural property related to the amount of product felt between fingertip and skin. It relates to the 'firmness', 'thickness' or 'viscosity' of a liquid or fluid semi-solid. The higher the index of viscosity, the more resistant to withdrawal is the sample. This is an indicator of the cohesiveness and also the consistency or viscosity of the sample.[3]

Figure 3 shows the calculation of textural parameters, obtained using both tests, for ten aqueous surfactant solutions based on SLS and cocamidopropyl betaine (3:1 ratio) thickened by different thickeners. Different thickeners cause structural rearrangement of the formulations, changing their behaviour.

Texture characterisation showed that the formulation that contains lauryl lactate presented relatively higher values of the sum of all parameters studied. Formulations thickened by aqueous, water-soluble, organic synthetic polymers were characterised by smaller textural parameters, except for the work of shear where PEG derivatives showed a value comparable to oligomeric surfactants.

Formulation thickened by PEG-160 sorbitan triisostearate (Kao's Kaopan TW-IS399S) exhibit relatively high index of viscosity values. Similar texture characterisation was found for formulations thickened by PEG-160 sorbitan triisostearate and hydroxyethyl cellulose. Xanthan gum showed the largest value of consistency.

Conclusion

It is known that texture analysis can be correlated by sensorial analysis.[4] Moreover the experiments are easy to perform and are typically reproducible. Therefore, it can be used to understand the role of different additives in a personal care formulation and predict the consumer's acceptance in a less time-consuming and less expensive manner.

This study demonstrated that thickening agents play an important role on the mechanical properties of personal care formulations because they can strongly influence physical, texture and sensorial parameters. The association of the knowledge of the thickeners' mechanisms and textural characterisation of each thickening agent helps formulators to make the correct choice of them for personal care products. ●

** – Also contributing to this article were Núria Marimon and Bernat Pi of Kao Chemicals Europe, on the mechanism understanding of thickeners and Noèlia Loza of Kao Corporation Spain on textural analysis. SAXS measurements are part of a project that has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 731019 (EUSMI). The author would like to thank to Marc Obiols-Rabasa, senior scientist at CR Competence and industrial liaison officer of EUSMI, for coordination and helpful technical discussions.*

*** – EXCEPARL LM-LC and KAOPAN TW-IS399S are both trademarks of Kao Corporation*

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