Survey of chemical substances in consumer products
no. 39, 2004

Survey and emission of chemical substances from incense

Torben Eggert

Ole Christian Hansen

Danish Technological Institute

Danish Environmental Protection Agency

Danish Ministry of the Environment

Contents

Preface

This report on survey, emission and evaluation of chemical substances released from incense is a part of the Danish Environmental Protection Agency's programme "Survey of chemical substances in consumer products".

The purpose of survey and measuring emission of chemical substances from incense is to determine which chemical substances that are released during burning of incense and to evaluate the exposure to the consumer of incense.

The study was already in its early days expanded from incense sticks to incense in general, i.e. as incense sticks without a stick, cones, nuggets, granulates and herbs.

The project is prepared by the Danish Technological Institute.

The persons involved are:

Torben Eggert,	responsible for the project and responsible for performing the emission measuring
Ole Christian Hansen,	evaluation of measured chemical substances
Eva Pedersen,	chemical analyses.

The project was followed by a steering committee consisting of:

Anette Albjerg Ejersted, Danish Environmental Protection Agency
Annette Orloff, Danish Environmental Protection Agency
Torben Eggert, Danish Technological Institute
Ole Christian Hansen, Danish Technological Institute

Importers/retailers have had an opportunity of commenting on the report before publication. Several comments from these are included in the report. All importers/retailers have been very interested in the report result. They will in the future give advice to their costumers regarding the importance of ventilation in the room after using incence so that the smoke can emit. That way incense can be used as safe as possible.

Special thanks are given all the importers/retailers who have contributed with knowledge and information of the use patterns types of products and delivering of samples to the investigation. They have all been very cooperative and given valuable knowledge to the project.

Sammenfatning og konklusioner

Som et led i Miljøstyrelsens kortlægning af kemiske stoffer i en række forbrugerprodukter ønskes viden om, hvilke stoffer der afgives fra røgelse. Projektet "Kortlægning og afgivelse af kemiske stoffer i røgelse" udføres i 3 faser. Undersøgelsen omfatter kortlægning af markedet, kvalitative og kvantitative analyser samt en sundhedsmæssig vurdering af eventuelle sundhedsskadelige effekter fra stoffer frigivet ved anvendelsen af røgelse.

Markedet omfatter røgelsespinde, røgelse i fast form som pinde eller toppe, som granulat eller i løs vægt (afbrændes på glødende røgelsestrækul). Anvendelsen er spredt. Forbruget antages at være stort hos især indvandrere og i visse alternative miljøer af religiøse, terapeutiske eller andre årsager. Markedet i Danmark er rimeligt uoverskueligt.

Der foregår ingen produktion af røgelse i Danmark. Importen er spredt på få store og et ukendt antal små importører. Import via Internettet er antageligt forekommende, men en stor del hjembringes formentligt også via udlandsrejsende. Opmærksomheden omkring alternativ medicin (healing, aromaterapi, osv.) kan have betydet en øgning af salget de senere år, men også almindelige livsstilsændringer kan have være med til at øge forbruget af røgelse.

Et råt estimat af import og forbrug var mellem 1-10 tons/år. En vurdering baseret på samme forbrugsmønster som i USA indikerer et årligt forbrug på ca. 3 tons.

Der blev indkøbt 36 forskellige typer røgelse og af dem udvalgtes 12 til screening. Det vil sige, der blev foretaget head-space analyser af flygtige stoffer fra de uantændte røgelser. Baseret på disse resultater blev der herefter foretaget en kvantitativ analyse af kemiske stoffer i røgen fra 6 udvalgte røgelsespinde og toppe.

De afgivne mængder af røg blev opfanget under afbrænding ved kontrollerede forhold i laboratoriet. Aerosoler blev opfanget på glasuldsfilter og de øvrige komponenter opfanget på aktivt kul, XAD2 og DNPH filtre. Filtrene analyseredes, og resultaterne blev omregnet til mængde per røgelsespind og per time. De af Miljøstyrelsen udvalgte stoffer blev herefter vurderet enkeltvis.

Undersøgelsen af røgelse viser, at det ikke kan udelukkes, at der kan være visse sundhedsmæssige problemer forbundet med anvendelsen af røgelse for forbrugeren.

Andre undersøgelser støtter, at røgen fra røgelse kan indeholde stoffer, som kan være sundhedsskadelige. Der kan være tale om akutte effekter som irritation af øjne, næse og hals, og ved længere tids eksponering kan der være tale om kontaktallergi eller ligefrem om endnu mere alvorlige effekter.

Undersøgelsen viste, at det specielt var forbrændingsprodukter, som er kendte fra ufuldstændig forbrænding af organisk materiale, der var problematiske.

Det burde ikke undre, eftersom forbrændingen foregår som en glødebrænding ved temperaturer, der blev målt til omkring 200-360°C.

Det må derfor kraftigt anbefales at foretage udluftning under og/eller efter røgelsen er anvendt. Det vil reducere koncentrationen af forbrændingsrester i luften til under de kritiske koncentrationer, der er skønnet i undersøgelsen. Erfaringen er, at der alligevel bliver tilstrækkeligt duftstof tilbage med de ønskede virkninger.

Summary and conclusions

The Danish Environmental Protection Agency's programme on survey of chemical substances in consumer products initiated a study on chemicals released from incense. The project "Survey and release of chemical substances from incense" is performed in three phases. The study includes a survey of the market, qualitative and quantitative analyses and a health assessment of potential adverse effects from substances released during use of incense sticks and incense.

The market includes incense sticks, incense in solid form as sticks (joss sticks) or cones, granulates or powders. The loose weight types are ignited by glowing charcoal. The consumption is disperse. The use of incense is assumed high within immigrants and in certain alternative groupings for religious, therapeutic or other causes. The Danish market on incense is fairly chaotic.

No production of incense sticks takes place in Denmark. The import is scattered on a few large and an unknown number of minor importers. Import via the Internet is presumable but a large part is assumed brought in from abroad by tourists and other travellers or personal contacts. The focus on alternative medicines (healing, aromatherapy, etc.) may have increased sales in recent years.

A preliminary estimate of import and consumption was 1 to 10 tonnes per year. An estimate based on the assumption of similar use pattern as in the USA indicates an annual consumption of approximately 3 tonnes.

36 different types of incense were purchased and from them 12 were selected for screening analysis. The analyses were performed as head-space analysis of volatile compounds released from the unignited product. Based on the results, six incenses were selected for quantitative analyses of volatile compounds in the incense smoke.

The incense smoke was sampled during incense burning under controlled laboratory conditions. The aerosols were sampled by glass fibre filter and the gasses absorbed on active carbon, XAD2 and DNPH filters. The filters were extracted and analysed and the results recalculated to amount of chemical substance per incense stick or top and amount emitted per hour. Chemical substances selected by the Danish Environmental Protection Agency were then assessed individually.

The study on incense shows that health risks to the consumer from the use of incense can not be excluded.

Other studies support the result that incense smoke contains chemical substances that may cause health risks. It could be acute effects like irritation to the eyes, nose or throat. On long-term exposure, the effects could be contact dermatitis or even worse effects.

The study showed that especially combustion products known from incomplete combustion of organic material were problematic. This would not be surprising since the combustion takes place as a glow burning at temperatures measured to be about 200 to 360ºC.

It is therefore highly recommended to ventilate the location during and/or after the use of incenses. Ventilation may reduce the exposure concentration of combustion residues in the air to concentrations below the critical values estimated in the study. The experience is that sufficient amounts of the fragrances containing the envisaged odorous effects still remain in the air.

1 Introduction

The Danish Environmental Protection Agency wished to perform a survey of the market of incense sticks in Denmark. The initial project formulation was later expanded to include incenses in other forms i.e. besides incense sticks also solid forms such as granulates, cones and powders (e.g. dried herbs or herbal mixtures).

1.1 Product description

Basically, incense is dried plants (herbs or wood) which is pulverised and mixed with resins. The sticks in incense sticks may be of sandalwood, bamboo of similar material that has the ability to burn together with the wrapped plant ingredients. Some incense mixtures are composed of dried and finely chopped herbs, woods and roots, others from resins and balsams as small pellets or granules. Incense may be mixtures but may also consist of one single type of incense based on single plants or plant parts. Besides, an addition of essential oils can be used that can be natural or synthetic

A traditional method is described as a paste of pulverised botanical material, water, charcoal, etc. wrapped around a bamboo stick. After drying the stick is dipped into perfumed essential oils or powders.

The survey showed that on the Danish market, 4 common types of incense existed: loose incense (granulate or powder), cones, incense sticks with and without solid stick. The latter was a long thin solid incense substance without stick.

The loose incenses typically consisted of few compounds. They may be dosed according to need but requires a heating source to burn.

Other incense types consist typically of four basal ingredients: the aromatic substance, a base or substance that may help to keep the burning going, a binding agent to keep the mixture together and a liquid to glue the entire product together while it is formed.

The aromatic substances may be a herb, spice or a fragrance chosen according to the purpose. The base is usually a substance that burns easily and releases little or no smell. The base is necessary as most herbs have low ability to burn by itself. The base may be powdered wood such as very fine sawdust, sandalwood or other wood species, needles from evergreen woods (e.g. pines), etc. The speed of burning can be regulated using talc to slow down and potassium nitrate (saltpetre) to increase the combustion.

The binding agent is typically resins or similar.

The liquid is typically essential oils.

The manufacture of incense and incense sticks are currently often performed by mass production in factories with the exception of countries where the manufacture traditionally is a handicraft, e.g. India and countries in Southeast Asia. Production ways of incense depends however very much of the type of incense and the producer.

1.2 Use

The use of incense goes so far back in time that the origin is unknown but the use is spread widely in the entire world. The burning of aromatic plants as incense is probably the oldest method to use fragrances. The use to overwhelm or drown bad smell, which inevitably had to be combined with evil, has probably been recognised in early days. The step to use incense more specifically within religious, cultic and healing purposes appears to be taken at several places independently of each other. Descriptions of such uses exist in Europe, Africa, Asia, South America and North America.

Incense is currently used as a common name for a series of compounds acting cleansing, medically and consciousness expanding.

The use within monotheism (Catholicism, Buddhism, Islam, etc.) as votive or sacrifice has a long tradition behind it.

Current religions use incense: both within Christianity (in Roman Catholic and Greek Catholic religious ceremony) as well as in Islam. The uses are also widely spread in the East, e.g. within Buddhism and Hinduism.

In America description of the use within shamanism and other Indian uses (sweathouses and other cleansing processes, e.g. sage in cleansing processes).

Several of the essential oils are known to have antimicrobial effects. The effect to microorganisms is probably a result of the plants originally having developed the substances to their own defence against attack from microorganisms, insects, etc.

The uses apart from ceremonial such as consciousness expanding substance and in aromatherapy in healing procedures have also been described.

Meditation and yoga may in certain situations also use incense as a part of the procedures.

The use of incense does however not have to be related to the described religious, ceremonial or healing purposes. A larger part of the consumers uses the incense as pure pleasure. Some connect the use of incense with a cosy atmosphere and it is a part a their regular daily life.

1.3 Use types

For religious purposes and shamans often use mixtures, however, for meditation pure herbal types are often used.

The quality may vary from pure herbs to mixtures of herbs or with the addition of synthetic compounds (chemically synthesised aromatics). The purity is often directly related to the price level where mixtures and synthetic aromatics are less expensive than pure herbal types.

For healing often pure herbs or essential oils are used (the latter is not included in this study).

The most common incenses in Denmark is probably the less expensive types of mixtures that can be purchased in ethnic shops (Indian, Chinese, Pakistani, Thai, etc.), ”Christiania”, 10-kroner shops, etc. It mostly concerns mixtures. The quality may vary and include or exclude synthetic oils. The price is often low.

Besides from these there are a lot of different incense mixtures on the market e.g. Arabian, Indonesian, Japanese, Tibetan, etc. Also via the Internet and Health shops are different types of mixtures and pure herbal incenses purchased.

1.4 Use method

Incense sticks are ignited and the flame blown out so that the product glows while emitting smoke and aromatics (fragrances).

The incense may be ignited directly but may also be placed on glowing incense coal (charcoal compressed as briquette) and during burning release smoke and aromatics. This method is especially used for loose incense such as powders and granulates.

A few of the dealers include instructions. They suggests in their instruction to air the smoke (ventilate the room) so that only the fragrance remains in the room. It is also suggested that an entire incense stick may be too much and recommend incense to be used in small amounts.

1.5 Target groups

The target group of consumers of incense is wide but assumed to be 15 to 55 years old for the less expensive mixtures and 30 to 55 years old for the more advanced uses of more expensive and/or pure herbal types. The consumers are often women.

Excluding proper religious ceremonial purposes the use for meditation or as consciousness expanding substance is common among certain groups of the population. Incent is also used just to create a cosy atmosphere and as a part of pleasure and enjoyment in their daily life.

Some use within the erotic line of business or among homosexuals is indicated on the labels of the packages and by certain retailers.

2 Survey

2.1 Amount

Due to a widely dispersed individual import and no specific registration in Statistics Denmark, the assessment of the consumption is based on conversations with single importers. However, the consumption could not be narrowed down to a more specific amount than ”a few tonnes”. Besides the import of ready-made products, imports of herbs, aromas, etc for home manufacturing by people within religious or healing groups and smaller companies also exist.

The survey was tried performed traditionally by searching in statistics and by inquiries to importers and retailers.

The survey was found to be difficult as no structure of few importers and retailers existed. On the contrary, the market was characterised by anarchy: From a few importers to many retailers importing on their own to consumers buying via the Internet, bringing incenses home from travels, etc.

Several retailers were visited and questioned to find the importers. A few importers have been found. The import by single importers varied from a few kilos to approximately 500 kilos per year. Retailers informed that the sale of incense varied from a few kilos to 125 kg per year. The sales were by several shopkeepers stated to be increasing.

Based on the identified importers approximately 1 ton of incense was imported per year.

Statistics Denmark does not have a specific category for incense or incense sticks. The categories closest to incense are a total figure for plant resins, dried herbs or single data on specific plant oils. Those figures indicate an import of approximately 20 tonnes (Danmarks Statistik 2002). However, the statistics are uncertain due to a mixture with other commodity groups. Because the import of dried herbs, spices and aromatics to a large extent is used within the food and perfumery industries, these figures can not be used in this survey.

Based on interviews with importers and retailers the consumption was estimated to be between 1 and 10 tonnes per year.

An estimate could also be based on an assumption that the pattern of consumption in Denmark is similar to that of the United States of America. In the USA, the consumption is estimated to at least 17 million $ exclusive of manufacturing for private uses (Knight *et al.* 2001). If the total value is assessed at 20 million $ corresponding to approx. 150 million DKK and assuming a population of approx. 300 million, the consumption is 0.5 DKK/inhabitant. The retail price in Denmark is on average the same as in the USA: approx. 10 DKK for 10 grams or 1 DKK/g. Thus, in Denmark, a similar consumption by 5 million inhabitants would correspond to 5 million × 0.5 = 2.5 million g or 2500 kg.

It is assessed from the interviews that a large part is imported directly by the single retailers from the producing countries or via the Internet. Purchase via the Internet can be performed by both retailers and consumers.

The retailers were especially ethnic shops (Indian, Chinese, Pakistani, Thai, etc.) and a few Danish shops such as Søstrene Grene, 10 kroner shops. Besides that single businesses may import incense for spot articles (e.g. COOP Danmark).

It is concluded that the private import from minor retailers and consumers is approximately 2-3 times the identified import. Thus the total consumption is estimated to be approx. 3000 kg/year.

2.2 Sampled types

Of the 36 collected samples the products are distributed as:

1) Incense sticks with stick and consisting of different mixtures or specified fragrance types such as lemon, lavender, lily, rose, vanilla etc.

2) Incense sticks without stick consisting of mixtures and often with a specified fragrance.

3) Incense cones consisting of mixtures or with a specified fragrance type.

4) Incense mixtures as granulate consisting of mixtures or with a specified fragrance type.

5) Incense as dried plant parts. The latter usually burned on incense charcoal.

Of the 36 collected samples, 12 are selected for qualitative analysis (screening).

3 Measuring and chemical analyses

By the burning of incense, particle (aerosols) and gas pollutants may be formed. Because it is mainly organic materials that is burned a series of different chemical compounds may be formed. The chemical substances contained in the incense may transform into other chemical substances during the burn besides a number of smoke particles.

A total of 36 samples were purchased. The sampling stopped as repetitions of samples became more frequent. Of the 36 different incense sticks, cones, etc. collected, 12 samples were chosen in co-operation with the Danish Environmental Protection Agency for qualitative analysis. The qualitative analysis was conducted as a screening analysis by head-space. This should give an impression of which chemical substances to expect.

3.1 Qualitative analysis (Screening)

The examination is performed as a primary screening of different incense sticks and other incense types by a head-space analysis to elucidate which stimulating fragrances that are added. The screening should at the same time indicate which collecting absorbents to select in connection with monitoring and analysis of the emission from incense sticks during burning. 12 different kinds of incense with varying stimulating additives were screened (cf. table 3.1).

Table 3.1 Samples selected for screening by head-space analysis

Lab. no.	Type	Origin	Fragrance	Comment
1	Cone	Indian	lavender	
2	Stick	Chinese	Lemon	
3	Granulate/Herbs	German/Arabic	Arabic mixture	
4	Herbs	German/Arabic	Ayurvedic	
5	Stick	Indian	Cannabis	
6	Stick	Chinese	? green colour	Chinese text
7	Stick	Thailand	? yellow colour	Thai text, with elephants
8	Stick	Hong Kong	Musk	
9	Cone	Indian	Sandal	
10	Stick	Indian	Sali sai baba	
11	Stick	Japanese	Aloewood	
12	Stick	Japanese	Cedarwood	

12 different incense sticks/-cones/-granulates were examined for their emission of chemical substances after heating to 100°C using head-space – GC/MS analysis. A known quantity was measured in a 22 ml head-space glass container. The amount weighed is presented in the table below (table 3.2).

Table 3.2 Weighed amount for head-space analyses

Lab. no.	Incense mrk.	Producing country	Weighed amount, grams
1	Lavender Cone	India	1.09
2	Lemon stick	China	0.94
3	Arabic mixture, powder	Germany	0.91
4	Ayurvedic, stick	Germany	0.98
5	Mysore Cannabis stick	India	1.43
6	Green stick	China	0.60
7	Elephant stick	Thailand	1.21
8	Wild Musk stick	Hong Kong	1.35
9	Maharaja sandal stick	India	0.87
10	Sali Sai Baba stick	India	1.00
11	Aloe Wood stick	Japan	0.71
12	Cedar Wood stick	Japan	0.58

The following analyses were performed:

- Analysis for volatile organic compounds (VOC) added to and released from unignited incense. The incense sticks were placed in a head-space glass container and heated to 100°C for one hour. A gas sample was then taken and analysed using GC/MS.
- Identification of components by comparison of the NIST 98 library spectre.
- Presenting the composition in percent of the identified components on basis of area-percentages.

The results are given in Appendix A.

The found chemical components are presented according to the retention time. The retention time is increased at increased molecular weight and therefore presents an impression of the distribution of molecular sizes.

It was found that many compounds could not be identified. Of these most were in the hydrocarbon group $C_{10}H_{16}$, which indicate that it may concern different terpenes (volatile plant compounds).

3.2 Quantitative analysis

Selection of types for quantitative analysis
Depending on which substances that were observed in the screening analysis an initial health evaluation of the identified substances was performed. The health screening was based on available literature and had the purpose to ascertain that the substances to be focused on in the quantitative analyses were the most relevant. The selection was performed in co-operation with the Danish Environmental Protection Agency.

3.2.1 Measuring programme

To measure the amount of pollution and which substances that are emitted from burning of incense, the incense material (incense sticks, -cones or granulate) was examined in laboratory tests.

The incense material was placed under a funnel. Aerosols and vapours from the burning incense was sucked through diverse filters located in the test set-up (Figure 3.1).

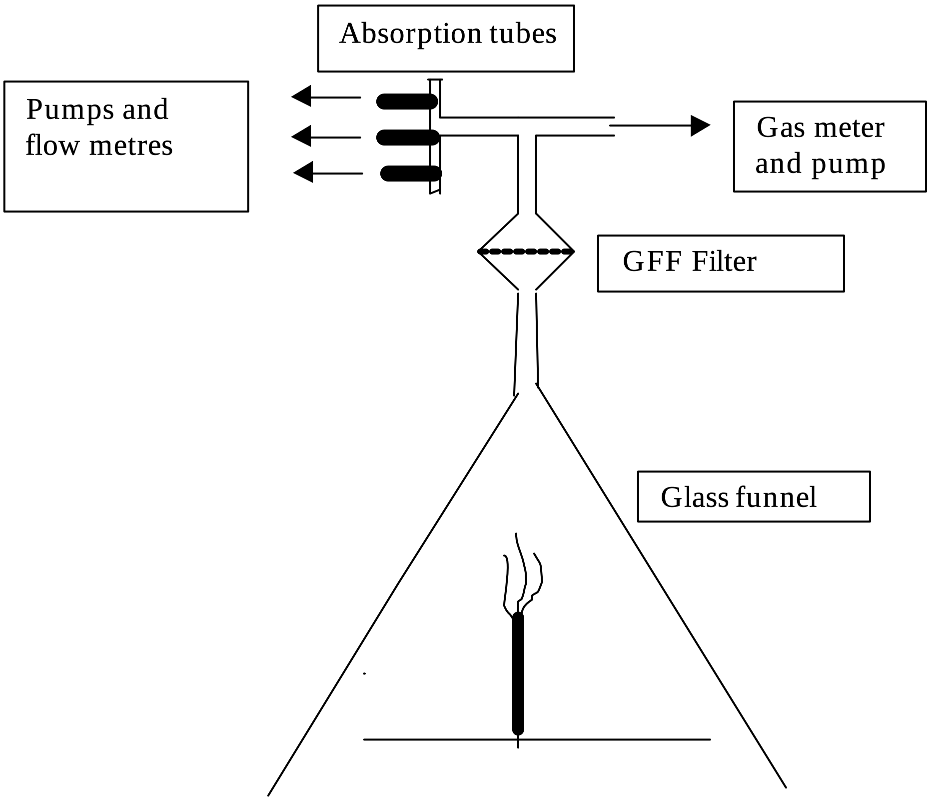


Figure 3.1 Test set-up

Aerosols were sampled on 47 mm glass fibre filters mrk. Whatman GF/F. The filters were previously glowed in an oven for 2 hours at 200°C, conditioned at 23°C and 50% relative humidity (RH) for 12 hours before they were weighed. After the exposure the filters were conditioned for minimum 12 hours at 23°C and 50% RH, and then weighed and analysed for organic components using GC-MS.

The filters were placed in a special filter holder, which was connected to a reciprotor pump with gas meter connection.

Gaseous VOC compounds were sampled on XAD2 filters mrk. Supelco Orbo 43. The VOC compounds were sampled in a partial air stream after the filter at a flow of 1.0 l/min. using a constant flow pump mrk. SKC.

Aldehydes were sampled on silicagel filters impregnated with 2,4-dinitro-phenyl-hydrazin (DNPH) mrk. Supelco L_PDNPH S10. The aldehydes were sampled in a partial air stream after the filter at a flow of 1.0 l/min. using a constant flow pump mrk. SKC.

The VOCs were sampled on charcoal filters mrk. SKC 266-09. The VOCs were sampled in a partial air stream after the filter at a flow of 1.0 l/min. using a constant flow pump mrk. SKC.

The incense was weighed before being placed in the test set-up. The test sampling period was approx. 1 hour.

Before the incense was placed in the test set-up it had been burning for 1 minute to secure an even burning.

Double determinations were performed on all analyses and the relative standard deviation (%RSD) calculated.

The detection level for the different techniques will be depending on which compounds that are detected and the volume of air sucked through (dilution). By sampling one cubic metre of air, the detection limit would be as presented in the table below (table 3.4).

Table 3.4 Detection limits and the uncertainty of measuring

Method	Detection limit of the method, mg per component	Detection limit Concentration, mg/m^3	Uncertainty %
GC-MS, screening	0.1-0.5	--	--
GC-MS solid adsorbent	0.1-1	0.1-1	10
GC-MS (PAH)	0.002-0.01	0.002-0.01	10
HPLC solid adsorbent	0.03 – 0.1	0.03-0.1	10

Selected incense for quantitative emission measurements and analyses

Based on the head-space analyses and in co-operation with the Danish Environmental Protection Agency, 6 of the purchased incenses were selected for qualitative analysis of chemical substances emitted during burning of incense. The selected types are presented in the table below.

Table 3.5 Samples selected for quantitative analysis

Lab. no. (ID no.)	Type	Origin	Fragrance
1	Cone	Indian	lavender
2	Stick	Chinese	lemon
4	Stick	German/Indian	ayurvedic
8	Stick	Hong Kong	musk
10	Stick	Indian	sali sai baba
12	Stick	Japanese	cedar wood

Data on the studied incense sticks/cones

In the table below, specified information is given on: weight of the incense, burning duration for 1 incense stick and the burning temperature in the glow of the incense stick.

Table 3.6 Specified data on the selected incenses used in the quantitative analysis

Incense mrk.	Lab. no.	Weight of 1 stick/cone gram	Burning period for 1 stick/cone, minutes	Temperature in glow °C
Lavender Cone	1	1.07	25	340 - 360
Lemon Stick	2	1.17	40	280 - 290
Ayurvedic Stick	4	0.98	36	300 - 320
Wild Musk	8	1.35	45	220 – 240
Sali Sai Baba	10	1.00	50	220 – 230
Cedar Wood	12	0.36	30	200 - 210

The results of the quantitative analysis are given in Appendix B.

In table 3.7, the results from the individual tests are summarised. In the table, the results on total aerosol based on gravimetric measurements and total amount of volatile organic components (TVOC) are presented, and the sum of pollutions added up. Since the burning duration varies between incense sticks, the results are presented both as mg/time and as mg/incense stick or – cone (i.e. mg/incense unit).

Table 3.7 Emission of aerosols and vapours (TVOC: Total VOC)

Lab. no.	Total aerosol mg/h	TVOC vapour mg/h	Sum aerosol + vapours, mg/h	Total aerosol mg/incense unit	TVOC vapour mg/incense unit	Sum aerosol + vapour mg/incense unit
1	121.155	30.009	151.164	50.619	13.517	64.136
2	45.610	18.863	64.473	30.668	12.960	43.628
4	61.531	12.782	74.313	41.302	8.351	49.653
8	164.191	33.032	197.223	136.265	29.255	165.520
10	109.729	14.814	124.543	108.642	12.667	121.309
12	31.164	10.156	41.320	16.499	4.252	20.751

Evaluatin of the emission is performed in chapter 5.

The individual chemical substances identified in the quantitative analysis er presented in Appendix B, the adding up in Appendix C.

At a meeting in November 2003, it was decided in co-operation with the Danish Environmental Protection Agency to perform a health assessment of the effects from the following substances, which were observed in the quantitative analysis of the emission from the burning of incense:

Aldehydes:
- Acetaldehyde
- Acrolein
- Formaldehyde
- Furfural

Aromatic hydrocarbons:
- Benzene
- Styrene
- Toluene
- Xylene

Others:
- Benzofuran
- 4,4-Diamin-3,3-dimethyl-1,1-biphenyl
- 2,6-Dimethyl-7-octen-2-ol
- 4-Methoxy-4-vinylphenol
- alfa-Terpineol
- Vanilline

4 Health assessment

4.1 Evaluation basis

Incense sticks are manufactured from incense mass of dried pulverised herbs and wood kept together with a binding agent. The incense sticks contain or is added different forms of aromatic (perfumed) or stimulating compounds that often are herbs or extracts from plants, wood, etc.

The burning of incense sticks causes the emission of a strong smoke and fragrance. Because the burning in general takes place in confined environments (e.g. closed rooms) the influence may be heavy.

Since incense sticks are not labelled, which substances they are manufactured from the smoke and the added stimulating substances may pose a health problem.

Incense sticks can be purchased in specialised shops or on the Internet. The labelling usually concerns the country of origin (China, Indonesia, India, etc.), which fragrance is dominant or which effect the fragrances are stated to have or affect (headaches, stress, or similar).

After the qualitative analyses are performed, the results are evaluated. Data on the individual substances such as threshold limit values, effect levels, no observed adverse effect level (NOAEL) or lowest observed adverse effect level (LOAEL), or other relevant data are used, as they are available. If data are unavailable, alternatively information from analogous substances or data based on structure analyses on the chemical substance (QSAR: quantitative structure analysis relationship) may be used. A comparison with the EU classification criteria is performed.

The exposure of the consumer is evaluated on basis of consumer scenarios. The principles for the evaluation will be based on the EU revised Technical Guidance Document (EC 2003) for risk assessments. The exposed consumers will in consideration of realistic *worst case* be adults with a body weight of 70 kg and children with a body weight of 10 kg.

The primary exposure route for incense is considered to be via inhalation (i.e. inhalation of vapours and aerosols).

The exposure will depend on contact parameters such as frequency and duration of the use of the product, the amount of product used at each event and the concentration of the contained chemical substances. Because most often one incense stick is used at a time, the consumer scenario will be based on 1 incense stick burned in a room of limited volume of 20 m^3 with an air change (ventilation) of 0.5 times per hour. The burning duration of the individual incense sticks varies between 25 to 50 minutes (cf. table 3.6).

Therefore, to be able to compare the incenses, an exposure during the burning of one incense stick in a 20 m^3 room is calculated as µg substance per incense stick (µg/incense stick) and the exposure per hour by continuous burning for one hour (µg/hour).

For the evaluation of the level of exposure, different scenarios based on the measured emission are calculated in a box model (standard room of 20 m^3 with an air change of 0.5 times/hour). This will be discussed in a separate section.

4.1.1 Method

Of the chemical substances found in the emissions from the incense it was evaluated which substances appeared to be the most problematic. The selection was made in agreement with the Danish Environmental Protection Agency. Data on the individual substances were then procured from available sources with the purpose of a health hazard evaluation based on known information from previous Danish and foreign monographs, reviews, etc. The data on toxicity found were then compared with the concentrations estimated in the used scenarios.

The methodology used is approximately the same as recommended in connection with risk assessment in the European Union (EU) i.e. Technical Guidance Document (TGD 2003). In the TGD the potential risk to the consumer is estimated as the ratio between the predicted exposure concentration (PEC) and the predicted no-effect concentration (no-adverse-effect level (NOAEL). NOAEL is usually based on mammalian data other than humans: typically rats, mice and rabbits. Therefore, safety factors are introduced to cover differences extrapolating from other animals to humans. This is expressed either by attaching a fixed safety factor (SF) or by expressing the margin of safety (MOS), which represents the distance of the estimated concentration to the NOAEL. Typically MOS is preferred to be above 100.

The safety factor is interpreted as being a margin of safety applied to a NOAEL to produce a value below which exposures are presumed to be without significant health risk (i.e. safe). The safety factor is traditionally composed of a factor 10 for extrapolation between species (animal to human, intraspecies variation), a factor 10 to protect the most sensitive individuals of the population (e.g. children: interspecies variation). A third factor is applied depending on the data and may vary. For instance it is 10 if LOAEL (lowest observed adverse effect level) is used instead of NOAEL. The total safety factor is a result from multiplication of the three factors.

The effect level divided by the safety factors or the assessment factor is used to evaluate whether there is reason of concern (concern level) or a further refinement of methodology or data is necessary. Thus the evaluation may be expressed on basis of concentration divided by the safety factor or MOS (humans).

The classification authorised in Denmark (Miljøministeriet 2002), which is an implementation of the EU classification (28th amendment to EU directive 67/548/EEC), is used in the evaluation. For the evaluation of each compound is used the threshold limit values obligatory for the working environment in Denmark (Arbejdstilsynet 2002) applied with a safety factor of 100. The safety factor is derived by recalculating threshold limit value from the working environment based on 8 hours per day for 5 days a week to indoor values at

24 hours a day for 7 days a week ($24/8 \times 7/5 = 4.2$), applying an extra safety factor of 10 for sensitive individuals and an extra factor of 2: a total of 100. This means that a safety margin of 100 is used.

The threshold limit value for the working environment (Arbejdstilsynet 2002) is only valid where the chemical substances are used in the production. The threshold limit values are based on 8-hour time weighted average (a working day). It is important to note that the threshold limit value does not include consumers at home.

Other parameters included for the health evaluation were:

ADI: Acceptable Daily Intake. A value calculated from NOAEL by an official authority as an acceptable daily intake (mg/kg body weight/day. ADI is usually based on chemical substances in food.

C-value: Contribution value: The C-value is defined in Miljøstyrelsen (2002) as the total maximal allowed contribution to the air pollution from an enterprise to the environment outside the production site.

RfC Reference concentration. RfC is an inhalation reference concentration based on the assumption that a threshold limit value for certain toxic effects exists. The value is based on NOAEC from inhalation studies of subchronic or chronic character and includes safety factors. The value is given in mg/m^3.

RfD Reference dosis. RfD is an oral reference dosis based on the assumption that a threshold limit for certain toxic effects exists. The value is based on NOAEL from subchronic or chronic studies using oral administration and includes safety factors. The value is given in mg/kg body weight/day.

TDI: Tolerable Daily Intake. Almost identical to ADI but usually based on chemical pollutants.

4.1.2 Evaluation methodology

Effect level

The effect level for each incense is based on evaluation of individual substances. The established Danish threshold limit values are used when they exist. When no Danish threshold limit values exist, foreign threshold limit values are used including description of their background, if available.

The used threshold limit values for the measured substances are presented in Appendix B with the classification.

The indoor air quality depends of several factors (ventilation, temperature, etc.) and other sources. In this report only the contribution from incense is considered but it should be noted that other sources to the same chemical compound may exist in the consumer´s residence (e.g. by smoking, cooking, volatiles from paint, lacquers, carpets, etc.).

The exposure of the consumer in the home is besides the concentration in the indoor air also dependent on the exposure duration. Because the exposure duration may vary considerably, a maximal exposure of 1 hour is assumed. However, the ventilation is included using an assumed air change in the indoor scenarios of 0.5 times per hour, i.e. 50% of the air is exchanged every hour.

Inhalation

Exposure to the substance via inhalation may occur from inhalation of vapours and aerosols. The vapours are sampled on XAD2, DNPH and charcoal filters. The aerosols are sampled on Whatman Glass fibre filters, which also sample particles like smoke, soot, etc.

The exposure period may theoretically extend from the acquisition or purchase of the incense until it is used. The substances, to which consumer is exposed during the holding period, may approximately be assumed to be the substances observed in the "head-space" analyses.

The exposure via inhalation is expressed as the concentration of the chemical substance in the air in the breathing zone and expressed as an average concentration over a reference period, e.g. 8 hours for the working environment. For the consumers of incense the exposure period may be from the time, which 1 incense stick takes to burn to considerably longer time if more incense is burned and the duration for all emission products to be ventilated out of the room/home.

For estimation of the exposure via inhalation, the inhalation rate must be known, the size of the room and the emission rate of the substance to the room or the concentration in the room.

The inhalation rate for an average adult is set to 20 m^3/day corresponding to 0.83 m^3/hour (standard in TGD 2003) and for a child to 3 m^3/day corresponding to 0.125 m^3/hour.

The concentration in closed rooms is assumed to be higher than in ventilated rooms. For the calculation of the concentration in the room it is assumed that the substance is emitted instantly to the entire room and is homogeneously dispersed. The size of the standard room is set to 8 m^2 and the height 2.5 meter, i.e. the volume of the room is 20 m^3.

The concentration in inhaled air can then be calculated according to the equation:

$$C_{inh} = \frac{Q_{prod} \times Q_{air}}{V_{room}} \quad (mg/m^3)$$

C_{inh}	Concentration in inhaled air	mg/m^3	
Q_{prod}	Quantity of incense (product) used in the room	g	
Q_{air}	Quantity substance emitted from the incense to the room	mg/g	
V_{room}	Volume of the room	m^3	Used: 20 m^3

Amount of inhaled substance is then (TGD 2003):

$$I_{inh} = \frac{F_{resp} \times C_{inh} \times Q_{inh} \times T_{contact}}{BW} \times N_{event} \quad (mg / kgBW / day)$$

I_{inh}	Amount inhaled substance	mg/kg bw/d	
F_{resp}	Inhalable or respirable fraction of the substance		set to 1 (i.e. 100%)
C_{inh}	Concentration in the air	mg/m^3	
Q_{inh}	Inhalation rate for adult	$m^3/hour$	(adult: 0.83 $m^3/hour$)
$T_{contact}$	Duration of exposure	hours	
N_{event}	Number of events		(usually per day)
BW	Body weight	kg	(Used: Adult: 70 kg Child: 10 kg

As a starting point as previously mentioned a scenario of a room with the volume 20 m^3 is used. The size of the room is deliberately assumed small considering the realistic "worst case" but including an air change of 0.5 times per hour.

In return it could be argued that the incense does not distribute itself evenly throughout the room or instantly. A scenario using an air volume of 2 m^3 around the exposed person may be more realistic. However, such a high concentration would probably be of short duration and present large variations in the exposure. Therefore it was chosen to maintain a distribution in 20 m^3 as a reasonably high "average" of what would be expected as normal during use of 1 incense unit (incense stick or cone) which may take 25 to 50 minutes.

Product evaluation
A comparison of each product was not the purpose of this study. The survey was to focus on which substances could be found in a representative selection of incense types and if they could be expected to cause any problems to the consumer of incense.

An attempt of comparison has been performed anyway considering only the range observed in the study. For comparison a common unit is needed and the effects from the emitted substances are widely different. Therefore, a comparison based on the emission of volatile organic compounds and the emission of aerosols is used. The aerosol emission expresses the amount of particle material emitted during burning of incense. Refer to chapter 5 for further details.

