Candles

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The High-Quality Candle

Tradition, Environment, Health

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Zusammenfassung

In den letzten Jahren ist nicht nur ein Anstieg des Kerzenverbrauches, sondern auch eine gesteigerte Nachfrage nach hochwertigen Kerzen zu verzeichnen. Mit zunehmendem Qualitats- und Umweltbewußtsein des Verbrauchers sind auch die Anforderungen an die Kerzenqualitat gestiegen.
Die in den Medien haufig gefuhrte Diskussion über die durch brennende Kerzen verursachte Belastung mit Schadstoffen wie polyzyklischen aromatischen Kohlenwasserstoffen und die Gefährdung durch Polychlordibenzodioxine und -furane, die auf lila Kerzen zurückgefuhrt wird, ist nach neueren wissenschaftlichen Erkenntissen völlig unbegründet. Abbrandversuche haben ergeben, daß bei 20 gleichzeitig brennenden Kerzen im Vergleich mit Reinluftgebieten (z. B. Schwarzwald) keine höheren Konzentrationen an polyzyklischen Kohlenwasserstoffen entstehen. Durch die Analysenergebnisse der Raumluftkonzentrationen an Polychlordibenzodioxinen und -furanen konnte gezeigt werden, daß die Werte nach dem Abbrennen von 20 lila gefärbten Kerzen nicht erhoht waren.
Durch die wissenschaftlichen Untersuchungen wurde somit nachgewiesen, daß brennende Kerzen, (lila) gefarbt oder lackiert, kein gesundheitliches Risiko darstellen.

Abstract

In recent years an increase not only in candle consumption, but also in the demand for high-quality candles has been observed The requirements for the quality of candles have increased along with growing consumer quality-consciousness and environmental awareness.
According to the latest scientific findings frequent discussions in the media, concerning problems with harmful substances such as polycylic aromatic hydrocarbons produced by burning candles and the risks caused by polychlordibenzodioxines and polychlordibenzofuranes resulting from burning purple candles, have been discovered to be completely unfounded. Experiments have shown that burning 20 candles simultaneously does not produce a higher concentration of polycylic aromatic hydrocarbons than that found in pollution-free zones (e.g. the Black Forest). Results prove that indoor-air concentrations of polychlordibenzodioxines and polychlordibenzofuranes did not increase after burning 20 purple-dyed candles.
Consequently, scientific tests have established that burning (purple-) dyed or varnished candles does not present any health risk.

Introduction

Originally, the candle was used exclusively as a source of light. The forerunner of the candle was the torch, which was superseded by oil and tallow lamps as a means of lighting. From the 15th century on, wealthy families used beeswax candles instead, due to the disadvantages caused by the bad smell and dirt produced when using tallow candles and oil lamps. The great halls of fortresses and castles were lit primarily by beeswax candles, whereas cloisters used tallow and wax candles. The production of stearin candles has been known since the first half of the 19th century. Shortly thereafter it was discovered that the paraffin found in petroleum could also be used for manufacturing candles. Despite the introduction of other sources of light, such as the petroleum, gas and electric light, the candle has not disappeared from daily life. Nowadays it is impossible to imagine life without candles gracing festive occasions, religious events and, of course, romantic settings. In addition to the warm light it sheds, a burning candle creates a feeling of cosiness, comfort and well-being.
For some time the media has reported on harmful substances such as aldehyde, polycyclic aromatic hydrocarbons and dioxines, which arise from burning candles. Chloranil, the base product employed in the production of purple dye, has also been discussed.
This report aims, among other things, to document the results of scientific studies carried out to investigate the emission of harmful substances when burning high-quality candles.

Raw materials for candles – burning material

High-quality candles are made of wax, a collective term used for various products of animal, vegetable or mineral origin. The term wax involves several substance classes which differ in their chemical structure, but have common properties such as meltability or insolubility in water.
Essentially, beeswax, stearin and paraffin are the three basic raw materials best suited for the production of candles. Beeswax is made up of a mixture of waxy acidic esters, free waxy acids and hydrocarbons, stearin of a pure fatty acid mixture and paraffin of a mixture of solid hydrocarbons. Hydrocarbons are compounds of carbon and hydrogen, called paraffins owing to their very low reactivity (parum affinis). Paraffin waxes industrially produced from petro-

leum have been the major product in the manufacture of wax for decades. These are relatively economical and are used extensively in the production of cheese wax, paper for bread packaging and candles. Paraffin is the main raw material for candle production and is used in the manufacture of nearly all high-quality candles (candles for household use, Advent and Christmas).
The mineral oil fractions containing paraffin are dissolved and cooled by suitable methods, causing the paraffin to crystallize. After separating the liquid element, the appropriate purification process is used to form the finished product. Products customary in trade are made up of straight and branched hydrocarbons with 17 to 40 carbon atoms.

