Sensory profiling of cosmetic products: Could it be easier?
Use of rheology and textural analysis

Abstract
Sensory evaluation studies are performed in order to obtain full sensory profile of the cosmetic product. Since these studies are comprehensive, time-consuming and consequently expensive, the potential use of instrumental measurements that correlate with sensory properties is being extensively assessed. The existing studies confirm that direct and good correlations could be found between instrumentally measured parameters and some sensory attributes. Certain sensory attributes, used for the description of the product in pick up and rub in phase, could be predicted to some extent by instrumental, i.e., rheological and textural measurements. Therefore, sensory profiling could be simplified and consequently more cost-effective with the employment of instrumental tools.

INTRODUCTION
In order to appear in the market modern cosmetics have to fulfill a set of regulatory demands, mainly focused on efficacy and safety. Nevertheless, consumers’ acceptance is undeniably the most important factor determining a product’s market life. Regarding consumer acceptance, proper sensory characteristics have to be achieved for every cosmetic product. From consumers’ point of view, one could say that sensory characteristics are as significant as efficacy and safety; moreover, they represent the biggest part of products’ sales potential (1). Therefore, it’s no surprise that sensory evaluation has gained great importance in R&D and gathered scientists of different profiles around something that became an interesting scientific field.

Although a proper sensory analysis requires the use of a panel of human evaluators, certain efforts have been made in order to include instrumental measurements in sensory evaluation. In the field of emulsions research and development, rheological measurements and texture analysis are regarded as highly informative techniques. This paper is the review of current possibilities in sensory evaluation focusing on the use of rheology and texture analysis as instrumental tools in sensory evaluation of cosmetic emulsions.

SENSORY EVALUATION
Sensory properties
The smell of coffee, the flavor of ice cream, the sound made when the shampoo bottle is opened, the texture of sweater, the smell of conditioner, the skin feel after the body lotion has being rubbed in, all of these and much more activate our senses, whether we are aware of it or not. Sensory evaluation is defined as a behavioral science, a scientific method used to evoke, measure, analyze and interpret those responses to products’ or materials’ characteristics as perceived through the sense of sight, smell, touch, taste and hearing (2). Therefore, the sensory property of a product could be any attribute that stimulates some of our 5 senses. It is quite
clear, from the definition above, that a set of extensive skills drawn from a range of disciplines, e.g. biological sciences, psychology, experimental design and statistics, as well as work of specialists from different areas, is needed in this scientific field. Proper sensory evaluation is performed, together with adequate sensory attributes selection, depending on the type of product or material investigated.

**Sensory evaluation in cosmetics**

The importance of sensory properties in cosmetics is unquestionable. The products' and packages' visual characteristics, the sound made when opened and closed, the smell of the product, sometimes even the taste and, most importantly, the properties perceived through the sense of touch, all represent cosmetics sensory characteristics. Since the consumers are emotionally attached to their cosmetics, sensory characteristics could create an emotional link between the consumer and the product. Therefore, optimization of sensory characteristics leads to consumer satisfaction.

Nowadays, the adequate sensory characteristics, alongside the efficacy and safety, are considered a necessity. Moreover, the appropriate sensory attributes represent the most significant part of a product's sales potential and hence, the product's failure could be caused by a mismatch between its sensory characteristics and consumers' needs and expectations (1).

Fulfilling the consumers' requests is an imperative in the personal care industry. Thus, for adequate sensory characteristics to be achieved, the sensory evaluation studies are performed for the purpose of their constant improvement, engaging a considerable number of researchers (1, 3-5). The standard evaluation of sensory properties is carried out by a selected or trained panel in objective testing. There is also a possibility of conducting a subjective testing measuring the consumers' reactions to the sensory properties of products. The consumer product sensory evaluation is conducted according to adequate sensory evaluation standards, like the ASTME's standards practice for descriptive skinfeel analysis, which is instrumental in the assessment of cosmetic creams and lotions [6]. Before any sensory study, one has to make a considerate and rational choice of sensory attributes, suited for investigated product/products. At the same time, the measuring procedure, precise definition and scale/descriptive terms have to be defined for each sensory attribute (Table 1). Thus, the results of a sensory study could be obtained as descriptive terms (Table 2) or numerical values, usually presented in diverse informative charts (Figure 1).