5 Evaluation of the emission

To evaluate the potential pollution in rooms in which incense is burned a simple theoretical box model may be used. A room with a known air volume and air change is used.

In this study, the following assumptions are used in the calculations:

Room volume: 20 m^3
Air change: 0.5 times per hour, i.e. 10 m^3/h

It is presumed that the ventilated air is without pollutants and that the emitted pollution is homogeneously mixed in the room. The model is shown in figure 5.1.

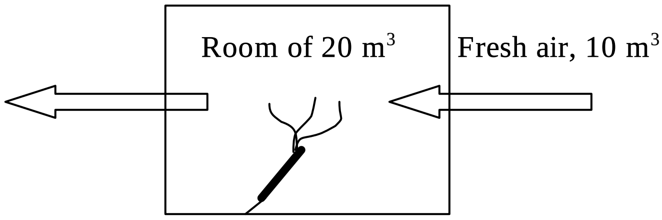


Figure: 5.1: Box model

Burning incense results in gradually increasing pollution until an equilibrium concentration is reached typically after a few hours where emissions from the burning incense equals the amount ventilated out of the room. The course as shown in figure 5.2 will be normal if the pollution emission is constant.

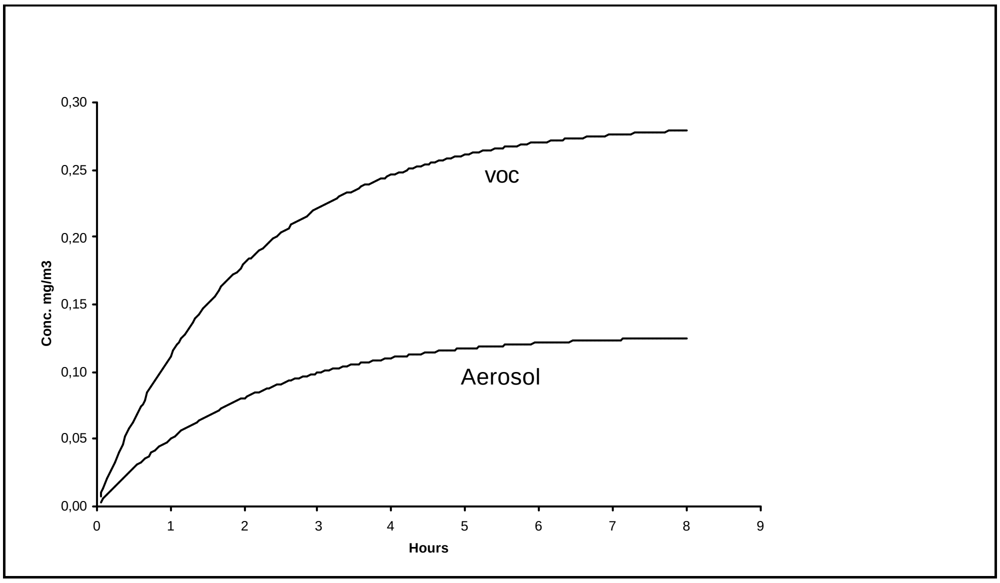


Figure 5.2 Theoretical course of the air concentration of aerosols and VOC in a room of 20 m^3 with an air change of 0.5 times per hour as defined in the text

At burning of incense it is presumed that only one stick/cone is burned. The burning duration of the examined products was between 25 and 59 minutes. The course of pollution in the room is shown for all incenses in Appendix C. Below is shown examples of graphs of the lowest and the highest emissions of pollutants, respectively.

In table 5.1, the results from the individual tests are presented. In the table, the results of total aerosol determined gravimetrically, total volatile organic components (TVOC) from the list (cf. appendix) and the sum of pollutants are summarised. Because the burning period varies between incense sticks/cone, the results are presented as mg/hour and as mg/unit (i.e. mg/incense stick or mg/incense cone).

Table 5.1 Emission of aerosols and vapours (TVOC: Total VOC)

Lab. no.	Total aerosol mg/h	TVOC gas mg/h	Sum aerosol + gas mg/h	Total aerosol mg/unit	TVOC gas mg/unit	Sum aerosol + gas mg/unit
1	121.155	30.009	151.164	50.619	13.517	64.136
2	45.610	18.863	64.473	30.668	12.960	43.628
4	61.531	12.782	74.313	41.302	8.351	49.653
8	164.191	33.032	197.223	136.265	29.255	165.520
10	109.729	14.814	124.543	108.642	12.667	121.309
12	31.164	10.156	41.320	16.499	4.252	20.751

From table 5.1 it can be observed that the total pollution from incense per unit (incense stick or cone) varies between 41 and 197 mg/hour (Lab. no. 12 and 8, respectively). Thus, the variation between the selected incense sticks was large.

The emission mg/h is presented to enable comparison of the emissions from the examined products. The emission mg/unit (incense stick or cone) is presented to calculate the pollution that will be generated in the room (box model).

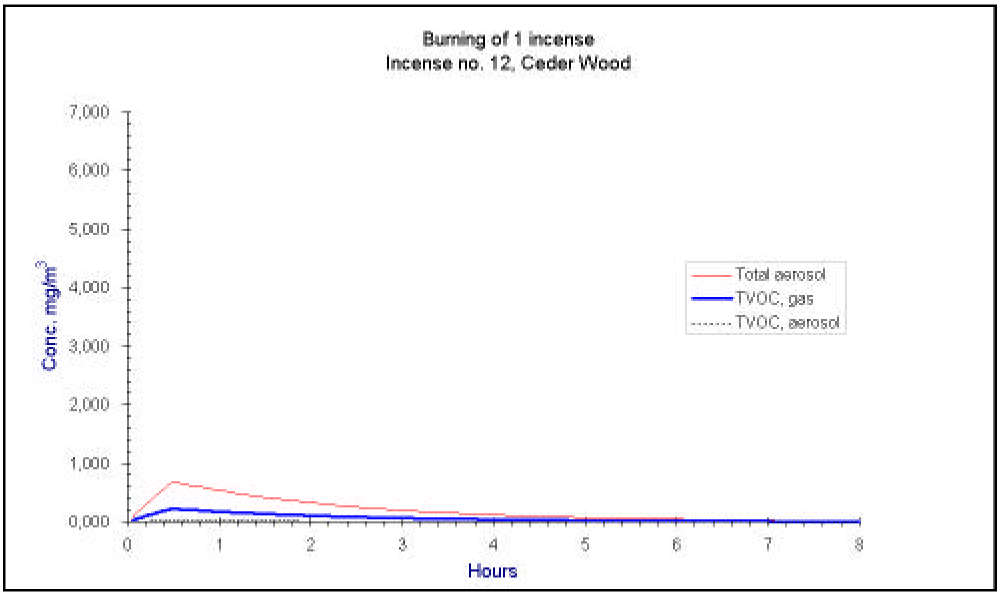


Figure 5.3 Example of the course of pollution from the incense with the least aerosol and VOC emission

In figure 5.3 is shown that the maximal aerosol concentration was found to 0.69 mg/m^3. Total VOC (TVOC) was found to 0.22 mg/m^3. For comparison the same scale as in the next figure (figure 5.4) has been used.

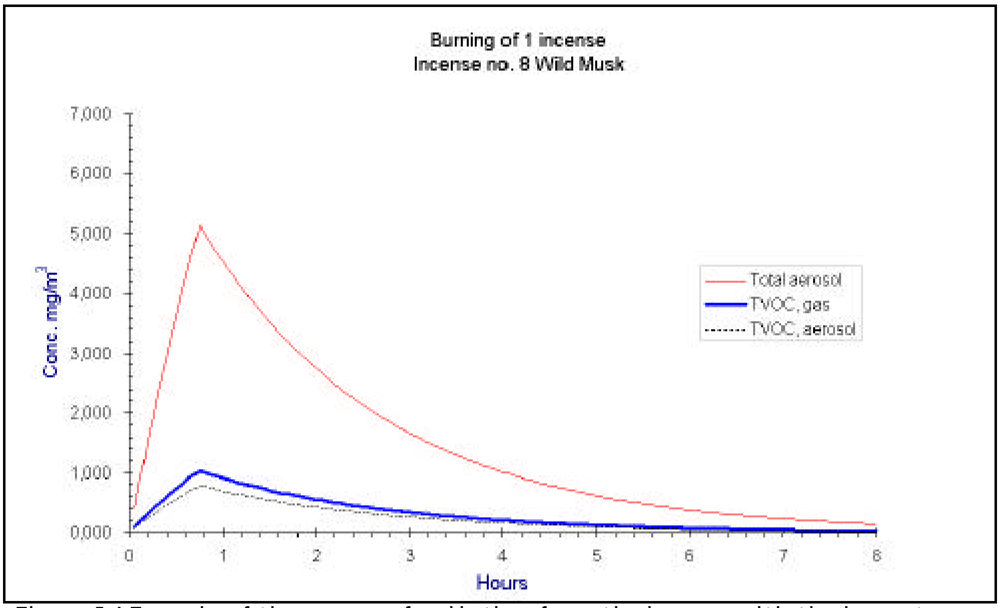


Figure 5.4 Example of the course of pollution from the incense with the largest aerosol and VOC emission

In figure 5.4 is shown that the maximal aerosol concentration was found to be 5.13 mg/m^3 and TVOC was found to 1.03 mg/m^3.

The aerosol part in the performed tests was between 70 and 88% of the total pollution.

The aerosols consist of a mixture of organic and inorganic materials such as VOC, resins, ashes, soot, etc. Some of the VOCs were identified, cf. appendix C.

The vaporous/gaseous pollution consists of VOCs. A large number of compounds were identified (cf. appendix B). Some of these VOCs are classified as hazardous if inhaled (e.g. acrolein), possible carcinogenic (e.g. formaldehyde) to carcinogenic (benzene). These compounds were found in high to very high amounts in all tests (cf. table 5.2). Therefore, the course of the concentration evolution of these compounds in a known room (box model) for an 8-hour period has been shown for Lab. no. 1 in figure 5.5 and Lab. no. 8 in figure 5.6.

Table 5.2 Emission of benzene, formaldehyde and acrolein per hour and per unit (one incense stick or cone)

Lab. no.	Benzene mg/h	Formaldehyde mg/h	Acrolein mg/h	Benzene mg/unit	Formaldehyde mg/unit	Acrolein mg/unit
1	1.48	11.35	2.27	0.62	5.28	1.06
2	1.46	1.77	0.96	0.98	1.27	0.69
4	1.11	4.40	1.05	0.75	2.82	0.68
8	8.98	5.98	1.00	7.45	5.92	0.99
10	0.70	6.06	1.74	0.69	4.83	1.39
12	0.50	3.42	0.65	0.27	1.19	0.23

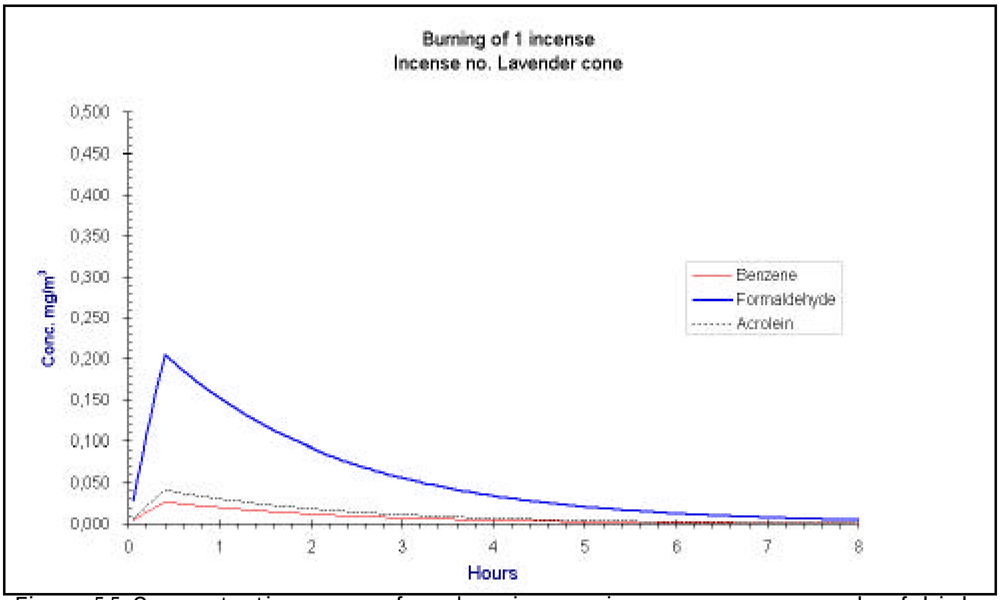


Figure 5.5 Concentration course from burning one incense cone as example of high formaldehyde concentration

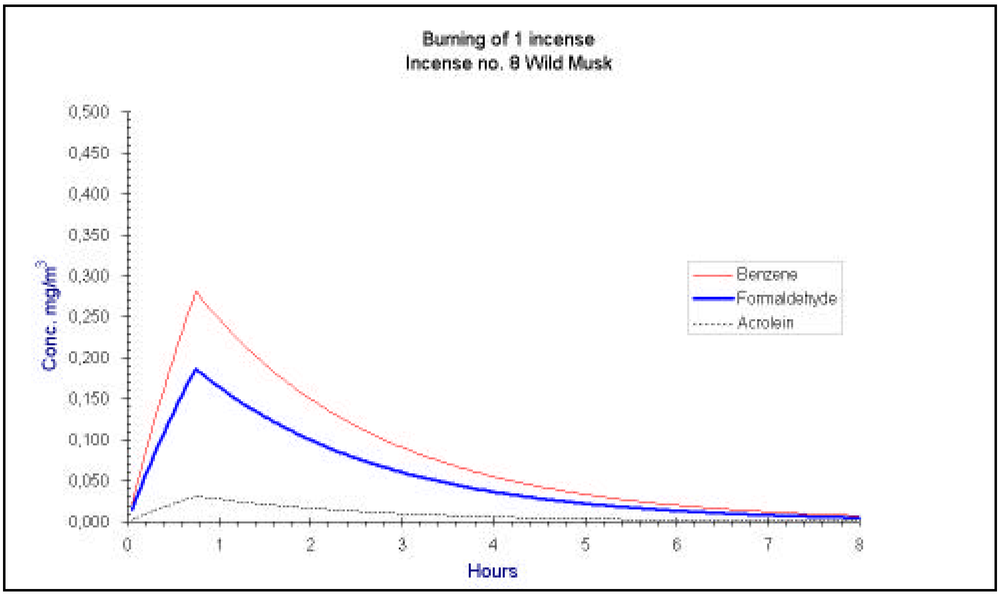


Figure 5.6 Concentration course from burning one incense stick as example of high benzene concentration.

The threshold limit values for the working environment (according to Arbejdstilsynet 2002) are:

Substance	Threshold limit value (TLV), mg/m^3	equivalent to (µg/m^3)
Benzene	1.7	1700
Formaldehyde	0.4	400
Acrolein	0.12	120
Organic dust total (Aerosols)	3	3000

Acrolein was measured to maximum 59 µg/m^3 (lab. no. 10).

Formaldehyde was measured to maximum 205 µg/m^3 (lab.no. 8).

Benzene was measured to maximum 281 mg/m^3 (lab.no.8).

Evaluation of results
Based on several measurements performed by e.g. the Danish Technological Institute typical levels of the below mentioned compounds are measured indoors in residences to:

Substance	Indoor levels, µg/m^3
Benzene	3 – 10
Formaldehyde	30 – 50
Acrolein	< 1
TVOC	100 – 500
Organic dust total (Aerosols)	50 – 100

The threshold limit value for aerosols (organic dust, total) is set to 3 mg/m^3 (Arbejdstilsynet 2002). This value is valid for production enterprises. For normal residences typical values are 0.05-0.10 mg/m^3 at “non-smoking” and typically 0.3-0.5 mg/m^3 at “smoking” homes. This means that the maximal found aerosol concentrations using both calculation methods (per incense stick or cone and burning per hour, cf. table 5.3) exceed the threshold limit value in Lab. no. 1, 8 and 10 in relation to mg/m^3/hour and for Lab. no. 8 and 10 in relation to mg/m^3/incense stick, which must be considered unacceptable for the indoor climate.

Tabel 5.3 Maximal concentrations calculated using the box model during burning for 1 hour and 1 incense stick/cone, respectively

Lab. no.	Aerosol Max. conc. mg/m^3/hour	TVOC Max. conc. mg/m^3/hour	Aerosol Max. conc. mg/m^3/incense unit	TVOC Max. conc. mg/m^3/ incense unit
1	4.77	0.48	2.20	0.22
2	1.79	0.47	1.27	0.34
4	2.42	0.29	1.59	0.19
8	6.46	0.99	5.13	0.78
10	4.32	1.08	3.80	0.95
12	1.23	0.03	0.69	0.02

The aerosol values for incenses not mentioned here can be found in Appendix C.

Based on the box model it may take up to 8 hours before the concentration of aerosols has declined to a typical indoor level.

Based on the box model it may take up to 6-8 hours before the concentration level of acrolein has declined to a typical indoor level.

Based on the box model it may take up to 4 hours before the concentration level of formaldehyde has declined to a typical indoor level.

Based on the box model it may take up to 8 hours before the concentration level of benzene has declined to a typical indoor level.

It is concluded that the burning of incense may cause a significant increase of the indoor air pollution when the incense is burned indoors.

Assessment of the amount of aerosol from incense compared to cigarette smoke

The total amount of aerosol from burning of incense may be compared to the total amount of aerosol formed when a cigarette is burning in an ashtray.

The aerosol amount from a cigarette (”Prince”) is measured and the emission and concentrations calculated as for the incense (results in table below). Following (measured) assumptions were used:

Burning period for 1 cigarette: 15 min.
Aerosol amount emitted: 34.1 mg

Table 5.4 Summary of the aerosol emission per incense or cigarette unit and per hour, respectively, and maximal concentration that arises in a room of 20 m^3 with fresh air change of 0.5 times/hour (box model).

Lab. no	Emission mg/unit	Emission mg/hour	Max. conc. $mg/m^3/hour$	Max. conc. $mg/m^3/unit$	Corresponding to no. of cigarettes
1	50.6	121.2	4.77	2.20	1.5
2	30.7	45.6	1.79	1.27	0.9
4	41.3	61.5	2.42	1.59	1.2
8	136.3	164.2	6.46	5.13	4.0
10	108.6	109.7	4.32	3.80	3.2
12	16.4	31.2	1.23	0.69	0.5
Prince cigarette	34.1	136.4	5.40	1.60	

From the table is shown that there is a large difference in the amount of smoke emitted from the incense stick. The lowest emission is from lab. no. 12 and highest is lab. no. 8. A comparison of the amount of smoke from burning of one incense stick /cone to cigarettes the results varied between 0.5 to 4 cigarettes (cf. last column in table).

In figure 5.7 is presented the aerosol emission course, comparable to the incenses

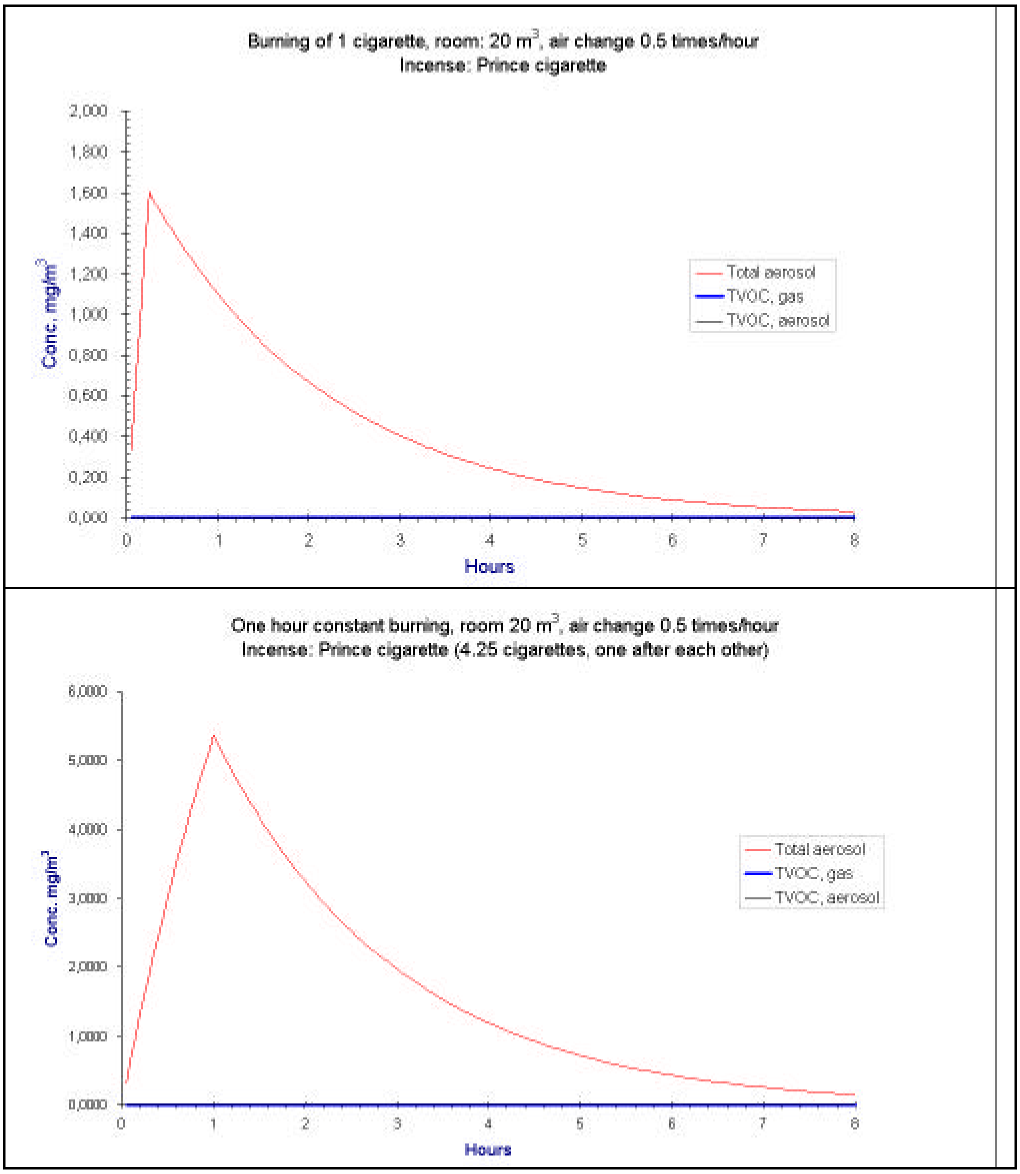


Figure 5.7
Top: Aerosol emission from the burning of one cigarette (in ashtray)
Bottom: Aerosol emission during one hour constant burning of cigarettes

6 Substance evaluations

In this section, the specific chemical substances selected by the Danish Environmental Protection Agency to be of interest in this context have been evaluated. It concerns:

Aldehydes	Acetaldehyde
	Acrolein (Acrylaldehyde)
	Formaldehyde
	Furfural
Aromatic carbohydrates	Benzene
	Styrene
	Toluene
	Xylene
Other aromatics	Benzofuran
	4,4-Diamine-3,3-dimethyl-1,1-biphenyl
	Vanillin
Terpenes	2,6-Dimethyl-7-octen-2-ol
	2-Methoxy-4-vinylphenol
	alfa-Terpineole

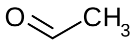
The evaluation is based on the principles and methods mentioned in the previous section. The evaluations are concluded for each substance with an assessment of whether they may be of concern to the consumer of incense based on the variations found in the selected samples of incense.

6.1 Aldehydes

Aldehydes are typically volatile organic compounds characterised by their irritating properties. Aldehydes irritate skin, eyes and the upper respiratory tract. The low molecular weight aldehydes, the halogenated aliphatic aldehydes, and the unsaturated aldehydes are particularly irritating. The mucous membranes of the nasal and oral passages and the upper respiratory tract are affected, producing a burning sensation, an increased ventilation rate, bronchial constriction, choking, and coughing. The eyes tear, and a burning sensation is noted on the skin of the face. During low exposures, the initial discomfort may abate after a few minutes (5 to 10 minutes) if the exposure is ceased but the sensation will recur if exposure is resumed after the interruption (Clayton and Clayton 1981).

6.1.1 Acetaldehyde

Identification

Name	Acetaldehyde
CAS no.	75-07-0
EINECS no.	200-836-8
Molecular formula	$C_2 H_4 O$
Molecular structure	
Molecular weight	44.05 g/mol
Synonyms	Ethyl aldehyde
	Ethanal
	Acetic aldehyde

The melting point is -123°C. The boiling point is 20.1°C. The water solubility is high (miscible) to 10^6 mg/l at 25°C (Riddick *et al.* 1986). The vapour pressure is 120.2 kPa at 25°C (902 mmHg, Boublik *et al.* 1984). The octanol/water partition coefficient is measured to log Kow 0.5 (Sangster 1989).

Classification

Acetaldehyde is classified in the List of dangerous substances (Miljøministeriet 2002).

Fx;R12	Extremely flammable
Carc3;R40	Possible risks of irreversible effects
Xi;R36/37	Irritant. Irritating to eyes and respiratory system

Origin

Acetaldehyde is used in the production of a long series of chemical substances.

Acetaldehyde may also be formed during combustion processes from gasoline, diesel and organic material. The latter may contribute to the explanation of the findings in all incense types during burning.

Health

Some data have been found on acute toxicity. Of those are mentioned:

Acute oral, rat	LD_{50}	660 mg/kg	IPCS: 1995
Acute oral, mouse	LD_{50}	1230 mg/kg	IPCS 1995
Acute inhalation, rat	LC_{50}, 0.5 h	38000 mg/m^3	Appleman *et al.* 1982
Acute inhalation, rat	LC_{50}, 4 h	24000 mg/m^3	Appleman *et al.* 1982

Acute exposure to acetaldehyde vapour may irritate the eyes, skin and the respiratory tract. Long-term or chronic exposure has been shown to damage the respiratory tract in rats. In hamsters, chronic exposure to acetaldehyde produced changes in the nasal mucosa and trachea, growth retardation and increased kidney weight (IPCS 1995).

In a study on human volunteers exposed to different concentrations of acetaldehyde in air, it was observed that a concentration of 45 mg/m^3 did not induce significant irritation (IPCS 1995).

Of studies with prolonged exposure a study on irritation in rats was found. The rats were exposed to acetaldehyde for 6 hours per day, 5 days a week for 4 weeks. NOAEL was 273 mg/m^3 (Appleman *et al.* 1986).

An increased incidence of nasal tumours in rats and laryngeal tumours in hamsters has been observed following inhalation exposure to acetaldehyde. Acetaldehyde was therefore classified by IARC in group 2B: *Possible carcinogenic to humans on the basis of sufficient evidence for carcinogenicity in experimental animals and inadequate evidence in humans* (IARC 1999).

Acetaldehyde may cause effects on the central nervous system, respiratory tract and kidney resulting in chronic alcohol-like intoxication and a lowering of consciousness. The effects may be delayed (IPCS 1995).

Threshold limit values
The threshold limit value for the working environment is 25 ppm equivalent to 45 mg/m^3 with notation LK. **L** denotes that the threshold limit value is a ceiling value that at no time must be exceeded. **K** means that the substance is adopted on the list of substances, which are considered carcinogenic (Arbejdstilsynet 2002).

Based on irritation in humans a tolerable concentration is assessed of: 45 mg/m^3/20 = 2 mg/m^3 = 2000 µg/m^3 where no effects were observed in human volunteers and 20 is the safety factor (10 intraspecies variation and 2 for low data quality (IPCS 1995)).

Based on a 4 weeks rat study (Appleman *et al.* 1986) with NOAEL 273 mg/m^3 and a safety factor of 1000 (10 for interspecies, 10 for intraspecies and 10 for non-chronic study and the seriousness of the effect (carcinogenicity)) a tolerable concentration of 0.3 mg/m^3 = 300 µg/m^3 was derived (IPCS 1995).

The inhalation reference concentration value (RfC) is by US-EPA set to 9 µg/m^3 based on degeneration of olfactory epithelium in rats. NOAEL was 273 mg/m^3. The exposure was 6 hours per day in 5 days/week for 4 weeks (Appleman *et al.* 1986). Recalculated to 24 hours exposure/day for 7 days/week is: $273 \times 6/24 \times 5/7 = 48.75$ mg/m^3. When corrected for respiration rate of 0.17 m^3/day for rats and 20 m^3/day for humans and for the exposure area in the extra-thoracic region of 11.6 cm^2 in rats and 177 cm^2 in humans results in: $48.75 \times 0.17/20 \times 177/11.6 = 8.7$ mg/m^3 (NOAEL, HEC - human equivalent concentration). Using a safety factor of 1000 (10 for intra- and 10 for interspecies and 10 for subchronic to chronic extrapolation) a RfC value of 9 µg/m^3 is derived (US-EPA, IRIS 1991).

Absorption
Acetaldehyde is absorbed into the body when inhaled (IPCS 1995). No values were found and therefore 100% absorption is assumed.

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense cone and burning of incense for one hour in a room of 20 m^3.

Calculation example:
C inhalation = 4478 / 20 = 224 µg/m^3 (incense ID no. 8).

The remaining exposure concentrations have been calculated from a box-model using an air change of 0.5 times per hour (table 5.1).

Adult

Inhalation, 1 piece of incense = (141×0.83×1)/70 = 1.67 µg/kg bw/day (ID no. 8)
Inhalation, 1 hour = (276×0.83×1)/70 = 3.27 µg/kg bw/day (ID no. 1)

Child
Inhalation, 1 piece of incense = (141×0.125×1)/10 = 1.76 µg/kg bw/day (ID no. 8)

Table 6.1 Emission, air concentration and uptake by inhalation of acetaldehyde

ID no.	Emission		C Inh. 1 pc. in room	C_{max} inh, 1 pc. incl vent.	C_{max} inh, 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	3267	7022	163	127	276	1.51	1.59	3.27
2	2690	3763	135	102	148	1.21	1.28	1.75
4	1472	2294	74	60	90	0.71	0.75	1.07
8	4478	4523	224	141	198	1.67	1.76	2.35
10	2048	2569	102	89	101	1.06	1.11	1.20
12	1070	2107	103	46	83	0.55	0.58	0.98

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

Because no threshold limit values for effects from the amount taken up by the body was found, they have not been considered.

Considering the exposure via inhalation, the estimated concentrations are below the threshold limit value for working environment of 45 mg/m^3 with a margin of safety (MOS) above 163. Therefore, it is evaluated that no immediate health risk to the exposure from acetaldehyde existed.

The risk is also evaluated small in relation to a NOAEC of 9 mg/m^3 and the remaining threshold limit values referred to above.

However, the RfC of 9 µg/m^3 (an American inhalation RfC based on carcinogenicity) was exceeded. The course of the inhalation exposure by burning one incense cone, which was the incense type that resulted in the highest emission of acetaldehyde, is presented in the figure below.

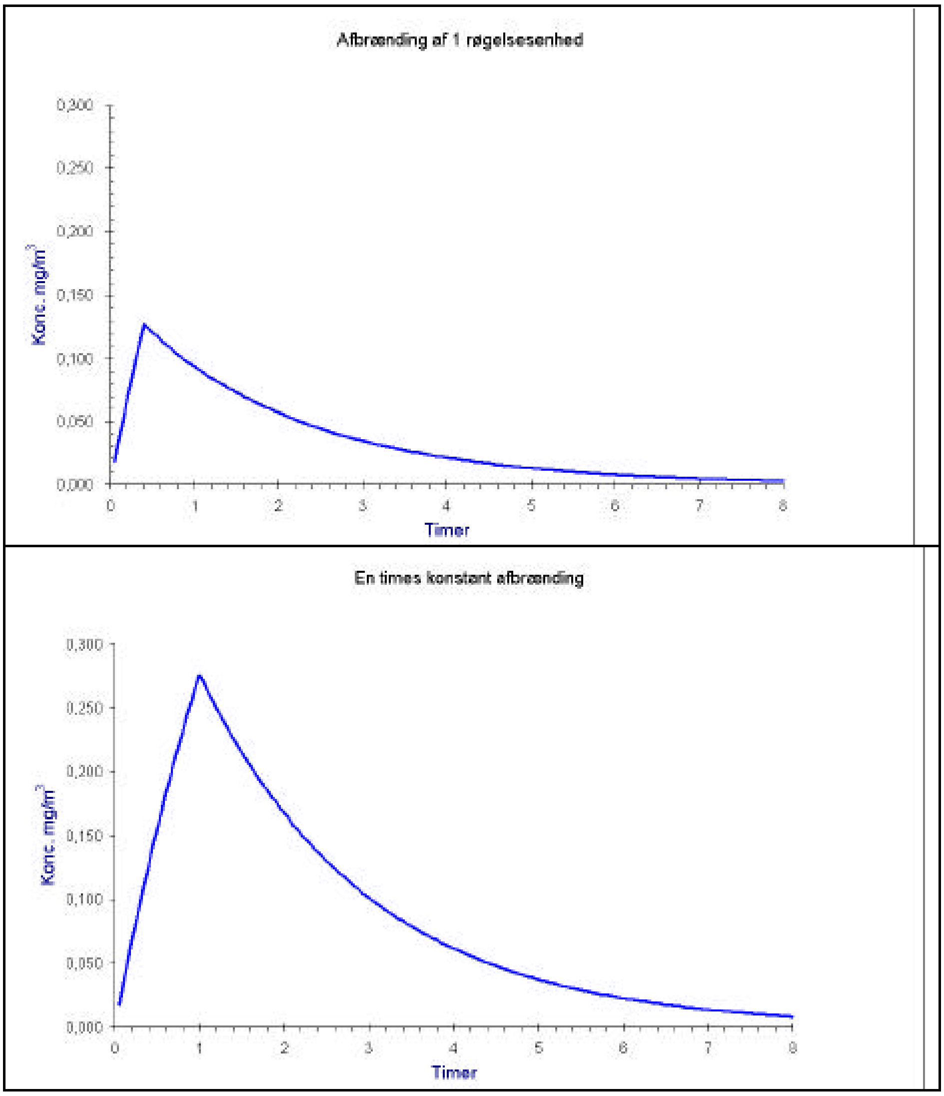


Figure 6.1 Box model presentation of the course of exposure from acetaldehyde during burning of one incense cone, top graph (the incense type that emitted the most acetaldehyde). The buttom graph is the same incence burning continuously for one hour (timer = hours, Konc. mg/m^3 = Conc. mg/m^3).

On basis of the box model's graphic presentation of the maximal emission from incense type ID no. 1, it will take up to 6 hours after the burning of an incense cone before the concentration is reduced to 9 µg/m^3 (the RfC value) assuming an air change of 0.5 times per hour (cf. figure 6.1, top graph).

Conclusion

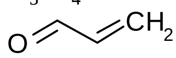
The largest amount of acetaldehyde was emitted from the incense cone (Lab. ID no. 1) with emissions of approximately twice the remaining incense types.

Although acetaldehyde is known for being an irritant to the eyes and respiratory tract the threshold limit values were not exceeded during burning of one piece of incense (stick or cone).

However, it is recommended not to expose oneself to chronic exposure as the concentration may exceed the threshold limit value for chronic exposure of 9 µg/m^3 significantly.

6.1.2 Acrolein

Identification

Name	Acrolein
CAS no.	107-02-8
EINECS no.	203-453-4
Molecular formula	$C_3 H_4 O$
Molecular structure	
Molecular weight	56.06 g/mol
Synonyms	Acrylaldehyde 2-Propenal

The melting point is –87.7°C. The boiling point is 52.6°C. The water solubility is 212000 mg/l at 25°C. The vapour pressure is 36.5 kPa at 25°C (274 mmHg, Daubert and Danner 1985). The octanol/water partition coefficient is measured to log Kow –0.01 (Hansch *et al.* 1995).

Classification

Acrolein is classified in the List of dangerous substances (Miljøministeriet 2002):

F;R11	Highly flammable
Tx;R26	Very toxic by inhalation
T;R24/25	Toxic in contact with skin and if swallowed
C;R34	Causes burns
N;R50	Very toxic to aquatic organisms

Origin

Acrolein is manufactured as pure substance from propene but is also an intermediate in the manufacture of acrylic acid and several other chemical compounds. Acrolein may also be formed during incomplete combustion of oil products and organic material (ECB 2001). Incomplete combustion may add to the explanation of the findings of acrolein from burning of incenses.

Health

Since the exposure is primarily via inhalation, those data are mainly used in the evaluation.

A number of data on acute toxicity were recovered of those are mentioned:

Acute oral, rat	LD_{50}	42-46 mg/kg	ECB 2001
Acute oral, mouse	LD_{50}	14-28 mg/kg	ECB 2001
Acute inhalation, rat	LC_{50}, 4 t	18-21 mg/m^3 (vapour)	ECB 2001
Acute inhalation, rat	LC_{50}, 1 t	65 mg/m^3 (vapour)	ECB 2001
Acute inhalation, rat	LC_{50}, 30 min	300 mg/m^3 (vapour)	ECB 2001
Acute inhalation, rat	LC_{50}, 10 min	750 mg/m^3 (vapour)	ECB 2001

The toxicity by inhalation is dependent on the duration of the exposure: the longer time the more toxic (cf. table above). By inhalation, eyes and nasal irritation and reduced inhalation rate were observed (ECB 2001).

