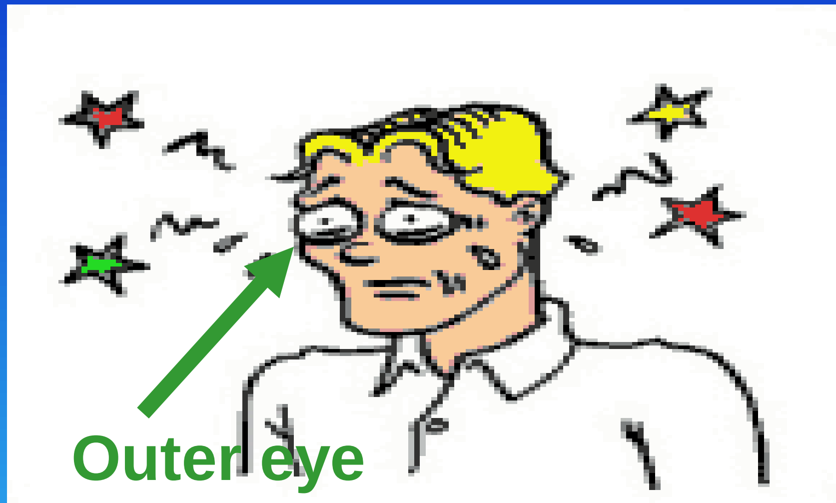
Tør luft og indeklimakemi – de tveæggede svær i kontormiljøet



Peder Wolkoff

FORSKNINGSCENTER FOR ARBEJDSMILJØ
NATIONAL RESEARCH CENTRE FOR THE WORKING ENVIRONMENT

”Syg bygning syndromet”

Hvorfor luftforureningerne 

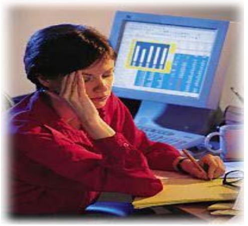
”tør luft”

~1980

”SBS”

Lav relativ fugtighed

Luftforureninger, VOCer, partikler, etc



God luft kvalitet =

NATIONAL RESEARCH CENTRE
FOR THE WORKING ENVIRONMENT

Special Article

PHYSICAL AND PHYSIOLOGIC PRINCIPLES OF AIR CONDITIONING

PART II

C. P. YAGLOU, M.S.
BOSTON

WINTER AIR CONDITIONING

Humidification. — Artificial humidification, about which so much is heard in connection with winter air conditioning, was shown in the first part of this paper [5] to be relatively unimportant from the standpoint of comfort and, so far as is known, not essential from the standpoint of health.

While a relative humidity of between 40 and 60 per cent would probably be more normal and perhaps more healthful than one between 20 and 30 per cent, it is practically impossible to maintain this high range in cold weather on account of excessive condensation and freezing on the windows and sometimes inside the exposed walls.

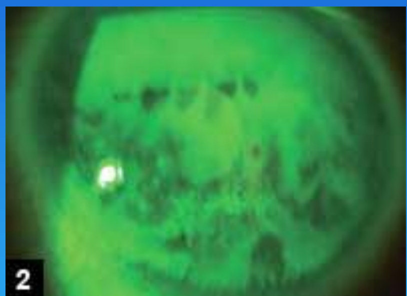
Yaglou, *JAMA* **109** (1937) 945-950.

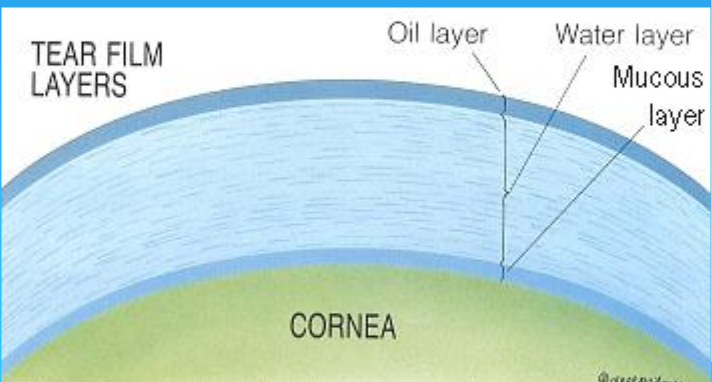
Lav relativ fugtighed: Virkninger på ?