The main drawbacks of the sensory studies are that they are comprehensive, time-consuming and consequently expensive. Together with the previously mentioned shortcomings, whenever relying on volunteers' subjective evaluation one should be aware of the uncertainty and imprecision of the results acquired in this manner. Therefore, the potential use of instrumental measurements that correlate with sensory properties is being extensively assessed.

The new instruments which could adequately describe sensory properties are being developed, in order to make the sensory evaluation more cost-effective.
Solvay is launching Jaguar® LS, the ideal conditioning guar polymer for modern shampoo formulations.

Consumers’ expectations and habits constantly evolve and as new trends emerge, shampoo formulators are now challenged to design more environmentally-friendly and cost-efficient products. To meet these expectations, several options are being explored, such as a reduced use of some ingredients (silicones, sulfates...) or even a total absence of some others (ethoxylates).

In particular, the design of less concentrated shampoos, containing a significantly lower proportion of surfactants, is intensely sought after. However, this is a new formulation field which may lead to shampoos with poorer performances for the consumer.

With consumers increasingly aware of their own impact on the environment and a world faced with raw material inflation and consumption, Solvay has developed Jaguar® LS, the guar solution which delivers the benefits expected by consumers and formulators from shampoos relying on less surfactants and chemicals while not compromising on performance.

**Do more with less!**

- effective in shampoo formulations containing less surfactant
- good foam volume especially in combination with Miranol® amphotacete
- solution for natural shampoo
- transparency in formulation
- perceivably good hair conditioning, even without silicones

**Jaguar® LS delivers richer sensorial hair feel**

In historical, surfactant-rich chassis, cationic guar has been well-known for the nice, rich and soft feel they bring to hair. Being substantive to hair, Jaguar® LS is the grade which provides this silky feel even in innovative formulations containing less surfactant when other cationic polymers lose their performance in such chassis.

**Foam volume generated as measured by an expert panel**

**Superior hair feel as measured by an expert panel**

*Graphs showing foam volume and hair feel improvements with Jaguar® LS compared to other surfactants.*

*Sulfate-containing formulation, based on 9.6% total surfactant*
**Jaguar® LS: A natural based polymer to bring Superior Conditioning versus PQ-10s in cost-efficient shampoos**

Jaguar® LS is a cationic polymer of natural origin that is best suited for formulating shampoos designed with less surfactant. Jaguar® LS delivers optimum conditioning and foam from this challenging chassis. It helps formulators to create environmentally-friendly shampoos thanks to its formulation versatility and high transparency. Jaguar® LS shows a significantly higher efficiency than PQ-10 polymers, at lower doses, allowing cost-efficiency.

All polymers formulated in a 9.6% total surfactant formulation. Damaged bleached Caucasian Hair used for the combing tests.

**Key Benefits**

**Consumers**
- Best-in-class conditioning from formulations containing less surfactant (less irritating and eco-friendly)
- Detangling & Combing from root to tip
- Smooth wet hair feel during shampooing and after
- Fly-away control whilst maintaining hair volume
- Suitable for all types of hair, including damaged bleached and colored hair

**Formulators**
- Best-in-class conditioning from formulations containing less surfactant (cost effective and more sustainable)
- Allows formulation flexibility and suitable for transparent formulations
- Efficient with a wide range of anionics and amphotericics, including EO-free surfactants
- A solution for silicone-free natural formulations
- Eco-friendly profile, non-ecotoxic for aquatic organisms

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**Jaguar® LS reduces fly-away without compromising on hair volume**

Even in low surfactant formulations Jaguar® LS delivers rich conditioning and sensorial feel without build-up on hair. In addition it promotes hair volume without any fly away drawbacks compared to some polymers such as PQ-10 which leads to static. For soft, touchable hair without fly away in any weather, Jaguar® LS is the solution.