Parent *et al*. (1992a) administered acrolein in water daily via gavage to rats, 70/sex/group, at dose levels of 0, 0.05, 0.5 and 2.5 mg/kg bw/day. Dosing volume was 10 ml/kg. The exposure period was 2 years. LOAEL was 0.5 mg/kg/day in both sexes and NOAEL 0.05 mg/kg/day.

Feron *et al*. (1978) exposed 6 rats/sex/concentration, 10 Syrian golden hamsters/sex/concentration and 2 Dutch rabbits/sex/concentration for 6 hours/day, 5 days/week for 13 weeks to 0, 0.4, 1.4 or 4.9 ppm (equivalent to 0, 0.9, 3.2, or 11 mg/m^3) acrolein in a whole-body exposure chamber. Three male and three female rats died during exposure at the highest dose. Histopathological changes in the nasal cavity, lung, larynx and trachea were graded as slightly, moderately or severely affected. Based on this a LOAEL was set to 0.9 mg/m^3. In the study, the rats were the most sensitive species.

Acrolein vapours affect aggressively and irritating to mucous epithelium. In animal studies, the LC_{50}-value was found at approx. 20 mg/m^3 for rats. In controlled human studies, eye irritation was observed at 0.13 mg/m^3 and respiratory irritation at 0.34 mg/m^3 after 5-10 minutes exposure. Concentration levels of 1-2 mg/m^3 induced severe irritation with tears after only a few seconds. The acute toxic potential of acrolein is assessed to be the most critical effect, as the substance due to its high reactivity directly affects the mucous epithelium surfaces (Miljøstyrelsen 2002).

Threshold limit values

The threshold limit value for the working environment is 0.05 ppm corresponding to 0.12 mg/m^3 (Arbejdstilsynet 2002).

An irritation threshold limit value is based on sensory irritation in mice where a RD_{50} of 40 mg/m^3 was observed (RD_{50} is the inhalation concentration that makes half the test animals to change their respiration rate). The irritation limit value was calculated to: $RD_{50} \times 0.03/40 = 0.03\ mg/m^3$ (Larsen *et al.* 1999).

The RfD-value 0.5 µg/kg/day is based on a study on reduced survival with a NOAEL 0.05 mg/kg/day and the application of a safety factor of 100: i.e. $0.05/100 = 5\times10^{-4}$ mg/kg/day (Parent *et al.* 1992).

The RfC-value 0.02 $µg/m^3$ is based on a subchronic rat inhalation study (Feron *et al.* 1978). In the study, a LOAEL 0.4 ppm equivalent to 0.9 mg/m^3, was observed. The LOAEL was adjusted from the study where the exposure was 6 hours/day, 5 days/week to continuous exposure as follows: $0.9\ mg/m^3 \times 6/24\times 5/7 = 0.16\ mg/m^3$. The adjusted LOAEL was then recalculated to a "human exposure equivalent concentration" by correction of the inhalation rate of 0.2 m^3/day for rats and 20 m^3/day for humans and the exposure area of the extra-thoracic region of 15 cm^2 in rats and 200 cm^2 in humans. This would result in: $0.16\times0.2/20\times 200/15 = 0.021\ mg/m^3$ (NOAEL, HEC - human equivalent concentration). Applying a safety factor of 1000 (10 for intra- and 10 for interspecies variation and 10 for adjustment from subchronic to chronic exposure duration) would give a RfC value of 0.02 $µg/m^3$ (US-EPA, IRIS).

The human data on eye irritation at 0.13 mg/m^3 after a few minutes of exposure could be used as starting point for a threshold limit value calculation. Applying a safety factor of 10 to extrapolate from effect level to no-effect level and a further safety factor of 10 to consider differences in individual sensitivity to acrolein would result in a threshold limit value of 0.001 mg/m^3. Thus, for acrolein a contribution value (C-value) of 0.001 mg/m^3 was set (Miljøstyrelsen 2002).

Absorption

The absorption via inhalation in dogs was dosis independent and varied between 82 and 84% (ECB 2001).

Evaluation

At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
C max inhalation = 1388 / 20 = 69 $\mu g/m^3$ (ID no.10)

Adult
Inhalation, 1 piece of incense = (60.3×0.83×1)/70 = 0.71 µg/kg bw/day (ID no. 10)
Inhalation, 1 hour = (89.3×0.83×1)/70 = 1.06 µg/kg bw/day (ID no. 1)

Child
Inhalation, 1 piece of incense = (60.3×0.125×1)/10 = 0.75 µg/kg bw/day (ID no. 10)

Table 6.2 Emission, air concentration and uptake via inhalation of acrolein

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m³	µg/m³	µg/m³	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	1056	2270	52.8	41.1	89.3	0.49	0.51	1.06
2	686	959	34.3	26.6	37.7	0.32	0.33	0.45
4	675	1052	33.8	27.3	41.4	0.32	0.34	0.49
8	987	997	49.3	31.2	39.2	0.37	0.39	0.46
10	1388	1741	69.4	60.3	68.5	0.71	0.75	0.81
12	332	654	16.6	14.5	25.7	0.17	0.18	0.30

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was below the threshold limit for the working environment of 120 $\mu g/m^3$ but only with a margin of safety of 1 to 2, which is considered unsatisfactory when considering consumers and not a working environment.

The C-value of 1 $\mu g/m^3$ is exceeded.

The estimated exposure concentrations exceed the RfC value of 0.02 $\mu g/m^3$, which was based on a NOAEL 0.02 mg/m^3.

The absorption via inhalation is (compared with the oral RfD) exceeded for most incense types already by burning one incense stick or cone for both adults and children.

Conclusion
The emissions of acrolein indicate an exceeding of what is considered reasonable during burning of all incenses. The odour threshold value of 407 µg/m^3 was not exceeded which means that there was no direct warning by smell. However, the concentrations of the substance are below the limit value for eye irritation of 130 µg/m^3.

Chronic effects can not be excluded at prolonged exposure. And this is where the exceeding of the threshold limit values based on chronic data become critical.

To avoid health problems, ventilation during or after the burning of incenses should be a principal rule.

6.1.3 Formaldehyde

Identification

Name	Formaldehyde
CAS no.	50-00-0
EINECS no.	200-001-8
Molecular formula	$C H_2 O$
Molecular structure	$O{=}CH_2$
Molecular weight	30.03 g/mol
Synonyms	Formalin (formaldehyde 37% solution) Methaldehyde Methylene oxide Oxymethylene

Formaldehyde is a gas at room temperature. The melting point is -92°C. The boiling point is -19°C. The water solubility is high. The information varies but the most realistic level is between 400,000 mg/l (at 20°C) and 550,000 mg/l because polymers are formed at ≥55% solutions (the solution becomes opalescent, IPCS 2002). The vapour pressure is high: 518 kPa at 25°C (Boublik *et al.* 1984) in its pure form (gas). The vapour pressure for a 37% solution is 202.6 Pa at 20°C. The octanol/water partition coefficient is measured to log Kow 0.35.

Air concentrations associated with sensory irritation is generally above 0.3 to 0.5 ppm (0.3 to 0.6 mg/m^3) (IPCS 1989, 2002).

Classification
Formaldehyde is classified in the List of dangerous substances (Miljøministeriet 2002):

Carc3;R40 R43	Possible risks of irreversible effects. May cause sensitization by skin contact
T;R23/24/25	Toxic. Toxic by inhalation, in contact with skin and if swallowed
C;R34	Corrosive. Causes burns

It is noted that concentrations 1-5% are classified Carc3; R40 R43 and concentrations 0.2 to 1% classified R43.

Origin

Formaldehyde is used in several products and processes. Only the most relevant to this project are mentioned.

Formaldehyde is added to several consumer products as preservative to prevent microbial destruction of the product. Formaldehyde is contained in several colorants, either in the manufacture or as preservative. Hatch and Maibach (1995) has mentioned 9 resins, which release different amounts of formaldehyde.

Health
Formaldehyde is toxic to humans and the compound is suspected to be carcinogenic. In epidemiological studies on humans exposed to formaldehyde in the working environment, no causal relation between formaldehyde exposure and nasal-or lung tumours could be observed. Based on the data of formaldehyde's mode of action, formaldehyde is probably not carcinogenic to humans at low exposures, especially at exposure conditions that do not induce cytotoxic effects (IPCS 1989).

Formaldehyde is an eye and skin irritant.

Acute toxicity
Several data on acute toxicity exist. Of these are mentioned:

Acute oral, rat	LD_{50}	600 mg/kg	IUCLID 2002
Acute oral, mouse	LD_{50}	42 mg/kg	IUCLID 2002/RTECS
Acute dermal, rabbit	LD_{50}	270 mg/kg	IPCS 1989
Acute inhalation, rat	LC_{50}, 4 h	578 mg/m^3 (480 ppm)	IPCS 1989
Acute inhalation, mouse	LC_{50}, 4 h	497 mg/m^3 (412 ppm)	IPCS 1989

Relating to acute inhalation toxicity the mentioned values of LC_{50} below 1 mg/l (4 h exposure), which is a low value, indicate that the compound is toxic by inhalation of the pure substance.

Several long-term and chronic studies exist. The results are thoroughly discussed in several references, e.g. IPCS (1989 and 2002).

Repeated oral administration via drinking water to rats over 2 years showed a highest dosis without permanent effects (NOAEC) of 260 mg/l, corresponding to 15 and 21 mg/kg body weight for male and female rats (Til *et al.* 1989).

Inhalation between 3 days to 2 years showed a NOAEC of 1.2 mg/m^3 (1 ppm) with lesions of the nasal epithelium in rats (CICAD 2002).

Formaldehyde is known for its ability to cause sensitisation (allergy). Especially formaldehyde is recognised as being allergenic via skin contact and respiratory system (Thomsen 1990).

Formaldehyde is suspected to be carcinogenic to human. However, there is limited evidence in humans for the carcinogenicity but there is sufficient evidence in experimental animals for the carcinogenicity of formaldehyde in inhalation studies. IARC, therefore, has considered that formaldehyde is probably carcinogenic to humans and placed the substance in group 2A (IARC 1995).

Threshold limit values

For formaldehyde, the Danish working environment authorities (Arbejdstilsynet) has set a norm value of 0.15 mg/m^3. In buildings in use, the concentration in the indoor air varies between 0.01 and 0.20 mg/m^3, depending on its sources. This is at concentrations around the WHO guidance value of 0.1 mg/m^3. Very sensitive persons can smell formaldehyde and even react with mucous and especially eye irritation at concentrations as low as 0.06 mg/m^3. Concentrations above 0.05 mg/m^3 may induce an increased incidence of symptoms and inconvenience. The Danish working environment authorities (Arbejdstilsynet) accepts a maximal concentration of formaldehyde of 0.15 mg/m^3 in indoor climate. However, the threshold limit for industrial working environment is higher: 0.4 mg/m^3 (Arbejdstilsynet: www.at.dk, 2003).

The threshold limit value for the working environment (TLV) is 0.4 mg/m^3 with notation HK. H means that the substance can be absorbed through the skin. K means that the substance is adopted on the list of substances that may cause cancer (Arbejdstilsynet 2002).

The RfD-value 0.2 mg/kg/day is based on reduced weight gain and histopathological changes observed in a 2-year oral administration rat study. LOAEL was observed to be 82 mg/kg/day and NOAEL 15 mg/kg/day (Til *et al.* 1989). Applying a safety factor of 100 an oral reference dose (RfD) was calculated to 0.2 mg/kg/day.

Evaluation

Formaldehyde is known to be allergenic by contact both via inhalation and skin (Thomsen 1990). The concentrations that in the long term may elicit allergic reactions are unknown. The presence of formaldehyde can be a problem for persons who already are allergic to formaldehyde. It is to be expected that allergic persons may react to even small concentrations but no studies on the subject were found.

At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:

Cmax inhalation = 5922 / 20 = 296.1 µg/m^3

Adult

Inhalation, 1 piece of incense = (210×0.83×1)/70 = 2.5 µg/kg bw/day (ID no. 10)

Inhalation, 1 hour = (447×0.83×1)/70 = 5.3 µg/kg bw/day (ID no. 1)

Child

Inhalation, 1 piece of incense = (210×0.125×1)/10 = 2.63 µg/kg bw/day (ID no. 10)

Table 6.3 Emission, air concentration and absorption via inhalation of formaldehyde

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hou r	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	5281	11352	264	206	447	2.44	2.58	5.30
2	1266	1771	63	49	70	0.58	0.61	0.83
4	2823	4399	141	114	173	1.35	1.43	2.05
8	5922	5982	296	187	235	2.22	2.34	2.79
10	4826	6055	241	210	238	2.49	2.63	2.82
12	1735	3417	87	76	134	0.90	0.95	1.59

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was of the same order as the occupational threshold limit value of 400 µg/m^3 with a margin of a factor <1 to about 6, which is considered unsatisfactory when applied to consumers.

Conclusion

Formaldehyde is suspected to be carcinogenic by inhalation. The concentrations estimated for inhalation must be considered unacceptable relating to the referred exposure scenarios as the calculated exposure concentrations are of the same order as or close to the threshold limit value set for industrial working environment.

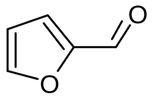
The norm value set by the national working environment authorities for indoor climate 150 µg/m^3 is exceeded on several accounts even for scenarios including ventilation.

The oral RfD value 200 µg/kg bw/day is not exceeded. However, due to the uncertainty by extrapolating from intake of formaldehyde administered via drinking water to absorption via inhalation, the other values based on inhalation studies were given precedence in the evaluation.

It is concluded that the threshold limit for indoor climate was exceeded in several cases and therefore a health risk can not be excluded. Ventilation after burning of incenses is recommended.

6.1.4 Furfural

Identification

Name	Furfural
CAS no.	98-01-1
EINECS no.	202-627-7
Molecular formula	$C_5 H_4 O_2$
Molecular structure	
Molecular weight	96.09 g/mol
Synonyms	2-Furaldehyde 2-Furancarboxaldehyde Furfuraldehyde

The melting point is –36.5°C. The boiling point is 161.7°C. The water solubility is 83000 mg/l at 20°C. The vapour pressure is 295 Pa at 25°C (2.21 mmHg, Daubert and Danner 1989) or 144 Pa at 20°C (CICAD 2000). The octanol/water partition coefficient is low with a measured log Kow 0.41 (Hansch *et al.* 1995).

Classification

Furfural is classified according to the List of dangerous substances (Miljøministeriet 2002):

Carc3;R40	Possible risks of irreversible effects
Xn;R21	Harmful. Harmful in contact with skin.
T;R23/25	Toxic. Toxic by inhalation and if swallowed
Xi;R36/37	Irritant. Irritating to eyes and respiratory system

It is noted that the classification is dependent on the concentration:

conc.>=25%:	Xn;R21 T;R23/25 Xi;R36/37 Carc3;R40
20%<=conc.<25%:	T;R23/25 Xi;R36/37 Carc3;R40
5%<=conc.<20%:	T;R23/25 Carc3;R40
1%<=conc.<5%:	Xn;R20/22 Carc3;R40

Origin

Furfural is used in the manufacture of resins and several other products. Furfural is added to several products as taste and or fragrance additive. Furfural is present in several foods as a natural part or as a contamination. Furfural is found in essential oils from a series of plants such as citronella (*Cymbopogon nardus*), camphor (*Cinnnamomum camphora*), lavender (*Lavendula vera*), lime (*Citrus aurantifolia*) and sassafras (*Sassafras albidum, Sassafras officinale*),.

Furfural may also be formed by thermal decomposition of carbohydrates, which may contribute to an explanation of the findings in all incenses during burning.

Health

Furfural is acute toxic to humans and the substance is suspected to be carcinogenic.

Several data on acute toxicity have been found. Of these are mentioned:

Acute oral, rat	LD_{50}	122 mg/kg	CICAD 2000

Acute oral, mouse	LD_{50}	1333mg/kg	JECFA 1999
Acute inhalation, rat	LC_{50}, 4 h	940 mg/m^3 (235 ppm)	CICAD 2000
Acute inhalation, rat	LC_{50}, 1 h	756 mg/m^3 (189 ppm)	CICAD 2000

Irritation of the respiratory system and lung damages is observed at single and repeated exposure via inhalation (CICAD 2000).

No reports on irritation to eyes and respiratory tract at exposure to 40 mg/m^3 (10 ppm) during 8 hours or at 80 mg/m^3 during 4 hours were found (CICAD 2000).

In a 13 weeks inhalation study, Syrian golden hamsters were exposed to furfural vapours for 6 hours/day, 5 days/week in 13 weeks. NOAEL was 20 ppm equivalent to 77 mg/m^3 (JECFA 1999, CICAD 2000).

A 13 weeks diet toxicity study on rats is performed. At 82 mg/kg changes in the liver in 5 out of 10 male rats were observed while there were no changes at 53 mg/kg bw/day (measured concentrations). NOAEL was therefore set to 53 mg/kg bw/day (JECFA 2001).

A 90 days rat study from the American National Toxicology Program (NTP) was found. On basis of reduced body weight increase and histopathology a LOAEL was set to 11 mg/kg bw/day. As this was the lowest concentration used, no NOAEL could be established (NTP 1981 study referenced in IRIS 2003).

Absorption
The absorption of vapour via lungs and skin is demonstrated. At the exposure of 30 mg/m^3, between 75 and 82% was absorbed via the lungs (JECFA 1999). In the evaluation 100% are used, as more specific data were not retrieved.

Threshold limit values
The threshold limit value for the working environment is 2 ppm equivalent to 7.9 mg/m^3 with notation HK meaning penetrable to skin and under suspicion of being carcinogenic (Arbejdstilsynet 2002).

The ADI 0.5 mg/kg bw/day is set on the basis of NOAEL 53 mg/kg in the 13 weeks rat study and applying a safety factor of 100 (JECFA 2001).

The RfD-value is set on the basis of the 90-days rat study by NTP. Based on LOAEL 11 mg/kg/day and applying a safety factor of 3000 (10 for inter- and 10 for intraspecies variation, 10 for extrapolating from subchronic to chronic data and a factor of 3 for using a LOAEL) an oral reference dosis (RfD) of 11/3000 = 0.003 mg/kg bw/day was derived (IRIS 2003).

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 333 / 20 = 16.7 µg/m^3 (ID no. 10)

Adult

Inhalation, 1 piece of incense = (12×0.83×1)/70 = 0.14 µg/kg bw/day (ID no. 10)
Inhalation, 1 hour = (13×0.83×1)/70 = 0.15 µg/kg bw/day (ID no. 10)

Child
Inhalation, 1 piece of incense = (12×0.125×1)/10 = 0.15 µg/kg bw/day (ID no. 10)

Table 6.4 Emission, air concentration and absorption via inhalation of furfural

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	229	547	11.5	10	22	0.12	0.13	0.26
2	92	138	4.6	4	5	0.05	0.05	0.06
4	82	122	4.1	3	5	0.04	0.04	0.06
8	86	103	4.3	3	4	0.04	0.04	0.05
10	333	336	16.7	12	13	0.14	0.15	0.15
12	43	82	2.2	2	3	0.02	0.03	0.04

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was below the threshold limit value for the working environment of 7.9 mg/m^3 with a factor of >350, which is considered acceptable.

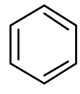
Considering absorption via inhalation the amounts were below the RfD-value of 3 µg/kg/day. Because the value was calculated including a safety factor, no further safety is applied.

Conclusion
Furfural is considered not to have adverse effects to the health of the consumer at the estimated concentrations.

6.2 Aromatic hydrocarbons

6.2.1 Benzene

Identification

Name	Benzene
CAS no.	71-43-2
EINECS no.	200-753-7
Molecular formula	C_6H_6
Molecular structure	
Molecular weight	78.11 g/mol
Synonyms	Benzol

The melting point is 5.5°C. The boiling point is 80.1°C. The water solubility is 1800 mg/l at 25°C. The vapour pressure is 13.3 kPa at 25°C. Octanol/water partition coefficient is measured to between log Kow 1.56 and 2.15 (IPCS 1993).

Classification
Benzene is classified in the List of dangerous substances (Miljøministeriet 2002):

Carc1;R45	May cause cancer
F;R11	Highly flammable
T;R48/23/24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed

NOTE:
The classification has been changed since then. Benzene is included in the 29th revision list (ATP 2003) with a more rigorous classification. This means that it is not yet implemented in Danish regulation but probably will be at the next revision of the List of dangerous substances:

F;R11	*Highly flammable*
Carc. Cat. 1; R45	*May cause cancer*
Mut. Cat. 2; R46	*May cause heritable genetic damage*
T; R48/23/24/25	*Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed*
Xn;R65	*Harmful: may cause lung damage if swallowed.*
Xi;R36/38	*Irritant. Irritating to eyes and skin*

Origin
Benzene is extracted from oil products of which benzene is a component or as a side-product from the manufacture of other chemical substances. The use is mainly as an intermediate in the manufacture of several chemical compounds. Benzene can also be formed by combustion of organic material, which may contribute to an explanation of its presence during burning of all incense tested.

Health
Several data on acute toxicity were found. Of these are mentioned:

Acute oral, rat	LD_{50}	810-10000 mg/kg	ECB 2003
Acute inhalation, rat	LC_{50}, 4 h	44500 mg/m^3	ECB 2003

High concentrations of benzene vapours are irritating to the mucous membranes of the eyes, nose and respiratory tract (ECB 2003).

From the toxicological point of view, areas of concern are mutagenicity, carcinogenicity, repeated dose toxicity and reproductive toxicity.

In a 13 weeks study, 50 rats/sex/group were exposed to benzene vapour (whole body exposure) at concentrations of 3.2, 32, 96 or 960 mg/m^3 (1, 10, 30 or 300 ppm) for 6 hours/day, 5 days/week for 13 weeks. Only at the highest dosis effects were observed on the blood system (haematological effects on the peripheral blood circulation) and reduced weight of the thyroid. No other effects were observed. Based on this the NOAEC was set to 96 mg/m^3 (Ward *et al*. 1985).

Rothman *et al.* (1996) has performed a cross-sectional study of 44 workers exposed to a range of benzene concentrations and 44 age- and gender-matched unexposed controls, all from Shanghai, China. The median (range) concentration in an 8-hour working period (TWA: Time Weighted Average) was 23 (3.2–64) mg/m^3. LOAEL was observed to be 7.6 ppm equivalent to 24.3 mg/m^3 (IRIS).

Benzene is a known human carcinogen based upon evidence presented in numerous occupational epidemiological studies. Significantly increased risks of leukaemia, chiefly acute myelogenous leukaemia (AML), have been reported in benzene-exposed workers in the chemical industry, shoemaking, and oil refineries (ECB 2003).

Threshold limit values

The threshold limit value for the working environment is 0.5 ppm equivalent to 1.6 mg/m^3 with notation HK (penetrable to the skin and carcinogenic) (Arbejdstilsynet 2002).

The reference values are based on Rothman *et al.* (1996).
The median concentration, 8-hour TWA was 23 mg/m^3. The found TWA was adjusted from a working day with a respiration volume of 10 m^3 to 24 hours respiration volume of 20 m^3/day and recalculated from 5 days to 7 days/week continuous exposure: 23 mg/m^3 ×10/20 m^3 ×5/7 days = 8.2 mg/m^3. The value is then applied a safety factor of 270 based on an application factor 10 for intraspecies variation, 3 for subchronic to chronic extrapolation, 3 for effect level extrapolation and 3 for data deficiencies: RfC = 8.2/270 = 0.03 mg/m^3 (IRIS).

For comparison, an inhalation RfC based on LOAEL 7.6 ppm from Rothman *et al*. (1996) study was also calculated. Recalculation and adjustment as above to continuous exposure resulted in a LOAEL of: 24.3×(10/20 m^3)×(5/7 days) = 8.7 mg/m^3. The adjusted $LOAEL_{ADJ}$ was divided by a safety factor of 900 (10 for using LOAEL in stead of NOAEL, 10 for intraspecies variation, 3 for subchronic to chronic extrapolation and 3 for data deficiencies), which gives a RfC value: 8.7 mg/m^3 / 900 = 0.009 mg/m^3 (IRIS).

The oral RfD value 4.0 x 10^{-3} mg/kg/day is based on a recalculation from inhalation exposure 8.2 mg/m^3 (Rothman *et al*. 1996) to 1.2 mg/kg bw/day. The calculation was performed as: 23 mg/m^3 ×10/20 m^3 ×5/7 days = 8.2 mg/m^3. Assuming that the absorption via inhalation was 50% and 100% via oral intake, an extrapolation from inhalation to "oral" intake may be estimated: 8.2 mg/m^3 ×20 m^3/day ×0.5 (50%) / 70 kg = 1.2 mg/kg bw/day. Applying a safety factor of 300 (10 for intraspecies variation, 3 for effect level, 3 for subchronic to chronic and 3 for data deficiencies) a RfD value: 1200/300 = 4 µg/kg bw/day is derived (IRIS 2003).

Absorption

Benzene is easily absorbed via inhalation and skin contact (ECB 2003).

Inhalation studies in rodents suggested that the uptake of benzene by the lungs was related to the concentration in a non-linear manner. For inhalation exposures, the mean percentage of inhaled ^{14}C-benzene absorbed and retained in the tissues and blood during a 6-hr exposure decreased from 33% to 15% in rats, and from 50% to 10% in mice, as the exposure concentration was increased from approximately 26 to 2600 mg/m^3 (8 to 812 ppm). Greater absorption of benzene at lower concentrations by mice than rats is partially explained by physiological differences in respiratory rate and tidal volume (Sabourin *et al*. 1987).

An inhalation study with the exposure to 150-352 mg/m³ (47-110 ppm) of benzene for 2-3 hours showed that during the first five minutes of exposure 78-80% were extracted from the inhaled air, but after one hour, the extraction was reduced to approximately 50% (range 20-60%) (Srbova *et al.* 1950 summarised in ECB 2003).

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3. The absorption is set to 50%.

Calculation example:
Maximal concentration in room, Cmax inh = 7451 / 20 = 373 µg/m^3 (ID no. 8)

Adult
Inhalation, 1 piece of incense = (281×0.83×0.5)/70 = 1.67 µg/kg bw/day (ID no. 8)
Inhalation, 1 hour = (353×0.83×0.5)/70 = 2.09 µg/kg bw/day (ID no. 8)

Child
Inhalation, 1 piece of incense = (281×0.125×0.5)/10 = 1.76 µg/kg bw/day

Table 6.5 Emission, air concentration and absorption via inhalation of benzene

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	619	1482	31.0	26.9	58.3	0.16	0.17	0.35
2	976	1464	48.8	40.6	57.6	0.24	0.25	0.34
4	748	1114	37.4	28.9	43.8	0.17	0.18	0.26
8	7451	8978	372.6	281	353	1.67	1.76	2.09
10	693	700	34.7	24.2	27.5	0.14	0.15	0.16
12	266	502	13.3	11.1	19.8	0.066	0.069	0.12

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was below the threshold limit value for the working environment of 1.6 mg/m^3 in most cases but above for one of the incenses. This is evaluated to be unsatisfactory when the concentration concerns consumers in an ordinary home and not the working environment.

Relating to the inhalation the concentrations are above the RfC value 9 µg/m^3. Some of the values are above and one value up to 10 times above the RfC value 30 µg/m^3.

The lowest margin of safety (MOS) = LOAEL/max. exposure = 8200/281 = 30, which is considered insufficient.

The RfD value 4 µg/kg bw/day was not exceeded.

It should be noted that benzene is a known carcinogenic substance where no safe level for exposure may be established (CSTEE 2003). An increased risk of cancer is estimated by the Dutch to concentrations above 20 µg/m^3 (Baars *et al.* 2001). Based on the Dutch value use of most of the tested incenses could be considered in that risk class.

Conclusion
Benzene is a carcinogen. The estimated limit for uptake was not exceeded but the calculated exposure concentrations are very close to and in a single case above the derived reference values.

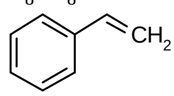
Benzene is in its last phases of the risk assessment in the EU (ECB 2003) where an air quality limit value of 5 µg/m^3 has to be implemented by January 2010. The value is set as low as it is assumed practical possible and reasonable to achieve within the time framework.

On the other side it should also be remembered that the exposure to benzene during refilling gasoline might cause concentrations in the breathing zone of 1.3 mg/m^3. Smokers are exposed to concentrations that may remind of the levels emitted from incense. According to WHO smokers may take up as much as 1.8 mg benzene/day compared to non-smokers approx. 0.05 mg/day (IPCS 1993).

It is concluded that the exposure to incense may contribute significantly to the intake of benzene if ventilation after burning incense is not performed.

6.2.2 Styrene

Identification

Name	Styrene
CAS no.	100-42-5
EINECS no.	202-851-5
Molecular formula	$C_8 H_8$
Molecular structure	
Molecular weight	104.15 g/mol
Synonyms	Benzene, ethenyl Ethenylbenzene Phenylethylene Vinylbenzene

The melting point is –30.6°C. The boiling point is 145.2°C. The water solubility is 300 mg/l at 25°C. The vapour pressure is 867 Pa at 25°C. The octanol/water partition coefficient is measured to log Kow 3.02 (ECB 2002).

Classification
Styrene is classified in the List of dangerous substances (Miljøministeriet 2002):

R10	Flammable

Xn;R20	Harmful: Harmful by inhalation
Xi;R36/38	Irritant: Irritating to eyes and skin
conc.>=12.5%:	Xn;R20 Xi;R36/38

Origin

Styrene is manufactured from benzene produced in the oil industry. Styrene is used to a large extent in the plastic- (polystyrene) and rubber industry but also in many other products. The findings of styrene in all incenses during burning may be because styrene can be formed during combustion of organic material.

Health

Styrene is not acute toxic.

Several data on acute toxicity have been found. Of these are mentioned:

Acute oral, rat	LD_{50}	5000 mg/kg	IPCS 26, 1983
Acute inhalation, rat	LC_{50}, 4 h	41000 mg/m^3	Koch 1984

The problematic health effect is that styrene is considered neurotoxic. Affecting the neurological development seems to be the most sensitive endpoint observed. In young rats exposed to 260 mg/m^3 effects were observed on behaviour and biochemical parameters in the brain (Kishi *et al.* 1992 in WHO 2000).

In occupationally exposed humans minor effects were observed such as effects on verbal abilities and disturbances to the vision at air concentrations of 107-213 mg/m^3. When the lowest value for precautionary reasons is used and recalculated from working hours to continuous exposure with a factor 2.4 and apply a further safety factor of 10 for inter-individual variation and 10 for extrapolating from LOAEL to NOAEL, a value of 107/(4.2×10) = 0.26 mg/m^3 (weekly average) is derived (WHO 2000).

Mutti *et al.* (1984) examined in a cross-sectional study the neuropsychological function in 50 workers whose mean duration of styrene exposure was 8.6 (SD of 4.5) years. Styrene exposure was assessed by the authors to correspond to air concentrations ranging from 10-300 ppm as a mean daily exposure. The concentration-response relationship between urinary metabolite concentration (mandelic acid and phenylglyoxylic acid levels normalised to creatinine in "morning-after" urine). A significant effect level was observed in the subgroup whose urine contained 150-299 mmole urinary metabolites/mole creatinine. Workers with metabolite concentrations of up to 150 mmoles/mole appeared to have no significant effects. This level is therefore designated as the NOAEL in this study. The authors state that this level of urinary metabolites corresponds to a mean daily 8-hour exposure to air styrene of 25 ppm (106 mg/m^3). 95% confidence interval is calculated for an 8-hour exposure at 100 ppm and the lower limit of the confidence calculation was 88% of the mean styrene exposure. This factor applied to the correction of NOAEL: 25 ppm × 0.88 = 22 ppm (94 mg/m^3).

In a subchronic oral study on dogs where the effect of styrene on red blood cells and the liver was studied after oral administration for 560 days, LOAEL was observed at 400 mg/kg/day and NOAEL set to 200 mg/kg/day (Quast *et al.* 1979).

In a 2-year three-generation rat study, rats were exposed to 125 mg/l (corresponding to 7.7 mg/kg/day for males and 12 mg/kg/day for females) and 250 mg/l (corresponding to 14 mg/kg/day for males and 21 mg/kg/day for females) in drinking water. The body weight was affected at 21 mg/kg/day, while male and female reproduction was not affected. Therefore, NOAEL was 14 mg/kg/day for males and 12 mg/kg/day for females (Van Appeldoorn *et al.* 1986).

There are only weak indications that styrene should be carcinogenic, however, IARC has evaluated the substance as possible carcinogenic to humans and placed the substance in group 2B (inadequate evidence in humans and limited evidence in experimental animals for the carcinogenicity of styrene: IARC 1994, WHO 2000). Apparently, the carcinogenicity potential of styrene is related to the metabolite styrene oxide, which is quickly transformed into styrene glycols (WHO 2000).

Threshold limit values

The threshold limit value for the working environment is 25 ppm equivalent to 105 mg/m^3 with notation LHK. **L** means that the threshold limit value is a ceiling value, which at no time must be exceeded. **H** means that the substance is penetrable to the skin. **K** means that the substance is adopted on the list of substances that may be carcinogenic (Arbejdstilsynet 2002).

WHO has given a 24 hours air quality guideline value of 800 µg/m^3 (IPCS 1983).

The inhalation RfC-value is set on basis of effects to the central nervous system (Mutti *et al.* 1984) with a NOAEL 94 mg/m^3 (cf. above). The value is calculated to continuous exposure and assuming that 10 m^3 air was the respiration rate during the working hours: 94 mg/m^3 $\times$ 10/20 m^3/day $\times$ 5/7 days = 34 mg/m^3 (NOAEL HEC, human equivalent concentration). The safety factor of 30 was based on the application of 10 for intraspecies variation and 3 for data deficiencies, thus, RfC = 34/30 = 1 mg/m^3 (IRIS).

The oral RfD-value is based on a subchronic oral study on dogs for 560 days where NOAEL was observed to 200 mg/kg/day (Quast *et al.* 1979). Applying a safety factor of 1000 (10 for inter-, 10 for intraspecies variation and 10 for extrapolation subchronic to chronic effects) the resulting RfD is: 200/1000 = 0.2 mg/kg bw/day (IRIS).

TDI is 120 µg/kg bw/day. A Dutch value (Van Appeldoorn *et al.* 1986, cf. above) is based on a 2-year rat study with a safety factor of 100 (Baars *et al.* 2001).

The odour limit value is 70 µg/m^3 in WHO (2000).

Absorption

Styrene is absorbed easily from the lungs. In different studies uptake has been measured to vary between 45 and 93% (IPCS 1983).

Evaluation

At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:

Cmax inhalation = 582 / 20 = 29.1 µg/m^3 (ID no. 4).

Adult
Inhalation, 1 piece of incense = (21×0.83×1)/70 = 0.25 µg/kg bw/day including ventilation (ID no. 4).
Inhalation, 1 hour = (34×0.83×1)/70 = 0.41 µg/kg bw/day (ID no. 4).

Child
Inhalation, 1 piece of incense = (21.3×0.125×1)/10 = 0.27 µg/kg bw/day (ID no. 4).

Table 6.6 Emission, air concentration and uptake by inhalation of styrene

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	88	211	4.4	4	8	0.05	0.05	0.09
2	207	310	10.4	9	12	0.11	0.11	0.14
4	582	867	29.1	21	34	0.25	0.27	0.41
8	493	594	24.7	19	23	0.23	0.24	0.27
10	215	217	10.8	8	9	0.09	0.10	0.11
12	69	130	3.5	3	5	0.04	0.04	0.06

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was below the threshold limit value for the working environment of 105 µg/m^3 but only with a factor of approx. 3, which is considered insufficient.

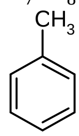
Relating to inhalation, the concentrations are below the RfC-value 1 mg/m^3 and below WHO´s air quality value of 0.26 mg/m^3.

Relating to the amount taken up the oral RfD was 0.2 mg/kg bw/day. Most of the calculated values were a factor of 500 to 1000 below. The calculated values lie with a factor of more than 300 times below the found TDI value of 0.12 mg/kg bw/day.

Conclusion
Based on the calculated scenarios there is not expected to be any health risks to the consumers due to the presence of styrene in the incense.

6.2.3 Toluene

Identification

Name	Toluene
CAS no.	108-88-3
EINECS no.	203-625-9
Molecular formula	$C_7 H_8$
Molecular structure	
Molecular weight	92.15 g/mol
Synonyms	methylbenzene phenylmethane

The melting point is -95°C. The boiling point is 111°C. The vapour pressure is 3800 Pa at 25°C. The water solubility is 515 mg/l. The octanol/water partition coefficient log Kow is experimentally determined to 2.65 (ECB 2003).

Classification

Toluene is classified in the List of dangerous substances (Miljøministeriet 2002):

F;R11	Highly flammable
Xn;R20	Harmful. Harmful by inhalation

NOTE:

Toluene is included in the 29th revision list (ATP 2003) with a more rigorous classification. This means that it is not yet implemented in Danish regulation but probably will be at the next revision of the List of dangerous substances:

F;R11	*Highly flammable*
Repr.Cat.3; R63	*Possible risk of harm to the unborn child.*
Xn;R48/20-65	*Harmful: danger of serious damage to health by prolonged exposure through inhalation, may cause lung damage if swallowed.*
Xi;R38	*Irritant. Irritating to skin*
R67	*Vapours may cause drowsiness and dizziness*

Health

Toluene is irritating to the skin and harmful to the health. Toluene is suspected to be reprotoxic, i.e. possible risk of harm to the unborn child.

