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Odour Measurement for Improved Scent Performance in Consumer Goods

»Smell is a potent wizard that transports us across thousands of miles and all the years we have lived«
(Helen Keller in: Gaye 2010)

After the sense of smell has been overseen for a long time in marketing, more and more companies are becoming aware of the power of this sense.
This is based on the findings that the sense of smell is closely associated with eliciting emotions and memories more than any other modality. This connection is explained by the odour processing structure as the signals are routed directly to the limbic system in which emotions and memories are processed. All the other senses enter the limbic system with previous detours.
In regards to marketing, research has shown that fragrances can have the power on impacting e.g. the recall on product information positively. Also, fragrances can impact the consumer's emotional state instantaneously in a good or bad way which can affect shopping and spending behaviour.
In addition to the unique way of processing smell, the sense of smell is one of our most primal and deeply rooted senses. When a person smells something, there is an immediate, instinctive response. *Pam Scholder Ellen* says »with all of our senses, you think before you respond, but with scent your brain responds before you think«. Therefore, the sense of smell has a potential to create uncensored reactions in marketing stimuli including the time spending, the willingness to buy, and the evaluative judgement.
In some consumer products e.g. deodorants or perfumes, fragrances represent the major driver of the consumer purchase. In others, fragrances are considered a secondary product attribute as it is used for enhancing certain product attributes in an unconscious evaluation or for distinguishing the product from alternative options. Scent enhances key information about the product such as a lotion's soothing quality or a cleansers' effectiveness. Fragrances in products represent usually only 0.5 %-2.0 %. But the performance and signal attributes claim a high percentage of almost 70-80 %.
Fragrances in products can help to increase product experience, while malodours can have the opposite effect. Therefore, it is important to measure how a products' scent is perceived based on scientific and reproducible methodologies.
These measurements can help R&D to optimize the product, support quality control, and to scientifically substantiate product claims.

- What is the longevity of my fragrance in my product?
- How is the fragrance perceived in different stages of consumer usage or in comparison to the benchmark?
- Where is the malodour generated?
- Is the masking/neutralising function of my product working?

Questions like these arise in many different industries. The following article explains how these questions can be answered, summarizing the basic odour measurement methodologies.
Odour measurement is differentiated into two major fields:

1. Sampling
2. Analysis

Sampling is highly depending on the product segment, the product itself, and the objective of the study. For certain product segments standards have been developed (e.g. Deodorant testing according to ASTM-E-1207-14). Based on the product usage and the decision if the test should be a laboratory set up or more consumer related, it is decided for a sampling method.

The analysis can be subdivided into

1. human sensory olfactory analysis
2. molecular analysis

Human Olfactory Analysis

Up to today, there is no analytical tool that can substitute the human nose completely. Even the most sensitive and most recent tools cannot always identify odour molecules while the human nose can detect a clear odour signal. Additionally, no analytical system can measure the human perception.
Standardization is the key for reliable results in human sensory olfactory analysis. The most common parameters are odour concentration, odour intensity and hedonic tone.
The odour concentration can be determined by measuring the odour threshold concentration which is defined as the concentration at which an odour molecule can be detected with a probability of 50 %.
For mixtures of odour molecules, it is possible to measure the odour concentration by the method of dynamic dilu-

Fig. 1 Olfactometric measurement.

Fig. 2 Direct evaluation using the PureSniff.

tion olfactometry, which is used worldwide. An olfactometer comprises a sophisticated system, which dilutes odour samples with neutral air and presents them to a test panel for assessment. To standardize such measurements the guidelines and norms of EN 13725 are to be applied and the odour concentration is measured in so-called Odour Units. (**Fig. 1**)

This parameter is useful to describe the odour impact of products. It can be used to measure - for instance - the odour reduction rate of neutralizers/filters or longevity of fragrances.

However, odour concentration does not correlate directly with the overall odour perception. For such measurements, other sensory methodologies have been developed.

To assess the odour perception in a repeatable way, the most common parameters measured are odour intensity and hedonic tone. It is a challenging task to determine these on an absolute scale since intensity and hedonic tone are somehow connected.

In daily life, people quickly distinguish if they like an odour or not, which can lead to approach or avoidance behaviour. Consumer research even suggests that odour perception primarily occurs in terms of its pleasantness or unpleasantness, the individually and positively evaluated stimulation of the olfactory sense.

Beyond pleasantness, individuals perceive and respond to a scent's intensity. The relationship between pleasantness and intensity is complex and can often be characterized by an inverted-U shaped function. The binding component is the concentration of the odour. A perfume smells good, perhaps even better as the concentration increases, but only up to a certain point. Beyond that point the scent gets so intense that it becomes unpleasant. Yet, with some scents, the relationship may be linear rather than bell-shaped: Whereas a light fish odour may be acceptable, the evaluation may become continually more unpleasant as the concentration increases.