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<th>PQ10</th>
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<td><img src="comparison.jpg" alt="Comparison of PQ10 and Jaguar® LS" /></td>
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- Detangibility & combing perceivedly improved with Jaguar® LS, especially at the tips
- No impact on hair volume, no build-up
- Reduction of fly-away:
  - 2 dilute shampoos based on 9.6% total surfacants - NO SILICONE Containing 0.5wt% of either a PQ10 or Jaguar® LS

Virgin & bleached dark brown Caucasian tresses, up to 5 shampoo cycles, drying at room temperature
Alongside this development of new computing methods, the existing techniques are also being evaluated for the purpose of modeling and analyzing sensory data, resulting in the fact that a great number of scientists of different profiles, as well as the researchers interested in cosmetics, work in the field of sensory evaluation (7-9).

**RHEOLOGY**

The cosmetics are used in enormous variety of purposes, but apart from this and considering their formulation type, cosmetics range from solutions to powders i.e. from fluid to solid state products. The emulsion systems, especially as semi-solid products, represent one of the biggest groups. Their importance as cosmetic products aside, emulsions have found a wide range of applications of which the following are certainly worth mentioning: food emulsions, paints, agrochemicals, pharmaceuticals, bitumen emulsions, inks and paper coating, adhesives and many household products.

Rheological (flow) properties of emulsion systems, obtained either by continual or oscillatory measurements, are some of the emulsions’ essential physical attributes (10). For decades, rheological measurements have been employed in characterization of emulsion systems, mainly in order to explore the systems’ colloidal structure and its physical stability. These measurements find practical application in quality control of both raw materials and final products, as well as in manufacturing processes’ management. They are also used to study the effect of different parameters on the quality of a final product. Additionally, rheological measurements can be implemented to evaluate a product when its actual usage is considered.

Regarding the sensory evaluation, it is well known that the application and acceptance of cosmetics are greatly dependent on the flow properties of the final product (11). Therefore, the sensory properties of emulsions which are influenced by their colloidal structure can be related to rheological measurements. The flow behavior in a steady state (continual) rheological measurements and the appearance of thus obtained rheological curves are often used for the prediction of a product’s behavior upon application. The parameters obtained from these measurements, such as different viscosity values, yield stress and hysteresis loop area value, are linked with certain sensory attributes. Topically applied preparations are expected to show certain resistance to the applied stress – manifested in rheology as yield stress (12). Afterwards, the system starts to flow, is practically spread to the applied area, and this is manifested as shear thinning and thixotropic behavior, which could be quantified with hysteresis area value. As for the viscosity, since it is a measure of system’s resistance to the flow, it is obvious how viscosity values could be used when discussing emulsions’ application, especially the rub-in application phase. Despite those facts, there is a lack of academic papers that investigate possible correlations between rheological measurements and sensory attributes of cosmetics. Moreover, the works published so far show the apparent insufficiency in the number of the assessed sensory attributes; usually it is just a spreadability, investigated in conjunction with rheological measurements.

Park and Song investigated the importance of yield stress and non-Newtonian flow behavior in actual application (13). Their results show that yield stress plays a crucial role in determining the thickness of the product film layer on the surface of the human body. These findings imply that the yield stress of the product should be large enough to disable products to flow out of a container when it is placed in an upside-down position and at the same time it should not be too large to offer an intensive resistance to flow during an application. In conclusion, the smaller the yield stress, the easier the product can be distributed on the human body. Similar were the findings of Brummer and Godesky which showed that the so-called “primary” skin feeling correlates with the shear stress at the onset of the flow and the dynamic viscosity (14). As for the “secondary” skin feeling, it correlates with the value of the stationary viscosity for the rate of shear prevailing at the end of the application to the skin. In other words, the perceivable consistency of a product (skin feeling during the rub-in phase) is determined by the maximum viscosity of the product. Lukic et al. (15) conducted a simplified sensory study and assessed selected sensory attributes with continual and oscillatory rheological measurements. Their study confirmed the assumption that high viscosity emulsion would be sticky and difficult to spread. Thus, the sample that scored the lowest for spreadability and slipperiness, also described as very sticky and very thick, was the sample with the highest maximal and minimal viscosity. This study established that slipperiness, defined as the rate of slipping and melting of the sample while being rubbed 2 times in circular motion over the back of the hand, directly correlates not only with the viscosity obtained from steady state (continual) measurement, but as well as with the elastic and viscous modulus from oscillatory measurements. Another sensory attribute from “before rubbing and pick-up phase” – texture, defined as...
impression of the thickness of the sample when it is rubbed between thumb and forefinger, was found to directly correlate with hysteresis loop area and yield stress. However, certain sensory attributes could not be interlinked with any rheological parameter; i.e. no correlation could be made.