Acute toxicity

Of acute data, several have been found. Of them is mentioned:

Acute oral, rat	LD_{50}	5500 mg/kg	Kimura *et al.* 1971
Acute dermal, rabbit	LD_{50}	12400 mg/kg	Smyth *et al.* 1969
Acute inhalation, rat	LC_{50} (6 h)	22 mg/l (22 g/m^3)	Bonnet *et al.* 1982
Acute inhalation, mouse	LC_0 (6 h)	24 mg/l (24 g/m^3)	Bonnet *et al.* 1982

Data on acute toxicity via inhalation were between 22 and 24 g/m^3, which do not present any immediate reason for concern. However, it was also observed that toluene even at low concentrations (from 285 mg/m^3) may induce headaches, dizziness, irritation and sleeplessness (ECB 2003).

An inhalation value for human with a LOEL 25 mg/m^3 has been found (Lewis 1999).

Toluene is recommended classified as reprotoxic, category 3 (27th ATP, cf. above), meaning that indications have been observed of possible risk of harm to the unborn child. Indications that repeated contact may cause allergic contact dermatitis has also been observed.

In a 13 week study on mice a LOAEL of 312 mg/kg/day was observed (WHO 2000).

A 90-days oral study on rats was found with a NOAEL of 625 mg/kg/day and a 2-year rat inhalation study with a NOAEC 300 ppm (1125 mg/m^3) (ECB 2003).

In humans experimentally exposed to toluene a concentration at and above 75 ppm (285 mg/m^3) resulted in headache, dizziness, a feeling of intoxication, irritation and sleeplessness. A NOAEC of 40 ppm (150 mg/m^3) is set for these effects (ECB 2003).

A study concerning the neurological effects in occupationally exposed persons. No NOAEL could be established. LOAEL was observed to be 332 mg/m^3 (88 ppm). LOAEL adjusted to continuous exposure was: $332 \times 10/20 \times 5/7 = 119$ mg/m^3 (Foo *et al*. 1990).

In a 2-year rat study with chronic inhalation a degeneration of the nasal epithelium was observed (NTP, 1990). NOAEL could not be established. LOAEL was 2261 mg/m^3 (600 ppm). Recalculating LOAEL to 24 hour/day and 7 days a week results in: 2261 mg/m^3 $\times$ 6.5/24 hours $\times$ 5/7 days = 437 mg/m^3. Adjusting the effect in the extra-thoracic region assuming that the respiration rate for rats was 0.27 m^3/day and that the epithelium in rats was 11.6 cm^2 and 177 cm^2 in humans, a resulting value would be: 437 $\times$ (0.24/20 m^3/day) $\times$ (177/11.6 cm^2) = 79 mg/m^3.

In humans, toluene is a known respiratory irritant with central nervous system (CNS) effects. Available studies could not provide NOAEL concentrations for either of these effects that should have been used in the evaluation of a potential basis for the RfC calculation. Consequently, the study of Foo *et al.* (1990) was used for the CNS effects, and that of the National Toxicology Program (NTP, 1990) for the irritant effects. Because the CNS effect was judged to be a more severe and relevant endpoint, the LOAEL for this effect was used to derive the RfC. Further, this effect is supported by a number of other occupational studies that show effects around 100 ppm.

Absorption
Data have been found on the dermal exposure and the uptake fraction is low. Dermal uptake at exposure to toluene vapours is measured to approx. 1% of the amount of toluene taken up via inhalation at exposure to the same concentrations (Riihimäki and Pfäffli 1978, Piotrowski 1967).

Uptake via inhalation is studied in humans. The uptake after 3 hours of exposure when at rest was approx. 50% of the inhaled amount of toluene. During work the uptake may be significantly higher. It was concluded that toluene is fast taken up by inhalation and that the amount depended on the respiration rate.

Threshold limit values
The threshold limit value for the working environment is 94 mg/m^3 equivalent to 25 ppm (Arbejdstilsynet 2002).

The inhalation RfC-value 0.4 mg/m^3 is based on the Foo *et al.* 1990 study mentioned above where a LOAEL was found and recalculated to 119 mg/m^3. Applying a safety factor of 300 (10 for intraspecies variation, 10 for extrapolating from LOAEL to NOAEL and 3 due to data deficiencies) results in RfC = 119/300 = 0.4 mg/m^3.

The TDI value 223 µg/kg bw/day is based on LOAEL 312 mg/kg/day in a 13 week study on mice (WHO 2000).

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 1252 / 20 = 62.6 µg/m^3 (ID no. 8).

Adult
Inhalation, 1 piece of incense = (47×0.83×1)/70 = 0.56 µg/kg bw/day including ventilation (ID no. 8).
Inhalation, 1 hour = (59×0.83×1)/70 = 0.70 µg/kg bw/day (ID no. 8).

Child
Inhalation, 1 piece of incense = (47×0.125×1)/10 = 0.59 µg/kg bw/day (ID no. 8).

Table 6.7 Emission, air concentration and uptake via inhalation of toluene

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh, 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	518	1239	25.9	22	49	0.26	0.28	0.58
2	814	1221	40.7	34	48	0.40	0.43	0.57
4	602	897	30.1	23	35	0.27	0.29	0.42
8	1252	1508	62.6	47	59	0.56	0.59	0.70
10	598	604	29.9	21	24	0.25	0.26	0.28
12	236	446	11.8	9	18	0.11	0.11	0.21

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was below the occupational threshold limit value of 94 mg/m^3 with a safety factor of >1500, which is assumed to be sufficient.

The RfC value 400 µg/m^3 is not exceeded.

The RfD value 223 µg/kg bw/day is not exceeded.

Conclusion
The emission of toluene from incense did not reach concentrations that cause concern for the consumers of incense sticks.

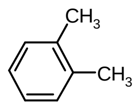
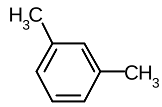
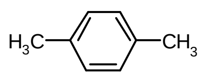
However, it should be noted that the amount of toluene in air could also be caused by other sources than incense. The actual indoor air concentration of toluene may therefore be higher than the estimated concentration.

6.2.4 Xylene

Xylene is used as solvent and in the production of colorants. Xylene consists of a mixture of the three isomers: o-, m-, and p-xylene with m-xylene as the dominant part (ratio approx. 20:40:20, respectively).

Identification

Name	Xylene
CAS no.	1330-20-7
EINECS no.	205-535-7
Molecular formula	$C_8 H_{10}$
Molecular structure	$C_6 H_4 (CH_3)_2$
Molecular weight	106.16 g/mol
Synonyms	Dimethylbenzene (3 isomers o-, m-, and p-xylene) Methyltoluene Xylol

Name	CAS no.	EINECS no.	Structure
ortho-xylene (1,2-dimethylbenzene)	95-47-6	202-422-2	
meta-xylene (1,3-dimethylbenzene)	108-38-3	203-576-3	
para-xylene (1,4-dimethylbenzene)	106-42-3	203-396-5	

The boiling point of xylene (mixture) is 138.5°C. The vapour pressure is 1065 Pa at 25°C (7.99 mmHg) (Daubert and Danner 1985). The water solubility is 106 mg/l at 25°C (Yalkowski and Dannenfelser 1992). The partition coefficient log Kow is experimentally determined to 3.12 (Hansch *et al.* 1995).

Classification
Xylene (and isomers) is adopted on the List of dangerous substances and classified (Miljøministeriet 2002):

R10	Flammable
Xn;R20/21	Harmful. Harmful by inhalation and in contact with skin
Xi;R38	Irritant. Irritating to skin

Health
Several acute and chronic data are found. Of these are mentioned:

Acute oral, rat	LD_{50}	3608 mg/kg (*o*-xylene) 5011 mg/kg (*m*-xylene)	IPCS 1997

		4029 mg/kg (*p*-xylene)	
Acute dermal, rabbit	LD_{50}	12180 mg/kg	IPCS 1997
Acute inhalation, rat	LC_{50} (6 h)	4330 ppm (*o*-xylene) 5796 ppm (*m*-xylene) 4591 ppm (*p*-xylene)	IPCS 1997
Chronic tests;			
Oral rat, 2 years,	NOEL	250 mg/kg	IPCS 1997
Inhalation, rat	LOAEL (6 h/d, 20 d)	870 mg/m^3 (200 ppm)	Hass and Jacobsen 1993

ATSDR (1995) points out that both animals and human data indicate that the mixtures of xylenes, m-, o- and p-xylene, all results in similar effects but that the single isomers are not necessarily equally potent in relation to a specific effect. Therefore, the evaluation is based on xylene mixture.

Prolonged exposure to organic solvents may cause brain damage. Generally, concentrations around 100 ppm are observed to be the NOEL for brain damages. 10 mg/m^3 is observed to be NOEL for teratogenic effects in animal studies (Hass and Jacobsen 1993).

Korsak *et al*. (1992) exposed groups of 12 rats to toluene, m-xylene, or a 1:1 mixture for 6 hours per day, 5 days per week at a concentration of 0 or100 ppm for 6 months or 1000 ppm for 3 months. In a second study, Korsak *et al*. (1994) exposed groups of 12 Wistar rats by inhalation to 0, 50, or 100 ppm m-xylene, n-butyl alcohol or a 1:1 mixture for 6 hours per day, 5 days per week for 3 months and evaluated similar endpoints as in the earlier study (Korsak *et al*., 1992). Sensitivity to pain was assessed by placing the animal on a hot plate (54°C) and measuring the time until the animal starts licking its paws. Rats exposed to 50 or 100 ppm m-xylene alone had statistically significantly increased sensitivity to pain at the end of the 3 months exposure period. LOAEL is set to 100 ppm and NOAEL 50 ppm.

Condie *et al.* (1988) has performed an oral rat study. A LOAEL of 150 mg/kg/day could be established but the effects were minor and there was no reason to believe that the NOAEL would be very different. The study is supported by NTP (1986), which in a chronic oral rat study observed a NOAEL of 179 mg/kg/day (cf. RfD below).

Xylenes are not classified for their carcinogicity. IARC has placed xylenes in Group 3, i.e. ”not classifiable as to its carcinogenicity to humans” (IARC 1999).

Threshold limit values
The threshold limit value for the working environment is 25 ppm equivalent to 109 mg/m^3 with notation H (penetrable to the skin) (Arbejdstilsynet 2002).

The TCA (tolerable concentration in air): 870 $\mu g/m^3$ (Baars *et al*. 2001). TCA is a guidance threshold limit value based on LOAEL 870 mg/m^3 (200 ppm) observed in an inhalation study where the critical endpoint was reproduction toxicity (Hass and Jacobsen 1993) and the application of a safety factor of 1000 (IPCS 1997).

The LCI-value 100 µg/m^3 is based on an animal study with a NOEL for teratogenic effect of 10 mg/m^3 (LCI = NOEL/10×10×1) (Larsen *et al.*1999).

The RfC: 0,1 mg/m^3 is based on Korsak *et al.* (1992). In the study, impaired motor co-ordination was observed with a NOAEL 50 ppm equivalent to 217 mg/m^3, which was recalculated to 217 mg/m^3 × 6/24 hours × 5/7 days = 39 mg/m^3. Applying a safety factor of 300 (10 for inter- and 10 for intraspecies variation and 3 for LOEL extrapolation to NOEL): 39/300 = 0.1 mg/m^3.

The TDI (tolerable daily intake): 150 µg/kg bw/day (based on Condie *et al.* 1988).

The oral RfD-value 0.2 mg/kg /day is based on a 2-year rat study where rats were administered xylene mixture daily for 5 days per week. A LOAEL was observed at 500 mg/kg/day and a NOAEL at 250 mg/kg/day (NTP 1986). Adjusted to chronic exposure the NOAEL value corresponded to 250 × 5/7 days = 179 mg/kg/day. Applying a safety factor of 1000 the RfD is derived at: RfD = 179/1000 = 0.2 mg/kg bw/day.

Absorption
Uptake via inhalation is found to be approx. 60% (ATSDR 1995, IPCS 1997). Because no further information was found, the evaluation is based on 100% absorption.

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 425 / 20 = 21.3 µg/m^3 (ID no. 8).

Adult
Inhalation, 1 piece of incense = (16×0.83×1)/70 = 0.19 µg/kg bw/day (ID no. 8).
Inhalation, 1 hour = (20×0.83×1)/70 = 0.24 µg/kg bw/day (ID no. 8).

Child
Inhalation, 1 piece of incense = (16×0.125×1)/10 = 0.20 µg/kg bw/day (ID no. 8).

Table 6.8 Emission, air concentration and uptake via inhalation of xylene

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc.. incl vent	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	153	365	7.7	7	14	0.08	0.09	0.17
2	347	521	17.4	15	21	0.18	0.19	0.25
4	331	493	16.6	13	20	0.15	0.16	0.24
8	425	512	21.3	16	20	0.19	0.20	0.24
10	318	321	15.9	11	13	0.13	0.14	0.15
12	81	152	4.1	3	6	0.04	0.04	0.07

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.

Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.

The maximal concentration was below the threshold limit value for the working environment of 109 mg/m^3 with a factor of more than 5000, which is assumed to be sufficient.

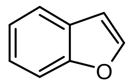
The calculated air concentrations are below the found threshold limit values and the absorbed amounts are far below the oral RfD value of 0.2 mg/kg/day.

Conclusion
There is no reason to believe that a health risk exists to consumers of incense sticks related to the emission of xylenes from incense.

6.3 Other aromatics (and benzyl derivatives)

6.3.1 Benzofuran

Identification

Name	Benzofuran
CAS no.	271-89-6
EINECS no.	205-982-6
Molecular formula	$C_8 H_6 O$
Molecular structure	
Molecular weight	118.14 g/mol
Synonyms	Benzo(b)furan 2,3-Benzofuran Coumarone 1-Oxindene

The melting point is <–18°C. The boiling point is 174°C. The water solubility is estimated to 535 mg/l at 25°C (QSAR). The vapour pressure is 58 Pa at 25°C, 0.44 mmHg (Chao *et al.* 1983). The octanol/water partition coefficient is measured to log Kow 2.67 (Hansch *et al*. 1995).

Classification
Benzofuran is not classified in the List of dangerous substances (Miljøministeriet 2002). In the advisory List for self-classification (Miljøstyrelsen 2001) the following is suggested:

Xn;R22 R43	Harmful. Harmful if swallowed. May cause sensitization by skin contact

Origin
Benzofuran is used in the manufacture of coumaron-indene resins and several other chemical compounds. The production is based on carbon tar oil. Several resins used in the manufacture of incense sticks may contain op to 10% benzofuran (Ullman: Furan and derivatives)

Benzofuran can also be formed during combustion of gasoline, diesel and waste (Budavari 1989). This may further contribute to an explanation of the findings of benzofuran during burning of incense.

Health
No studies on effects from inhalation of benzofuran could be found.

Only a few data on acute toxicity could be found. Of these are mentioned:

Mouse, intraperitoneal	LD50	500 mg/kg	NIOSH- MSDS

Very little information on the possible adverse effects to humans could be found. In rats and mice orally administered large quantities over a short period, liver and kidney damages were observed. Experimental animals exposed over a prolonged period to moderate levels showed liver, kidney, lung and stomach damages (NTP 1989).

In the American NTP programme, 14 days, 13 weeks and 2-year studies on mice and rats has been performed (NTP 1989). In the 14 days studies mice and rats were orally administered the doses 60, 120, 250, 500 and 1000 mg/kg bw/day. All animals exposed to 1000 mg died. On basis of especially nephrotoxic effects a LOAEL was established at 500 mg/kg/day and a NOAEL of 250 mg/kg/day. In the 13 weeks studies a NOAEL was established that with a few exceptions were 120 mg/kg/day for mice. The exception covers that in tests tumours were observed in liver, lung and stomach at 60 mg/kg/day, which was the lowest dosis. NOAEL was 60 mg/kg/day for rats. The 2-year mice- and rats tests were performed at the doses 30, 60 and 120 mg/kg/day administered orally by gavage, 5 days per week for 103 weeks. LOAEL was observed at 30 mg/kg/day but because serious kidney damages were observed in the rats study at 30 mg/kg/day, which was the lowest exposure level this LOAEL could not be used to establish a NOAEL (ATSDR 1992).

No studies relating to effects by inhalation were found.

IARC has evaluated that there is insufficient evidence for carcinogenicity in humans while there were sufficient evidence on carcinogenicity in experimental animals. IARC has placed benzofuran in group 2B: Benzofuran is a possible carcinogenic to humans (IARC 1995).

Threshold limit values
No threshold limit values for benzofuran were found.

The American OEHHA (1999) suggests a maximal allowed daily intake of 0.05 µg/day (No Significant Risk Level (NSRL), OEHHA 1999).

Absorption
No data found.

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 512 / 20 = 25.6 µg/m^3 (ID no. 8).

Adult

Inhalation, 1 piece of incense = (19×0.83×1)/70 = 0.23 µg/kg bw/day (ID no. 8).
Inhalation, 1 hour = (24×0.83×1)/70 = 0.28 µg/kg bw/day (ID no. 8).

Child
Inhalation, 1 piece of incense = (19×0.125×1)/10 = 0.24 µg/kg bw/day (ID no. 8).

Table 6.9 Emission, air concentration and uptake via inhalation of benzofuran

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m³	µg/m³	µg/m³	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	94	225	4.7	4	9	0.05	0.05	0.11
2	303	545	15.2	13	18	0.15	0.16	0.21
4	-	-						
8	512	617	25.6	19	24	0.23	0.24	0.28
10	208	210	10.4	7	8	0.08	0.09	0.09
12	-	-						

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.
-: not detected.

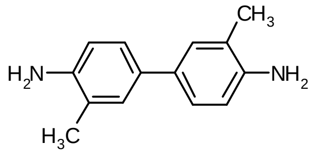
Since no established threshold limit values or similar were found, LOAEL 30 mg/kg/day may be used even though serious effects at this lowest tested level were observed. The estimated uptakes via inhalation were all below 0.3 µg/kg bw/day This means that there is a margin of safety of 30 000/0.3 = 100 000 between LOAEL and the estimated maximal uptake level.

Most chemical furan-compounds appear to have similar effects: cell damages, especially in kidneys and liver. For tetrahydrofuran a temporary TDI of 10 µg/kg bw/day and a Tolerable Concentration in Air, TCA-value, of 35 µg/m³ was found (Baars *et al*. 2001). For furfural an oral RfD-value of 0.003 mg/kg/day (cf. above, section 5.1.4) was found. The proximity of these values supports a threshold limit value of approx. 1 to 10 µg/m³.

Conclusion
Based on the limited available information it is assumed that no health concern to the consumers is to be expected from the emission of benzofuran from burning of incense.

6.3.2 4,4-Diamine-3,3-dimethyl-1,1-biphenyl (4,4'-bi-o-toluidine)

Identification

Name	4,4-Diamine-3,3-dimethyl-1,1-biphenyl
CAS no.	119-93-7
EINECS no.	204-358-0
Molecular formula	$C_{14} H_{16} N_2$
Molecular structure	
Molecular weight	212.30 g/mol
Synonyms	4,4'-bi-o-toluidine 3,3-Dimethylbenzidine 3,3'-dimethyl-1,1'-Biphenyl -4,4'-diamine Bianisidine

The melting point is 131.5°C. The boiling point is 339°C. The water solubility is 1300 mg/l at 25°C (Yalkowsky and Dannenfelser 1992). The vapour pressure is 23 mPa (1.7×10^{-4} mm Hg, US-EPA 1993, ASTER database). The octanol/water partition coefficient is measured to log Kow 2.34 (Hansch *et al*. 1995).

Classification

4,4-Diamine-3,3-dimethyl-1,1-biphenyl is classified under the name 4,4'-bi-o-toluidine in the List of dangerous substances (Miljøministeriet 2002):

Carc2;R45	May cause cancer
Xn;R22	Harmful. Harmful if swallowed.
N;R51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment

Origin

4,4-Diamine-3,3-dimethyl-1,1-biphenyl is used as an intermediate in the production of dyes and pigments (RTECS 2003). The substance is especially used in the production of azo-colorants. NIOSH lists 480 colorants, which is based on 4,4-diamine-3,3-dimethyl-1,1-biphenyl (using the synonym 3,3-dimethylbenzidine, NTP 1991).

Azo-colorants containing o-toluidine regulated as regards uses in leather goods and textile that may come into contact with the skin or mouth (Danish Statutory Order on banning import, sale and use of certain azo-colorants: ”Bekendtgørelse om forbud mod import, salg og anvendelse af visse azofarvestoffer, BEK nr 755 af 15/08/2003”). According to the Statutory Order the use of azo-colorants is banned in textiles and leather goods that may come into direct contact with the human skin or mouth for a prolonged period, if these azo-colorants, which may release one or more of the aromatic amines listed in annex 2 of the Statutory Order, are present at concentrations above 30 ppm in the finished goods or in the coloured parts thereof.

Health

Acute exposure to high concentrations of 4,4-diamine-3,3-dimethyl-1,1-biphenyl may irritate the nose and throat.

No information on the acute effects of 4,4-diamine-3,3-dimethyl-1,1-biphenyl in animals was found.

Effects on liver, kidney, gall bladder, bone marrow, thymus, lymph nodes and body weight are observed in rats chronically exposed to 4,4-diamine-3,3-dimethyl-1,1-biphenyl hydrochloride in drinking water (NTP 1991).

No data on effects to humans were available. IARC has assessed that sufficient evidence of carcinogenicity in animals existed and placed the substance in group B2: The agent is possibly carcinogenic to humans (IARC 1987).

ACGIH (2002) states that the substance is a confirmed animal carcinogen with unknown relevance to humans and applies a skin notation.

Threshold limit values
NIOSH has recommended an exposure limit value (REL: recommended exposure limit) of 0.02 mg/m^3 as a 60 minutes ceiling value with skin notation, i.e. the substance is penetrable to the skin (NIOSH 2001).

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 139 / 20 = 7 µg/m^3 (ID no. 10).
Adult
Inhalation, 1 piece of incense = (3×0.83×1)/70 = 0.036 µg/kg bw/day (ID no. 10).
Inhalation, 1 hour = (4×0.83×1)/70 = 0.047 µg/kg bw/day (ID no. 10).

Child
Inhalation, 1 piece of incense = (3×0.125×1)/10 = 0.038 µg/kg bw/day (ID no. 10).

Table 6.10 Emission, air concentration and uptake via inhalation of 4,4-diamine-3,3-dimethyl-1,1-biphenyl

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	-	-						
2	18	20	0.9	1	1	0.012	0.013	0.012
4	20	30	1.0	1	1	0.012	0.013	0.012
8	-	-						
10	139	141	7.0	3	4	0.036	0.038	0.047
12	-	-						

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.
-: not detected.

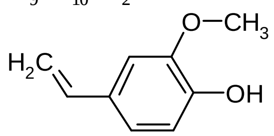
The calculated concentrations in the room air were below the recommended ceiling value of 20 µg/m^3 by NIOSH. Because no other limit values were available this value was used in this context.

An NTP study on 3,3-dimethylbenzidine dichloride administered orally via drinking water to rats exists. The results were evaluated to be invalid to derive a RfD and a RfC value. The 2-year study was stopped after 14 months because the number of test animals exposed to 1.8-12.9 mg/kg bw/day was reduced too much after a strong development of neoplasm in most groups (NTP 1991).

Conclusion
The estimated concentrations were below the NIOSH recommended exposure limit and on basis of this no immediate health risk is assumed from 4,4-diamine-3,3-dimethyl-1,1-biphenyl emitted from the incense.

6.3.3 2-Methoxy-4-vinylphenol

Identification

Name	2-Methoxy-4-vinylphenol
CAS no.	7786-61-0
EINECS no.	232-101-2
Molecular formula	$C_9 H_{10} O_2$
Molecular structure	
Molecular weight	150.18 g/mol
Synonyms	4-ethenyl-2-methoxy- phenol 4-Vinylguaiacol 4-Hydroxy-3-methoxystyrene p-Vinylcatechol-o-methyl ether

The melting point is estimated to 50°C. The boiling point is estimated to 247°C. The water solubility is estimated to 926 mg/l at 25°C. The vapour pressure is estimated to 1 Pa at 25°C (0.0077 mmHg). The octanol/water partition coefficient is estimated to log Kow 2.24 (QSAR estimates).

Classification
2-Methoxy-4-vinylphenol is not classified in the List of dangerous substances (Miljøministeriet 2002).

Origin
2-methoxy-4-vinylphenol is a natural fragrance in plants and fruit and is often recovered from juice (e.g. Maarse 1996).

2-methoxy-4-vinylphenol is used as fragrance and flavour in perfumes and foods.

Health
No studies on the effects via inhalation of 2-methoxy-4-vinylphenol were available.

Threshold limit values

No threshold limit values are found but the molecule resembles vanillin with the methyl group replaced by oxygen (cf. section 5.3.4). Therefore, the same threshold limit value is used. By JECFA vanillin is placed in structure class I i.e. applied a group-ADI of 0.05 mg/kg.

Absorption
Because no information was found, 100% adsorption is assumed.

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 130 / 20 = 6.5 µg/m^3 (ID no. 1).

Adult
Inhalation, 1 piece of incense = (5×0.83×1)/70 = 0.06 µg/kg bw/day (ID no. 1).
Inhalation, 1 hour = (12×0.83×1)/70 = 0.14 µg/kg bw/day (ID no. 1).

Child
Inhalation, 1 piece of incense = (5×0.125×1)/10 = 0.06 µg/kg bw/day (ID no. 1).

Table 6.11 Emission, air concentration and uptake via inhalation of 2-methoxy-4-vinylphenol

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	130	312	6.5	5	12	0.06	0.06	0.14
2	35	52	1.8	1	2	0.01	0.01	0.02
4	20	29	1.0	0.7	1	0.01	0.01	0.01
8	78	94	3.9	2	4	0.02	0.03	0.05
10	-	-						
12	55	105	2.8	2	4	0.02	0.03	0.05

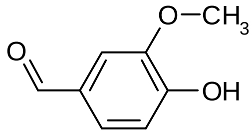
C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.
-: not detected.

The maximal estimated uptake from air was below the group-ADI value of 50 µg/kg bw/day with a further safety margin of approx. 350, which is considered sufficient.

Conclusion
2-methoxy-4-vinylphenol is not considered a health problem during use of incense at the measured concentrations.

6.3.4 Vanillin

Identification

Name	Vanillin
CAS no.	121-33-5
EINECS no.	204-465-2
Molecular formula	$C_8 H_8 O_3$
Molecular structure	
Molecular weight	152.15 g/mol
Synonyms	4-hydroxy-3-methoxy-benzaldehyde 3-methoxy-4-hydroxy-benzaldehyde 4-hydroxy-m-anisaldehyde methylprotocatechuic aldehyde vanillaldehyde

The melting point is 81.5°C. The boiling point is 284°C (Kirk-Othmer 1991). The vapour pressure is 0.016 Pa at 25°C (0.00012 mmHg) (Yaws 1994, HSDB) or 0.33 Pa (OECD 1996). The water solubility is 11000 mg/l at 25°C (Yalkowsky and Dannenfelser 1992). The octanol/water partition coefficient log Kow is measured to 1.23 (OECD 1996).

Classification
Vanillin is not classified (Miljøministeriet 2002).

Origin
Vanillin is present as a natural compound in plants and is identified in plant oils, balsams, resins and wood. The best known natural source is the plant *Vanilla planifolia* in the Orchid family (Kirk-Othmer + Ullman).

Vanillin is also manufactured synthetically from guaiacol but mainly from lignin which is the main component in waste from sulphite pulp in the paper industry (Hocking 1997).

Vanillin is used in foods (”vanilla”), pharmaceuticals and in the cosmetics and perfume industry.

Vanillin has been identified in smoke from burning wood and in cigarette smoke (OECD 1996).

Health
Vanillin is a phenol aldehyde with reactive aldehyde- and hydroxyl moieties in the molecule.

Acute toxicity:

Acute oral, rat	LD_{50}	3925 mg/kg	OECD, SIDS 1996
Acute oral, mouse	LD_{50}	4333 mg/kg	ECB 2000
Acute oral, rat	LD_{50}	1580 mg/kg	Kirwin and Galvin 1993
Acute oral, guinea pigs	LD_{50}	1400 mg/kg	Kirwin and Galvin 1993
Acute, inhalation, rat	LC_0 (4 h)	41.7 mg/m^3	ECB 2000 (IUCLID)

Acute, inhalation, mouse	LC_0 (2 h)	41.7 mg/m^3	ECB 2000 (IUCLID)

Acute toxicity was not observed after inhalation of vapours from saturated solutions. However, irritation was observed after application to the skin and mucous membranes (Kirk-Othmer, vol 23 1983).

A 30 days inhalation test with exposure for 4 hours/day, 5 days a week to saturated vapours at 20°C showed no mortality but reduction in body weight and effects to liver and to the haemoglobin level (ECB 2000).

A 4 months inhalation study showed that 15 mg/m^3 (LOAEL) affected nerves and cardiovascular systems, liver and blood systems. Therefore, NOAEL is set to 0.5 mg/m^3 (ECB 2000).

Several diet toxicity tests are performed and summarised in IUCLID (ECB 2000) and SIDS (OECD 1996). The most essential ones are presented below:

In a 14 weeks study with intragastric administration of 300 mg vanillin/kg to rats, twice weekly, produced no adverse effects.

Rats fed diets containing vanillin at levels of 20 mg/kg/day for 18 weeks had no adverse effects while 64 mg/kg/day for 10 weeks caused growth depression and damage to the myocardium, liver, kidney, lung, spleen and stomach.

Rats fed diets containing vanillin for 13 weeks exhibited growth depression and enlargement of the liver, kidney and spleen at dosage levels 5% (2500 mg/kg/day*), mild changes at 1% (500 mg/kg/day*), and no changes at 0.3% (150 mg/kg/day*).
Four to six week old rats maintained for 91 days on diets containing vanillin exhibited no adverse effects at rates of 3000 ppm (150 mg/kg/day*), mild adverse effects at 10,000 ppm (500 mg/kg/day*) and growth depression and enlargement of the liver, kidney and spleen at 50,000 ppm (2500 mg/kg/day*).
Rats fed dietary levels of vanillin of 10,000 ppm (500 mg/kg/day*) for 16 weeks, 1000 ppm (50 mg/kg/day*) for 27-28 weeks, 20,000 or 50,000 ppm (1000 or 2500 mg/kg/day*) for 1 year, or 5000, 10,000, or 20,000 ppm (250, 500, or 1000 mg/kg/day*) for 2 years exhibited no adverse effects on growth or haematology and produced no macroscopic or microscopic changes in tissues (Hagan *et al*. 1967).
Rats fed for 5 weeks on a diet of vanillin at 0.5 g/kg of the diet showed symptoms of intoxication, including decreases in adrenal vitamin C and in liver protein (Kirwin and Galvin 1993).

**Based on a food factor of 0.05 for a 0.35 kg rat (US-EPA 1985).*

The highest NOEL from the 1-year repeated dose toxicity rat study with oral administration was 50000 ppm corresponding to 2500 mg/kg/day. NOEL in the 2 years rat study was 1000 mg/kg bw/day. The latter value from Hagan *et al.* (1967) is used by WHO to derive an ADI-value.

Teratogenicity, genotoxicity and carcinogenicity tests are performed that were all negative, i.e. there was no indications of such effects (OECD 1996).

Threshold limit values
A threshold limit value for the working environment was not available (Arbejdstilsynet 2002).

CLV (Concentration limit value) of 1.5 mg/m^3 (vapour, aerosol), May 1990 (state Standard of USSR according to OECD 1996).

An ADI (Acceptable Daily Intake) of 10 mg/kg has been agreed between FAO/WHO and EU (OECD 1996) based on NOEL 1000 mg/kg bw/day from a 2-year rat study (Hagan *et al.* 1967).

JECFA has placed vanillin in structure class I together with other terpenoid substances, i.e. vanillin is applied a group-ADI of 0.05 mg/kg/day.

Absorption
No data were available on adsorption. Therefore, 100% adsorption is used.

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 797 / 20 = 40 µg/m^3 (ID no. 10).

Adult
Inhalation, 1 piece of incense = (24×0.83×1)/70 = 0.28 µg/kg bw/day (ID no. 10).
Inhalation, 1 hour = (28×0.83×1)/70 = 0.33 µg/kg bw/day (ID no. 10).

Child
Inhalation, 1 piece of incense = (24×0.125×1)/10 = 0.30 µg/kg bw/day (ID no. 10).

Table 6.12 Emission, air concentration and uptake via inhalation of vanillin

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	70	168	3.5	6	14	0.07	0.08	0.17
2	47	70	2.4	2	3	0.02	0.03	0.04
4	95	140	4.8	4	6	0.05	0.05	0.07
8	448	540	22.4	14	21	0.17	0.18	0.25
10	797	805	39.9	24	28	0.28	0.30	0.33
12	40	75	2.0	2	3	0.02	0.03	0.04

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.
-: not detected.

From the table above it can be observed that none of the amounts taken up vía inhalation results in a dose above the ADI of 50 µg/kg bw/day. Therefore, no health risks are anticipated for the consumers from the exposure to vanillin emitted from burning incense.

The WHO suggested ADI of 10 mg/kg bw/day was not exceeded.

Conclusion
Vanillin causes no health risk at inhalation of the amounts found by analysis of the selected incenses.

6.4 Terpenoids

Terpenes are naturally made from isoprene which are formed as a part of plant (and animal) biosynthesis. They are found anywhere in nature and in foods. Terpenes exist in essential oils. Terpenes may origin from the use of plant oils and resins in the incense mixtures as fragrance, base substance or solvent.

A small part of commercial pine oil is still made from natural sources but the main part is synthetically produced by hydrating pinene. Synthetic pine oil is composed of tertiary terpinoide alcohols.

Terpenes are generally irritating to the mucous membrane. Turpentine from pine trees is sensitising to the skin. Sensitising is, however, not confirmed for the individual terpenes except for 3-carene, CAS no. 13466-78-9 (ASS 2000).

alfa-Terpineol (cf. below) and linalool (3,7,-dimethyl-1,6-octadiene-3-ol, CAS. no.: 78-70-6) are probably the most common terpenoide alcohols which appear to a varying degree in all plants (FFHPVC-TC 2001). The primary exposure to the two mentioned substances is from spices, carrots, orange juice, fruit, wine and tea (Stofberg and Grundschober 1987).

Terpenes found in analyses:

Name	Chemical name	CAS no.
Camphene	2,2-dimethyl-3-methylene- Bicyclo 2.2.1 heptane,	79-92-5
Cedrol	3R-(3.a.,3a.b.,6.a.,7.b.,8a.a.) - octahydro-3,6,8,8-tetramethyl-1H-3a,7-Methanoazulen-6-ol	77-53-2
Cedrandiol		62600-05-9
Isoborneol	exo-1,7,7-trimethyl-Bicyclo 2.2.1 heptan-2-ol	124-76-5
Isobornylacetate	exo-1,7,7-trimethyl-Bicyclo 2.2.1 heptan-2-ol acetate	125-12-2
Lilial	4-(1,1-dimethylethyl)-methyl-Benzenepropanal	80-54-6
b-Myrcene	7-methyl-3-methylene-1,6-Octadiene	123-35-3
a-Terpineol	(p-menth-1-en-8-ol) 4-trimethyl-3-Cyclohexene-1-methanol	98-55-5
b-Terpinol		1000150-76-1
Thujopsene		470-40-6

Terpenoide primary alcohols are found in essential oils. Terpenes are formed naturally via the isoprene pathway, which is a natural part of the plant biosynthesis and therefore commonplace in plants.

Some closely related terpenoids were found. The chemical category called ”terpenoide tertiary alcohols and related esters” includes terpenoide aliphatic tertiary alcohols and related acetate esters and the alicyclic tertiary alcohol alfa-terpineol.

Terpenoids identified by the analyses were:

Name in the analyses	(synonym)	CAS no.
3,7-Dimethyl-1,6-octadien-3-ol	(Linalool)	78-70-6
3,7-Dimethyl-1,6-octadien-3-ol		10281-55-7
3,7-Dimethyl-1,6-oktadien-3-ol, acetate	(Linalylacetate)	115-95-7
3,7-Dimethyl-2,6-octadien-1-ol	(Geraniol)	106-24-1
2,6-Dimethyl-7-octen-2-ol	(Dihydromyrcenol)	18479-58-8
3,7-Dimethyl-6-octen-1-ol		1117-61-9
3,7-Dimethyl-6-octenal	(Citronellal)	106-23-0
trans-Cinnamaldehyde		14371-10-9
Eugenol		97-53-0
alfa-Terpineol	4-trimethyl-3-Cyclohexen-1-methanol	98-55-5
alfa-Terpinyl acetate	4-Trimethyl-3-cyclohexen-1-methanol acetate	80-26-2

The group has been examined by the U.S. Flavor and Fragrance Industry, which together with other manufacturers of flavour and fragrances has formed a consortium for the purpose: the Flavor and Fragrance High Production Volume Consortia (FFHPVC). The Terpene Consortium, which participates in FFHPVC co-ordinates the test programme and has compiled information on physical-chemical data, toxicity, etc.

The melting points are <0°C, the boiling points are typically about 200-230°C. The vapour pressure is typically at 3-10 Pa and log Kow around 3.

The acute toxicity is low with LD_{50}-values for rats at the level 3000-6000 mg/kg (FFHPVC). Dermal LD_{50} values for rabbits are low with values around 2500-5000 mg/kg. Inhalation ED_{25} values are low but no levels are mentioned (FFHPVC).

Reproduction toxicity studies are performed with geranial and neral. Assuming that they are slightly more toxic than the corresponding alcohols, the aldehydes may be used for a conservative evaluation of the toxicity of the alcohols (geraniol and nerol are trans and cis isomers of 3,7.dimethyl-2,6-octadien-1-ol, respectively). In a two-generation reproduction study on rats a maternal NOAEL of 50 mg/kg/day was found.