Requirements for high-quality candles

Quality and description regulations for candles were published for the first time in 1966 and revised in February 1993 by the RAL Deutsches Institut für Gutesicherung und Kennzeichnung [German Institute for Quality Control] (1) under the designation RAL 040 A2 and with the purpose of informing consumers about candles.
Candle consumption has grown steadily over the past few years, and this trend seems to be continuing. Consumer quality-consciousness has also increased, however, and with it the preference for high-quality beeswax, stearin and paraffin candles. Consumers react critically to poor quality, e.g. soot build-up, due to growing environmental awareness. As a result, standards for high-quality candles as well as their use have increased. The following requirements refer to burning conditions with no draft:

- good stability, i.e. candle should not bend at normal room temperature.
- a constant and quiet flame; contained water droplets is often the reason for a crackling flame. Irregular flickering is frequently due to an oversized wick.
- the formation of a correct burning surface below the flame; this ensures that the amount of candle material that is used up by the flame will melt per unit of time.
- smoking or soot build-up; often due to an incorrect relationship between candle diameter and wick size.
- lack of ash build-up; ashes can build up due to non-burnable materials (impurities in candle material or dyes).
- wick position.

The »candle material« or »candle mass« which makes up the body of the candle is composed of raw materials for candles such as beeswax, stearin and paraffin. Additional materials such as binding, hardening and clouding agents, dyes and other substances such as perfumes are utilized.
Wick quality, also subject to strict requirements, will not be dealt with further this report. An optimal relationship between (candle) raw materials, wick and dye must be achieved for various production methods (pouring, drawing, pressing, extruding, dipping) to ensure problem-free burning. The correct balance of wax mixture, candle form as well as type and thickness of the wick being used has an effect on burning and also influences negative properties such as soot build-up or dripping. Furthermore, the wax mixture itself must evidence certain properties which are required for candle production. It must be able to be pressed, melted, drawn, poured or worked on when soft. As previously mentioned, paraffin is the raw material most often used in the manufacture of candles due to its particular suitability for candle production. Composition candles such as church candles, made from a mixture of paraffin and stearin, solid fats, solid wax or beeswax, are also customary in trade in addition to pure paraffin candles.
Various types of paraffin are used for pouring, drawing, pressing, extruding or dipping, depending on the production process selected. Pure paraffin is colorless, tasteless and odorless, and only full-refined paraffin is used in manufacturing high-quality candles. Any possible harmful substances are removed by a modern, environmentally-friendly purification process (e.g. high-pressure hydrogenation [2]) and the paraffins are then subject to constant quality controls.
As mentioned above, not only are the raw materials, production process and wick important, but the dye used is decisive when burning high-quality candles. There are various possibilities for dying candles:

- dying: before being pressed, the candle material is dyed with a fat-soluble dye or a suitable pigment of the desired color.
- dipping: the candle body is immersed in a dye-bath which has achieved the required color with the use of pigments. Consequently, the candles are only dyed on the surface.
- coating with colored varnish.

To ensure safety and quality of these candles, various tests are carried out on burning (a constant and bright light), soot-production (minimal soot build-up), dripping, homogeneity, color quality, wick function, stability, breakage and mechanical stability. The basic product must appear to be dry, i.e. it should not be greasy, fatty, oily or sticky, and should be light in color and odorless. Candle stability is important, especially when several candles are burning simultaneously and could influence each other.

Scientific Experiments of Indoor Air After Candle-burning

a) Measurements of polycyclic aromatic hydrocarbons (PAH) concentrations

Harmful substances from the PAH substance class are produced by pyrolysis (incomplete burning) of organic materials and emitted extensively into the environment when burning various products (gasoline, diesel fuel, tobacco and wood, coal and oil firing).
In burning tests using 20 candles, dyed or varnished with oil-based dye or pigment, the PAH concentrations formed were measured in a test-room of 18.5 m^2 (2.6 m high). Benzo(a)pyrene (BaP), the most widely-known and frequently-tested representative of this substance class, is regarded as the indicator for the simultaneous existence of several of these harmful substances in their respective media (water, soil, air). The concentrations of BaP recorded after burning candles, shown in **Tab. 1,** are representative of PAH levels when compared with atmospheric concentrations in rural and urban areas as well as in passive smoke from cigarettes. The range of values of the BaP concentrations measured is shown in **Fig. 1.**
As the values show, the amount of BaP emitted during burning is very low. The BaP concentration produced after burning either dyed or varnished candles lies between 0.4 and 1.2 ng/m^3 (3), based on the control value (the level in the empty room prior to the experiment). This indicates that PAH concentrations are not higher when burning 20 candles simultaneously, e.g. on a Christmas tree, than in pollution-free zones, e.g. rural areas.
Both **Tab. 1** and **Fig. 1** also show that concentrations up to 5 times as high are

