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HUMAN REACTIONS TO INDOOR AIR POLLUTION: N-DECANE

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Abstract

A dose-response study of human reactions to n-decane was performed in a climate chamber. 63 healthy subjects, randomly selected from the normal population were exposed to n-decane concentrations of either 0, 10, 35 or 100 ppm in a controlled double blind study using a latin square exposure design. The most significant findings related to indoor air quality were dose-dependent changes in irritation of mucous membranes, sensation of increased odour intensity and reduced air quality. Adaptative changes were seen at the highest exposure levels, but not at the levels relevant for non-industrial environment. Among the physiological measurements the tear film stability decreased in all exposed groups. In conclusion even small concentrations of the relatively inert n-decane gave symptoms similar to those in the WHO definition of the sick building syndrome.

Introduction

n-Decane ($C_{10}H_{22}$) is a common indoor air pollutant originating from building materials (4). In spite of this very few reports on human reactions to n-decane are available. To evaluate human reactions to n-decane a controlled experiment was performed in a climate chamber. The main purpose of the study was to evaluate the effect of occupational exposure levels but this presentation will focus on some results of the experiment relevant for non-industrial environments.

Material and methods

The study was performed in the climate chamber with four subjects per day exposed through 6 hrs to either 0, 10, 35 or 100 ppm (1 ppm eq 5.82 mg/m^3). There were four exposure days per week during four weeks, and no subject participated more than once. This required 64 subjects. One day, however only three subjects participated. An exposure day included pre-exposure measurements, exposure measurements and post exposure measurements. The exposure groups were exposed according to a latin square design to eliminate week and weekday interactions. All four exposure groups were matched with regard to age, sex, number of smokers, and level of school education. No differences in temperature-, humidity- and noise exposure levels in the climate chamber were seen among the exposure groups.

Subject selection

From the population in Aarhus 1025 subjects aged 18 to 60 years were

ndomly selected and invited by letter to participate. 210 responded itively and 121 were accepted for the main study after a preliminary vestigation including a medical examination and several tests. The se- ction criteria are shown in table 1.

ble 1: Criteria for inclusion in the study

Age between 18 and 60.
No alcohol or drug addiction.
No serious diseases (heart, lung, eye, cancer etc).
No allergy.
No heavy occupational exposure to solvents.
No reduced olfactory sense (anosmia)

Among those accepted, 63 subjects completed the study. These 63 had the e average sex and age distribution as the original population.

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The exposure system and climate chamber conditions are described in ils elsewhere (5).

Subjective complaints were registrered in two ways by visual analouge es (5). By a questionaire, 25 questions concerning olfactory sensa- s, indoor climate sensations, irritative sensations, and neurologi- symptoms were answered, before and 3 times during exposure. Differen- from preexposure answers were used as variables. Secondly using a li- potentiometer, the subjects should set an indicator to quantitate the sation of irritation in mucous membranes of eyes, nose and throat (5). jects were told to change the setting of the indicator, whenever they any change in irritation levels, and they were reminded to check the tion of the indicator every 15 minutes.

Physiological measurements included examination of the eyes. Tear film ility was measured before and 3 times during exposure, using a slit microscope. Subjects were seated in a fixed position after instal- on of 10 µl 1% Na-fluorescein. Stability was measured by the time from ink to break up of the precorneal tear film, as seen in the micro- pe in cobalt blue light (7). Mean of three measurements were calcula- Changes in eye redness were measured photographically by comparison preexposure photograph with a postexposure photograph. Comparisons of ness in an area limited laterally by the lids and medially by the ea were performed in a double blind design (3). Cytological examina- of small samples of conjunctival secretions (mucus and tears) taken er the lower lid was performed by microscopy. Samples were fixed on s slides with formaldehyde, stained by formol-fuchsin eosin and the el number of polymorphonuclear leucocytes, lymphocytes, columnar, idal and squamous epithelium were counted by a single trained nician (3,7).

Statistical evaluation was performed by a mainframe version SPSS (6) ysis of variance and t-tests was performed initially to analyse ges during exposure. Afterwards regression analysis was performed to the dose-dependency, with the square root of exposure as the indepen- variable. When the data did not approximate normal distributions CHI- or Kruskal-Wallis one-way analysis of variance were used. A p-value than or equal to 0,05 was considered significant.