In an inhalation study groups of female rats were exposed to 85 ppm (vapour and aerosol) of a geranial/neral mixture for 6 hours/day during day 6-15 of the period of gestation. NOAEL was 35 ppm (FFHPVC).

Additives to foods are evaluated by an expert committee under WHO: JECFA. JECFA (1998) has prepared a grouping of additives to foods and applied TDI (human intake threshold) values:

Class	Limit value of intake/person/day	µg/kg bw/day*
Class I:	1800 µg/day	30 µg/kg bw/day
Class II:	540 µg/day	9 µg/kg bw/day
Class III:	90 µg/day	1,5 µg/kg bw/day

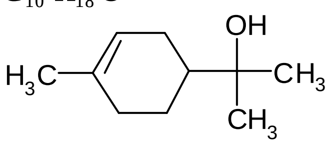
*: assumed 60 kg in JECFA 1998

In an evaluation of effects to health of esters of terpenoide alcohols in foods, 26 terpenoid esters on basis of structure similarities were placed together in Class I.

A group of analogous terpenoids (geranyl acetate, citral, citronellol and linalool) has been given an ADI of 0.05 mg/kg bw/day (JECFA 1998).

6.4.1 alpha-Terpineol

Identification

Name	alpha-Terpineol
CAS no.	98-55-5
EINECS no.	202-680-6
Molecular formula	$C_{10}H_{18}O$
Molecular structure	
Molecular weight	154.25 g/mol
Synonyms	4-trimethyl-3-cyclohexene-1-methanol 1-methyl-4-isopropyl-1-cyclohexene-8-ol p-menth-1-en-8-ol alpha-terpinenol

The melting point is 40°C. The boiling point is 220°C (Lewis 1999). The vapour pressure is 5.6 Pa at 25°C (0.042 mmHg, Li and Perdue 1995). The water solubility is 710 mg/l at 25°C (Li and Perdue 1995). The partition coefficient log Kow is experimentally measured to 2.98 (Li and Perdue 1995).

Classification

alpha-Terpineol is not classified under its own name but the substance is a mono-terpene. Terpenes are found in essential oils. Terpenes may arise from the use of plant oils and resins in the incense manufacture and as solvent. Terpenes are in general irritating to mucous membranes. Turpentine from pines is sensitising to the skin. The sensitising has however not been confirmed for individual terpenes except 3-carene, CAS no. 13466-78-9 (ASS 2000).

When alpha-terpineol is considered as vegetable turpentine (Miljøministeriet 2002), the classification is:

Turpentine, oil			
CAS number:	8006-64-2		
EF number:	232-350-7		
Classification:	R10	Flammable	
	Xn;R20/21/22-65	Harmful. Harmful by inhalation, in contact with skin and if swallowed. May cause lung damage if swallowed	
	Xi;R36/38 R43	Irritant. Irritating to eyes and skin. May cause sensitization by skin contact	
	N;R51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment	

Origin
alpha-Terpineol is a natural part of plants (Burdock 2001) and has only been found as volatile component in essential oils, fruit and fruit juice. alpha-Terpineol is also found in tobacco smoke (HSDB). Only a minor fraction of the consumed alpha-terpineol is manufactured from plant oils. The major part of alpha-terpineol is manufactured synthetically, i.e. by hydration of pinene from turpentine.

Extracted alpha-terpineol is used as fragrance and flavour in perfume, cosmetic and food industries.

alpha-Terpineol has previously been used as pesticide due to the effect of the substance as insecticide and microbiocide (US-EPA/OPP 1998).

Health
alpha-Terpenoid is a monoterpene. Based on pine oils terpineols are irritating to eyes and mucous membranes (Gosselin *et al.* 1984). According to Lewis (1996) heating releases acrid smoke and irritating fumes.

Acute toxicity:

Acute oral, rat	LD_{50}	4300 mg/kg	The Good Scents Company: MSDS 07/22/2003.
Acute oral, mouse	LD_{50}	2830 mg/kg	FFHPVC-TC 2001

Threshold limit values
Threshold limit values for the working environment is 25 ppm equivalent to 140 mg/m^3 using the value for high boiling aromatic hydrocarbons (terpenes, turpentine) (Arbejdstilsynet 2002).

On the basis of data, no limits for effects (NOAEL) for the specified substance could be established.

TDI: 30 µg/kg bw/day based on class I terpenoids (JECFA 1998).

Absorption
No data on skin absorption were available but the fat solubility of alfa-terpineols based on log Kow indicates that adsorption after inhalation is a probable exposure route. Besides HSDB contains information that the substance after inhalation could be measured in the blood stream.

Evaluation

At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 1004/ 20 = 50.2 µg/m^3 (ID no. 8).

Adult
Inhalation, 1 piece of incense = (38×0.83×1)/70 = 0.45 µg/kg bw/day (ID no. 8).
Inhalation, 1 hour = (48×0.83×1)/70 = 0.57 µg/kg bw/day (ID no. 8).

Child
Inhalation, 1 piece of incense = (38×0.125×1)/10 = 0.48 µg/kg bw/day (ID no. 8).

Table 6.13 Emission, air concentration and uptake via inhalation of alpha-terpineol

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	394	942	19.7	17	37	0.20	0.21	0.44
2	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
8	1004	1210	50.2	38	48	0.45	0.48	0.57
10	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.
Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.
-: not detected.

alpha-Terpineol is observed in 2 of the products at aconcentration above the detection limit.

The maximal concentration was below the threshold limit value for the working environment of 140 mg/m^3 with a safety factor of approx. 2800, which is considered sufficient.

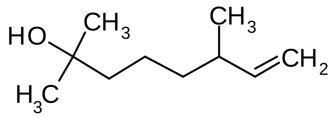
In relation to the JECFA group-ADI value of 0.05 mg/kg bw/day the margin of safety included a further factor 100, which is considered sufficient.

There was no concern relating to the TDI value of 30 µg/kg bw/day, therefore, it is assessed not to cause any health risk.

Conclusion
alpha-Terpineol causes no health risk to the consumer at exposure and inhalation at the amounts estimated from the analyses of the selected incenses.

6.4.2 3,7-Dimethyl-7-octen-2-ol

Identification

Name	3,7-Dimethyl-7-octen-2-ol
CAS no.	18479-58-8
EINECS no.	242-362-4
Molecular formula	$C_{10} H_{20} O$
Molecular structure	
Molecular weight	154 g/mol
Synonyms	2,6-Dimethyl-7-octen-2-ol Dihydromyrcenol

The melting point is estimated to -13°C. The boiling point estimated to 190°C (QSAR). The vapour pressure is 12.0 Pa at 25°C (Estimated, IUCLID 2000b). The water solubility is estimated to 252 mg/l at 25°C (QSAR, FFHPVC-TC 2001). The partition coefficient log Kow is estimated to 3.47 (QSAR 1995, FFHPVC-TC 2001).

Classification

3,7-Dimethyl-7-octen-2-ol is not classified under its own name but the substance is a terpenoid primary alcohol. Terpenoids are found in essential oils. The terpenoids may origin from the use of plant oils and resins in the incense manufacture and as a solvent.

When 3,7-Dimethyl-7-octen-2-ol is considered as a turpentine oil, the classification is (Miljøministeriet 2002):

Turpentine, oil, vegetable		
CAS no.:	8006-64-2	
EF no.:	232-350-7	
Classification:	R10	Flammable.
	Xn;R20/21/22-65	Harmful. Harmful by inhalation, in contact with skin and if swallowed. May cause lung damage if swallowed
	Xi;R36/38 R43	Irritant. Irritating to eyes and skin. May cause sensitization by skin contact
	N;R51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment

Origin

3,7-Dimethyl-7-octen-2-ol is a natural substance as mentioned above but can be produced synthetically by hydrohalogenation and hydrolysis of 2,6-dimethyl-2,7-octadien, a thermal degradation product of pinane hydroperoxide which is formed from alfa-pinene (FFHPVC-TC 2001).

3,7-Dimethyl-7-octen-2-ol is a fragrance, which is used in consumer products such as cosmetics, perfumes or other odorous products (IUCLID 2000b).

Health

Acute toxicity:

Acute oral, rat	LD_{50}	3600 mg/kg	IUCLID 2000b

3,7-Dimethyl-7-octen-2-ol is assumed to have an acute toxicity as the other terpenes, i.e. low.

3,7-Dimethyl-7-octen-2-ol was slightly skin irritating in a rabbit study performed according to EEC B4 (acute toxicity, skin irritation) but not sufficient to result in a classification irritant. In a human study using a 4% solution there was no skin irritation after 48 hours, the closed patch test was performed on 25 humans (IUCLID 2000b).

3,7-Dimethyl-7-octen-2-ol was moderately eye irritating in a rabbit Draize test. The substance was not sensitising in patch test on humans (IUCLID 2000b).

On basis of data no effect levels (NOAEL) could be established for the substance

Threshold limit values
The threshold limit value for the working environment is 25 ppm equivalent to 140 mg/m^3, based on high boiling aromatic hydrocarbons (terpenes, turpentine) (Arbejdstilsynet 2002).

Absorption
No data were available on skin absorption but the fat solubility of 3,7-dimethyl-7-octen-2-ol (based on the estimated log Kow) indicates that adsorption after inhalation is a probable exposure route.

Evaluation
At inhalation, the initial evaluation assumes the burning of one incense stick or cone, and the burning of incense for one hour in a room of 20 m^3.

Calculation example:
Cmax inhalation = 1514 / 20 = 75.7 µg/m^3

Adult
Inhalation, 1 piece of incense = (63×0.83×1)/70 = 0.75 µg/kg bw/day
Inhalation, 1 hour = (89×0.83×1)/70 = 1.06 µg/kg bw/day

Child
Inhalation, 1 piece of incense = (63×0.125×1)/10 = 0.79 µg/kg bw/day

Table 6.14 Emission, air concentration and uptake via inhalation of 3,7-dimethyl-7-octen-2-ol

ID no.	Emission		C inh 1 pc. in room	C_{max} inh 1 pc.. incl vent.	C_{max} inh 1 hour incl vent.	Inhalation, 1 pc., adult	Inhalation, 1 pc., child	Inhalation, 1 hour
	µg/unit	µg/hour	µg/m^3	µg/m^3	µg/m^3	µg/kg bw/d	µg/kg bw/d	µg/kg bw/d
1	-	-						
2	1514	2271	75,7	63	89	0,75	0,79	1,06
4	-	-						
8	-	-						
10	-	-						
12	-	-						

C inh 1 pc. in room: Concentration of the substance from burning 1 piece of incense distributed in the room without ventilation.

Cmax inh, 1 pc.: The maximal concentration in the room from burning 1 piece of incense based on the box model, i.e. including ventilation.
Cmax inh, 1 hour: The maximal concentration in the room from burning incense for 1 hour based on the box model, i.e. including ventilation.
-: not detected.

The maximal concentration was below the threshold limit value for the working environment of 140 mg/m^3 but with a safety factor of more than 1500, which is considered sufficient.

Relating to the JECFA group-ADI value of 0.05 mg/kg bw/day for terpenoids, a further safety factor of approx. 50 could be applied, which is considered sufficient.

There was not a problem with the WHO TDI value of 30 µg/kg bw/day. Therefore, the substance is considered not to cause any health risk.

Conclusion
3,7-dimethyl-7-octen-2-ol causes no health risk even at 100% absorption via inhalation of the concentrations estimated from the analyses of the selected incenses.

6.5 Summary

The results of the evaluation of the single substances are summarised below. The results are based on the burning of one incense unit (incense stick or cone).

Table 6.15 Summary of analyses, exposures and evaluation

Substance	No.	Analysis	Exposure (20 m^3 + vent.)	Uptake via inhalation	Evaluation
		µg/unit	µg/m^3	µg/kg bw/day	
Acetaldehyde	6/6	1070-4480	46-141	0.71-1.67	No health risk at acute but may not be excluded from chronic exposure
Acrolein	6/6	330-1390	15-60	0.32-0.71	Health risk at acute and chronic exposure can not be excluded
Formaldehyde	6/6	1266-5922	49-210	0.58-2.5	Health risk can not be excluded
Furfural	6/6	43-330	2-12	0.05-0.14	No health risk
Benzene	6/6	266-7451	11-281	0.07-1.67	Health risk at acute and chronic exposure can not be excluded
Styrene	6/6	69-582	3-21	0.04-0.25	No health risk
Toluene	6/6	236-1252	9-47	0.11-0.56	No health risk
Xylene	6/6	81-425	3-16	0.04-0.19	No health risk
Benzofuran	4/6	94-512	4-19	0.05-0.23	No health risk
4,4-Diamine-3,3-dimethyl-1,1-biphenyl	3/6	18-139	1-3	0.012-0.036	No health risk
2-Methoxy-4-vinylphenol	5/6	20-130	1-5	0.01-0.06	No health risk
Vanillin	6/6	40-448	2-24	0.02-0.30	No health risk
alfa-Terpineol	2/6	374-1004	17-38	0.20-0.45	No health risk
2,6-Dimethyl-7-octen-2-ol	1/6	1514	63	0.75	No health risk

7 Discussion and conclusion

7.1 Discussion

Incense to most consumers is related to ceremonial and/or religious purposes of different kinds, shamanism, healing, etc. The consumers of incense probably do not always think that the use may contribute significantly to changes in the indoor climate (apart from the desired effect) by release of a series of chemical substances to the indoor air and a considerable smoke development during the use.

Of the originally purchased 36 different types, 12 types were selected for analysis by ”head-space”, i.e. an analysis of which substances were released from the incense. The release was accelerated by heating the incense to 100°C for an hour. Of the 12 types, 6 were selected for analysis of substances emitted during the use of the incense.

This study showed that apart from the more or less fragrant substances that were released from the unignited incense, further substances were emitted during the use (burning) of the incense.

Of the many identified compounds it was evaluated that some were aromatic compounds and that some also could be attributed to an incomplete combustion of chemical substances.

This study does not aim at an evaluation of whether the released fragrances have the effects stated on the labelling or in the advertisements for the different incenses, it concerns solely a strict health assessment for the consumer of incense.

The individual substances that were selected for a closer evaluation include several typical combustion products. It is among those that the most harmful substances were found and at the same time the ones that presented the largest emissions during the use of the incense.

The aldehydes: acetaldehyde, acrolein and formaldehyde were emitted from all the analysed incenses in amounts that were evaluated to pose potential health risks at the estimated concentrations. The room volume in the scenario was set to 20 m^3 but even in larger rooms a health risk during use could not be excluded.

A short termed airing (ventilation) of the smoke after the burning would undoubtedly help to reduce the concentration of harmful substances. At the same time it must be remembered that the fragrance, which may have been the desired purpose will remain in sufficient amounts still to be smelled.

Benzene was the most health hazardous substance found from the tests. Benzene is known to be carcinogenic to humans. Benzene was emitted from all the tested incenses in amounts of 266 to 7451 µg/incense unit of approx. 1 gram. The estimated concentrations assuming instant distribution in a ventilated room of 20 m^3 with an air change of 0.5 times per hour was 11 to 281 $\mu g/m^3$. The concentrations taken up via inhalation were calculated to 0.07-1.67 µg/kg bw/day by burning of just one incense stick or cone per day.

The result is compared with other studies. For instance Löfroth *et al.* (1991) found that burning of incense cone and stick emitted 420 to 440 µg benzene/g burned incense. The incense sticks and cones used in this study weigh approx. 1 gram (varying between 0.4 and 1.4 g) and the level is therefore within the found variation. The threshold limit values for uptake via inhalation were not exceeded but the calculated exposure concentrations were very close to the effect concentrations evaluated by international organisations.

Several of the identified substances were classified irritant and harmful to inhale. Some of the substances were classified as under suspicion of being carcinogenic (cf. Appendix B).

In a literature search studies were found that showed a connection between exposure to smoke from incense and diseases such as cancer, asthma and contact dermatitis.

In an epidemiological study, a correlation between the use of incense and leukaemia in children was found. An increased risk of leukaemia was observed in children whose parents burned incense during pregnancy and while attending the newly born (Löwengart *et al.* 1987, Van Steensel-Moll 1985). In a study on brain tumours in children, an increased risk to children whose parents burned incense in the home was observed (Preston-Martin *et al.* 1982).

In a study on 414 children aged 0.7-13 years in Qatar, the burning of incense was found to be a contributing factor in astigmatic incidences (Dawod and Hussain 1995).
In a study on the influence of several factors on respiratory illnesses and symptoms in 4000 children from Taiwan, coughing was found to be associated with burning of incense (Yang *et al.* 1997). The authors argue that it may be related to formaldehyde, which is measured in Chinese incense (Lin and Wang 1994) and also refer to studies that show connection between formaldehyde and coughing (Daugbjerg 1989 and Broder *et al.* 1988).

Mutagenic properties in the smoke from incense are studied in several references. By comparing the mutagenic effect from incense, formaldehyde and acetaldehyde to *Salmonella typhimurium* T102 it was observed that the smoke from incense contained several highly active substances with a higher mutagenic potency than formaldehyde (Chang *et al*. 1997). The smoke from incense is also observed to be mutagenic to *S. typhimurium* TA98, TA100 and TA104 (Sato *et al.* 1980, Rasmussen 1987). Since Sato *et al.* (1980) in a study on the condensate from 8 Japanese incense sticks (joss sticks, 0.3 g/pc.) did not find the same mutagenicity in the extracts from incense sticks the author thinks that the mutagenic activity is caused by the combustion products from the included materials. Sato *et al*. (1980) further finds that the incense sticks are as much as or more mutagenic than cigarette smoke.

This study showed that the aerosol emission from one piece of incense was comparable to the aerosol emission from 0.5 to 4 cigarettes.

The burning of incense results in an emission of volatile compounds that may reach uncovered skin and cause contact dermatitis (Roveri *et al.* 1998).

The scientific committee for cosmetic products has identified 24 substances as recognised contact allergens (SCCNFP 1999). These substances were later regulated by Directive 2003/15/EC (EU 2003). Of these substances, this study identified 10 out of 24 substances in the selected incenses:

Table 7.1 Contact allergens from the SCCNFP list found during incense burning

Name in the analysis list (Appendix B)	Name in SCCNFP 1999	CAS no.
2H-1-Benzopyran-2-one	Coumarine	91-64-5
Benzylalcohol	Benzylalcohol	100-51-6
Benzylcinnamate	Benzylcinnamate	103-41-3
3,7-Dimethyl-1,6-octadien-3-ol	Linalool	78-70-6
3,7-Dimethyl-2,6-octadien-1-ol	Geraniol	106-24-1
Eugenol	Eugenol	97-53-0
Lilial	Lilial	80-54-6
d-Limonene	d-Limonene	5989-27-5
2-Methoxy-4-(1-propenyl)-phenol	Isoeugenol	97-54-1
2-(phenylmethylen)-octanal	Hexyl cinnamaldehyde	101-86-0

Whether the effect from contact allergens is the same at exposure via inhalation is a little uncertain but they are present or can also be recovered in aerosols, which potentially also may reach the skin surfaces.

Sooting

During the performing of the study several problems arised from the smoke evolution, which clogged the filters. The sampling period had to be reduced far below expected due to overload of the absorbent filters.

That sooting may be problematic can be illustrated by a study performed in Geneva, Switzerland, where it was decided to reduce the heating costs in a church by insulating the church and close the gravity-operated ventilation openings. After 3 years the church room was more discoloured than previously after 10-12 years. It was found to be soot from the burning of candles and incense (Huynh *et al.* 1991). The church room formed in a basilica pattern was 368 m long and 60 m wide, a total air volume of 11500 m^3 and a maximum height of the dome was >16 m. The annual consumption of incense used during the high mass was 1 kg. The smoke emitted from the incense calculated on basis of laboratory simulations to 192 g/year corresponding to 192 mg/g incense. Examination of the soot and estimations of the smoke formation showed that the sooting was mainly caused by the incense (cf. table 7.2).

Table 7.2 Annual consumption of candles and incense by the church and estimated production of smoke and aerosol indoors (Huyunh et al. 1991)

Source	Frequency of use	Consumption (per year)	Smoke produced (g/year)
Wax light	Permanently	135000 units	13.5
Large candles	Sunday	36 units	6.6
Incense	High mass	1 kg	192.0
Total			212.1

Sooting in homes from the use of incense may also be expected if this is not accounted for by airing or ventilation in the home. Based on the gravimetric measurements of the aerosols in this study, approximately 150 mg/g incense was collected.

7.2 Conclusion

The examination of incense sticks showed that it could not be excluded that certain health problems may be associated with the use of incense to the consumer. Other studies support that the smoke from incense may be harmful to health. It may concern acute effects like irritation of eyes, nose and throat but at prolonged exposure it may concern contact allergy or perhaps even more serious effects.

The study showed that it especially was the combustion products known from incomplete combustion of organic matter that were problematic. This should not wonder as the burning takes place as a slow glow burning at temperatures measured to be around 200 to 360ºC.

It is therefore highly recommended to perform airing of the room during or/and after the use of incense. This will reduce the concentration of combustion residues in the air to below the critical concentrations. The experience is that sufficient fragrance remains with the desired effects.

8 References

ACGIH (2002): TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.

Appleman LM, Woutersen RA, Feron VJ (1982): Inhalation toxicity of acetaldehyde in rats. I. Acute and subacute studies. Toxicology. 23: 293-297.

Appleman LM, Woutersen RA, Feron VJ, Hooftman RN, Notten WRF (1986): Effect of variable versus fixed exposure levels on the toxicity of acetaldehyde in rats. J. Appl. Toxicol. 6(5): 331-336.

Arbejdstilsynet (2002): Threshold limit values for stoffer og materialer. At-vejledning. C.0.1, Oktober 2002. Arbejdstilsynet, København.

ASS (2000): Hygieniska gränsvärden och åtgärder mot luftföroreningar. Arbetarskyddsstyrelsen, Solna, Sverige.

ATP (2003): 18th revision of the 29th Adaptation to Technical Progress of Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances. European Commission, European Chemicals Bureau, 8.08.2003.
NB ikke implementeret i dansk lovgivning i " bekg. af listen over farlige stoffer (Miljøministeriet 2002)

ATSDR (1992): Toxicological profile for 2,3-benzofuran. Agency for Toxic Substances and Disease Registry. U.S. Department of Health and Human Services. Atlanta, USA.

ATSDR (1995): Toxicological profile for xylenes. Agency for Toxic Substances and Disease Registry. U.S. Department of Health and Human Services, Public Health Service, Atlanta (GA), USA.

Baars AJ, Theelen RMC, Janssen PJCM, Hesse JM, van Apeldoorn ME, Meijerink MCM, Verdam L, Zeilmaker MJ (2001): Re-evaluation of human-toxicological maximum permissible risk levels. RIVM report 711701025. National Institute of Public Health and the Environment, Bilthoven, The Netherlands.

Bonnet P, Morele Y, Raoult G, Zissu D, Gradiski D (1982). Détermination de la concentration léthale$_{50}$ des principaux hydrocarbures aromatiques chez le rat. Arch. Mal. Prof. 34: 261-65.

Boublik T, Fried V, Hala E (1984); The vapour pressure of Pure Substances. Elsevier, Amsterdam.

Broder I Corey P, Cole P, Lipa M, Mintz S, Nethercott JR (1988): Comparison of health of occupation and characteristics of houses among control homes and homes insulated with urea formaldehyde foam. II. Initial health and house variables and exposure-response relationships. Environ. Res. 45: 156-178.

Budavari S (1989): The Merck Index - Encyclopedia of Chemicals, Drugs, and Biologicals. Merck and Co Inc. Rahway, NJ.

Burdock GA, ed. (2001): Fenaroli's Handbook of Flavor Ingredients. 4th Edition , CRC Press.

Chang HL, Kuo ML, Lin JM (1997): Mutagenic activity of inscense smoke in comparison to formaldehyde and acetaldehyde in *Salmonella typhimurium* TA102. Bull. Environ. Contam. Toxicol. 58: 394-401.

Chao J (1983): Vapour Pressure of solvents. J. Phys. Chem. Ref. Data 12: 1033-1063.

Chen CJ, Wu HY, Chuang YC, Chang AS, Luh KT, Chao HH, Chen KY, Cheng SG, Lai GM, Huang HH, Lee HH (1990): Epidemiologic characteristics and multiple risk factors of lung cancer in Taiwan. Anticancer Research 10(4): 971-976.

CICAD (2000): 2-Furaldehyde. Concise International Chemical Assessment Document no. 21. International Programme on Chemical Safety, World health Organization, Geneva.

CICAD (2002): Formaldehyde. Concise International Chemical Assessment Document 40. International Programme on Chemical Safety, World Health Organization, Geneva.

Clayton GD, Clayton FE, eds.(1981): Patty's Industrial Hygiene and Toxicology: Volume 2: Toxicology. 3rd ed. John Wiley Sons, 1981-1982. New York.

Condie LW, Hill JR, Borzelleca JF (1988): Oral toxicity studies with xylene isomers and mixed xylenes. Drug Chem. Toxicol. 11: 329-354.

CSTEE (2003): Opinion on the results of the risk assessment of Benzene, Human health part. Adopted by CSTEE during the 40th plenary meeting of 12-13 November 2003. European Commission. Health and Consumer Protection Directorate-General. Scientific Committee on Toxicology, Ecotoxicology and the Environment (CSTEE). Brussels.

Danmarks Statistik (2002): www.dst.dk

Daubert TE, Danner RP (1989): Physical and Thermodynamic Properties of Pure Chemicals. Data Compilation. Washington, D.C.: Taylor and Francis.

Daubert TE, Danner RP (1993): Physical and Thermodynamic Properties of Pure Chemicals. Supplement. Hemisphere Publ. Corp., NY.

Daugbjerg P (1989): Is particleboard in the home detrimental to health? Environ. Res. 48: 154-163.

Dawod ST, Hussain AA (1995): Childhood asthma in Qatar. Annals of Allergy, Asthma and Immunology. 75(4): 360-364.

ECB (2000): Vanillin, CAS 121-33-5. IUCLID Dataset. European Commission, European Chemicals Bureau, 18 February 2000.

ECB (2001): Acrylaldehyde. CAS no. 107-02-8, EINECS no. 203-453-4, risk assessment. European Risk Assessment Report No. 7. European Commission – Joint Research Centre. Institute for Health and Consumer Protection. European Chemicals Bureau. EUR 19728 EN, Ispra, Italy.

ECB (2002): Risk Assessment of Styrene. Draft May 2002. Prepared for the European Commission, European Chemicals Bureau by United Kingdom.

ECB (2003): Risk Assessment of Benzene. Draft 2003. Prepared for the European Commission, European Chemicals Bureau by United Kingdom.

ECB (2003): Risk Assessment of Toluene. CAS no. 108-88-3, EINECS no. 203-625-9. EU risk Assessment Report No. 33. European Commission – Joint Research Centre. Institute for Health and Consumer Protection. European Chemicals Bureau. EUR 20539 EN, Ispra, Italy.

EU (2003): Directive 2003/15/EC of the European Parliament and of the Council of 27 February 2003 amending Council Directive 76/768/EEC on the approximation of the laws of the Member States relating to cosmetic products. Off. J. E.U. L 66: 26-35, 11.3.2003.

Feron VJ, Kryusse A, Til HP (1978): Repeated exposure to acrolein vapor: subacute studies in hamsters, rats and rabbits. Toxicology 9: 47-57.

FFHPVC (2000): Test plan for terpenoid primary alcohols and related esters. The Flavor and Fragrance High Production Volume Consortia, The Terpene Consortium registration no. 1101125. Washington DC.

FFHPVC-TC (2001): Test plan for terpenoid tertiary alcohols and related esters. The Flavor and Fragrance High Production Volume Consortia, The Terpene Consortium. Washington DC. US-EPA no.AR201-129301A.

FFHPVC-TC (2001): Robust summaries for terpenoid tertiary alcohols and related esters. The Flavor and Fragrance High Production Volume Consortia, The Terpene Consortium. Washington DC. US-EPA no.AR201-129301B.

Foo S, Jeyaratnam J, Koh D (1990): Chronic neurobehavioral effects of toluene. Br. J. Ind. Med. 47(7): 480-484.

Gosselin RE, Smith RP, Hodge HC (1984): Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, Vol.II-260.

Hagan EC, Hansen WH, Fitzhugh OG, Jenner PM, Jones WI, Taylor JM, Long EL, Nelson AA, Brouwer JB (1967): Food flavouring and compounds of related structure. II. Subacute and chronic toxicity. Food Cosmet. Toxicol. 5; 141-157.

Hansch C, Leo A, Hoekman D (1995): Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. American Chemical Society, Washington, DC.

Hass U, Jacobsen BM (1993): Prenatal toxicity of xylene inhalation in the rat: a teratogenicity and postnatal study. Pharmacol. Toxicol. 73: 20-23.

Hatch KL, Maibach HI (1995): Textile dermatitis: an update (I). Resins, additives and fibers. Contact Dermatitis 32: 319-326.

Hocking MB (1997): Vanillin: Synthetic flavoring from spent sulfite liquor. J. Chem. Educ. 74: 1055.

Huynh CK, Savolainen H, Vu-Duc T, Guillemin M, Iselin F (1991): Impact of thermal proofing of a church on its indoor air quality: the combustion of candles and inscense as a source of pollution. Sci. Total Environ. 102: 241-251.

IARC (1987): 3,3-Dimethylbenzidine. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol 62: 7. International Agency for Reasearch on Cancer.

IARC (1994): Styrene. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol 60: 297. International Agency for Reasearch on Cancer.

IARC (1995): Formaldehyde. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol 62: 217. International Agency for Reasearch on Cancer.

IARC (1995): Benzofuran. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol. 63: 431. International Agency for Reasearch on Cancer.

IARC (1999): Acetaldehyde. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol. 71: 319. International Agency for Research on Cancer, World Health Organization, Geneva.

IARC (1999): Xylenes. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Vol. 71: 1189. International Agency for Reasearch on Cancer.

IPCS (1983): Styrene. Environmental Health Criteria 26. International Programme on Chemical Safety. World Health Organization, Geneva.

IPCS (1989): Formaldehyde. Environmental Health Criteria 89. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

IPCS (1992): Acrolein. Environmental Health Criteria 127. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

IPCS (1993): Benzene. Environmental Health Criteria 150. International Programme on Chemical Safety. World Health Organization, Geneva.

IPCS (1995): Acetaldehyde. Environmental Health Criteria 167. International Programme on Chemical Safety. World Health Organization, Geneva.

IPCS (1997): Xylenes. Environmental Health Criteria 190. International Programme on Chemical Safety. World Health Organization, Geneva, Switzerland.

IRIS 2003: Integrated Risk Information System. US Environmental Protection Agency (www.epa.gov/iris).

IUCLID: International Uniform Chemical Information Database. A database on ‘Existing Chemicals’ compiled by the European Chemicals Bureau (ECB), Ispra, Italy.

IUCLID (2000): 2,6-dimethyloct-7-en-2-ol, CAS no. 18479-58-8, EINECS no. 242-362-4. European Commission, European Chemicals Bureau.18 Feb. 2000.

IUCLID (2002): Formaldehyde, CAS no. 50-00-0, EINECS no. 200-001-8. European Commission, European Chemicals Bureau. Ispra, Italy.

JEFCA (1998): Esters derived from branched-chain terpenoid alcohols and aliphatic acyclic linear and branched-chain carboxylic acids. Safety evaluation of certain food additives and contaminants. WHO Food Additives Series 40. Prepared by the forty-ninth meeting of the Joint FAO/WHO Expert Committtee on Food Additives (JEFCA). International Programme on Chemical Safety, World Health Organization, Geneva.

JECFA (1999): Furfural. Safety evaluation of certain food additives and contaminants. WHO Food Additives Series 42. Prepared by the fifty first meeting of the Joint FAO/WHO Expert Committtee on Food Additives (JEFCA). International Programme on Chemical Safety, World Health Organization, Geneva.

JECFA (2001): Furfural (addendum). WHO Food Additives Series 46. Prepared by the Joint FAO/WHO Expert Committtee on Food Additives (JEFCA). International Programme on Chemical Safety, World Health Organization, Geneva.

Kimura ET, Ebert DM, Dodge PW (1971): Acute toxicity and limits of solvent residue for sixteen organic solvents. Toxicol. Appl. Pharmacol. 19: 699-704.

Kirk-Othmer (1983): Encyclopedia of Chemical Technology. 3rd.ed. J.Wiley & Sons New York 1983.

Kirwin CJ, Galvin JB (1993): Ethers. In: Clayton GD, Clayton FE, Eds. 1993. Patty's Industrial Hygiene and Toxicology, Vol.2, Part A, 4th ed. New York: John Wiley & Sons, pp. 445-525.

Kishi R, et al. (1992): Neurochemical effects in rats following gestational exposure to styrene. Toxicol. Letters 63(2): 141-146.

Knight L, Levin A, Mendenhall (2001): Candels and inscence as potential sources of indoor air pollution: Market analysis and literature review. US Environmental Protection Agency, Office of Research and Development, Washington DC.

Koch R (1984): A theoretical-methodological approach towards the evaluation of environmental pollutants. Toxicol. Environ. Chem. 1: 331.

Korsak Z, Sokal JA, Górny R (1992): Toxic effects of combined exposure to toluene and m-xylene in animals. III. Subchronic inhalation study. Polish J Occup Med Environ Health 5:27-33.

Korsak Z, Wisniewska-Knypl J, Swiercz R (1994): Toxic effects of subchronic combined exposure to n-butyl alcohol and m-xylene in rats. Int J Occup Med Environ Health 7:155-166.

Larsen A, Frost L, Funch LW, Hansen MK, Jensen LK, Knudsen BB, Mølhave L (1999): Emission af flygtige forbindelser fra træ, træbaserede materialer, møbler og inventar. Miljøprojekt no. 501. Miljøstyrelsen.

Lewis R.J (1999): Sax's Dangerous Properties of of Industrial Materials. 10th ed. Volumes 1-3 New York, NY: John Wiley & Sons Inc.

Li J, Perdue EM (1995): Preprints of Papers Presented at the 209th ACS National Meeting, Anaheim, CA, April 2-7, 1995, 35: 134-7 (HSDB).

Lin JM, Wang LH (1994): Gaseous aliphatic aldehydes in Chinese inscense smoke. Bull. Environ. Contam. Toxicol. 53: 374-381.

Löfroth G, Stensman C, Brandhorst-Satzkorn M (1991): Indoor sources of mutagenic aerosol particulate matter: smoking, cooking and inscence burning. Mutation Research 261: 21-28.

Löwengart RA, Peters JM, Cicioni C, Buckley J, Bernstein L, Preston-Martin S, Rappaport E (1987): Childhood leukemia and parents occupational and home exposures. J. Natl. Cancer Inst. 79: 39-46.

Maarse H (1996): Fruits. Volatile Compounds in Food. The Netherland’s Organisation for Applied Scientific Research, TNO. Holland.

Miljøministeriet (2002): Bekendtgørelse af listen over farlige stoffer. Bekendtgørelse no. 439 af 3. juni 2002. Miljøministeriet. Danmark.

Miljøministeriet (2002b): Bekendtgørelse om begrænsning af emissionen af flygtige organiske forbindelser fra anvendelse af organiske opløsningsmidler i visse aktiviteter og anlæg (VOC bekendtgørelsen). Bekendtgørelse no. 350 af 29/08/2002. Miljøministeriet. Danmark.

Miljøstyrelsen (2000): Listen over uønskede stoffer. Orientering fra Miljøstyrelsen no. 9. Miljøstyrelsen, København.

Miljøstyrelsen (2001): Rapport om Vejledende liste til selvklassificering af farlige stoffer. Miljøprojekt no. 635. Sammen med søgefunktion og exelfil under emnet Vejledende liste til selvklassificering af farlige stoffer under kemikalier på Miljøstyrelsens hjemmeside (www.mst.dk). Miljøstyrelsen, København.

Miljøstyrelsen (2002): B-værdivejledningen. Oversigt over B-værdier. Vejledning nr 2, 2002. Miljøstyrelsen, København.

Mutti A, Mazzucchi A, Rusticelli P, Frigeri G, Arfini G, Franchini I (1984): Exposure-effect and exposure-response relationships between occupational exposure to styrene and neuropsychological functions. Am. J. Ind. Med. 5: 275-286.

NIOSH (2001); 3,3-dimethylbenzidine. NIOSH Pocket Guide to Chemical Hazards & Other Databases. U.S. Department of Health & Human Services, Public Health Service, Center for Disease Control & Prevention. Publication No. 2001-145 (CD-ROM). August 2001.

NTP (1986): NTP technical report on the toxicology and carcinogenesis of xylenes (mixed) (60% m-xylene, 13,6% p-xylene, 17% ethylbenzene and 9,1% o-xylene in F344/N rats and B6C3F1 mice (gavage studies). National Toxicology Program. NTP TR 327, NIH Publ. No. 86-2583. Research Triangle Park, NC.

NTP (1989): NTP technical report on the toxicology and carcinogenesis studies of Benzofuran (CAS No. 271-89-6) in F344/N rats and B6C3F1 mice (gavage studies). National Toxicology Program Technical Report NTP TR 370, NIH Publ. No. 90-2825. Research Triangle Park, NC.

NTP (1990): Toxicology and carcinogenesis studies of toluene in F344/N rats and B6C3F1 mice (inhalation studies). National Toxicology Program Technical Report Series no. NTP TR 371. Research Triangle Park, NC. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, Bethesda, MD.

NTP (1991): Toxicology and carcinogenesis studies of 3,3-dimethylbenzidine dihydrochloride (CAS 612-82-2) in F344/N rats (Drinking water studies). National Toxicology Program. TR No. 390. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, Bethesda, MD.

