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The Quality Future for the Candle - a Burning Issue

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Introduction

The title of the presentation given to the European Candlemaker's Association in Odense, Denmark, in 2000, is **'The Quality Future for the Candle - a Burning Issue'.** Both interpretations of the title are meaningful as the candle does have a quality future, in other words a good future, if we define the quality management of our product and emphasise the quality of the product in conjunction with consumer protection.

The first question is: What makes a good or bad candle?

The key quality criteria are high quality raw materials (i.e. pure, clean), good burning behaviour resulting from optimal co-ordination between and balance of the materials used and the chosen wick, as well as the environmental impact of the product. In other words the chosen and defined quality criteria for the candle as a product guarantee consumer protection.

Special emphasis must be placed on the burning behaviour and the sooting behaviour of a candle. The problems of sooting will, therefore, be addressed in more detail.

However, to start from scratch we should first of all decide what candle quality is. **Picture 1a** shows a standard candle as normally produced and of the standard that we would like to produce in order to fulfil the consumers' quality expectations. The clear bright flame, the curve of the wick, the constant, regular burning of the right amount of wax at the right speed, are just some of the factors which denote a quality candle. Optimal burning behaviour is not only a requirement of the present day candle but has remained unchanged for the last hundred years or more as is shown in this 19th Century caricature(1) **picture 1b**. It is interesting to note in this picture that indirect reference was made to the quality of the materials used, be it tallow, wax or stearic acid. Shortly after the period depicted paraffin wax, which makes up the bulk of the material used for candle production nowadays, was discovered. As you can see our great grandparents could also tell what quality was and purchased accordingly.

Picture 1a Standard candle

Picture 1b 19th century caricature

The candle and its tradition are inextricably interwoven with quality discussions. It is our privilege to be dealing with a traditional product which, up to now, has successfully made the transition from century to century. It is our responsibility to ensure that this continues to be the case in the future.

(1) "Satyrical picture" 19th century, published in Vienna, 'Theaterzeitung' (Theatre Newspaper)

However, quality is many things to many people. They say beauty is in the eye of the beholder, and this certainly holds true in the candle world. All four candles shown here **(picture 2)** are top quality products and have been chosen, bought and paid for by consumers. They may not be to everyone's taste - but their quality cannot be disputed. The guaranteed quality of a candle must be taken for granted and is independent of appearance. As they say 'one man's meat is another man's poison'. Whether with a smooth or structured surface, whether plain or highly decorated, whether of traditional design or modern, taste is only indirectly related to quality.

Picture 2 Various types of candle

This is not the case when we are dealing with burning candles **(picture 3)**. Consumers must be protected from such poor quality products as these, which can also be considered as health hazards. Experts and laymen alike can easily use the burning behaviour to define candle quality and sooting, dripping or dangerous candles where the whole surface is alight are negative examples of the type that undermine all our past efforts to promote the positive image of the product. Just one such purchase can undo all the good work already done, not to mention rendering substantial amounts of time and finances invested in both quality assurance and PR ineffective and lead us to query scientific studies previously carried out.

Picture 3 Various types of burning candle

The definition of quality criteria for the candle is to comply with the needs and safety requirements of the consumer; this is one of the most important tasks for national and international associations. In the past there were no particular quality definitions, only a few general guidelines which were limited to classification and definition of types of candle or statements about the composition of materials used. Good quality is an integral part of the total product package.

The German RAL (GZ041) was the first clearly defined set of quality definitions for raw materials used and candles produced.
All candle quality criteria are based on the two categories of:

a) the candle itself
or
b) the burning process

Consumer protection is an integral element of both of these categories. The assurance of quality, which we should be able to give our customers, must guarantee that only raw materials certified to be non-hazardous to health may be used, that the candle burns well and that no toxic combustion gases are released. As well as safety the consumer expects that their decision to purchase will positively influence such factors as constant product reliability, stability and /or uniformity of shape. In addition to which the desired surface and fragrance must be taken for granted for the entire life of the product. Furthermore it is vital that any specifications given such as burning time, weight or measurements must be adhered to and kept within the acceptable range of tolerance. In addition to this, good burning properties like optimal luminosity, no visible sooting or dripping as well as the certainty that harmful substances will not be produced whilst burning must be indubitable.

These quality criteria and measuring methods, when defined, could form the basis for all quality agreements. Valid agreements must, therefore, contain the defined quality criteria and a description of the relevant measuring methods. In the opinion of the authors this should be prepared by technical circles in the individual candle associations and subsequently be made available to candle manufacturers.