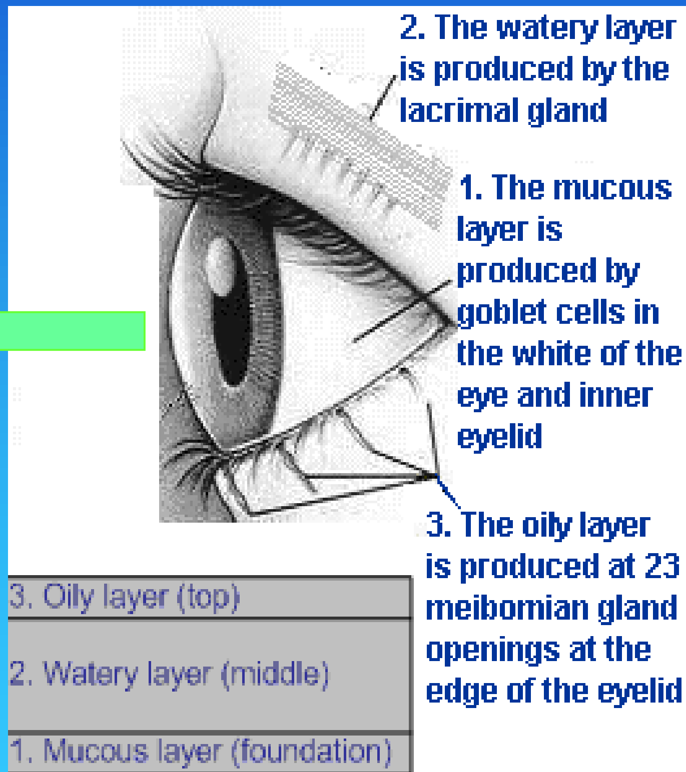
- Oplevet (umiddelbar) luftkvalitet
- Luftvejene (modstand) (astmatikere)
- Oplevelse af modstand i luftvejene
- Bakteriel modtagelighed i luftvejene
- Søvnkvaliteten
- Øjensymptomer
- Stemmebåndet
- Genophvirvling af partikler
- Overlevelse og transmission af influenza vira
- Huden

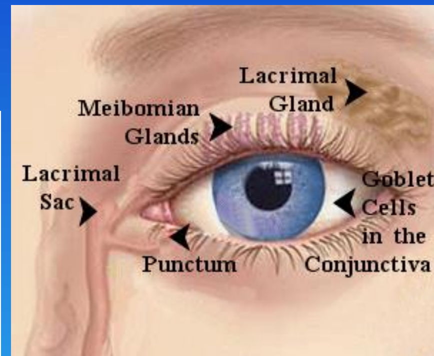
☹

water — **evaporation** → **Dessiccation**









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Dry eye spectrum in N. America

Dry Eye Spectrum

	Mild	Moderate	Severe
Symptoms	Occasional irritation, burning, itching	Frequent irritation, burning, itching, sensitivity to light	Persistent irritation, dryness, sensitivity to light, blurred vision
Remedy	Little or no use of artificial tears	Regular use of artificial tears	Frequent use of artificial tears, puncta plugs, ointments and prescription tears
Profile	Contact lens wearers, people with allergies, poor blinking habits, in low humidity areas.	Older population, contact lens wearers, people with allergies, poor blinking habits, in low humidity areas	Older population, people with medical conditions, hormonal changes in women, contact lens wearers
Affected Population	Almost Everyone (Mild → Severe)	60 Million Americans (Moderate → Severe)	10 Million Americans (Severe)