OECD (1996): Vanillin. SIDS Initial Assessment Profile. OECD Screening Information Data Sets (SIDS) Vol. 5, part 2.

OEHHA (1999): 2,4-Benzofuran. US Office of Environmental Health and Hazard Assessment.

Parent RA, Caravello HE. Long JE (1992): Two-year toxicity and carcinogenicity study of acrolein in rats. J Appl Toxicol 12(2):131-139.

Piotrowski J (1967). Quantitative estimate of the absorption of toluene in people (In Polish with English summary). Med. Pracy. 18; 213-223.

Preston-Martin S, Yu MC, Benton B, Henderson BE (1982): N-nitroso compounds and childhood brain tumors: a case-control study. Cancer Research 42(12): 5240-5245.

Quast JF, Humiston CG, Kalnins RY (1979): Results of a toxicity study of monomeric styrene administered to beagle dogs by oral intubation for 19 months. J.Work Environ. Health. 4(suppl.2): 127-135.

Rasmussen RE (1987): Mutagen activity of inscense smoke in *Salmonella typhimurium*. Bull Environ. Contam. Toxicol. 38: 827-833.

Riddick JA, Bunger WB, Sakano TK (1985): Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons.

Riihimäki V, Pfäffli P (1978). Percutaneous absorption of solvent vapors in man. Scand J Work Environ Health, 4, 73-85.

Rothman N, Li GL, Dosemeci M, Bechtold WE, Marti GE, Wang YZ, Linet M, Xi LQ, Lu W, Smith MT, Titenko-Holland N, Zhang LP, Blot W, Yin SN, Hayes RB (1996): Hematotoxicity among Chinese workers heavily exposed to benzene. Am. J. Ind. Med. 29: 236-246.

Roveri P, Andrisano V, Di Pietra AM, Cavrini V (1998): GC-MS analysis of inscenses for possible presence of allergenic nitromusks. J. Pharm. Biomed. Anal. 17: 393-398.

RTECS (2003): 3,3-Dimethylbenzidine. Registry of Toxic Effects of Chemical Substances (RTECS). U.S. Department of Health and Human Services.

Sabourin PJ, Chem BT, Lucier G (1987): Effect of dose on the absorption and excretion of 14C-benzene administered orally or by inhalation in rats and mice. Toxicol. Appl. Pharmacol. 87: 325-336.

Sangster J (1989): Octanol-water partition coefficients of simple organic compounds. J. Phys. Chem. Ref. Data 18: 1164.

Sato S, Makino R, Takahashi Y, Sugimura T, Miyazaki T (1980): Mutagenicity of smoke condensates from joss sticks. Mutant Research 77: 31-36.

SCCNFP (1999): Fragrance allergy in consumers: A review of the problem, analysis of the need for approximate consumer information and identification of consumer allergens. SCCNFP/0017/98 Final. The Scientific Committee on Cosmetic Products and Non-food Products Intended for Consumers. Brussels.

Smyth HF, Carpenter CP, Weil CS, Pozzani UC, Striegel JA, Nycum JS (1969). Range-finding toxicity data: List VII. Am Ind Hyg Assoc J, 30: 470-6.

Srbova J, Teisinger J, Skramovsky S (1950) Absorption and elimination of inhaled benzene in man. Arch. Ind. Hyg. Occup. Med. 2: 1-8.

Stofberg J, Grundschober F (1987): The composition ratio and food predominance of flavoring materials. Perfumer and Flavorist 12: 27-56.

TGD (2003): Technical Guidance Document on Risk Assessment in support of Commission Directive 93/67/EEC on risk assessment for new notified substances, Commission Regulation (EC) No. 1488/94 on risk assessment for existing substances and Directive 98/8/EC of the European Parliament and the Council concerning the placing of biocidal products on the market. 2nd edition. European Chemicals Bureau, Ispra, Italy. Office for Official Publications of the European Communities. Luxemburg.

Til HP, Woutersen RA, Feron VJ, Hollanders VHM, Falke HE, Clary JJ (1989): Two-year drinking water study of formaldehyde in rats. Food Chem. Toxicol. 27: 77-87.

Thomsen KG (1990): Allergi- og overfølsomhedfremkaldende stoffer i arbejdsmiljøet. AMI raport no. 34/1990. Arbejdsmiljøinstituttet, Arbejdstilsynet.

Ullmann (1993): Ullmann's Encyclopedia of Industrial Chemistry. 5th Ed. VCH Verlagsgesellschaft.

US-EPA (1985): Reference values for risk assessment. Environment Criteria Assessment Office. US Environmental Protection Agency, Cincinatti, OH.

US-EPA (2003): Aster database. Assessment Tools for the Evaluation of Risk (ASTER, online database). U.S. Environmental Protection Agency. Environmental Research Laboratory, Duluth, MN. 1993.

Van Appeldoorn ME et al (1986): Criteriadocument Styreen. National Institute of Public Health and the Environment. RIVM report no. 738513003. Bilthoven, The Netherlands.

Van Steensel-Moll HA, Valkenberg HA, Van Zanen GE (1985): Childhood leukemia and parental occupation. Am. J. Epidemiol 121: 216-224.

Verschueren (1996): Handbook of Environmental Data on Organic Chemicals. 3rd ed., Van Nostrand Reinhold, New York.

Wallace LA et al. (1991): Identification of Polar Volatile Organic Compounds in Consumer Products and Common Microenvironments, Res. Triangle Inst., Research Triangle Park, NC. Report 1991, USEPA/600/D-91.074, (NTIS PB-91-182865).

Ward CO, Kuna RA, Snyder NK, Alsaker RD, Coate WB, Craig PH (1985): Subchronic inhalation toxicity of benzene in rats and mice. Am. J. Ind. Med. 7: 457-473.

WHO (2000): Air quality guidelines for Europe. 2nd edition. WHO Regional Publications, European Series No. 91. World Health Organisation Regional Office for Europe, Copenhagen.

Yalkowsky SH, Dannenfelser RM (1992): The Aquasol Database of Aqueous Solubility. Fifth Ed, Tucson, AZ: Univ Az, College of Pharmacy.

Yang CY, Chiu JF, Cheng MF, Lin MC (1997): Effects of indoor environmental factors on respiratory health of children in a subtropical climate. Environmental Research 75:49-55.

Yaws CL (1994): Handbook of Vapour Pressure. Vol. 3: C8-C28 Compounds. Houston, Texas, Gulf Publ. Co.

Appendix A Substances found by qualitative analyses

Summary of chemical substances found in qualitative analyses (Head-space)

The numbers in the columns present the composition as area percentage of the identified components

Ret.time: Retention time in the HPLC analysis
Lab. no: The analysed incenses

Ret. time	Component	Lab. no. CAS no.	1	2	3	4	5	6	7	8	9	10	11	12
1.6	Formic acid-2-propenyl ester	1838-59-1		1										
1.99	2-Butanon	78-93-3						5						
2.11	Ethylacetate	141-78-6		3		3								
2.3	Acetic acid	64-19-7				3								
3.9	1-Pentanol	71-41-0									2.5			
4.43	Toluene	108-88-3		2										
5.85	3-Hexen-1-ol	544-12-7		0.5										
6.35	Styrene	100-42-5			18	1.5								
6.85	C10H16 eks. Alpha-pinene	80-56-8		0.5		5								
6.92	3,7-Dimethyl-1,6-octadiene	-		0.5										
7.07	C10H16	-				2								
7.23	Benzaldehyde	100-52-7	1.5	0.5				7						
7.38	C10H16 eks. beta-pinene	127-91-3		0.5		1								
7.43	C10H16 eks. Beta-myrcene	123-35-3		1										
7.5	Hexanoic acid ethylester	123-66-0		1										
7.6	Octanal	124-13-0		1										
7.65	Hexylacetata (Acetic acid hexylester)	142-92-7				2								
7.91	C10H16	-				1.5								
7.91	Terpene C10H16	-	2											
7.96	C10H16	-		26										
7.96	Eucalyptol	470-82-6				2	2							
8	Benzylalcohol	100-51-6	9	0.5				7		2	2.5			
8.18	C10H16 eks. 3-Carene	13466-78-9		1										
8.25	2-Methylbenzenemethanol	89-95-2								3				
8.26	Nonanol	143-08-8				5								
8.28	2,7- dimethyl-2,7-oktandiol	19781-07-8	6	23			44							
8.44	C10H16O	-		2										
8.46	Terpene C10H16 e.g.. 2-Carene	-	0.5											
8.53	C10H16	-										6	1.5	7
8.55	C10H16	-	9			1.5	2.5			18				
8.57	Nitrobenzene	98-95-3									8			
8.59	C10H16	-		17										
8.71	C10H16O	-		0.5										
8.75	Phenylmethylhydrazine	555-96-4								2	8	6		4
8.82	-	-	1											
8.86	6-octan-1-ol,3,7-dimethyl-,formate	105-85-1		1										
8.94	C10H16 e.g. 3-Carene	13466-78-9	1											
9.08	C10H16	-		0.5										
9.12	C10H16O	464-49-3	6											
9.12	C10H16O *Camphor 76-22-2	eks. 464-49-3							70					
9.16	Acetic acid phenylmethylester	140-11-4						16						
9.25	Eks. Bicyclo 2.2.1 heptan, 2-chlor-2,3,3-trimethyl-	Eks. 465-30-5												3
9.27	C10H16	-	3											
9.32	Bornylchloride	464-41-5											1.5	5
9.38	C10H18O Bicyclo 3.1.0. Hexan-2-ol, methyl-5-(1-methylethyl)-,(1.alpha.,2.alpha.,5.alpha.)-	17699-16-0		0.5										

Ret. time	Component	Lab. no. CAS no.	1	2	3	4	5	6	7	8	9	10	11	12
9.47	Octylacetate (acetic acid octylester)	112-14-1				52								
9.48	Linalylpropanoate /C10H16	0/-											1	
9.49	2,7-Dimethyl-2,6-oktadien-1-ol	22410-74-8										3		
9.49	C10H16	-	26					20		36	2.5			
9.49	C10H18O	-		7										
9.52	?	?					3							
9.63	6-Octen-1-ol, 3,7-dimethyl-, formate	105-85-1										13		
9.65	C13H26O trimethylcyclo-hexyl-2-butanol	-	3											
9.65	Nerylnitril/geranylnitril C10H15N	101660-61-1		1.5										
9.68	Dimethylethylcyclohexanol	98-52-2					2.5				9			
9.82	C10H16	-					2			3				
9.85	C10H16	-		0.5				5				13		
9.92	Nerylnitril/geranylnitril C10H15N	0/101660-61-1		1.5										
10.15	C10H16	-	2											
10.16	C10H18O	-										11		
10.2	Isobornylacetate	125-12-2				1.5								
10.25	C10H16	-					12							
10.26	C10H16	-	6											
10.55	C10H16	-	1.5											
10.56	4-Tert-butylcyclohexylacetate	32210-23-4				4	3							
10.68	C10H16	-	19											
10.82	4-(1,1-dimethylethyl)-cyclohexanol	98-52-2					2.5							
10.82	4-tert-butylcyclohexylacetate	32210-23-4				8								
10.97	Copaene – C15H24	3856-25-5			35									
11.03	C15H24	Eks. 11029-06-4				2						2		
11.04	C15H24	5208-59-3			25									
11.08	C15H24	Eks. 514-51-2											3	5
11.17	C15H24	Eks. 1135-66-6										4		
11.3	C10H12	6707-86-4	1											
11.33	C15H24	-								3				
11.34	C15H24	Eks. 87-44-5										4	21	20
11.47	C15H24 e.g. Thujopsene	Eks. 470-40-6											10	9
11.48	C15H24 e.g. Thujopsene	470-40-6				2				10				
11.59	2-Methoxynaphthalene	93-04-9										13		
11.63	?	?											3	
11.63	C15H24	Eks. 22567-17-												8
11.65	C15H24	-									4.5			
11.7	C15H24	Eks. 560-32-7											2	7
11.8	BHT – butyleret hydroxytoluene	128-37-0		1.5										
11.87	C15H24	Eks. 3691-11-0											5	9
11.96	C15H22 e.g. Benzene, 1-methyl-4-(1,2,2-trimethylcyclopentyl)-, (R)-	16982-00-6											5	3
12	Lilial C14H20O	80-54-6		0.5										
12.09	C12H16O3	2050-08-0	2											
12.13	C15H22	Eks. 34143-96-9											1.5	
12.38	Diethylphthalate	84-66-2					27	31	28	27	60	18	2	
12.73	C15H24	Eks. 496-61-4						4		2			27	6
12.97	3-cyclohexen-1-ol, 5-(2-butenylidene-4,6,6-trimethyl-, (E,E)- C13H20O	66465-81-4		0.5										
12.97	C15H24	Eks. 88-84-6											1	
12.99	?	?									3			
13.19	C15H24	Eks. 10219-75-											4.5	18
13.43	2-phenylmethylenoctanal	101-86-0		0.5	22									
SUM	in %		100	97	100	97	101	95	98	105	100	93	89	104
No. of	Components		18	29	4	17	10	8	2	10	9	11	15	13

Appendix B Substances found during burning

Chemical substances identified by quantitative analyses of incense Classification according to Statutory Order 349 (Miljøministeriet 2002). Substances marked "[...] self-clas" are classified according to the Danish EPA Advisory list for self classification of dangerous substances (Miljøstyrelsen 2001)

Component	CAS-no.	EINECS	Classification	TLV, mg/m3	Note
Acenaphthylene	208-96-8	205-917-1			
Acetaldehyde	75-07-0	200-836-8	Fx;R12 Xi;R36/37 Carc3;R40	45	LK
Acetyl-4-hydroxy-6-methyl-2H-pyran-2-on	771-03-9	212-227-4	[Xn;R22] self-clas		
Acrolein	107-02-8	203-453-4	F;R11 T;R24/25 Tx;R26 C;R34 N;R50	0.12	
d-Allose (7283-09-2)	1000126-28-1				
3-Allyl-6-methoxyphenol	501-19-9				
Anthracene	120-12-7	204-371-1			
Azulene	275-51-4				
Benzaldehyde	100-52-7	202-860-4	Xn;R22		
Benzene	71-43-2	200-753-7	Carc1;R45 F;R11 T;R48/23/24/25	1.6	HK
Benzocycloheptatriene	264-09-5				
Benzofuran	271-89-6	205-982-6	[Xn;R22 R43] self-clas		
Benzonitril	100-47-0	202-855-7	Xn;R21/22		
Benzophenone	119-61-9				
2H-1-Benzopyran-2-one	91-64-5				
Benzoic acid, 2-hydroxy-3-methylbutylester	87-20-7	201-730-4	[N;R51/53] self-clas		
Benzoic acid-ethylester	93-89-0				
Benzylalcohol	100-51-6	202-859-9	Xn;R20/22		
Benzylbenzoate	120-51-4	204-402-9	Xn;R22		
Benzylcinnamate	103-41-3	203-109-3	[N;R50/53] self-clas		
BHT	128-37-0	204-881-4	[Xn;R22 N;R50/53] self-clas	10	
Biphenyl	92-52-4	202-163-5	Xi;R36/37/38 N;R50/53	1	
Butylcyclohexyl-2,3-dicyano-benzoic acid	86377-40-4				
Camphene	79-92-5	201-234-8			
Capsaicin (or ethylhomovallinate 60563-13-5)	404-86-4				
Cedrol	77-53-2				
Cedrandiol	62600-05-9				
Cedrylpropylether	1000131-90-6				
Cinnamaldehyde	14371-10-9				
Cinnamyl / cinnamate					
1,3-Cyclohexadiene	592-57-4	209-764-1	[Xn;R22] self-clas		
3-Cyclohexen-1-methanol-4-trimethyl	98-55-5				
Decanal	112-31-2	203-957-4	[N;R50/53] self-clas		
Desaspidinol	437-72-9				
4,4-Diamin-3,3-dimethyl-1,1-biphenyl (4,4'-bi-o-toluidine)	119-93-7	204-358-0	Carc2;R45 Xn;R22 N;R51/53		
Dibenzofuran	132-64-9				
Diethylphthalate	84-66-2	201-550-6		3	
2,6-Dimethoxyphenol	91-10-1	202-041-1	[Xn;R22 R43] self-clas		
2,6-Dimethoxy-2-propenylphenol	6627-88-9	229-600-2	[R43] self-clas		
(4-(Dimethylamino)-phenyl)-phenylmethanon	530-44-9	208-478-4	[Xn;R22 R43] self-clas		
N,N-dimethylbenzenamine (N,N-dimethylanilin)	121-69-7	204-493-5	T;R23/24/25 Carc3;R40 N;R51/53	25	HK
1,1-Dimethylethyl-2-methoxy-4-methyl-3-benzene	83-66-9	201-493-7	[Xn;R22 N;R51/53] self-clas		
2,5-Dimethylfuran	625-86-5	210-914-3	[Xn;R22] self-clas		
1,5-Dimethyl-4-hexenyl-4-methylbenzene	644-30-4				
2,6-Dimethyl-naphthalene	581-42-0	209-464-0	[Xn;R22 N;R50/53] self-clas		
3,7-Dimethyl-1,6-octadien-3-ol	78-70-6				
3,7-Dimethyl-1,6-octadien-3-ol	10281-55-7				
3,7-Dimethyl-1,6-octadien-3-ol, acetate	115-95-7				
3,7-Dimethyl-2,6-octadien-1-ol (geraniol)	106-24-1	203-377-1	[N;R50] self-clas		
3,7-Dimethyl-6-octenal (citronellal)	106-23-0	203-376-6	[R43 N;R51/53] self-clas		
2,6-Dimethyl-7-octen-2-ol	18479-58-8	242-362-4			
3,7-Dimethyl-6-octen-1-ol	1117-61-9				

Component	CAS-no.	EINECS	Classification	TLV, mg/m3	Note
d-Limonene	5989-27-5	227-813-5	R10 Xi;R38 R43 N;R50/53		
Ethenylmethylbenzene (25013-15-4/622-97-9)	25013-15-4	246-562-2	[R43] self-clas	120	H
1-Ethenyl-3-methylbenzene (3-methylstyren)	100-80-1	202-889-2	[Xn;R22] self-clas	120	H
6-Ethenyl-6-methyl-1-(1-methylethyl)-3-cyclohexene	5951-67-7				
Ethylbenzene	100-41-4	202-849-4	F;R11 Xn;R20	217	K
1-Ethyl-2-methylbenzene	611-14-3	210-255-1	[N;R51/53] self-clas		
1-Ethyl-3-methylbenzene	620-14-4				
4-Ethyl-2-methoxy-phenol	2785-89-9	220-500-4	[Xn;R22] self-clas		
Eugenol	97-53-0	202-589-1	[Xn;R22 Mut3;R40 R43] self-clas		
Formaldehyde	50-00-0	200-001-8	T;R23/24/25 C;R34 Carc3;R40 R43	0.4	HK
Fluoren-9-one	486-25-9	207-630-7	[Mut3;R40] self-clas		
Furanon	497-23-4	207-839-3			
Furfural	98-01-1	202-627-7	Xn;R21 T;R23/25 Xi;R36/37 Carc3;R40	7.9	HK
2-Furanmethanol (furfurylalcohol)	98-00-0	202-626-1	Xn;R20/21/22	20	H
Geranylnitril	101660-61-1				
Hexadecanoic acid	57-10-3				
Hexadecanoic acid, methylester	628-97-7				
Hexahydro-cyclopenta-2-benzopyran	1222-05-5				
Hexahydro-methanoazulene	469-61-4	207-418-4	[N;R50/53] self-clas		
Hexylsalicylate					
n-Hexyl salicylate	6259-76-3	228-408-6	[Xn;R22 N;R50/53] self-clas		
4-Hydroxybenzamidine	1000139-78-0				
7-Hydroxy-3,7-dimethyl-octanal	107-55-5				
4-hydroxy-3,5-dimethoxybenzaldehyde	134-96-3	205-167-5	[R43] self-clas		
4-Hydroxy-3-methylacetophenone	876-02-8	212-880-5	[R43] self-clas		
4-(3-hydroxy-1-propenyl)-2-methoxyphenol	458-35-5	207-277-9	[R43 N;R50] self-clas		
4-(3-hydroxy-1-propenyl)-2-methoxyphenyl-ethyl					
1H-Inden, 1-methylene	2471-84-3				
Isoborneol	124-76-5	204-712-4	[R52/53] self-clas		
Isobornylacetate	125-12-2				
Lilial	80-54-6	201-289-8	[R43 N;R51/53] self-clas		
Linoleic acid ethylester	544-35-4				
2-Methoxy-4-methylphenol	93-51-6	202-252-9	[Xn;R22 R43] self-clas		
2-Methoxy-naphthalene	93-04-9				
2-Methoxy-phenol	90-05-1	201-964-7	Xn;R22 Xi;R36/38		
2-Methoxy-4-(1-propenyl)-phenol	97-54-1	202-590-7	Xn;R22 R43] self-clas		
2-Methoxy-4-vinylphenol	7786-61-0	232-101-2			
2-Methyl-9.10-anthracendione	84-54-8				
a-methylbenzenmethanol	98-85-1				
2-Methylbenzofuran	4265-25-2	224-249-1	[Mut3;R40 R43] self-clas		
3-Methyl-1,2-cyclopentandione	765-70-8				
Methyl dihydro-jasmonate	24851-98-7	246-495-9	[N;R50] self-clas		
5-Methyl-2-furancarboxaldehyde	620-02-0				
6-Mehtyl-5-hepten-2-one	110-93-0				
1-methyl-2-(1-methylethyl)-benzene (o-cymene)	527-84-4	208-426-0	[N;R51/53] self-clas	135	
2-methyl-3-phenyl-2-propenal	101-39-3				
2-Methyl-naphthalene	91-57-6	202-078-3	[Xn;R22 R43 N;R51/53] self-clas		
2-Methylphenol	95-48-7	202-423-8	T;R24/25 C;R34	22	H
4-Methylphenol (cresol)	106-44-5	203-398-6	T;R24/25 C;R34	22	H
6-Methyl-2-pyrazinylmethanol	77164-93-3				
a-Methylstyrene	98-83-9	202-705-0	R10 Xi;R36/37 N;R51/53	240	
1-Methyl-4-(1,2,2-trimethyl-cyclopentyl)-benzene	16982-00-6	241-061-5	[N;R50/53] self-clas		
b-Myrcene	123-35-3				
Naphthalene	91-20-3	202-049-5	Xn;R22 N;R50/53	50	
Nerylnitrile	1000108-90-5				
Octadecanoic acid	112-79-8				
Octahydro-dimethylazulene	3691-11-0				
Octahydro-methanoazulene	514-51-2	208-182-5	[N;R50/53] self-clas		
Octahydro-trimethyl-methanoazulene	546-28-1				
1,1-oxybis-2-propanol	110-98-5				
Patchouli alcohol	5986-55-0	227-807-2	[N;R50/53] self-clas		
Phenanthrene	1517-22-2				
Phenol	108-95-2	203-632-7	T;R24/25 C;R34	4	H

Component	CAS-no.	EINECS	Classification	TLV, mg/m3	Note
Phenylethylalcohol	60-12-8				
Phenylethyn	536-74-3	208-645-1	[Xn;R22] self-clas		
2-(phenylmethylen)-octanal	101-86-0				
2-Propenoic acid,3-phenyl,methylester	103-26-4				
Santatol, alpha (98718-53-7)	115-71-9	204-102-8	[N;R50/53] self-clas		
Styrene	100-42-5	202-851-5	R10 Xn;R20 Xi;R36/38	105	LHK
a-Terpineol (p-menth-1-en-8-ol)	98-55-5	202-680-6	[Xi;R36/37/38]MSDS		
b-Terpinol	1000150-76-1				
Tetradecanal	124-25-4	204-692-7	[N;R50/53] self-clas		
Tetrahydro-trimethylnaphthalene	475-03-6				
Thujopsene	470-40-6				
Toluene	108-88-3	203-625-9	F;R11 Xn;R20	94	H
Tricyclonona-3,6-diene	6006-24-2				
Trihydroxyphenyl-2-pentanone	1000116-2				
4-Trimethyl-3-cyclohexen-1-methanol	80-26-2	201-265-7	[N;R51/53] self-clas		
Triphenyl-1-pentanol	2294-95-3				
Undecene	821-95-4	212-483-7	[N;R50/53] self-clas		
Vanillin	121-33-5				
o,m,p-Xylene	106-42-3	203-396-5	R10 Xn;R20/21 Xi;R38	109	H

Appendix C Emission measurements

Incense, mrk.:	Lavender cone	Lab. no. 1	Date:	23. November 2003
			Project no.	1712753

Background measurement, room	Filter no.	Liter air
Charcoal	845	105
DNPH	847	105
XAD-2	846	140
GFF	722	1,970

Exhaust, process	Filter no.	Liter air
Charcoal	839	75
DNPH	856	1.05
XAD-2	840	70.5
GFF	771	464

	Background			Incense + background			Incense		
	Substance amount	Air-volume	Concen-tration	Substance amount	Air-volume	Concen-tration	Concen-tration	Emission	
CHARCOAL	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Benzene	<0.1	105	0	138	75	1,840	1,840	1,482	619
2.5-Dimethylfuran	0.36	105	3	9	75	126	122	98	41
Toluene	0.82	105	8	116	75	1,547	1,539	1,239	518
Furfural	<0.1	105	0	51	75	679	679	547	229
2-Furanmethanol	<0.1	105	0	22	75	297	297	239	100
m,p-Xylene	<0.1	105	0	34	75	453	453	365	153
Styrene	<0.1	105	0	20	75	263	263	211	88
Benzaldehyde	<0.1	105	0	10	75	131	131	106	44
Camphene	<0.1	105	0	18	75	240	240	193	81
Benzofuran	<0.1	105	0	21	75	280	280	225	94
Benzylalcohol	<0.1	105	0	31	75	411	411	331	138
D-limonene	<0.1	105	0	60	75	805	805	648	271
N,N-dimethylbenzenamine	<0.1	105	0	5	75	63	63	51	21
Isoborneol	<0.1	105	0	13	75	171	171	138	58
2-Methoxy-4-methylphenol	<0.1	105	0	10	75	137	137	110	46
a-Terpineol (p-menth-1-en-8-ol)	<0.1	105	0	88	75	1,170	1,170	942	394
3-Cyclohexen-1-methanol-4-trimethyl	<0.1	105	0	0	75	0	0	0	0
Isobornylacetate	<0.1	105	0	33	75	434	434	349	146
4-Trimethyl-3-cyclohexen-1-methanol	<0.1	105	0	62	75	828	828	666	278
Benzoic acid,2-hydroxy-3-methylbutylester	<0.1	105	0	26	75	343	343	276	115
n-Hexyl salicylate	<0.1	105	0	9	75	120	120	97	40
Sum VOC on CHARCOAL							10,325		

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
DNPH	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Formaldehyde	0.1	105	1	16	1.05	15,238	15,237	11,352	5,281

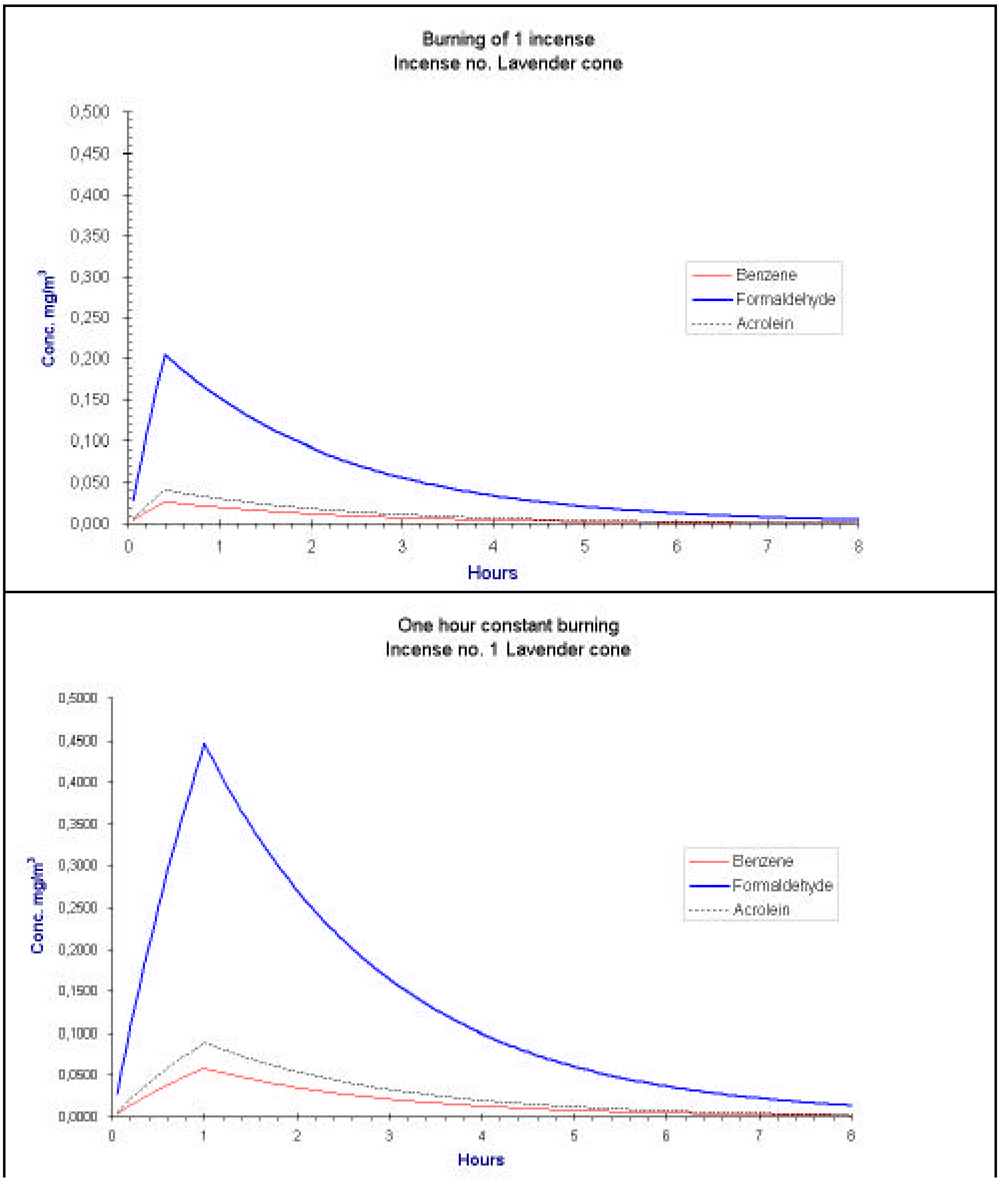
Acetaldehyde	0.34	105	3	9.9	1.05	9,429	9,425	7,022	3,267
Acrolein	0.08	105	1	3.2	1.05	3,048	3,047	2,270	1,056
Sum aldehydes on DNPH							27,709		

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substan ce amount	Air volume	Concen- tration	Concen- tration	Emission	
XAD-2	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
5-Methyl-2-furancarboxaldehyde	<0.1	140	0	4	70.5	55	55	44	19
Phenol	<0.1	140	0	9	70.5	134	134	108	45
Benzofuran	<0.1	140	0	5	70.5	68	68	55	23
1,1-oxybis-2-propanol	<0.1	140	0	7	70.5	94	94	76	32
2-Methoxy-phenol	<0.1	140	0	18	70.5	257	257	207	87
Cinnamaldehyde	<0.1	140	0	5	70.5	70	70	57	24
b-Terpinol	<0.1	140	0	2	70.5	23	23	18	8
3,7-Dimethyl-6-octen-1-ol	<0.1	140	0	4	70.5	58	58	46	19
2-methyl-3-phenyl-2-propenal	<0.1	140	0	1	70.5	21	21	17	7
Isobornylacetate	<0.1	140	0	6	70.5	80	80	65	27
2-Methoxy-4-vinylphenol	<0.1	140	0	12	70.5	174	174	140	58
Eugenol	<0.1	140	0	3	70.5	42	42	33	14
2-Methoxy-4-1-propenylphenol	<0.1	140	0	6	70.5	90	90	72	30
Vanillin	<0.1	140	0	5	70.5	73	73	59	25
Naphtalene	<0.1	140	0	4	70.5	54	54	43	18
Acenaphtylene	<0.1	140	0	0	70.5	6	6	5	2
Phenanthrene	<0.1	140	0	0	70.5	6	6	5	2
Antracene	<0.1	140	0	0	70.5	2	2	1	1
Sum VOC on XAD-2							1,306		

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substan ce amount	Air volume	Concen- tration	Concen- tration	Emission	
GFF	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
2-Methoxy-4-vinylphenol	<0.1	1,970	0	99	464	214	214	172	72
2.6-Dimethoxyphenol	<0.1	1,970	0	63	464	135	135	109	45
Vanillin	<0.1	1,970	0	167	464	360	360	290	121
3-Acetyl-4-hydroxy-6-methyl-2H-pyran-2-on	<0.1	1,970	0	68	464	146	146	118	49
2-Methoxy-4-1-propenylphenol	<0.1	1,970	0	99	464	214	214	172	72
2H-1-benzopyran-2-on	<0.1	1,970	0	99	464	214	214	172	72
d'Allose	<0.1	1,970	0	292	464	630	630	507	212
2.6-Dimethoxy-2-propenylphenol	<0.1	1,970	0	99	464	214	214	172	72
4-(3-hudroxy-1-propenyl)-2-methoxyphenol	<0.1	1,970	0	99	464	214	214	172	72
Hexadecanoic acid	<0.1	1,970	0	68	464	146	146	118	49
Octadecene acid	<0.1	1,970	0	146	464	315	315	254	106
2-Hydroxy-1.2-bis(4methoxyphenyl)ethanon	<0.1	1,970	0	610	464	1316	1316	1,059	443
Capsaicin	<0.1	1,970	0	710	464	1529	1529	1,231	514
Phenanthrene	<0.1	1,970	0	13	464	28	28	23	9
Sum VOC-aerosol on GFF							5,673		
Sum TVOC-aerosol on GFF				7,000	464	15,086	15,086		
Total aerosol on GFF	60	1,970	30	69,830	464	150,496	150,465		

Burning time for 1 stick/cone	25	min.
Weight of incense	1.07	g
Measuring period in minutes	50	min.
Gram incense burned	2.13	g
Gram incense burned/hour	2.56	g
Total air volumem^3	0.67	m^3
Temperature in glow	340-360	degrees
Gram incense burned, aldehydes	0.46	g
Measuring period in min., aldehydes	12	min.
Gram incense burned/hour, aldehydes	2,30	g
Total air volume m^3, aldehydes	0,15	m^3
VOC emission, CHARCOAL:	8,314	µg/hour
	3,246	µg/gram incense
	3,474	µg/incense
VOC emission, DNPH:	20,643	µg/hour
	8,975	µg/gram incense
	9,604	µg/incense
VOC emission, XAD-2:	1,052	µg/hour
	411	µg/gram incense
	439	µg/incense
Sum VOC (charcoal+XAD-2+DNPH):	30,009	µg/hour
	12,632	µg/gram incense
	13,517	µg/incense
VOC emission, GFF:	4,568	µg/hour
	1,784	µg/gram incense
	1,908	µg/incense
TVOC emission, GFF:	12,147	µg/hour
	4,743	µg/gram incense
	5,075	µg/incense
Total aerosol emission, GFF:	121,155	µg/hour
	47,308	µg/gram incense
	50,619	µg/incense

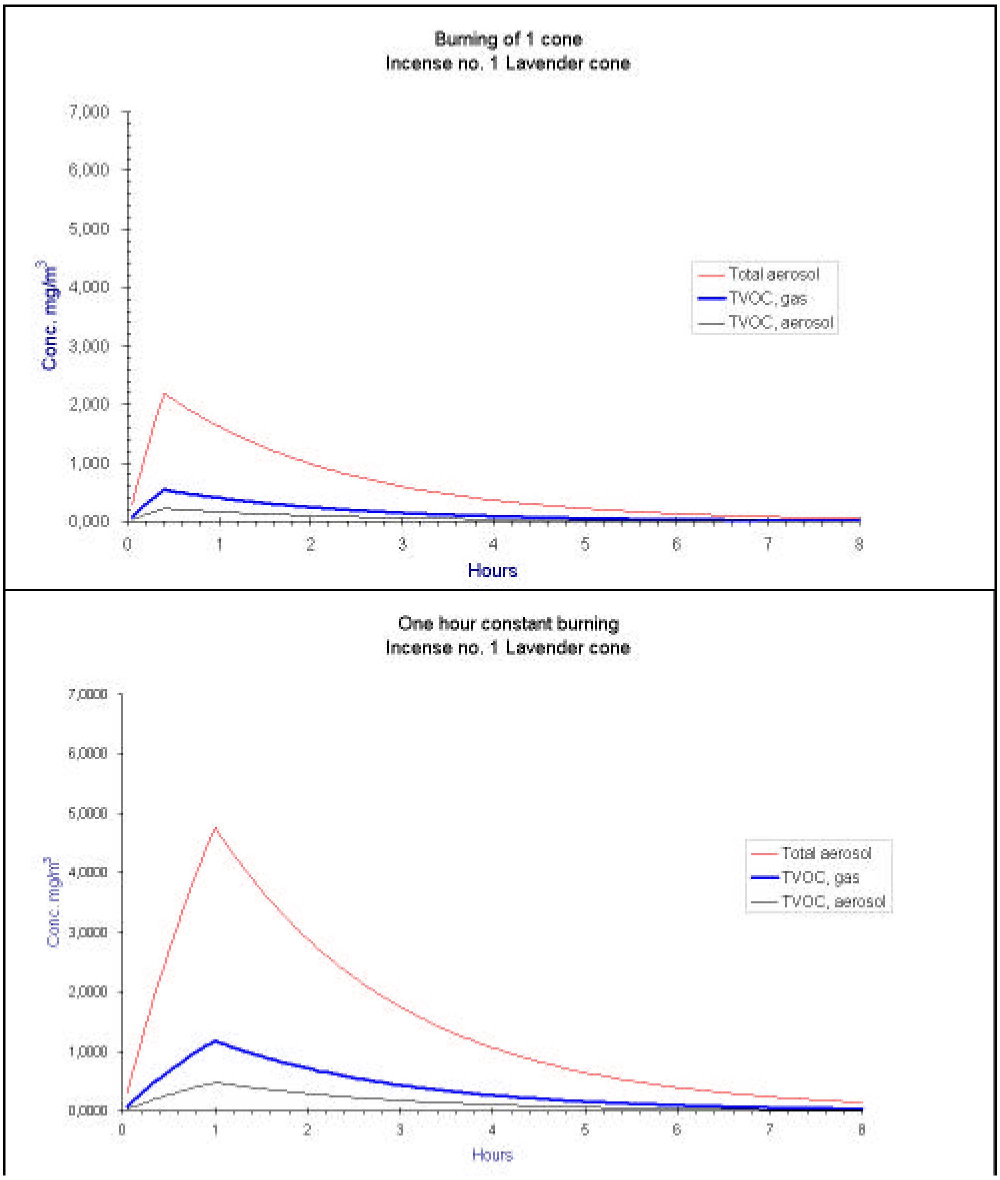
Boxmodel: 1 A



Catched concentrations of acrolein, formaldehyde and benzene during burning of one incense cone (top) and by continuous burning for one hour (bottom).