The initial decision to purchase can be based on a number of things for example reputation, individual taste (as we have seen) etc, but customer loyalty and re-purchasing is due to the reliability of all aspects of the product. In other words; its quality.

The consumers of today are a well informed discerning group who base their decision to buy or not to buy not only on spontaneous appeal but on background information and positive or negative connotations. The consumer is a sensitive creature prone to trends and influences. Once a product's image has been tarnished by negative publicity it is extremely difficult to re-establish trust and subsequent loyalty.
There have been many examples in recent years of scandals that have caused sales of the product in question to plummet. **Picture 4** shows some examples of scandals that have occurred in the food & beverages sector. Once consumers have turned their backs on a product it can, and usually does, take huge exertions and investments to regain the previous market share. For example it cost Perrier a cool 2 hundred million francs (about 35 million Euro) to clean up their image following the benzene scandal in 1990.

Of course quality assurance does mean making investments, but compared to the costs involved in product recall and re-marketing an image it is a small price to pay. Image safeguarding is obligatory**.**

Picture 4 Scandals undermine consumer confidence
(Source: Die Woche, Nr. 16, 14.04.1994 'Cancer from the Supermarket')

Unfortunately, the candle has not been spared from scandals either and we have had our work cut out in recent years to convince consumers that our products are not only attractive enhancements to their homes and businesses but are in no way hazardous to health. Here is a selection of issues from the recent past with which we are only too familiar:

- The magazine Ökotest: discussions about sulphur in paraffin wax
- discussions about soot
- lead in wicks
- dangerous combustible products
- Lilac candles (dioxin)
- USA: Proposition 65

Independent of whether they are true or not it takes a lot of time and trouble to maintain the positive image of the candle and to ensure that the consumer is well informed in the light of such an onslaught. The campaign lead by the German Candlemaker's Association, in collaboration with raw material producers and candle manufacturers, proved how important a joint approach to these problems is. This should continue at both a national and international level and the associations should serve as the platform.

An increase in candle consumption cannot easily be achieved whilst discussions are taking place about potential health and safety risks. The examples listed above are mainly linked to the purity of the raw materials used or related to the products resulting from burning.

The purity of the raw materials (e.g. hydrogenated quality, sulphur content, solvent residue content) plays a decisive role in the burning process that takes place in the candle’s flame. The connection between the burning process and possible soot emissions will be dealt with more closely later in this article.

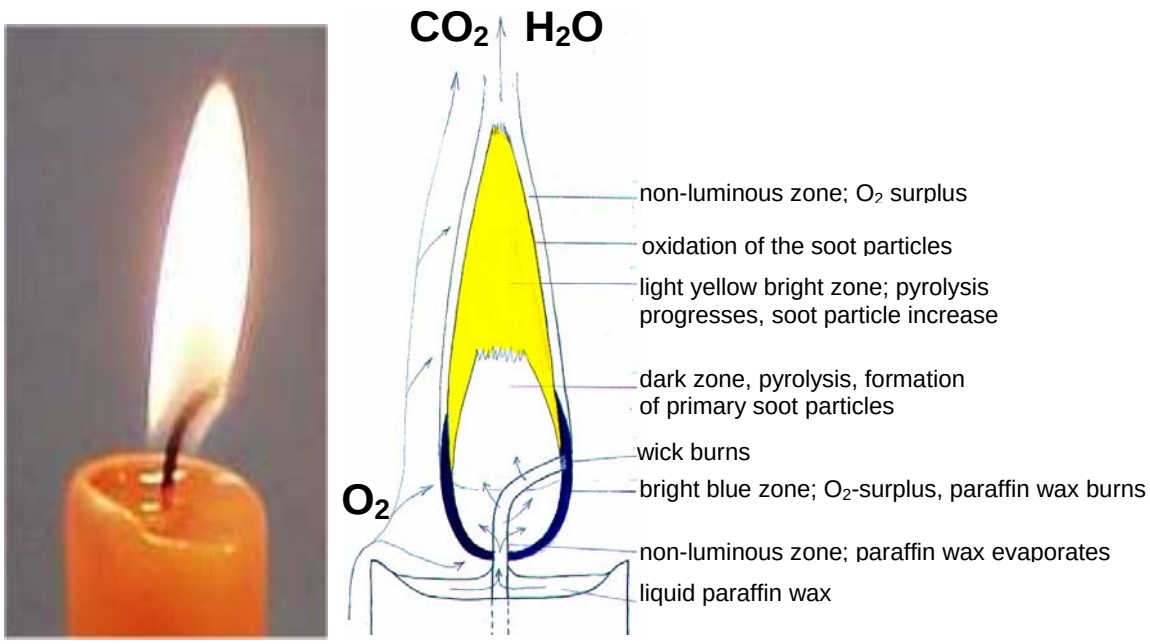
All of you enjoy seeing a candle burning well – especially one you have produced. The candle has a long tradition of bringing light and warmth to people in the past and can be used today to create a myriad of different atmospheres from luxury to vitalising. In the recent past there have been repeated discussions about undesirable substances present in the flame, which have caused the burning candle to be viewed with prejudice. This prejudice and scepticism can only be eliminated if the burning process and its side effects are clarified for the consumer.