TEXTURAL ANALYSIS

Textural analysis evaluates the mechanical characteristics of the emulsion system. This technique is commonly used in the food research field in order to provide information relevant for texture of the final product and consequently the product with satisfying sensory characteristics [16]. Many studies have also been carried out in the field of food science to develop an instrumental approach using textural analysis [17, 18]. Although some authors have already used this technique for characterization of topical preparations considering it to be one of the classic methods for evaluation of emulsion stability, it is expected to be even more helpful when developing consumer-acceptable cosmetic products [19, 20].

In the previously mentioned study, Lukic et al. established [15] a direct correlation between texture (sensory attribute) and firmness (texture attribute). As for slipperiness (sensory attribute), it directly correlates with the following texture attributes: consistency, cohesiveness and index of viscosity. In this work certain correlation between rheological and textural parameters were found and therefore it was confirmed that textural analysis, as a fairly simple measurement, can be used as a surrogate for rheological measurements, in order to characterize or compare semisolid systems regarding their mechanical and structural properties. The most recent study of Savary et al. established good correlation between instrumental and in vivo measurements of spreading [21]. Their work showed that the spreadability which was defined as the ease of moving the emulsion with index finger over a given distance correlated best with the spreading instrumentally measured using a Texture Analyzer in terms of work required to move weight on the surface.

THE COMBINED APPROACH IN SENSORY EVALUATION

The existing studies confirm that direct and good correlations could be found between instrumentally measured parameters and some sensory attributes (assessed by human). However, for some sensory attributes like adhesion, defined as the amount of the sample that stays on a forefinger after short contact with the sample in its container, there is no relationship with investigated instrumental measurements [15]. Also, one should be aware of the difficulty in identifying the physical nature of some sensory attributes. For that reason, when about to develop a new cosmetic product with consumer-satisfying sensory characteristics, it is undoubtedly necessary to conduct a detailed sensory evaluation study, in order to obtain full “thumb-print” of the product. However, certain sensory attributes, used for the description of the product in the pick up and rub in phase, could be predicted to some extent by instrumental, i.e. rheological and textural measurements. Therefore, determination of a preliminary sensory profile could be simplified and consequently more cost-effective with the employment of instrumental tools. On the other side, in the processes like reformulation and modifications of existing products, classic techniques like rheology and textural analysis alone could be used in order to predict behavior of the product in real-time conditions during manufacturing and application, and as an end point to develop a consumer-acceptable final product. This especially applies to the later phases in the products development, when one has to choose between similar formulations, for which only instrumental measurements could be used in order to differentiate products regarding esthetic aspect. It is also worth mentioning that for products with similar rheological behavior sensory profiles tend to be alike as well. Subsequently, one could compare its product with a well-positioned commercial product, with known sensory profile. In that manner, based only on instrumental measurements carried out for both the candidate and reference formulation, one could predict sensory profile for a new product. Aforementioned is particularly useful to small manufacturers usually equipped with devices like Rheometer and Texture Analyzer but without the ability to conduct a sensory evaluation studies themselves, or finance it as a form of outsourcing.

In conclusion, the combined approach referring to the use of instrumental tools and simplified sensory studies could be helpful and both time and money-saving tool for full characterization of a new cosmetic emulsion product.

REFERENCES AND NOTES