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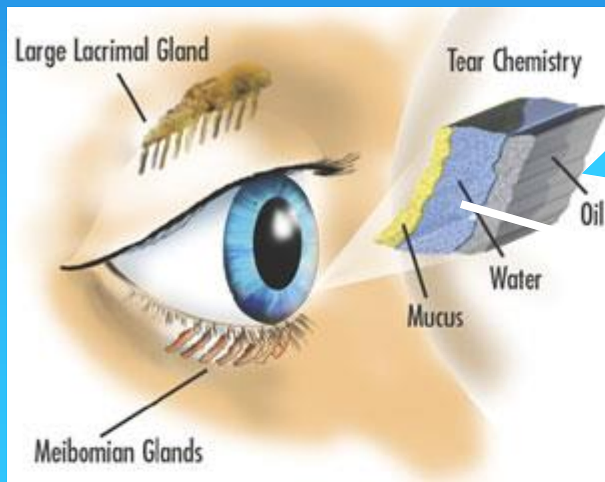
Tårefilmens stabilitet efter 2 timer
Fugtighedens betydning

Relative fugtighed %	Break-up tid ”Stabilitet” sek	Komfort $0\text{-}10_{bedst}$
35 ± 3	11.3	8.5
↓ 19 ± 4	8.3	7.7



vand

Gonzales-Garcia et al., *Invest. Opthalmol.* 48 (2007) 4026-4032.

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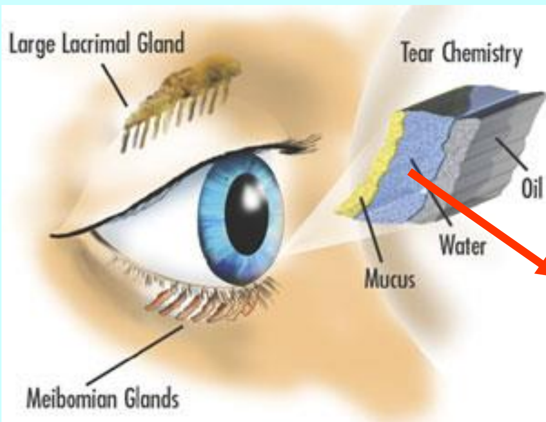
Changes in ocular and nasal signs and symptoms among air crew in relation to air humidification on intercontinental flights*

Høje ozon koncentrationer?

Ozon-reaktioner på overflader med human debris, fx ”sved”**



Relative humidity %	Break-up seconds	Dry eyes %	Tiredness %
10-14	5.0-7.3	66	50
21-25	7.7-9.2	39	26

*** Norbäck et al. *Scan J Work, Environ & Health* 32 (2006) 138-144.**

**** Wisthaler et al. *ES&T* 39 (2005) 4823-4832.**

Wolkoff, *Toxicol Lett* 199 (2010) 203-212.