Knowledge of exactly what happens in the flame and the processes involved is the basis for understanding the burning process. The vast multitude of combustion products formed during the burning process in the candle has lead to it being observed critically. Many of the substances shown in **picture 5** are harmless and most will be completely burnt up in the flame and become carbon dioxide or water, especially if we are dealing with a good quality candle.

Picture 5 Combustion products within the flame [(2)]

As you can see, in **picture 6,** there are different zones within the flame. The candle flame is a laminar diffusion flame, which means that its flow field is not marked by turbulence and that the mixing of fuel and oxygen from the atmosphere takes place via diffusion processes.
The wax is liquefied and is passed up through the wick to the flame where it burns and is gasified and is pyrolized in the dark, cone shaped, oxygen deficient inner zone of the flame. The paraffin wax fragments react with the oxygen in the atmosphere and produce steam. This releases energy in the form of heat and light. This energy continuously pyrolizes further fuel. A chain reaction has started and the candle continues to burn on its own. As hydrogen reacts preferentially with oxygen the carbon atoms remain in the flame and form small, cone shaped soot particles. These soot particles, which have a temperature of over 1000°C, glow and create the typical warm, yellow light of the flame that makes a candle so attractive. On leaving the flame they react with oxygen and are oxidised to carbon dioxide. When the carbon particles cluster to form larger units the necessary oxygen is not available or the temperature of the carbon particles is too low then the flame begins to soot.

[(2)] K.-H. Homann, Angew. Chem. 1998, 110 No 18, 2572-2590



Picture 6 Various zones of the candle's flame

Picture 7 shows a candle, which is sooting. Apart from the fact that it looks dreadful such candles dirty the immediate surroundings significantly. Naturally this leads to the consumer asking whether such candles are hazardous to health and exactly how dangerous soot is.

Soot characteristics:

- Elementary carbon from the incomplete incineration of organic fuels
- Particle shape: cone shaped, primary particles (nuclei) which coagulate to chains
- Particle size: 20 - 200 nm
- Particle surface: approx. 30 - 100 m^2/g

Picture 7 Sooting flame and soot characteristics

The following four questions are predominantly asked in connection with sooting:

1. What is the maximum amount of soot a burning candle can emit?

2. Is there a connection between the morphology and the physical structure/ composition of soot particles and their origin?

3. Is it certain that soot really originates from burning candles?

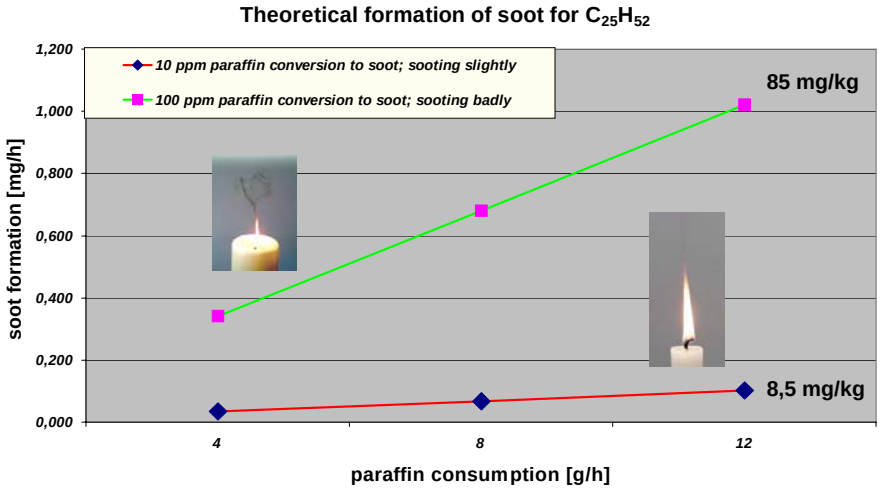
4. Which components is soot made up of and which health hazards does it present as a consequence?

The first three points are obviously of great interest for candle manufacturers and are often key elements of discussions and complaints arising from blackened walls and ceilings. This will be dealt with in more detail later.