Source/Atmosphere	BaP Content (ng/m³)
Indoor air before burning candles	≤ 0.4
20 candles with oil-based dye/pigment	0.5–1.2
20 varnished candles	0.4–1.0
Rural area (Black Forest, Bavarian Forest, Hunsrück[1])	0.4–1.5
Urban area (Duisburg[1])	5
Passive smoke from cigarettes[1]	22
TRK value[2]	2000

[1] From reports from the German Federal Environmental Agency (4), 1/79
[2] Technical concentration guideline

Tab. 1 Benzo(a)pyrene concentrations

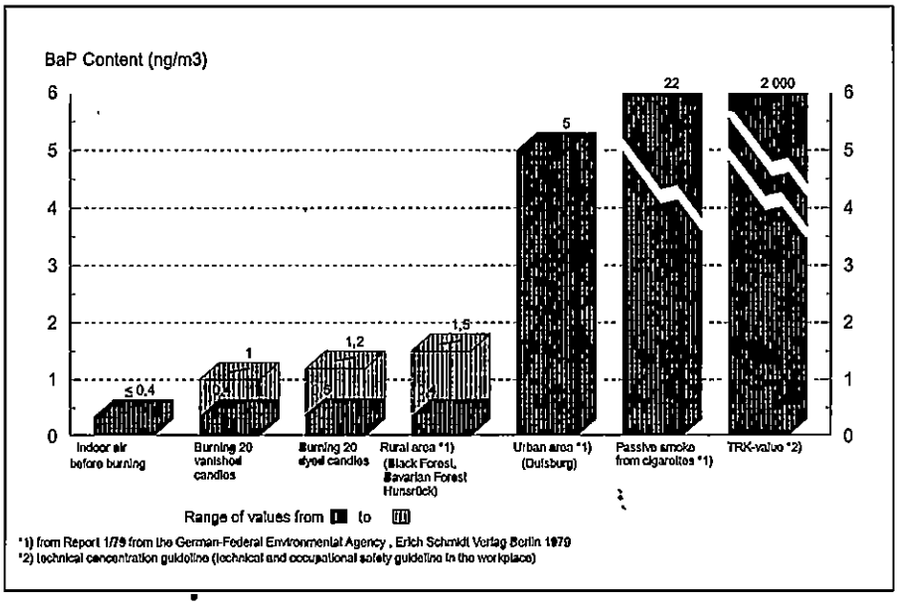

Fig. 1 Benzo(a)pyrene concentrations

found in urban areas. In comparison with the level recorded when burning 20 candles simultaneously, the BaP content in passive smoke from cigarettes, the amount of smoke inhaled not by smoking directly but inhaled passively with the air normally breathed, was up to 22 times higher. The technical concentration guideline in the workplace (TRK value, technical and occupational safety guideline) is up to 1000 times higher than the BaP concentration produced by candle flames (5).

b) Measurements of polychlordibenzodioxines and polychlordibenzofuranes concentrations

Traces of substances from the dioxines substance class can be found in nature. The most poisonous among them is 2,3,7,8-tetrachlordibenzodioxine, known from the Seveso accident.
Assessment of indoor-air concentrations of polychlordibenzodioxines and polychlordibenzofuranes were made both before and after burning 20 purple-dyed candles (250 mm long and 23 mm in diameter, approx. 60 g, with a 9-hour burning time) in a room measuring 18.5 m² (2.6 m high). The results have been compiled in **Tab. 2,** with an illustration of the values shown in **Fig. 2.** The study showed that the values of the polychlordibenzodioxines and polychlordibenzofuranes measured before burning were below the indoor precautionary level recommended by the Hamburg Health Authority (500 femtograms [fg = 10^{-15} g] ITE [Internationally-determined Toxicity Equivalents = value in relation to a reference substance in this substance category with the highest toxicity]/m³) and had not increased after burning the candles (6) The values presented in **Fig. 2** do not differ significantly.
Therefore scientific studies show that burning high-quality candles does not cause a significant increase in the content of harmful substances such as polycyclic aromatic hydrocarbons, polychlordibenzodioxines or polychlordibenzofuranes in enclosed areas.