The standardization of such measurements is very important. The VDI 3882 allows the rating of intensity on a 7 point scale by answering the question »How strong is the odour?«, while the measurement of hedonic tone, which can be performed at the same time, answers the question of »How pleasant is the odour?«. Depending on the information required, the intensity evaluation can be done with trained expert panels. The hedonic tone cannot be trained because it is highly depending on individual experiences. Depending on the target group of the product, a representative panel can be selected.

Beside intensity and hedonic tone, it is also possible to record odour acceptance or to focus on the odour character. One of the most demanding tasks is to establish a sensory description of the odour character as humans are not very good in transferring their odour perception into words. In an experiment, in which subjects had to name the scent of daily used product items (e.g. household products), the identification rate was less than 50 %. The rate of success improves when the familiarity of the scent increases, but, very commonly, people experience a feeling of recognition and familiarity while being unable to voice a verbal description or assign a semantic label. This is called the »tip-of-the-nose« phenomenon. It requires extensive training of expert panels prior to doing a sensory odour description. For many industries, different odour wheels have been developed which help less trained panellists to find the right descriptors

As a very important aspect of sensory odour measurements, it is necessary to highlight the need of consistent smelling. Even evaluation from the smelling strip has to be learned and trained. To facilitate consistent smelling, Odournet GmbH has developed the PureSniff device: This is an instrument which presents the headspace over a sample in undiluted form when a panellist activates a switch. It is a universal tool for preparing and presenting the headspace and thus presents the scent of a product in its pure form. (**Fig. 2**)

The assessing of scents by panellists is fast, and allows capturing sensory related information based on the human perception. Nevertheless, the measurement of molecular based information is mandatory for revealing important facts, which determine the scent performance over time.

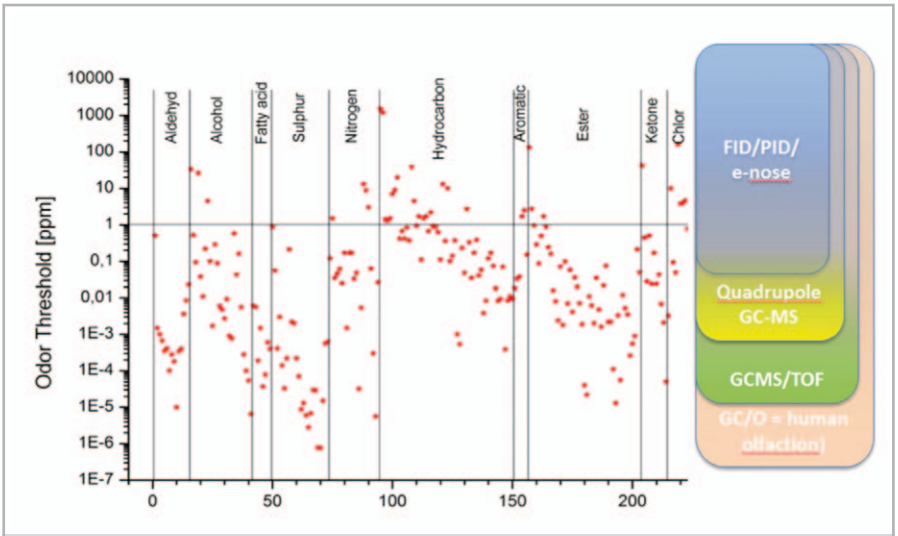

Fig. 3 Odor threshold at different concentration levels in relation to sensitivity of different analytical tools.

High-End Molecular Spectroscopy can be linked to human perception.

Over the last decades, Molecular Spectroscopy methods to analyze headspace compositions have evolved tremendously. Today's GC- MS/TOF instruments can detect molecular traces at concentration levels of a 100 times lower than standard GC-MS instruments. Scents, especially when they contain natural ingredients, reveal a high complexity. The combination with the human nose as complementary detector, allows recording the GC-Olfactometry trace (GC-Olfactogram). Linking the molecular information from GC- MS/TOF with the perceived intensity and perceived odour quality, allows detailed understanding of the key odour impact molecules present in the scent. With this analysis, it is also possible to identify molecules responsible for malodour in a product. (**Fig. 3**)

Very recently an interesting combination of analytical technology became available. GC-IMS in particular can be used to observe the 2D-fingerprint over time to study the dynamic changes of a cosmetic product or perfume after its application onto skin, or to compare the similarity/difference of products. Presence or absences of key components of a scent are seen immediately and sophisticated data processing methods allow the quantification and identification of the molecules of interest and the visualization of molecular headspace over time. And last but not least, it is possible to visualize the formation of off-notes during the product's shelf life.

Overall, odour measurements are helpful in supporting R&D in creating a positive product experience. Depending on the objective, they answer a variety of questions about odour reduction, longevity of fragrances, or molecular odour structure - among others. The most essential part is the compliance with standardized procedures for getting valid test results with high repeatability.

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