Maximum exposure levels for xylene, formaldehyde and acetaldehyde in cars

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Abstract

Although millions of individuals are exposed to emissions from articles inside cars, relatively little has been published about possible adverse health effects and about exposure levels that can be considered safe or “acceptable”. Xylene, formaldehyde and acetaldehyde represent typical examples of relevant volatile organic substances (VOC) released from articles inside cars. Recently, a concept for derivation of maximum exposure levels for volatile organic substances in cars has been published. In the present study we applied this concept to derive maximum exposure levels for xylene, formaldehyde and acetaldehyde and compared the resulting concentrations to exposure levels usually found inside of cars. We derived Short Term Exposure Levels Inside Automotive Vehicles (STELIA) of 29, 0.125 and 15.3 mg/m^3 for xylene, formaldehyde and acetaldehyde, respectively. These STELIAs should not be exceeded during short-term exposures, for instance when starting a car that had been heated up during parking in the sun. Exposure Levels Inside Automotive Vehicles (ELIA, chronic) for chronic exposure to non-genotoxic substances were 8.8, 0.125 and 0.635 mg/m^3 for systemic as well as 17.6, 0.125 and 1.7 mg/m^3 for local exposure to xylene, formaldehyde and acetaldehyde, respectively. Although, it is known that exposure limits for carcinogenic substances should be treated with caution, encouraged by the well documented threshold mechanisms we nevertheless derived ELIAs for Carcinogenic and Mutagenic Substances (ELIA, cm) resulting in 0.125 and 0.635 mg/m^3 for formaldehyde and acetaldehyde. If these ELIAs are matched against average concentrations of xylene, formaldehyde and acetaldehyde found in cars at 23 °C (1.22, 0.048 and 0.042 mg/m^3), there is no reason for concern. With respect to STELIAs and extrapolated concentrations at 65 °C (14.7, 1.47 and 1.68 mg/m^3, for xylene, formaldehyde and acetaldehyde, respectively), however, a reduction of the concentration of formaldehyde may be necessary.

Introduction

Although millions of individuals are exposed to emissions from articles inside cars, relatively little has been published about possible adverse health effects and about exposure levels that can be considered as acceptable. Indoor air quality is of interest for manufacturers, consumers and regulators. Catchphrases like *Sick Building Syndrome* or *Building Related Illness* draw a link between adverse health effects of residents to the quality of indoor air (Wiesmueller, 1997). One parameter between others that has an impact on indoor air quality is the emission of volatile organic substances from articles used in the indoor environment. Car manufacturers have individual lists of restricted substances to avoid allegations due to smell and toxic effects caused by emissions from articles used inside the car.

In the present study we concentrate on three volatile organic substances that usually can be measured inside cars with relatively high concentrations, namely xylene, formaldehyde and acetaldehyde. Recently, chamber tests have been performed to estimate typical concentrations of volatile organic substances in cars. Emissions depend on the temperature inside cars. Average concentrations of xylene, formaldehyde and acetaldehyde that may be observed in cars at 23 °C are 1.224, 0.048 and 0.042 mg/m^3 (FAT, 1998). At 65 °C the extrapolated concentrations for xylene, formaldehyde and acetaldehyde are 14.7, 1.68 and 1.47 mg/m^3.

Recently, a concept for derivation of maximum exposure levels for volatile organic substances in cars has been established (Schupp and Hengstler, 2004). Procedures for three types of maximum exposure levels have been suggested: (i) short-term exposures inside automotive vehicles (STELIA); (ii) chronic exposure to non-genotoxic substances (ELIA, chronic); and (iii) genotoxic substances acting by threshold mechanisms (ELIA, cm). Here, we applied this concept to derive maximum exposure levels for xylene, formaldehyde and acetaldehyde and compared the resulting concentrations to exposure levels that can be expected in cars.

Section snippets

Derivation of short term exposure levels inside automotive vehicles (STELIA)

A technique including three steps was used to derive short term exposure levels inside automotive vehicles for irritating and narcotic properties of VOCs (Schupp and Hengstler, 2004).