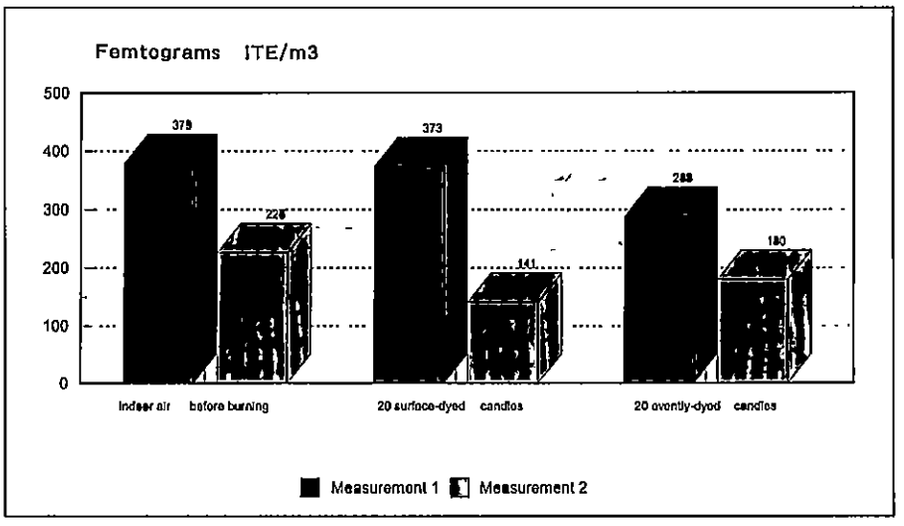

Fig. 2 Polychlordibenzodioxines and polychlordibenzofuranes concentrations

Test sample	Test No.	fg ITE/m³
Indoor air before burning candles	1	379
	2	226
20 surface-dyed candles	1	373
	2	141
20 evenly-dyed candles	1	288
	2	180

Tab. 2 Polychlordibenzodioxines and polychlordibenzofuranes concentrations while burning purple-dyed candles

Discussion and Final Conclusions

Studies of environmental compatibility of paraffin, in which biodegradability is examined, have shown that paraffin decomposes rapidly and completely (more than 60% within 4 weeks) under laboratory conditions and can be classified as biodegradable. Under natural condi-

tions, in open air under a leaf litter layer, complete decomposition also results, whereas paraffin decomposes at the same speed as paper and leaves (7). In addition, these paraffins do not accumulate in the biosphere, are not eco-toxic and, thanks to their excellent biodegradability, are environmentally-compatible (8).

The formation of aldehydes (e.g. formaldehyde, acetaldehyde, and acrolein) can be widely avoided if candles are burned in rooms with a sufficient supply of oxygen (excluding drafts).

In connection with polycyclic aromatic hydrocarbons, also mentioned at the beginning of the article, trial burnings with dyed and varnished candles have shown that higher concentrations of the potentially cancer-causing PAH were not found in a pollution-free zone (e.g. the Black Forest) as compared to a room where 20 candles are burning simultaneously (as, for example, on a Christmas tree).

According to current scientific information, the concentrations of dioxines assessed in the trial burning of purple candles are not related to health risks. The amount inhaled normally is extremely slight and comes to a small percentage of total daily intake, therefore remaining well below the concentrations considered damaging to one's health. Over 90 % of the average intake of dioxine occurs by ingesting normal foods such as dairy products, meat and fish.

The various headlines appearing in the press, e.g. referring to »Dioxines in Purple Candles« were refuted in a statement issued by a manufacturer of the pigment Violet 23 used in dying the candles. The manufacturer confirmed that the traces of polychlordibenzodioxines and polychlordibenzofuranes found in the pigment were considerably below the requirements stipulated in the legislation concerning toxic substances. In particular it should be mentioned that the tetrachlordibenzodioxine (2,3,7,8-tetrachlordibenzodioxine known as Seveso poison) and pentachlordibenzodioxine derivatives could not be detected in this pigment. The basic product chloranil, used in the synthesis of pigments, also falls below the required levels, so that the use of candles dyed with this product does not pose any health risk.

Toxicologists who were inquired on this subject were in agreement that there were no grounds for assuming that any risks were caused by burning purple-dyed candles. This was also confirmed by the results of indoor-air concentration experiments of polychlordibenzodioxines and polychlordibenzofuranes produced by burning purple-dyed candles. Therefore there is no health risk to a person in a room with 20 purple-dyed candles burning simultaneously as, for example, on a Christmas tree.

In conclusion it may be stated that evidence has been established by the results of scientific experimentation, showing no health risks to consumers by the presence of harmful substances (polycyclic aromatic hydrocarbons, polychlordibenzodioxines and polychlordibenzofuranes) when burning high-quality candles. Toxicologically speaking, neither the paraffins, used in the production of high-quality candles nor remaining in the vicinity of burning candles pose any health risk whatsoever.

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