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CLINICAL SCIENCE

The Effect of Low Humidity on the Human Tear Film

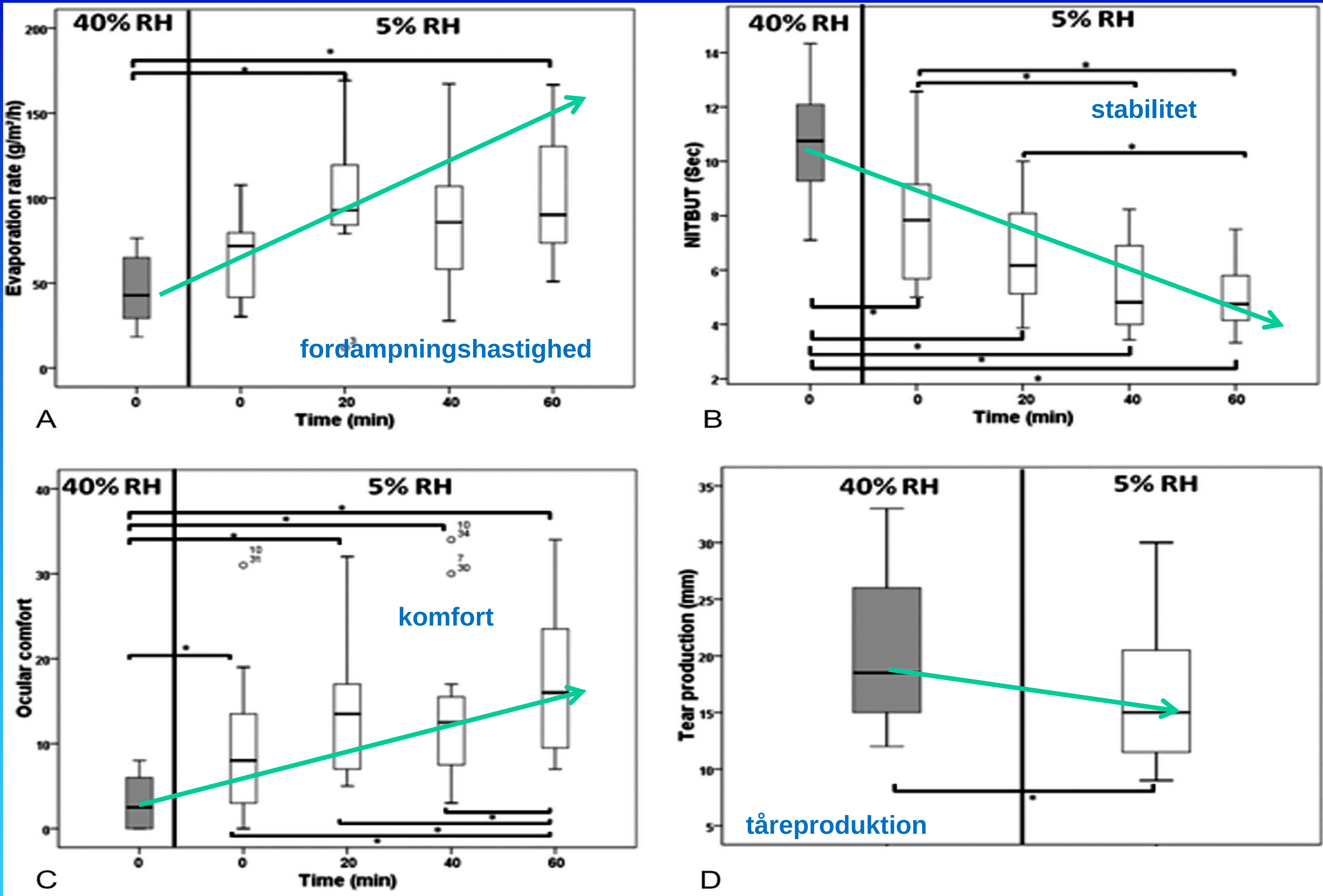
Ali A. Abusharha, BSc and E. Ian Pearce, PhD

Conclusions: Evaporation rate, tear LLT, ocular comfort, tear stability, and production were adversely affected by low RH. The tear film parameters observed after exposure to a desiccating environment for 1 hour were similar to those of the dry eye patient. Therefore, to avoid tear film disruption and possible ocular surface damage, the environmental conditions of dry locations need to be improved or the tear film should be protected against adverse environmental conditions.

Key Words: tear film, relative humidity

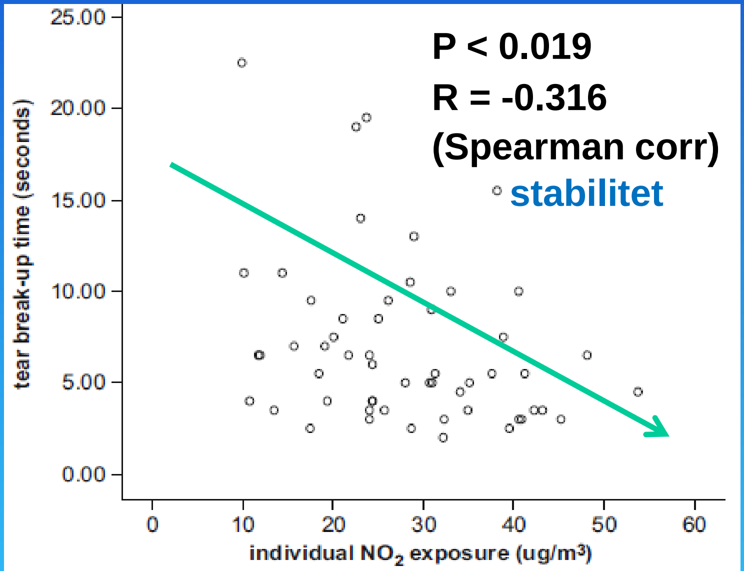
(*Cornea* 2013;32:429–434)

Glidende overgang mellem sygdom og øjensymptom oplevet på kontoret



Abushara, Pearce, *Cornea* 32 (2013) 429-434.