The fourth point was, unfortunately, topical quite recently as it was being discussed in connection with consumer protection matters being disputed e.g. the massive attacks which were made on the candle in North America California (Proposition 65).
Numerous reports from institutes and environmental laboratories[3] bear conclusive witness to the fact that if the raw materials used are of the prescribed level of purity, in conjunction with the correct choice of wick and paraffin wax, a burning candle will present no hazard to health whatsoever.

Literature currently available presents varying facts pertaining to the amount of soot emitted from a candle. The fluctuation in the figures is due to the differing testing methods used and is occasionally influenced by other factors and interests.
To be honest, we must admit that every burning candle has the potential to produce soot. Even a top quality candle subjected to detrimental or fluctuating external circumstances such as draught, may soot in due course. If a candle is not sooting visibly it may still be emitting up to 1mg of soot per kilogram of candle without this being apparent to the naked eye.

A candle, which is deemed to be between the classifications of sooting and non-sooting products, will emit between 2 - 10 mg soot per kg of candle material. The maximum emission for a really badly sooting candle is between 80-100mg/kg. A higher level is, theoretically, not possible as long as the flame is being fed by the wick and the complete surface of the candle is not alight. So all results that are radically higher must be doubted, or at least viewed sceptically, as they exceed the maximum threshold. In **picture 8** the theoretical soot formation of a paraffin with the C number of 25 is depicted.



Picture 8 Soot graph

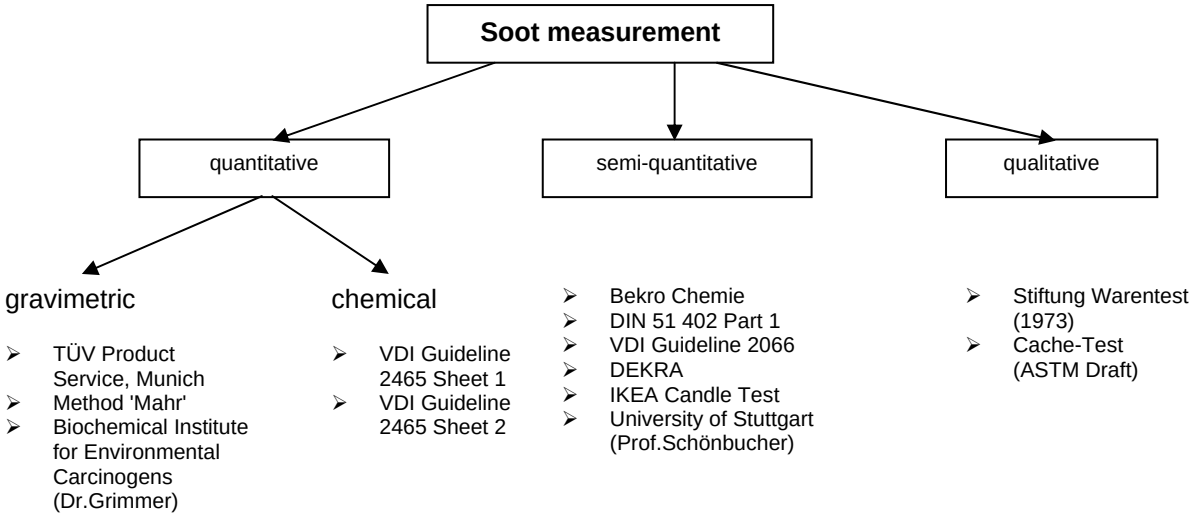
The next important question is the allocation of the soot to its real origin.
The German Candlemaker's Association has put a great deal of effort into finding a satisfactory answer as to how to determine the origin of soot conclusively. However, at present we must admit that none of the investigations carried out have led to totally reliable methods being named, which guarantee conclusive, watertight results. Two different promising directions are currently being followed, chemical analysis of soot and visual verification using electron microscopy.
Chemical analysis of the PAH distribution in soot can help to define the soot's 'fingerprint' and may be able to eliminate some other sources. The difference between particle structures, size and construction/shape are the differentiating criteria that can be defined and made visible when using the electron microscope. Scientific investigations have shown that types of soot

(3) K.-H. Schwind, J. Hosseinpour, H. Fiedler, C. Lau, O. Hutzinger, UWSF-Z. Umweltchem. Ökotox. 6 (5)

differ according to their origin. Generally speaking the differences are based on burning conditions such as flame temperature and the mix/ ratio of fuel and oxygen.

One can read of a vast number of methods that claim to be able to determine the origin of soot. These methods range from the complicated, such as VDI directive 2465, to simple, such as the so-called 'tile test' which was being discussed by the US Candlemaker's Association.