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Boxmodel 1B



Catched concentrations of aerosol, divided on total aerosol, TVOC (total volatile components) as vapour ("gas") and aerosol during burning of 1 incense cone (top) and by continuous burning for one hour (bottom). The amount is given as mg/m^3.

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Incense, mrk.:	Lemon stick Lab. no. 2	Date:	3. november 2003

Background measurement, room	Filter no.	Liter air
Charcoal	845	105
DNPH	847	105
XAD-2	846	140
GFF	722	1,970

Project no. 171275 3

Exhaust, process	Filter no.	Liter air
Charcoal	830	90
DNPH	859	0.99
XAD-2	831	90
GFF	798	615

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substanc e amount	Air volume	Concen-tration	Concen-tration	Emissio n	
CHARCOAL	µg	Liter	µg/m^3	µg	liter	µg/m^3	µg/m^3	µg/h	µg/unit
Benzene	<0,1	105	0	149	90	1,656	1,656	1,464	976
2,5-Dimethylfuran	0.36	105	3	9	90	101	98	87	58
Toluene	<0.1	105	8	125	90	1,389	1,381	1,221	814
Furfural	<0.1	105	0	14	90	156	156	138	92
m,p-Xylen + ethylbenzene	<0.1	105	0	53	90	589	589	521	347
Styrene	<0.1	105	0	32	90	350	350	310	207
Benzaldehyde	<0.1	105	0	9	90	101	101	89	59
Benzonitrile	<0.1	105	0	18	90	202	202	178	119
a-Methylstyrene	<0.1	105	0	11	90	120	120	106	71
Benzofuran	<0.1	105	0	46	90	514	514	454	303
1-methyl-2-(1-methylethyl)benzene	<0.1	105	0	18	90	197	197	174	116
d-Limonene	<0.1	105	0	135	90	1,498	1,498	1,324	883
2,6-Dimethyl-7-octen-2-ol	<0.1	105	0	231	90	2,569	2,569	2,271	1,514
3,7-Dimethyl-1,6-octadien-3-ol	<0.1	105	0	176	90	1,959	1,959	1,732	1,154
Naphthalene	<0,1	105	0	36	90	403	403	357	238
Nerylnitril	<0.1	105	0	19	90	216	216	191	127
Geranylnitril	<0.1	105	0	25	90	278	278	246	164
Diethylphthalate	<0.1	105	0	13	90	144	144	127	85
Sum VOC on charcoal							12,430		

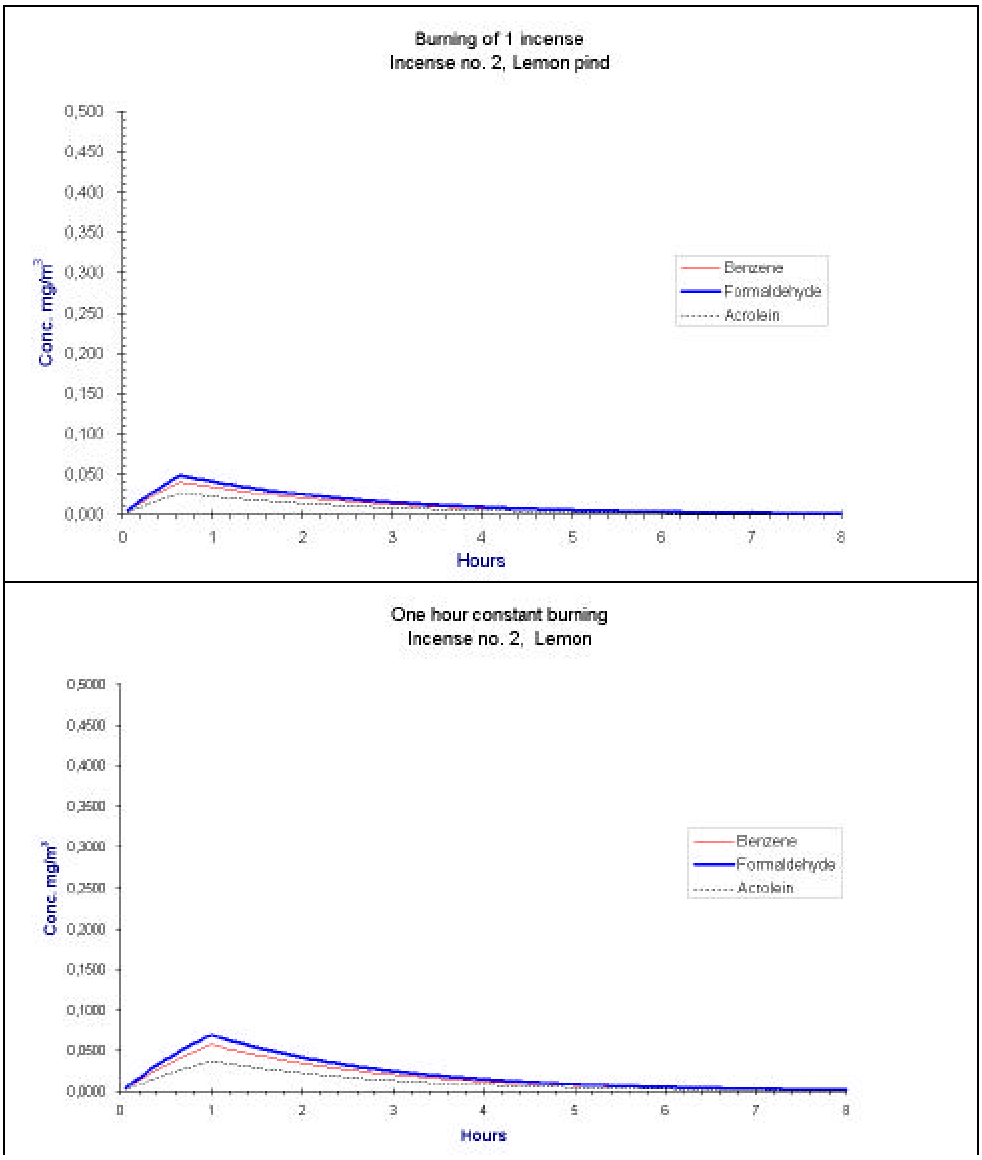
	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substanc e amount	Air volume	Concen-tration	Concen-tration	Emission	
DNPH	µg	liter	µg/m^3	µg	liter	µg/m^3	µg/m^3	µg/h	µg/unit
Formaldehyde	0.1	105	1	2.4	0.99	2,424	2,423	1,771	1,266
Acetaldehyde	0.34	105	3	5.1	0.99	5,152	5,148	3,763	2,690
Acrolein	0.08	105	1	1.3	0.99	1,313	1,312	959	686
Sum aldehydes on DNPH							8,884		

XAD-2	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
3,7-Dimethyl-1,6-octadien-3-ol	<0.1	140	0	1	90	12	12	11	7
Phenol	<0.1	140	0	7	90	76	76	67	45
b-Myrcene	<0.1	140	0	2	90	20	20	18	12
Ethenylmethylbenzene	<0.1	140	0	1	90	13	13	12	8
Azulene	<0.1	140	0	4	90	43	43	38	26
Decanal	<0.1	140	0	8	90	87	87	77	52
Benzocycloheptatriene	<0.1	140	0	1	90	14	14	12	8
2-Methoxy-4-vinylphenol	<0.1	140	0	5	90	58	58	52	35
4-Hydroxy-3-methylacetophenon	<0.1	140	0	0	90	0	0	0	0
2,6-Dimethoxyphenol	<0.1	140	0	9	90	100	100	89	60
Biphenyl	<0.1	140	0	4	90	40	40	35	24
BHT	<0.1	140	0	24	90	264	264	233	157
Lilial	<0.1	140	0	13	90	146	146	129	87
Dibenzofuran	<0.1	140	0	2	90	20	20	18	12
Methyl dihydrojasmonate	<0.1	140	0	6	90	71	71	62	42
2-(phenylmethylen)-octanal	<0.1	140	0	37	90	416	416	367	247
2-(phenylmethylen)-octanal	<0.1	140	0	7	90	79	79	70	47
Hexahydro-cyclopenta-2-benzopyran	<0.1	140	0	5	90	52	52	46	31
4,4-Diamin-3,3-dimethyl1,1-biphenyl	<0.1	140	0	3	90	30	30	26	18
Acenaphtylene	<0.1	140	0	1	90	12	12	10	7
Phenanthene	<0.1	140	0	1	90	8	8	7	5
Antracene	<0.1	140	0	0	90	2	2	2	1
Sum VOC on XAD-2							1,563		

GFF	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
2.6-Dimethoxyphenol	<0.1	1,970	0	44	615	72	72	64	43
Vanillin	<0.1	1,970	0	49	615	79	79	70	47
Lilial	<0.1	1,970	0	53	615	87	87	77	52
Methyl dihydrojasmonate	<0.1	1,970	0	102	615	166	166	147	99
4-Hydroxy-3,5-dimethoxybenzaldehyde	<0.1	1,970	0	49	615	79	79	70	47
2.6-Dimethoxy-2-propenylphenol	<0.1	1,970	0	80	615	130	130	115	77
2(Phenylmethylen)oktanal	<0.1	1,970	0	889	615	1,445	1,445	1,278	859
Hexahydro-cyclopenta-2-benzopyran	<0.1	1,970	0	120	615	195	195	172	116
Hexadecanoic acid methylester	<0.1	1,970	0	138	615	224	224	198	133
Trihydroxyphenyl-2-pentanone	<0.1	1,970	0	102	615	166	166	147	99
Linoleic acid, ethylester	<0.1	1,970	0	382	615	621	621	549	369
Phenanthrene	<0.1	1,970	0	19	615	31	31	27	18
Sum VOC-aerosol on GFF							3,297		
Sum TVOC-aerosol on GFF				3,000	615	4,878	4,878		
Total aerosol on GFF	60	1,970	30	31,750	615	51,626	51,596		

Burning time for 1 stick/cone	40	min.
Weight of incense	1.17	g
Measuring period in minutes	60	min.
Gram incense burned	1.74	g
Gram incense burned/hour	1.74	g
Total air volume m^3	0.88	m^3
Temperature in glow	280-290	degrees
Gram incense burned, aldehydes	0.30	g
Measuring period in minutes, aldehydes	11	min.
Gram incense burned/hour, aldehydes	1.64	g
Total air volume m^3, aldehydes	0.13	m^3
VOC emission, CHARCOAL:	10,988	µg/hour
	6,315	µg/gram incense
	7,389	µg/incense
VOC emission, DNPH:	6,493	µg/hour
	3,968	µg/gram incense
	4,643	µg/incense
VOC emission, XAD-2	1,382	µg/hour
	794	µg/gram incense
	929	µg/incense
Sum VOC (Charcoal+XAD-2+DNPH):	18,863	µg/hour
	11,077	µg/gram incense
	12,960	µg/incense
VOC emission, GFF:	2,915	µg/hour
	1,675	µg/gram incense
	1,960	µg/incense
TVOC emission, GFF:	4,312	µg/hour
	2,478	µg/gram incense
	2,900	µg/incense
Total aerosol emission, GFF:	45,610	µg/hour
	26,213	µg/gram incense
	30,669	µg/incense

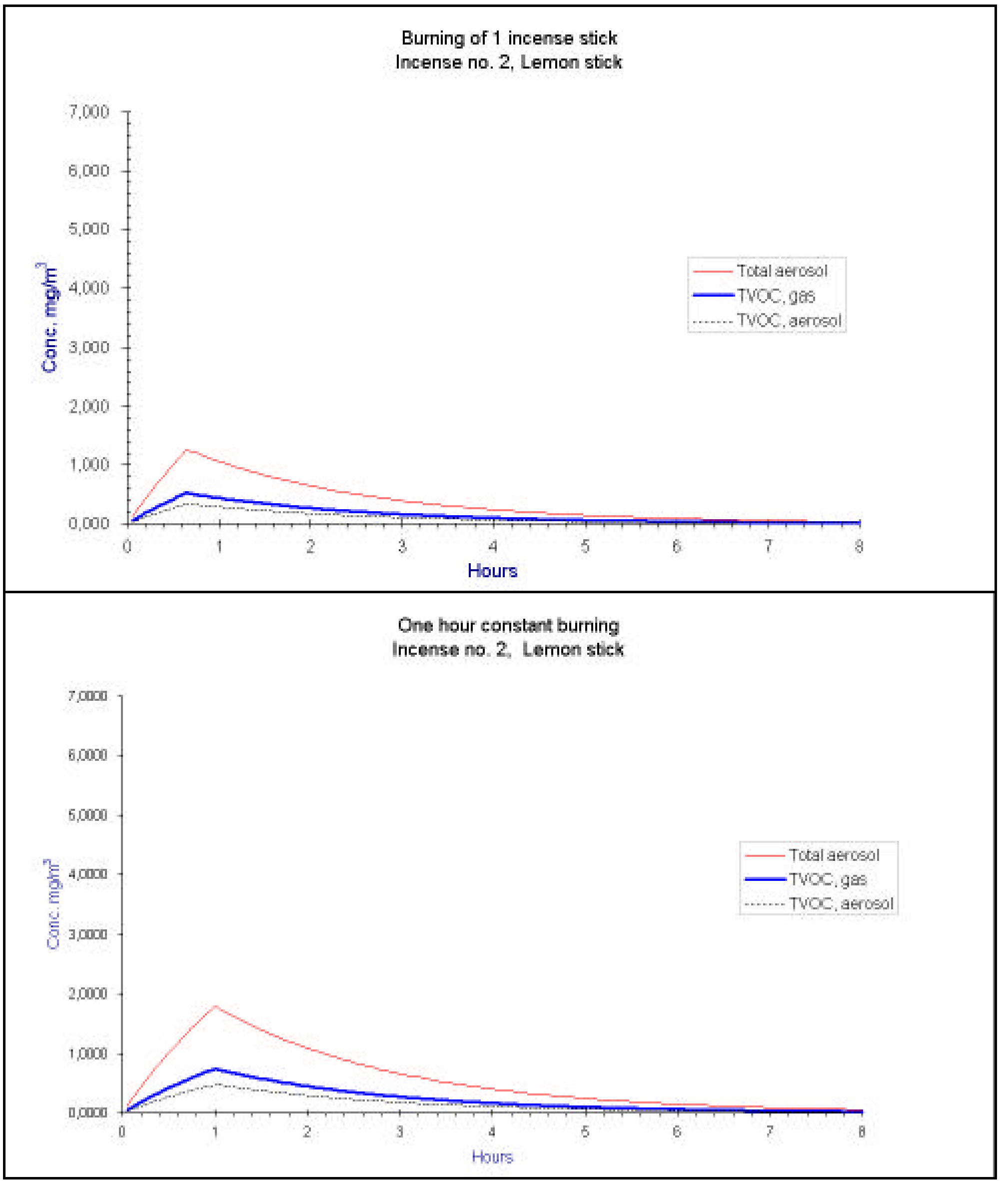
Boxmodel 2A



Catched concentrations of acrolein, formaldehyde and benzene during burning of one incense stick (top) and by continuous burning for one hour (bottom).

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Boxmodel 2 B



Catched concentrations of aerosol, divided on total aerosol, TVOC (total volatile components) as vapour ("gas") and aerosol during burning of 1 incense cone (top) and by continuous burning for one hour (bottom). The amount is given as mg/m^3

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Incense, mrk.:	Ayurvedisk	Lab. no. 4	Date: 3. november 2003

Background measurement, room	Filter no.	Liter air	Project no. 1712753
Charcoal	845	105	
DNPH	847	105	
XAD-2	846	140	
GFF	722	1,970	

Exhaust, process	Filter no.	Liter air
Charcoal	836	62
DNPH	854	0.69
XAD-2	837	90
GFF	769	430

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
CHARCOAL	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Benzen	<0.1	105	0	104	62	1,677	1,677	1,114	748
1,3-Cyclohexadien	<0.1	105	0	6	62	92	92	61	41
Toluen	0.36	105	3	84	62	1,355	1,351	897	602
Furfural	<0.1	105	0	11	62	184	184	122	82
Xylener, Ethylbenzene	<0.1	105	0	46	62	742	742	493	331
o,m,p-Xylene	0.82	105	8	*	62	0	0	0	0
Phenylethyne	<0.1	105	0	37	62	599	599	398	267
Styrene	<0.1	105	0	81	62	1,306	1,306	867	582
benzaldehyde	<0.1	105	0	15	62	238	238	158	106
1-Ethyl-2-methylbenzene	<0.1	105	0	15	62	238	238	158	106
1-Ethyl-3-methylbenzene	<0.1	105	0	6	62	92	92	61	41
Ethenylmethylbenzene	<0.1	105	0	12	62	192	192	127	86
2-Methylbenzoefuran	<0.1	105	0	8	62	123	123	82	55
Azulene	<0.1	105	0	6	62	92	92	61	41
Sum VOC on charcoal							6,927		

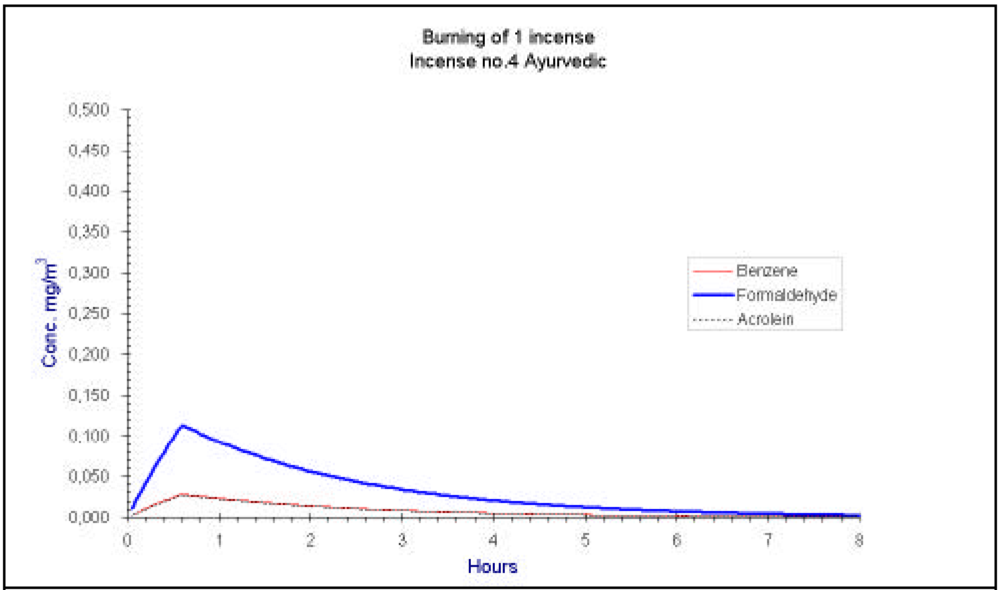
	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
DNPH	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Formaldehyde	0.1	105	1	4.6	0.69	6,667	6,666	4,399	2,823
Acetaldehyde	0.34	105	3	2.4	0.69	3,478	3,475	2,294	1,472
Acrolein	0.08	105	1	1.1	0.69	1,594	1,593	1,052	675
Sum aldehydes on DNPH							11,734		

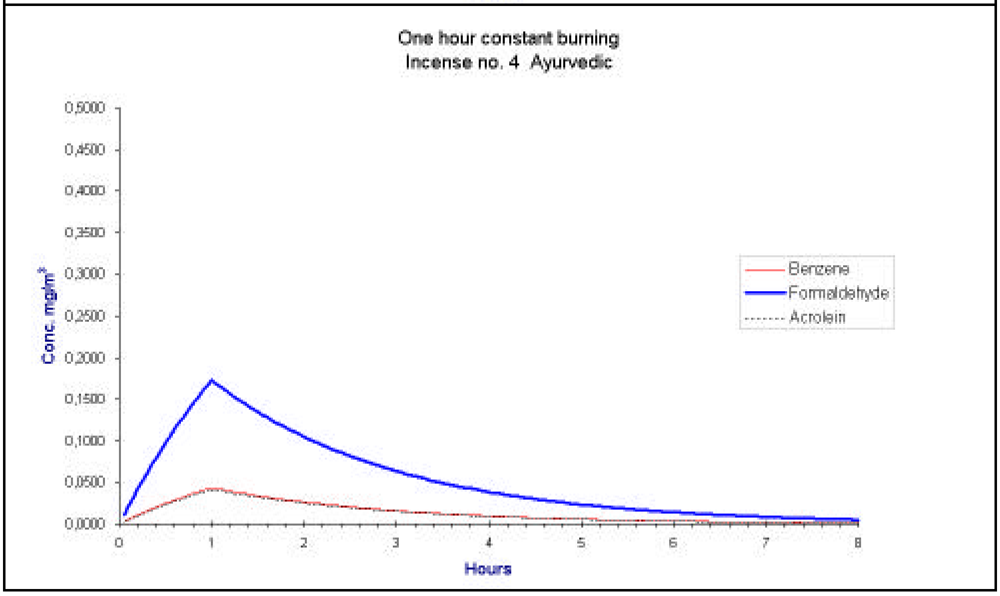
XAD-2	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Phenol	<0.1	140	0	8	90	90	90	60	40
Ethenylmethylbenzene	<0.1	140	0	1	90	11	11	7	5
4-Mehtylphenol	<0.1	140	0	1	90	12	12	8	5
2-Methoxy-phenol	<0.1	140	0	5	90	53	53	35	24
2-Methoxy-4-methylphenol	<0.1	140	0	2	90	19	19	12	8
4-Hydroxybenzamidine	<0.1	140	0	10	90	109	109	73	49
2-Methoxy-4-vinylphenol	<0.1	140	0	4	90	44	44	29	20
2-Methyl-naphthalen	<0.1	140	0	1	90	11	11	8	5
2,6-Dimethoxyphenol	<0.1	140	0	7	90	81	81	54	36
3-Allyl-6-methoxyphenol	<0.1	140	0	1	90	10	10	7	4
2-Propenois acid,3-phenyl,methylester	<0.1	140	0	3	90	37	37	24	16
Vanillin	<0.1	140	0	3	90	35	35	23	16
2,6-Dimethylnaphthalen	<0.1	140	0	4	90	46	46	31	21
2-(phenylmethylen)-octanal	<0.1	140	0	1	90	17	17	11	7
4,4-Diamin-3,3-dimethyl1,1-biphenyl	<0.1	140	0	4	90	45	45	30	20
Naphtalene	<0.1	140	0	3	90	30	30	20	13
Acenapthylene	<0.1	140	0	1	90	7	7	4	3
Phenanthrene	<0.1	140	0	0	90	3	3	2	1
Sum VOC on XAD-2							659		

GFF	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Benzoic acid	<0.1	1,970	0	82	430	191	191	127	85
2.6-Dimethoxyphenol	<0.1	1,970	0	57	430	132	132	88	59
Vanillin	<0.1	1,970	0	76	430	176	176	117	79
3-Phenyl-2-propenoic acid	<0.1	1,970	0	366	430	852	852	566	380
2-Methoxy-4-1-propenylphenol	<0.1	1,970	0	25	430	59	59	39	26
d'Allose	<0.1	1,970	0	44	430	103	103	68	46
4-Hydroxy-3.5-dimethoxybenzaldehyde	<0.1	1,970	0	38	430	88	88	59	39
Santalol	<0.1	1,970	0	101	430	235	235	156	105
Desospidinol	<0.1	1,970	0	51	430	118	118	78	52
Benzylbenzoate	<0.1	1,970	0	19	430	44	44	29	20
Trihydroxyphenyl-2-pentanon	<0.1	1,970	0	114	430	264	264	176	118
Benzylcinnanate	<0.1	1,970	0	44	430	103	103	68	46
Cinnamyl cinnamate	<0.1	1,970	0	95	430	220	220	146	98
Phenanthren	<0.1	1,970	0	7	430	16	16	11	7
Sum VOC-aerosol on GFF							2,601		
Sum TVOC-aerosol on GFF				4,700	430	10,930	10,930		
Total aerosol on GFF	60	1,970	30	39,860	430	92,698	92,667		

Burning time for 1 stick/cone	36 min.
Weight of incense	0.98 g
Measuring period in min.	60 min.
Gram incense burned	1.46 g
Gram incense burned/hour	1.46 g
Total air volume m^3	0.66 m^3
Temperature in glow	300-320 degrees
Gram incense burned, aldehydes	0.28 g
Measuring period in min., aldehydes	11 min.
Gram incense burned/hour, aldehydes	1.53 g
Total air volume m^3, aldehydes	0.12 m^3
VOC emission, CHARCOAL:	4,600 µg/hour
	3,151 µg/gram incense
	3,088 µg/incense
VOC emission, DNPH:	7,745 µg/hour
	5,071 µg/gram incense
	4,969 µg/incense
VOC emission, XAD-2	438 µg/hour
	300 µg/gram incense
	294 µg/incense
Sum VOC (CHARCOAL+XAD-2+DNPH):	12,782 µg/hour
	8,521 µg/gram incense
	8,351 µg/incense
VOC emission, GFF:	1,727 µg/hour
	1,183 µg/gram incense
	1,159 µg/incense
TVOC emission, GFF:	7,258 µg/hour
	4,971 µg/gram incense
	4,872 µg/incense
Total aerosol emission, GFF:	61,531 µg/hour
	42,145 µg/gram incense
	41,302 µg/incense

Boxmodel 3 A

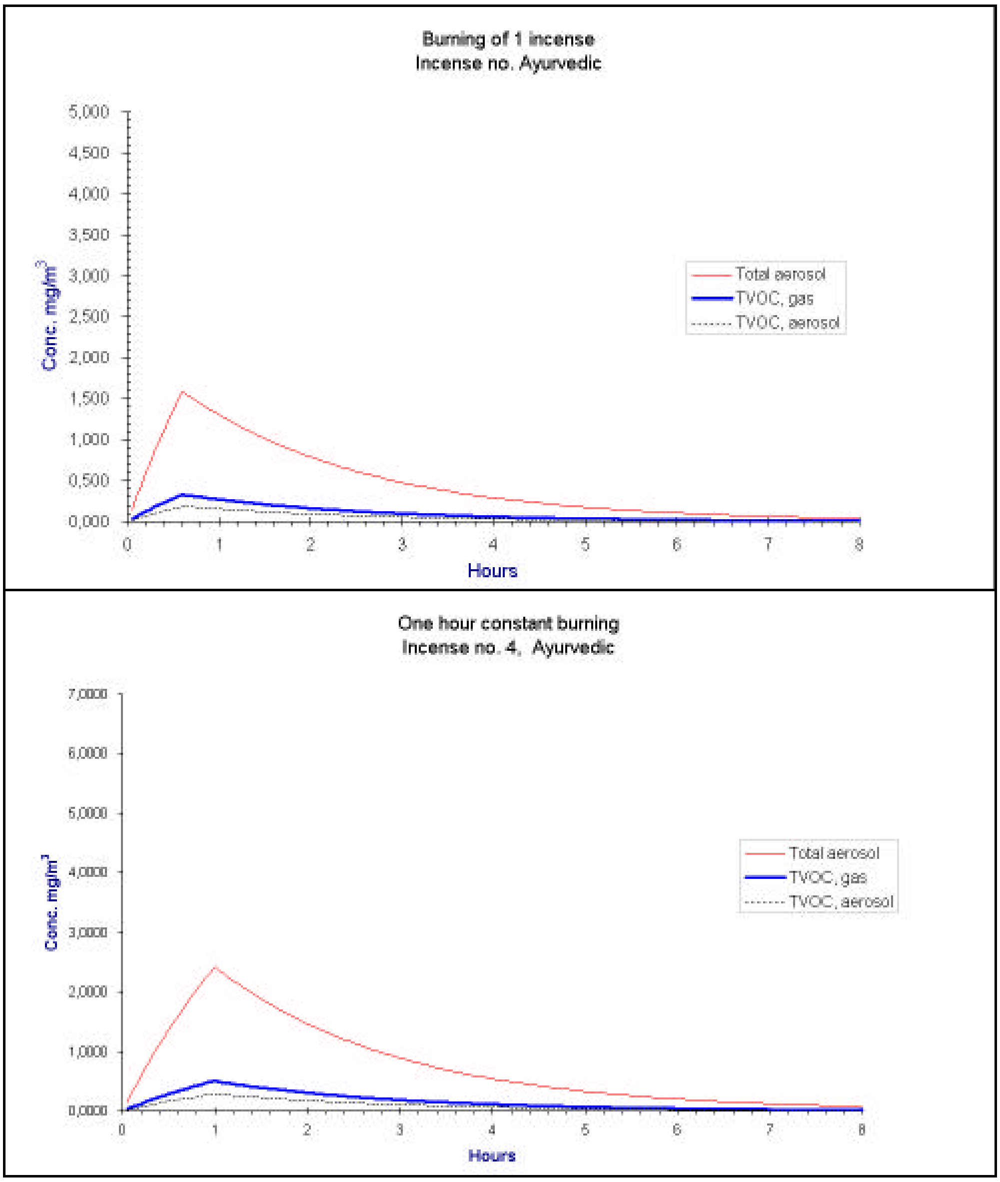




Catched concentrations of acrolein, formaldehyde and benzene during burning of one incense stick (top) and by continuous burning for one hour (bottom).

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Boxmodel 3 B



Catched concentrations of aerosol, divided on total aerosol, TVOC (total volatile components) as vapour (gas) and aerosol during burning of one incense stick (top) and by continuous burning for one hour (bottom). The amount is given as mg/m^3.

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Incense, mrk.:	Wild Musk	Lab. no. 8	Date: 3. november 2003

Background measurement, room	Filter no.	Liter air
Charcoal	845	105
DNPH	847	105
XAD-2	846	140
GFF	722	1,970

Project no. 1712753

Exhaust, process	Filter no.	Liter air
Charcoal	827	45
DNPH	855	0.96
XAD-2	828	67.5
GFF	797	626

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
CHARCOAL	µg	Liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Benzene	<0.1	105	0	386	45	8,578	8,578	8,978	7,451
Toluene	0.36	105	3	65	45	1,444	1,441	1,508	1,252
Furfural	0.82	105	8	5	45	107	99	103	86
Styrene	<0.1	105	0	26	45	568	568	594	493
Benzaldehyde	<0.1	105	0	10	45	223	223	234	194
Benzonitrile	<0.1	105	0	10	45	215	215	225	187
a-Methylstyrene	<0.1	105	0	3	45	62	62	65	54
Benzofuran	<0.1	105	0	27	45	589	589	617	512
d-Limonene	<0.1	105	0	9	45	189	189	198	164
3,7-Dimethyl-1,6-octadien-3-ol	<0.1	105	0	15	45	329	329	344	286
Xylenes	<0.1	105	0	22	45	489	489	512	425
Benzoic acid-ethylester	<0.1	105	0	55	45	1,233	1,233	1,291	1,071
a-Terpineol(p-menth-1-en-8-ol)	<0.1	105	0	52	45	1,156	1,156	1,210	1,004
3-Cyclohexen-1-methanol-4-trimethyl	<0.1	105	0	0	45	0	0	0	0
3,7-Dimethyl-1,6-oktadien-3-ol, acetate	<0.1	105	0	3	45	59	59	62	51
Tetrahydro-trimethylnaphthalene	<0.1	105	0	3	45	69	69	72	60
1H-3a,7-Methanoazulene-2,3,4,7,8,8a-hexahydro-3,6-	<0.1	105	0	5	45	114	114	120	99
Thujopsene	<0.1	105	0	21	45	475	475	497	413
1-Methyl-4-(1,2,2-trimethylcyclopentylbenzene	<0.1	105	0	4	45	80	80	84	70
Diethylphthalate	<0.1	105	0	173	45	3,853	3,853	4,033	3,347
Cedrol	<0.1	105	0	13	45	299	99	313	260
Sum VOC on charcoal							20,122		

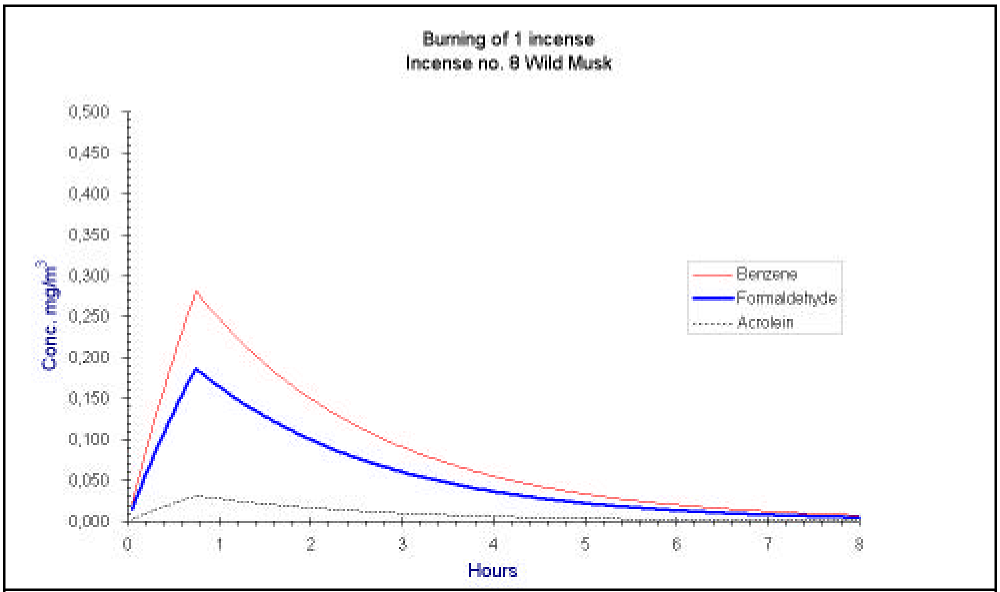
	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
DNPH	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Formaldehyde	0.1	105	1	7.8	0.96	8,125	8,124	5,982	5,922
Acetaldehyde	0.34	105	3	5.9	0.96	6,146	6,143	4,523	4,478
Acrolein	0.08	105	1	1.3	0.96	1,354	1,353	997	987
Sum aldehydes on DNPH							15,620		

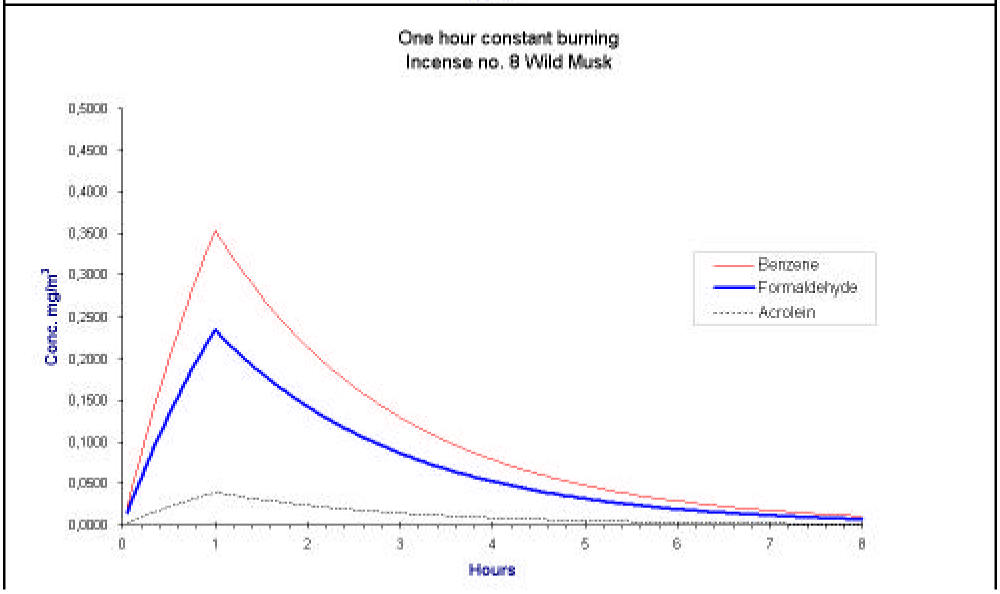
XAD-2	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	ug	liter	$\mu g/m^3$	ug	liter	$\mu g/m^3$	$\mu g/m^3$	µg/h	µg/unit
Benzofuran	<0.1	140	0	2	67.5	34	34	36	30
Benzylalkohol	<0.1	140	0	4	67.5	59	59	62	51
a-methylbenzenmethanol	<0.1	140	0	2	67.5	23	23	24	20
Phenylethylalkohol	<0.1	140	0	4	67.5	59	59	62	51
2-Methoxy-4-vinylphenol	<0.1	140	0	2	67.5	29	29	30	25
4-Hydroxy-3-methylacetophenone	<0.1	140	0	0	67.5	0	0	0	0
2,6-Dimethoxyphenol	<0.1	140	0	2	67.5	32	32	34	28
2-Methoxy-4-(1-propenyl)phenolvinylphenol	<0.1	140	0	3	67.5	46	46	48	40
Biphenyl	<0.1	140	0	5	67.5	80	80	84	70
2H-1-Benzopyran-2-one	<0.1	140	0	3	67.5	46	46	48	40
Naphtalene	<0.1	140	0	2	67.5	36	36	37	31
Acenaphthylene	<0.1	140	0	0	67.5	4	4	4	3
Sum VOC on XAD-2							448		