Results

In the questionaire a significant dose effect relationship was found ($p < 0.0001$) in all exposed groups for questions concerning the indoor climate quality (fig. 1), measured immediately after concentration had reached the desired level. The effects were dose-dependent. Similar results were encountered by the two questions related to odours, strength and quality. No dose-dependent differences were, however, found at the end of exposure day for these questions, as the effects apparently decreased during the exposure period, indicating adaption.

In the pocentiometer test (mucous membrane irritation) significant dose-dependency was encountered too, but due to the inhomogeneity of variances neither the performed analysis of variance nor the regression analysis are conclusive. A non parametric analysis however, showed significantly increased scores for exposed groups compared with non exposed.

Changes in cellular contents of tear fluids were significant only for the cuboidal cells in a Kruskal Wallis one-way analysis of variance but only the 35 ppm group reacted (table 2). Changes in polymorphonuclear cells were not significant but seemed to be insignificantly dose-related. For lymphocytes, columnar epithelium, and squamous epithelium no changes were seen. Measurement of eye redness showed no effect of exposure.

Table 2: Change in cell counts in conjunctival secretion during the day. Mean of differences.

Cell type	0 ppm	10 ppm	35 ppm	100 ppm
Polymorphonuclear leucocytes	-186*	-62*	1	27
Cuboidal epithelium*	-3	0	5**	-12

* $p < 0.05$ for difference less than zero (Wilcoxons test for paired measures)
** $p < 0.05$ for difference greater than zero (Wilcoxons test)
* $p < 0.05$ Kruskal Wallis one-way analysis of variance.

Tear film stability showed decreasing values both during the day and with increasing exposure ($p < 0.035$). Statistical analyses are presented for the last measurement only, ie just before the end of exposure. No changes were seen during the day among the subjects exposed to clean air. Figure 2 shows differences from morning to evening in the exposure groups. Since differences were strongly negatively correlated with morning values, the morning values were included in the analysis as a covariate, but the relation to exposure was still significant ($p < 0.001$) and dose-dependent.

Discussion and conclusion

The reactions of humans to low exposure levels of volatile organic compounds as n-decane are of interest. Of relevance for non-industrial environments we found low dose effects for the subjective scaling of indoor

imate and odors. Our findings of decreased tear film stability are of terest, since this parameter is of value in the diagnosis of a dry eye, d since decreased tear film stability is correlated with increased pre- lence of complaints among office-workers in Denmark (2). The present re- lts of cell counts in tear fluid may not be conclusive, but due to indi- tions of dose-related effects one should consider these results as indi- tive for future investigations. Support for the effects in this study is und in studies of white spirits with similar reactions in tear stability asurements (8) and in studies of low dose exposures of sensitive sub- cts with similar answers in the questionaires (5).

In conclusion we find that these results support the hypothesis that door air contamination with volatile organic solvant can provoke some of e symptoms used by a WHO expert group (1) in the definition of the sick lding syndrome.

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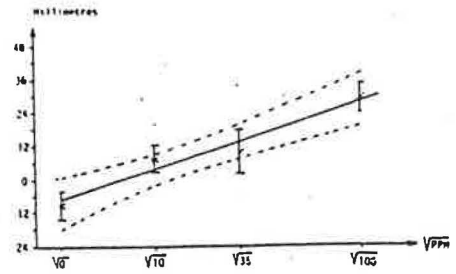

Fig. 1, Sensation of indoor climate graded by visual analogue scales as a function of square root of concentration. To each concentration are the mean (x) and standard error (pins) shown. Regression line (solid line) and 95% confidence limits (broken lines) of this is shown.

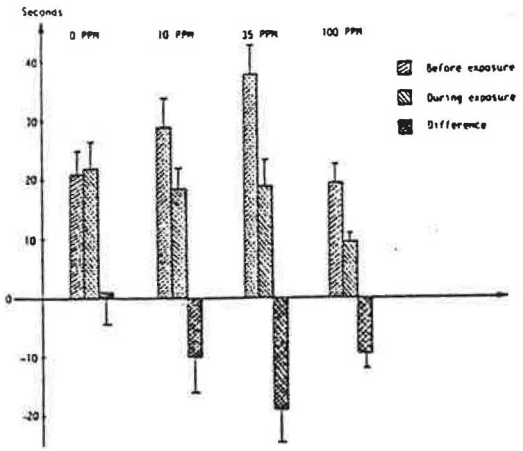

Fig. 2, Means (bars) and standard errors (pins) of break up time of tear film (seconds), before and during exposure, for each of the four exposure groups. Similarly, means and standard errors for the differences between the two are shown.