Tårefilm break-up tid vs personlig NO_2 eller partikel eksponering impact af oxidanter på osmolalitet



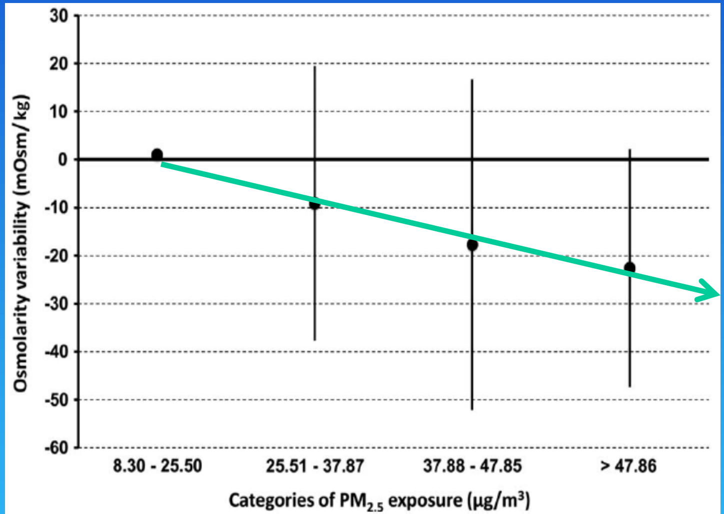


FIGURE 1. Effects of $PM_{2.5}$ exposure (quartiles) on tear osmolarity (milliosmole per kilogram of water).

NO_2 som mål for trafik/forbrændingsproces

Novaes et al. *Environ Res* 2010 110 372-374.