GFF	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	ug	liter	$\mu g/m^3$	ug	liter	$\mu g/m^3$	$\mu g/m^3$	µg/h	µg/unit
Tricyclonona-3.6-diene	<0.1	1,970	0	570	626	911	911	953	791
2-Methoxy-4-vinylphenol	<0.1	1,970	0	38	626	61	61	64	53
2.6-Dimethoxyphenol	<0.1	1,970	0	113	626	181	181	189	157
Vanillin	<0.1	1,970	0	323	626	516	516	540	448
2-Methoxy-4-1-propenylphenol	<0.1	1,970	0	75	626	120	120	125	104
2H-1-benzopyran-2-one	<0.1	1,970	0	300	626	479	479	502	416
d'Allose	<0.1	1,970	0	128	626	204	204	214	178
Diethylphthalate	<0.1	1,970	0	9,788	626	15,636	15,636	16,365	13,582
Cedrol	<0.1	1,970	0	315	626	503	503	527	437
2.6-Dimethoxy-2-propenylphenol	<0.1	1,970	0	98	626	157	157	164	136
4-(3-hudroxy-1-propenyl)-2-methoxyphenol	<0.1	1,970	0	338	626	540	540	565	469
Benzylbenzoate	<0.1	1,970	0	600	626	958	958	1,003	833
9H-fluoren-9-one	<0.1	1,970	0	83	626	133	133	139	115
Hexahydro-4-cyclopenta-2-benzopyran	<0.1	1,970	0	210	626	335	335	351	291
2-Methyl-9.10-antracendione	<0.1	1,970	0	98	626	157	157	164	136
Phenanthrene	<0.1	1,970	0	16	626	26	26	27	22
Sum VOC-aerosol on GFF							20,890		
Sum TVOC-aerosol on GFF				15,000	626	23,962	23,962		
Total aerosol on GFF	60	1,970	30	98,220	626	156,901	156,871		

Burning time for 1 stick/cone	45	min.
Weight of incense	1.35	g
Measuring period in min.	45	min.
Gram incense burned	1.22	g
Gram incense burned/hour	1.63	g
Total air volume m^3	0.79	m^3
Temperature in glow	220-240	degrees
Gram incense burned, aldehydes	0.25	g
Measuring period in min., aldehydes	11	min.
Gram incense burned/hour, aldehydes	1.36	g
Total air volume m^3, aldehydes	0.14	m^3
VOC emission, CHARCOAL:	21,061	µg/hour
	12,947	µg/gram incense
	17,479	µg/incense
VOC emission, DNPH:	11,502	µg/hour
	8,435	µg/gram incense
	11,387	µg/incense
VOC emission, XAD-2	469	µg/hour
	288	µg/gram incense
	389	µg/incense
Sum VOC (CHARCOAL+XAD-2+DNPH):	33,032	µg/hour
	21,670	µg/gram incense
	29,255	µg/incense
VOC emission, GFF:	21,865	µg/hour
	13,441	µg/gram incense
	18,146	µg/incense
TVOC emission, GFF:	25,080	µg/hour
	15,418	µg/gram incense
	20,814	µg/incense
Total aerosol emission, GFF:	164,191	µg/hour
	100,937	µg/gram incense
	136,265	µg/incense

Boxmodel 4 A

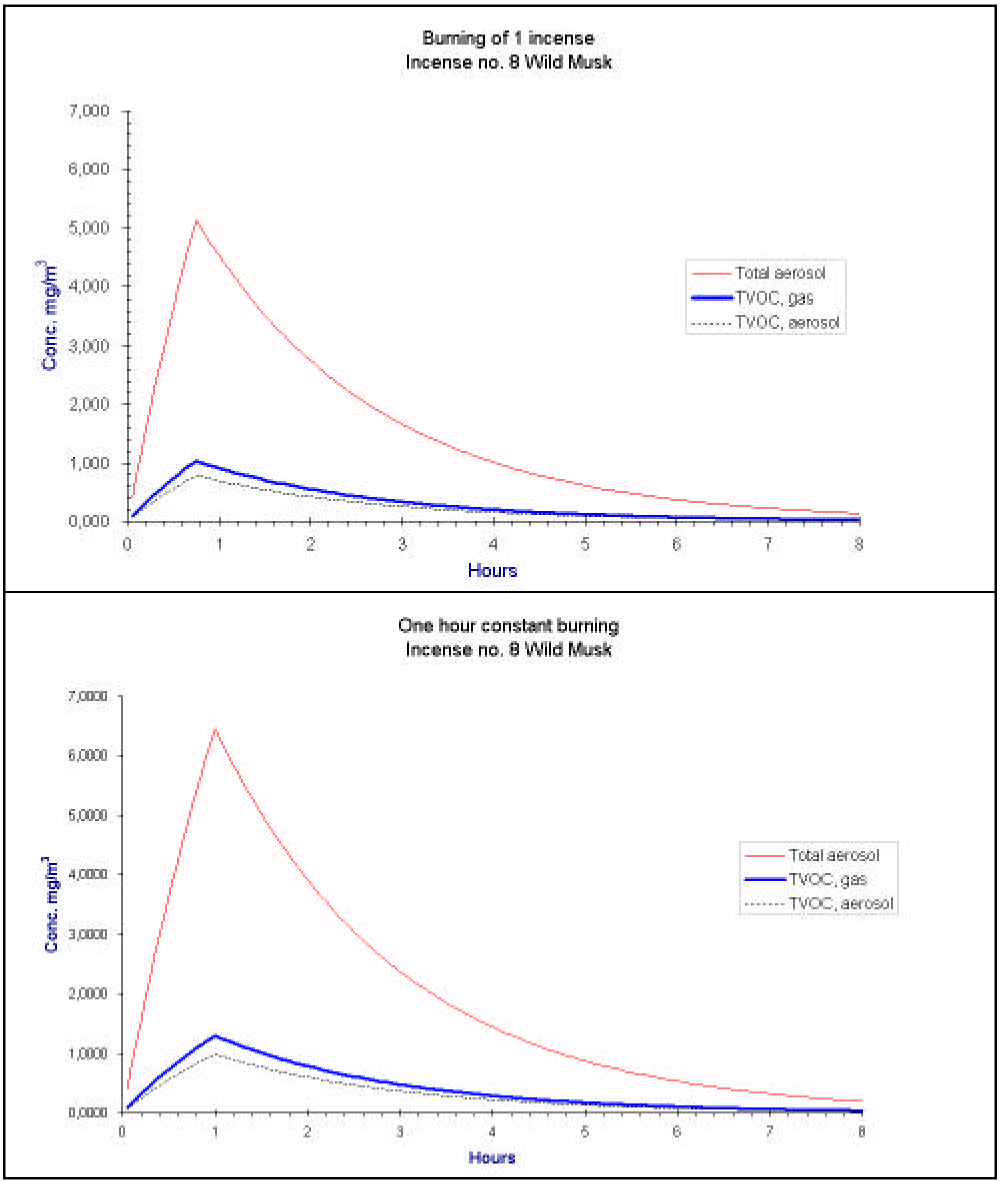




Catched concentrations of acrolein, formaldehyde and benzene during burning of one incense stick (top) and by continuous burning for one hour (bottom).

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Boxmodel 4 B



Catched concentrations of aerosol, divided on total aerosol, TVOC (total volatile components) as vapour (gas) and aerosol during burning of one incense stick (top) and by continuous burning for one hour (bottom). The amount is given as mg/m^3.

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Incense, mrk.:	Sali Sai Baba	Lab. no. 10	Date: 3. november 2003

Background measurement, room	Filter no.	Liter luft
Charcoal	845	105
DNPH	847	105
XAD-2	846	140
GFF	722	1,970

Project no. 1712753

Exhaust, process	Filter no.	Liter air
Charcoal	833	45
DNPH	857	0.96
XAD-2	834	34
GFF	768	560

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
CHARCOAL	µg	Liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Benzene	<0.1	105	0	45	45	1,000	1,000	700	693
2,5-Dimethylfuran	<0.1	105	0	8	45	170	170	119	118
Toluene	0.36	105	3	39	45	867	863	604	598
Furfural	<0.1	105	0	22	45	480	480	336	333
m,p-Xylene	0.82	105	8	21	45	467	459	321	318
Styrene	<0.1	105	0	14	45	310	310	217	215
5-Methyl-2-furancarboxaldehyde	<0.1	105	0	2	45	54	54	38	37
6-Mehtyl-5-hepten-2-one	<0.1	105	0	11	45	240	240	168	166
a-Methylstyrene	<0.1	105	0	5	45	104	104	73	72
Benzofuran	<0.1	105	0	14	45	300	300	210	208
3,7-Dimethyl-1,6-octadien-3-ol	<0.1	105	0	6	45	134	134	94	93
Benzoic acid, ethylester	<0.1	105	0	4	45	79	79	55	55
2,6-Dimethylnaphthalene	<0.1	105	0	3	45	59	59	41	41
Sum VOC on charcoal							4,253		

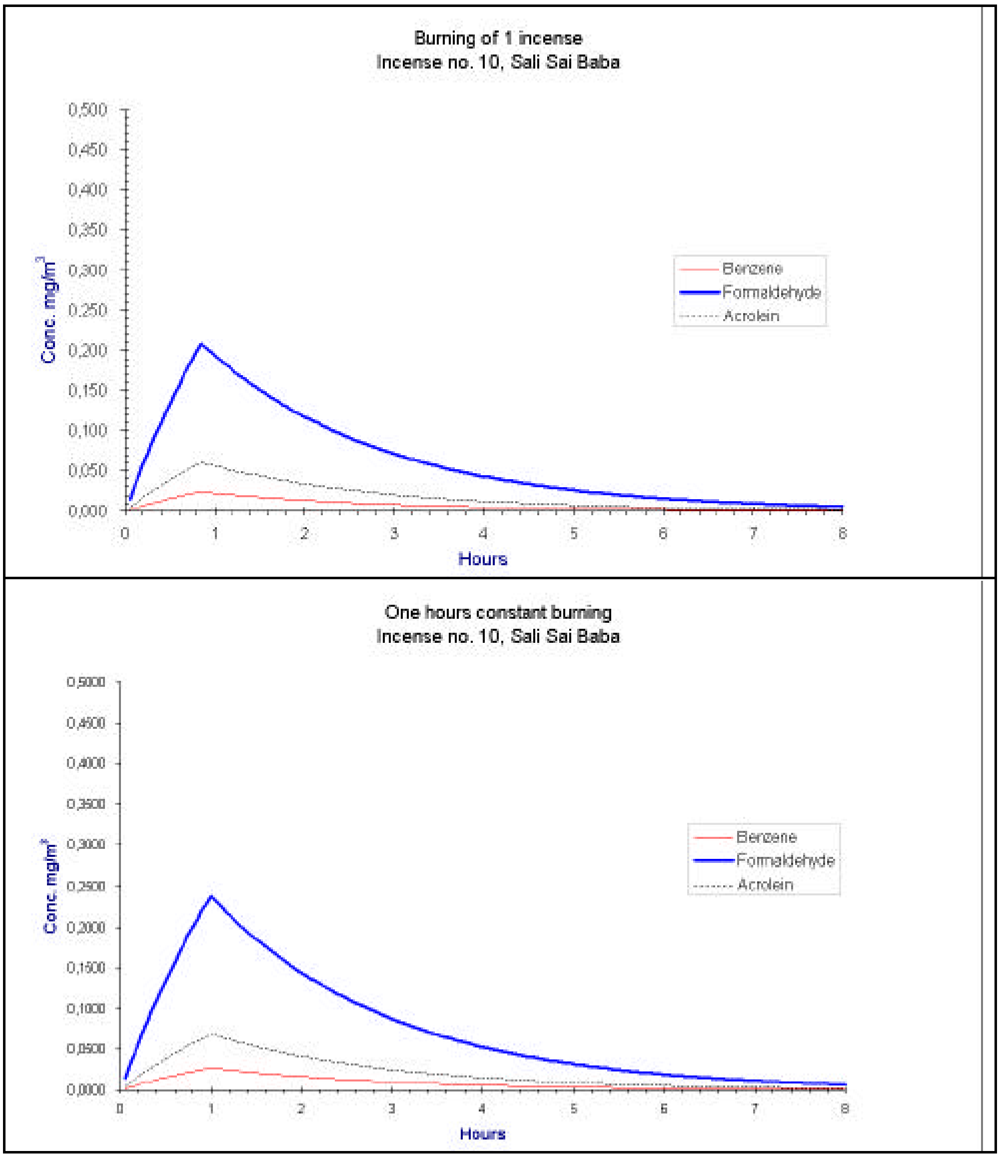
	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
DNPH	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Formaldehyde	0.1	105	1	7.3	0.96	7,604	7,603	6,055	4,826
Acetaldehyde	0.34	105	3	3.1	0.96	3,229	3,226	2,569	2,048
Acrolein	0.08	105	1	2.1	0.96	2,188	2,187	1,741	1,388
Sum Aldehydes on DNPH							13,016		

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substan ce amount	Air volume	Concen -tration	Concen -tration	Emissio n	
XAD-2	ug	liter	µg/m³	ug	liter	µg/m³	µg/m³	µg/h	µg/unit
Benzofuran	<0.1	140	0	4	34	120	120	84	83
6-Methyl-2-pyrazinylmethanol	<0.1	140	0	4	34	109	109	76	75
3,7-Dimethyl-1,6-octadien-3-ol	<0.1	140	0	2	34	69	69	48	48
Phenylethylalcohol	<0.1	140	0	3	34	100	100	70	69
3,7-Dimethyl-6-octenal	<0.1	140	0	1	34	29	29	20	20
3,7-Dimethyl-2,6-octadien-1-ol	<0.1	140	0	2	34	69	69	48	48
7-Hydroxy-3,7-dimethyl-octanal	<0.1	140	0	7	34	206	206	145	143
Vanillin	<0.1	140	0	4	34	127	127	89	88
2H-1-Benzopyran-2-on	<0.1	140	0	9	34	253	253	177	175
2-Methoxy-naphthalene	<0.1	140	0	9	34	258	258	180	179
Diethylphthalate	<0.1	140	0	13	34	387	387	271	268
Benzophenone	<0.1	140	0	2	34	50	50	35	34
Naphtalene	<0.1	140	0	2	34	46	46	32	32
Acenaphylene	<0.1	140	0	0	34	6	6	4	4
Phenanthrene	<0.1	140	0	0	34	3	3	2	2
Benzylbenzoate	<0.1	140	0	1	34	37	37	26	25
1,1-Dimethylethyl-2-methoxy-4-methyl-3-benzen	<0.1	140	0	4	34	105	105	73	72
4,4-Diamin-3,3-dimethyl1,1-biphenyl	<0.1	140	0	4	34	131	131	92	91
Sum VOC on XAD-2							2,102		

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen -tration	Substan ce amount	Air volume	Concen -tration	Concen -tration	Emissio n	
GFF	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
5-Hydroxy-2-furancarboxaldehyde	<0.1	1,970	0	344	560	615	615	431	426
7-Hydroxy-3,7-dimethyloctanal	<0.1	1,970	0	142	560	253	253	177	176
Vanillin	<0.1	1,970	0	502	560	897	897	628	622
2,6-Dimethylnaphthalene	<0.1	1,970	0	48	560	85	85	60	59
2H-1-Benzopyran-2-on	<0.1	1,970	0	334	560	596	596	417	413
Diethylphthalate	<0.1	1,970	0	1,064	560	1,901	1,901	1,331	1,317
Tetradecanal	<0.1	1,970	0	80	560	144	144	100	99
Patchouli alkohol	<0.1	1,970	0	67	560	120	120	84	83
Benzyl benzoate	<0.1	1,970	0	297	560	530	530	371	367
1,1-Dimethylethyl-2-methoxy-4-methyl-3-benzene	<0.1	1,970	0	613	560	1,094	1,094	766	758
P-Ethoxy-2-diazoacetophenone	<0.1	1,970	0	100	560	179	179	126	124
Butylcyclohexyl-2,3-dicyano-benzoic acid	<0.1	1,970	0	92	560	164	164	115	114
Triphenyl-1-pentanol	<0.1	1,970	0	239	560	427	427	299	296
4,4-Diamin,3,3-dimethyl-1,1-biphenyl	<0.1	1,970	0	113	560	201	201	141	139
Sum VOC-aerosol on GFF							156,786		
Sum TVOC-aerosol on GFF				22,000	560	39,286	39,286		
Total aerosol on GFF	60	1,970	30	87,800	560	156,786	156,755		

Burning time for 1 stick/cone	50	min.
Weight of incense	1.00	g
Measuring period in min.	60	min.
Gram incense burned	1.01	g
Gram incense burned/hour	1.01	g
Total air volume m^3	0.70	m^3
Temperature in glow	220-230	degrees
Gram incense burned, aldehydes	0.23	g
Measuring period in min., aldehydes	11	min.
Gram incense burned/hour, aldehydes	1.25	g
Total air volume m^3, aldehydes	0.15	m^3
VOC emission, CHARCOAL:	2,977	µg/hour
	2,947	µg/gram incense
	2,947	µg/incense
VOC emission, DNPH:	10,365	µg/hour
	8,262	µg/gram incense
	8,262	µg/incense
VOC emission, XAD-2	1,472	µg/hour
	1,457	µg/gram incense
	1,457	µg/incense
Sum VOC (CHARCOAL+XAD-2+DNPH):	14,814	µg/hour
	12,667	µg/gram incense
	12,667	µg/incense
VOC emission, GFF:	109,750	µg/hour
	108,663	µg/gram incense
	108,663	µg/incense
TVOC emission, GFF:	27,500	µg/hour
	27,228	µg/gram incense
	27,228	µg/incense
Total aerosol emission, GFF:	109,729	µg/hour
	108,642	µg/gram incense
	108,642	µg/incense

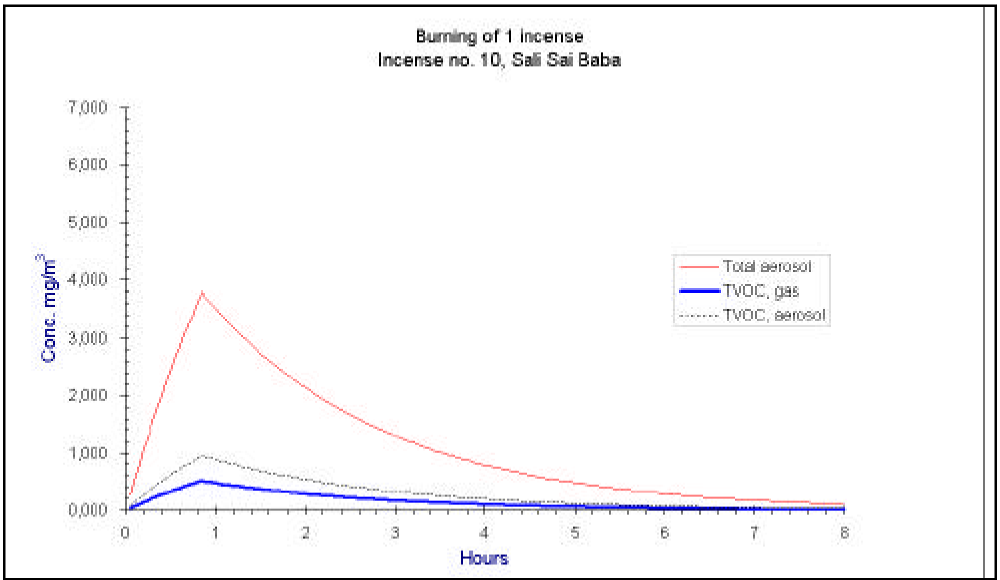
Boxmodel 5 A

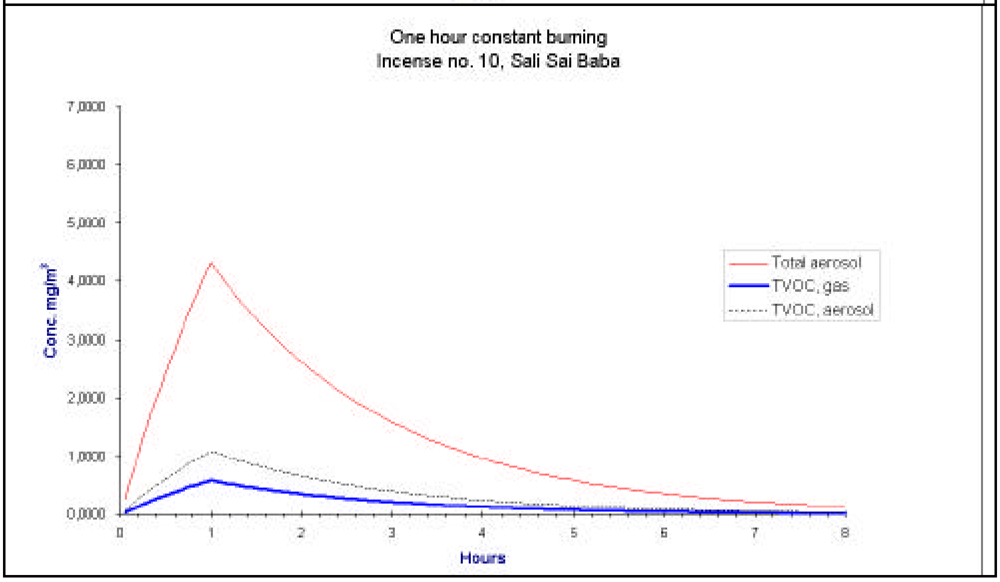


Catched concentrations of acrolein, formaldehyde and benzene during burning of one incense stick (top) and by continuous burning for one hour (bottom).

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Boxmodel 5 B





Catched concentrations of aerosol, divided on total aerosol, TVOC (total volatile components) as vapour (gas) and aerosol during burning of one incense stick (top) and by continuous burning for one hour (bottom). The amount is given as mg/m^3.

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Incense, mrk.:	Cedar Wood	Lab. no. 12	Date: 3. november 2003

Background measurement, room	Filter no.	Liter air
Charcoal	845	105
DNPH	847	105
XAD-2	846	140
GFF	722	1,970

Project no. 1712753

Exhaust, process	Filter no.	Liter air
Charcoal	842	60
DNPH	858	1.05
XAD-2	843	60
GFF	770	612

	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
CHARCOAL	µg	Liter	µg/m^3	µg	liter	µg/m^3	µg/m^3	µg/h	µg/unit
Benzene	<0.1	105	0	38	60	633	633	502	266
Toluene	0.36	105	3	34	60	567	563	446	236
Furfural	<0.1	105	0	6	60	104	104	82	43
o,m,p-Xylene	0.82	105	8	12	60	200	192	152	81
Styrene	<0.1	105	0	10	60	164	164	130	69
Benzen,1-ethenyl-3-methyl	<0.1	105	0	3	60	52	52	41	22
Oktahydro-methanoazulene	<0.1	105	0	8	60	130	130	103	54
Hexahydro-methanoazulene	<0.1	105	0	32	60	536	536	424	225
Oktahydro-trimethyl-methanoazulene	<0.1	105	0	9	60	156	156	123	65
Oktahydro-dimethylazulene	<0.1	105	0	7	60	121	121	96	51
1-Methyl-4-(1,2,2-trimethylcyclopentylbenzene	<0.1	105	0	8	60	138	138	110	58
Cedrol	<0.1	105	0	65	60	1,080	1,080	856	453
Patchouli alcohol	<0.1	105	0	17	60	285	285	226	120
Sum VOC on charcoal							4,154		

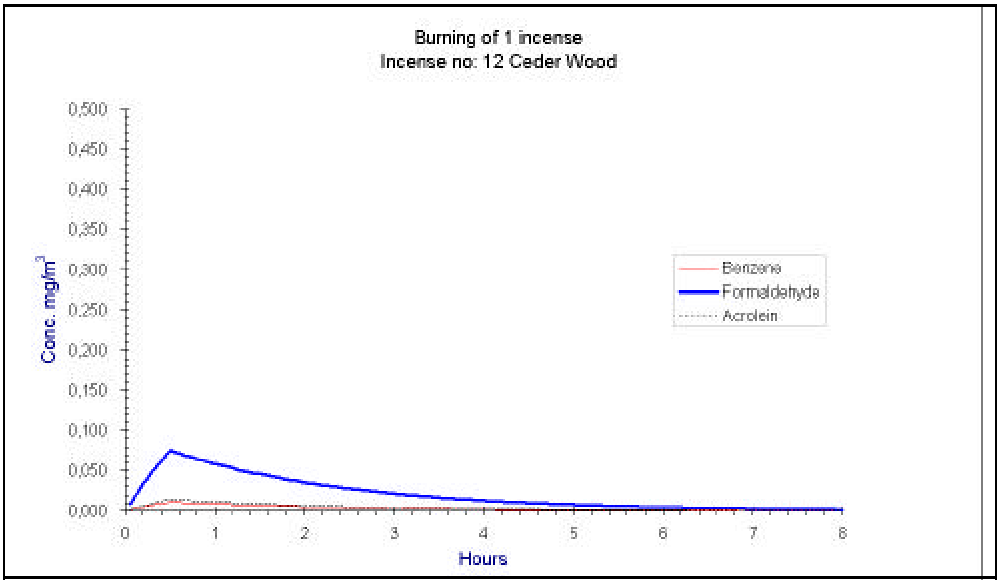
	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
DNPH	µg	liter	µg/m^3	µg	liter	µg/m^3	µg/m^3	µg/h	µg/unit
Formaldehyde	0.1	105	1	4.7	1.05	4,476	4,475	3,417	1,735
Acetaldehyde	0.34	105	3	2.9	1.05	2,762	2,759	2,107	1,070
Acrolein	0.08	105	1	0.9	1.05	857	856	654	332
Sum Aldehydes on DNPH							8,090		

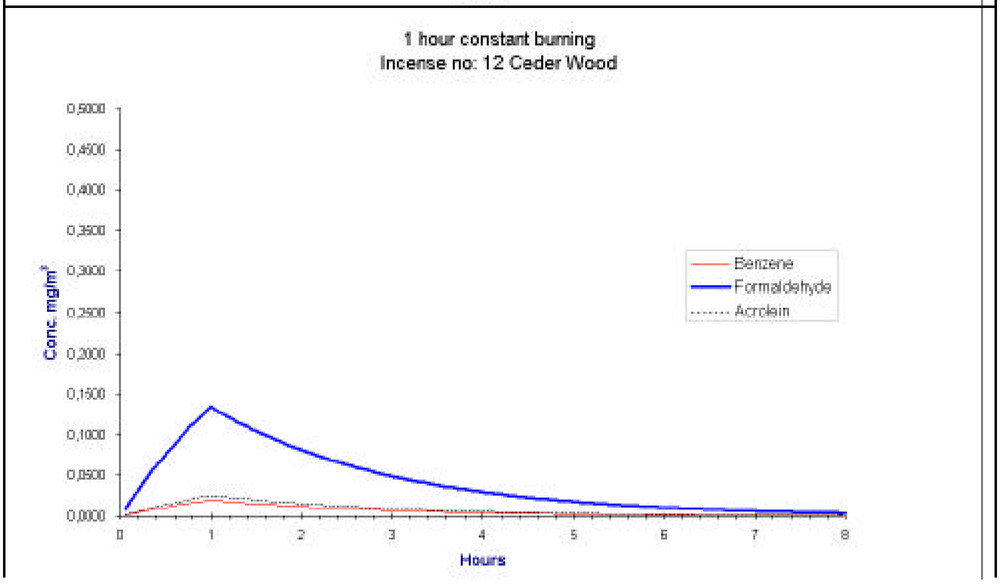
XAD-2	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	µg	liter	µg/m³	µg	liter	µg/m³	µg/m³	µg/h	µg/unit
Furfural	<0.1	140	0	6	60	101	101	80	43
Furanon	<0.1	140	0	2	60	41	41	32	17
5-Methyl-2-furancarboxaldehyde	<0.1	140	0	3	60	54	54	43	23
Phenol	<0.1	140	0	6	60	99	99	79	42
Benzene,1-ethenyl-3-methyl	<0.1	140	0	1	60	13	13	10	5
3-Methyl-1,2-cyclopentandione	<0.1	140	0	1	60	12	12	10	5
2-Methylphenol	<0.1	140	0	1	60	11	11	9	5
4-Methylphenol	<0.1	140	0	2	60	30	30	24	13
Undecene	<0.1	140	0	1	60	15	15	12	6
2-Methoxy-phenol	<0.1	140	0	5	60	76	76	60	32
1H-Inden, 1-methylene	<0.1	140	0	2	60	26	26	20	11
2-Methoxy-4-methylphenol	<0.1	140	0	5	60	82	82	65	34
4-Ethyl-2-methoxy-phenol	<0.1	140	0	2	60	35	35	28	15
2-Methoxy-4-vinylphenol	<0.1	140	0	8	60	132	132	105	55
Eugenol	<0.1	140	0	1	60	15	15	12	6
Vanillin	<0.1	140	0	1	60	24	24	19	10
1,5-Dimethyl-4-hexenyl-4-methylbenzene	<0.1	140	0	1	60	22	22	17	9
6-Ethenyl-6-methyl-1-(1-methylethyl)-3-cyclohexene	<0.1	140	0	1	60	22	22	18	9
Dibenzofuran	<0.1	140	0	2	60	36	36	29	15
Diethylphthalate	<0.1	140	0	1	60	21	21	17	9
Sum VOC on XAD-2							869	688	364

GFF	Background			Incense + background			Incense		
	Substance amount	Air volume	Concen-tration	Substance amount	Air volume	Concen-tration	Concen-tration	Emission	
	ug	liter	µg/m³	ug	liter	µg/m³	µg/m³	µg/h	µg/unit
2.6-Dimethoxyphenol	<0.1	1,970	0	11	612	18	18	14	7
Vanillin	<0.1	1,970	0	44	612	71	71	56	30
2-Methoxy-4-1-propenylphenol	<0.1	1,970	0	16	612	27	27	21	11
d'Allose	<0.1	1,970	0	55	612	89	89	71	37
1-Methyl-n-vanillyl-2-phenethanamin	<0.1	1,970	0	16	612	27	27	21	11
Cedrol	<0.1	1,970	0	229	612	374	374	296	157
Cedrylpropylether	<0.1	1,970	0		612	0	0	0	0
2.6-Dimethoxy-2-propenylphenol	<0.1	1,970	0	60	612	98	98	78	41
4-(3-hydroxy-1-propenyl-2-methoxyphenol	<0.1	1,970	0	60	612	98	98	78	41
Cedran-diol	<0.1	1,970	0	11	612	18	18	14	7
Desaspidinol	<0.1	1,970	0	27	612	45	45	35	19
Dimethylaminophenylmethanone	<0.1	1,970	0	44	612	71	71	56	30
Naphtalene	<0.1	1,970	0	2	612	3	3	3	1
Acenaphtylene	<0.1	1,970	0	1	612	1	1	1	0
Phenanthrene	<0.1	1,970	0	3	612	5	5	4	2
Sum VOC-aerosol on GFF							945		
Sum TVOC-aerosol on GFF				600	612	980	980		
Total aerosol on GFF	60	1,970	30	24,100	612	39,379	39,349		

Burning time for 1 stick/cone	30	min.
Weight of incense	0.36	g
Measuring period in min.	60	min.
Gram incense burned	0.68	g
Gram incense burned/hour	0.68	g
Total air volume m^3	0.79	m^3
Temperature in glow	200-210	degrees
Gram incense burned, aldehydes	0.13	g
Measuring period in min., aldehydes	11	min.
Gram incense burned/hour, aldehydes	0.71	g
Total air volume m^3, aldehydes	0.14	m^3
VOC emission, CHARCOAL:	3,290	µg/hour
	4,838	µg/gram incense
	1,742	µg/incense
VOC emission, DNPH:	6,178	µg/hour
	8,713	µg/gram incense
	3,137	µg/incense
VOC emission, XAD-2	688	µg/hour
	1,012	µg/gram incense
	364	µg/incense
Sum VOC (CHARCOAL+XAD-2+DNPH):	10,156	µg/hour
	14,563	µg/gram incense
	5,243	µg/incense
VOC emission, GFF:	748	µg/hour
	1,101	µg/gram incense
	396	µg/incense
TVOC emission, GFF:	776	µg/hour
	1,142	µg/gram incense
	411	µg/incense
Total aerosol emission, GFF:	31,164	µg/hour
	45,830	µg/gram incense
	16,499	µg/incense

Boxmodel 6 A

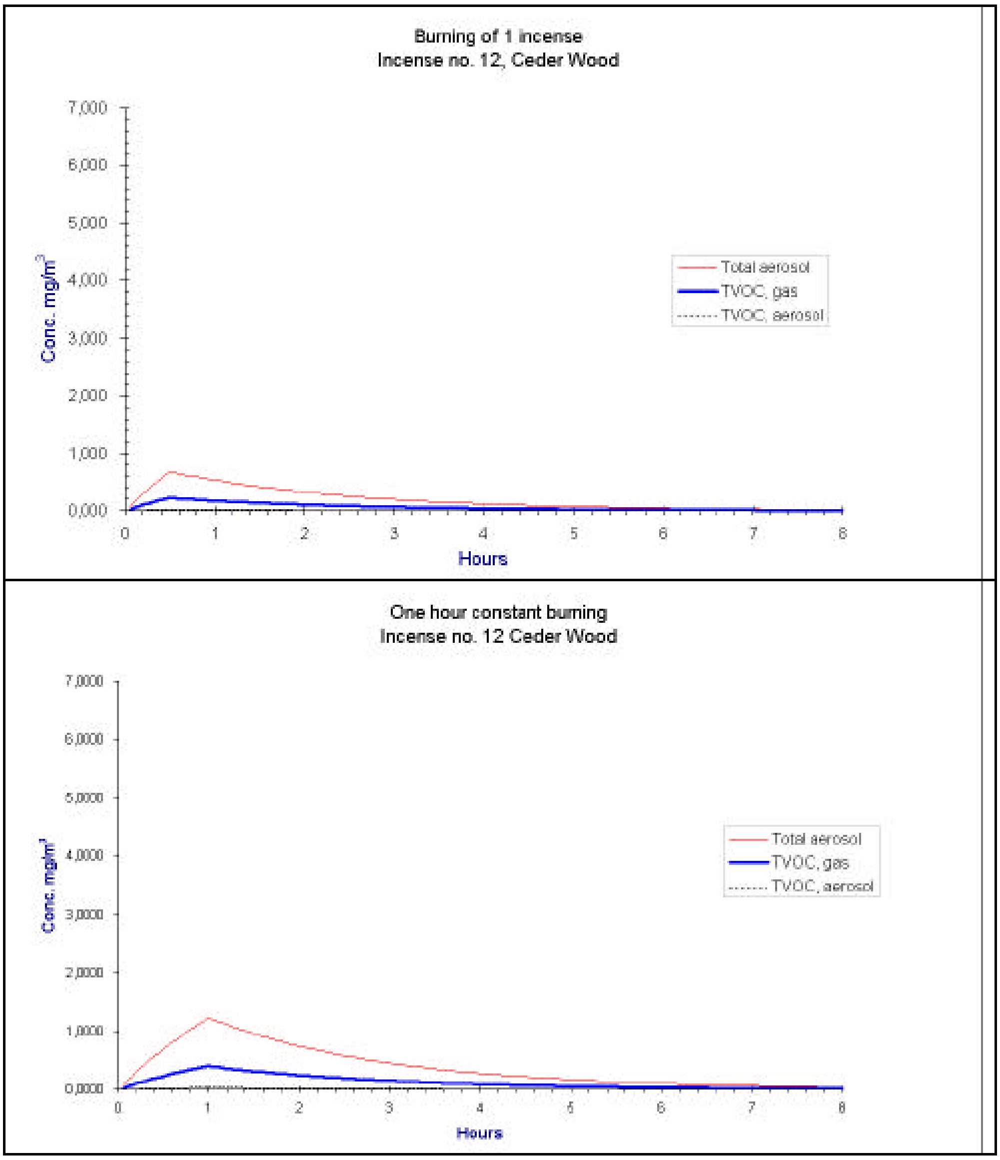




Catched concentrations of acrolein, formaldehyde and benzene during burning of one incense stick (top) and by continuous burning for one hour (bottom).

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.

Boxmodel 6 B



Catched concentrations of aerosol, divided on total aerosol, TVOC (total volatile components) as vapour (gas) and aerosol during burning of one incense stick (top) and by continuous burning for one hour (bottom). The amount is given as mg/m^3.

The model shows the course of concentration during evolution and removal in a room of 20 m^3 with an air change of 0.5 times per hour.