Picture 9 gives an overview of the wide variety of methods for measuring soot currently in use**.** A multitude of methods has been developed over the years and there are things to be said for and against most of them.



Picture 9 Soot measuring methods

Generally speaking they can be divided into three groups:

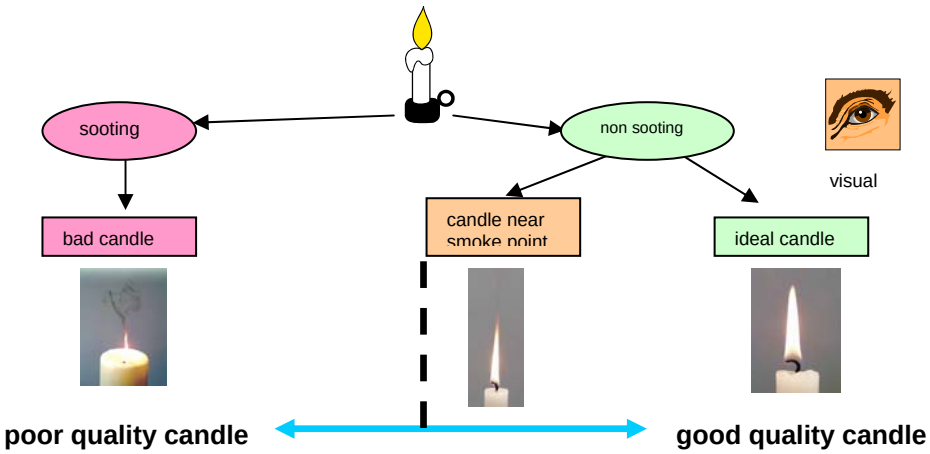
- quantitative measuring methods to define the amount of soot
- semi-quantitative measuring methods
- those which concentrate on the measurement of quality (to determine the soot components)

It is necessary for the candle industry to decide upon a single method so that future quality discussions can be based on objective comparisons, which have the same starting point. However, it should be clearly said that all of the methods listed here, although they may be suitable in the development phase e.g. to fix values in connection with soot related discussions, are unsuitable for simple production control. For control during the production process a quick, simple method is necessary.

The main factors which influence the formation of soot should be considered first. These are the fuel/oxygen ratio, the flame temperature and the critical fuel flow (which is probably better known as the wax consumption per hour).
Oxygen deficiency can result from too many candles being burnt simultaneously within a confined space whereas temperature influences can result from draughts. Temperature also plays a decisive role in the complete incineration of the soot. If the temperature sinks below 1000ºC the oxidisation of the soot will halt, irrespective of how much oxygen is available. However, the most important factor is the critical fuel flow.

Quality control during candle production must be able to differentiate between a candle that complies with and fulfils quality demands and one which does not. In order to observe the sooting behaviour it is only of importance to decide whether a candle is sooting or not.

Knowledge of soot amount and/or composition is of no importance in this case. No special measuring method is necessary, a simple visual check is sufficient to ascertain whether the candle is sooting or not **(picture 10)**. Only candles that can be classified as borderline to sooting need to be especially observed.



Picture 10 Soot measuring methods for practical use

It is, therefore, suggested that a simple method that will monitor and notify you if sooting occurs be integrated into existing production controls. It is not necessary to have a complicated, costly method that will be time consuming to operate. Nor is it necessary at this stage to ascertain accurate figures, the type of soot structure or its composition. Using the existing burning test conditions the determination of the wax consumption and the evaluation of its parameters in relation to the critical fuel flow (determined during the development phase of the candle) is important information related to the sooting behaviour. The existing measuring methods should be extended to incorporate a procedure that gives notification of sudden soot emission. An optical process e.g. scattered light and use of an absorptiometer measurement linked to an acoustic signal could be used. Sooting candles could thus be quickly singled out visually and the necessary steps taken to avoid the formation of soot.

To summarise, it is absolutely imperative that candle producers and raw material suppliers agree on criteria for top quality and collaborate to ensure that only candles that fulfil the given criteria reach the market. The consumer, not only the dealer/trader or retail chain, must be able to recognise quality seals which differentiate this standard of quality.
The establishment of a quality standard for candles must be a joint target for all candle producers, despite all competitive pressures. The national and international associations should adopt the role of the enablers for such activities.

The candle has a long tradition, originally offering warmth and light. In Europe today it symbolises comfort, romance and relaxation. Consistent production growth is a sign of this development. It is our duty to guarantee that this positive trend continues and that the candle maintains a valuable position in the world of tomorrow. We should not be the generation to jeopardise this by realising quick profit through poor quality products.

"It is better to burn a candle than to complain about the darkness but better still to burn a good quality candle".