Torricelli et al. *Cornea* 32 (2013) e11

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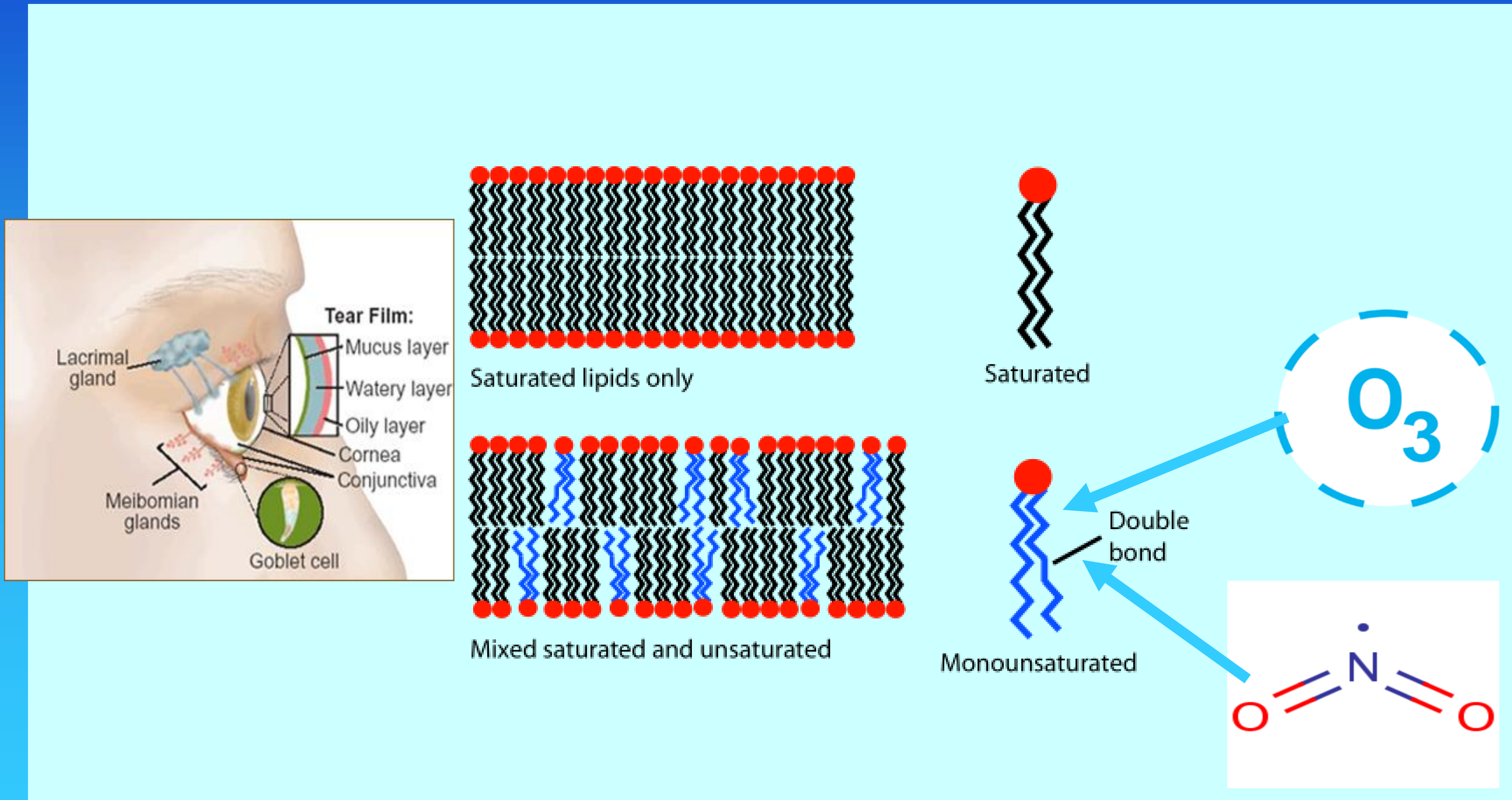
Umættede vs mættede kulstofkæder
Phase transition temperaturer



Borchman et al *Invest Ophtalmol Vis Sci* **52** (2011) 3805-3817.

Betydningen for tårefilmens stabilitet:
rel. fugt, temperatur, altitude, luftforureninger

	Vand tab	BUT	Film tykkelse	Wetness receptor medieret	Surfaktant egenskaber	Stabilitet of PTF
Øget relativ fugtighed	↓	↑	↑			☺
Høj temperatur Cornea	↑	↓	(↓)	↓	↓	☹
Reduceret tryk (høj altitude)	↑	↓				☹
VOCer indoors • Non-reaktive • Reaktive	nej	nej	nej	Trafik		😐 ☹
Indoor partikler Aggressive aerosoler (OH^-)	?	?	?			😐 ☹

EPI studier and eksposure studier peger på at lav fugt og høj temperatur er detrimental for PTF stabiliteten

↑ = Større effekt. ↓ = Mindre effekt.

☺ = Stabiliserende effekt på PTF. 😐 = Ingen effekt på PTF. ☹ = Destabiliserende effekt på PTF.

Riskofaktorer der ændrer tårefilmens fysiology
og resulterer i “ydre” øjensymptomer

Individuel:

- Alder/køn
- Øjensygdomme
- Kontaktlinser
- Kosmetik (personlige plejemidler)
- Kirtel dysfunktion
- Hygiejne (hånd og øjne)
- Ukomplette blink
- Medicin

Arbejdsmiljø:

- PC arbejde:
  - varighed, gaze, position*
- Ergonomi (indre øje)

Indemiljø:

- Luftforureninger (irritants)
- Lav rel. fugtighed
- Høj temperatur
- Høj altitude
- Høj lufthastighed (træk)
- Geografisk placering

* Belysning

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Konklusion
øjen- og luftvejssymptomer i indemiljøer/kontormiljøer