Results and discussion

Recently, we suggested a technique to derive maximum exposure levels inside a car for chronic and short-term exposures (Schupp and Hengstler, 2004). This technique includes three different types of maximum exposure levels, namely: (i) exposure levels inside automotive vehicles (ELIA, chronic) for chronic exposure to non-genotoxic substances; (ii) short term exposure levels inside automotive vehicles; and (iii) ELIAs for carcinogenic and mutagenic substances, ELIA (cm) acting by threshold

STELIA

For Xylene relevant toxicological endpoints are summarized in the Critical Data Evaluation for MAK values (Deutsche Forschungsgemeinschaft, 1993). Based on central-nervous disorders, including balance disorders, longer reaction times, headache, nausea and at higher concentrations irritation in exposed persons, the Occupational Exposure Limit was provisionally set at 440 mg/m^3. At this concentration a slight influence on some individuals can not be excluded. As a conservative approach the xylene

STELIA, ELIA (chronic) and ELIA (cm)

Toxicological data for formaldehyde are summarized in the critical data evaluation for MAK values (Deutsche Forschungsgemeinschaft, 2000). Formaldehyde is irritating to exposed persons from 0.625 mg/m^3 upwards. The eyes are the most sensitive organs, followed by the mucous membranes of the upper respiratory tract. Tests with volunteers revealed that a concentration of 0.370 mg/m^3 is not irritating, so this concentration was defined as MAK-value (Deutsche Forschungsgemeinschaft, 2000, Schlink et

STELIA

The US EPA derived a Reference Concentration for acetaldehyde of 9 µg/m^3 (United States Environmental Protection and Agency, 1991). This level is based on sub acute, sub chronic and chronic inhalation studies with different species. In sub acute exposure studies with Wistar rats (6 h/day, 5 days/week, 4 weeks) the NOAEC against the most sensitive endpoint, degeneration of the olfactory epithelium, was 273 mg/m^3. The LOAEC in that study was 910 mg/m^3. In another sub acute inhalation study with

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- **Photoionization-induced NO⁺ chemical ionization time-of-flight mass spectrometry for rapid measurement of aldehydes and benzenes in vehicles**

  2021, Talanta

  Citation Excerpt :

  In-vehicle air pollution has become a major concern to public health in recent years [12–14]. For example, according to the China New Car Quality Research SM (IQS) reports released by J.D. Power in 2018 and 2019 [15,16], the air pollutants inside vehicles has become the highest consumer problem for the two consecutive years [17]. Therefore, a variety of standards were established by many countries to restrict the maximum values of major VOCs in newly manufactured vehicles and specify the sampling and determination methods for in-vehicle VOCs [18–22].

- **Predicting the emission characteristics of VOCs in a simulated vehicle cabin environment based on small-scale chamber tests: Parameter determination and validation**

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  FAT (1998) measured the average acetaldehyde concentrations in vehicles at 23 °C, and reported a result of 42 μg/m3. Schupp et al. (2005) combined the test results of FAT and the influence of temperature on VOC emissions, and found that the acetaldehyde concentration in a vehicle at 65 °C was 1470 μg/m3. Mapou et al. (2013) analyzed the data from the RIOPA study, and found that the mean in-cabin acetaldehyde concentrations of 115 vehicles was 17.6 μg/m3 for the temperature range of 10–35 °C.

- **A longitudinal study of environmental risk factors for subjective symptoms associated with sick building syndrome in new dwellings**

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  Throughout the phylogenetic kingdoms, aldehyde dehydrogenases (ALDHs) are essential enzymes through metabolism of toxic aldehydes generated from endogenous sources (e.g. deaminated neurotransmitters), diet (e.g. ethanol) or through pollution (e.g. volatile aldehydes from combustion) [1–8].

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  A recently described technique for the deviation of STELIA's and ELIA's was applied (Schupp and Hengstler, 2004a; Schupp et al., 2005) with modifications.

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