- Tværfaglig vurdering “altid” nødvendig

- Normalt høje koncentrationer af forureninger påkrævet – hvis kausalitet
- Påvirkning af lugt skal ikke undervurderes (kontormiljøer)
- Mange risikofaktorer kan spille ind, inkl. miljø-, arbejdsplads- og individuelle faktorer (især øjensymptomer)
- Traffikforurening vigtig (transport)

- Lav rel fugtighed (øjne)
- Oxidative eller aggresive stoffer
- Arbejdssituationen
- Forbrændingsprocesser (rygning, traffik)

Relevante artikler

- **Wolkoff, P. Indoor air pollutants in office environments: assessment of comfort, health, and performance.**

  ***Int J Hyg Environ Health*, 216 (2013) 371-394.**

- **Wolkoff, P., Kärcher, T., Mayer, H. Problems of the outer eyes in the office environment: An ophthalmologic approach.**

  ***J Occup Environ Med*, 54 (2012) 621-631.**

- **Wolkoff, P. Ocular discomfort by environmental and personal risk factors altering the precorneal tear film.**
- ***Toxicol Lett*, 199 (2010) 203-212.**

- **Wolkoff, P., Kjærgaard, S.K. The dichotomy of relative humidity in office-like environments.**
- ***Environ Int*, 33 (2007) 850-857.**

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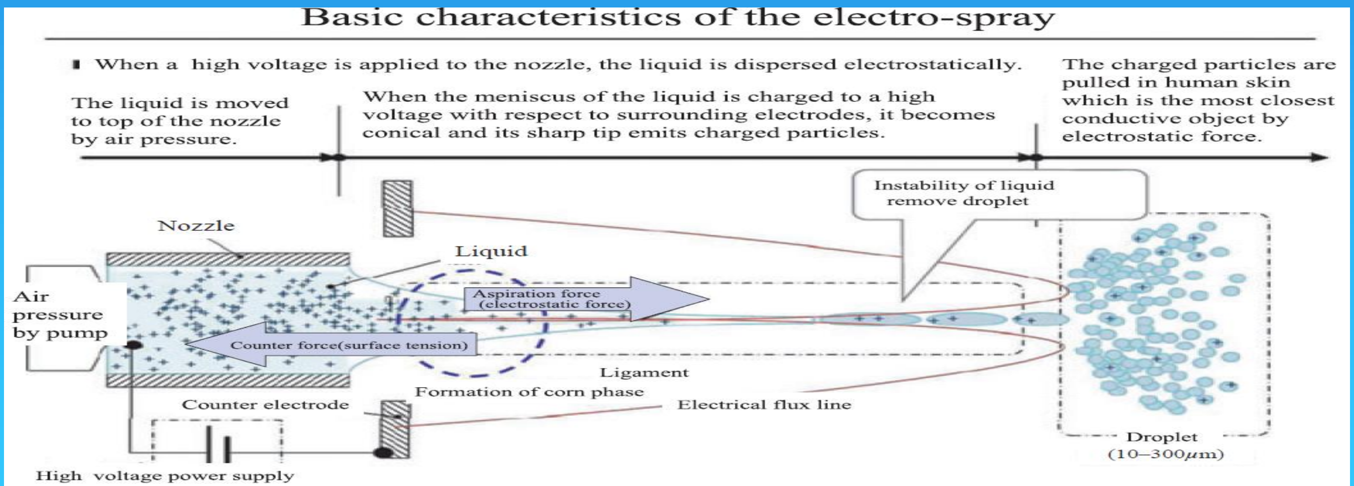
Acta Ophthalmologica 2012

Efficacy of a novel moist cool air device in office workers with dry eye disease

Masatoshi Hirayama,[1] Dogru Murat,[1] Ying Liu,[1] Takashi Kojima,[1] Tetsuya Kawakita[1,2] and Kazuo Tsubota[1,2]

[1]Department of Ophthalmology, School of Medicine, Keio University, Tokyo, Japan
[2]Minami-Aoyama Eye Clinic, Tokyo, Japan

Conclusion: Moist cool air device use provided symptomatic relief of ocular dryness and improvement on tear stability in office workers with DED. This new device seems to be a safe and promising alternative in the treatment of DED.



Fugt og VOC emission fra materialer og møbler

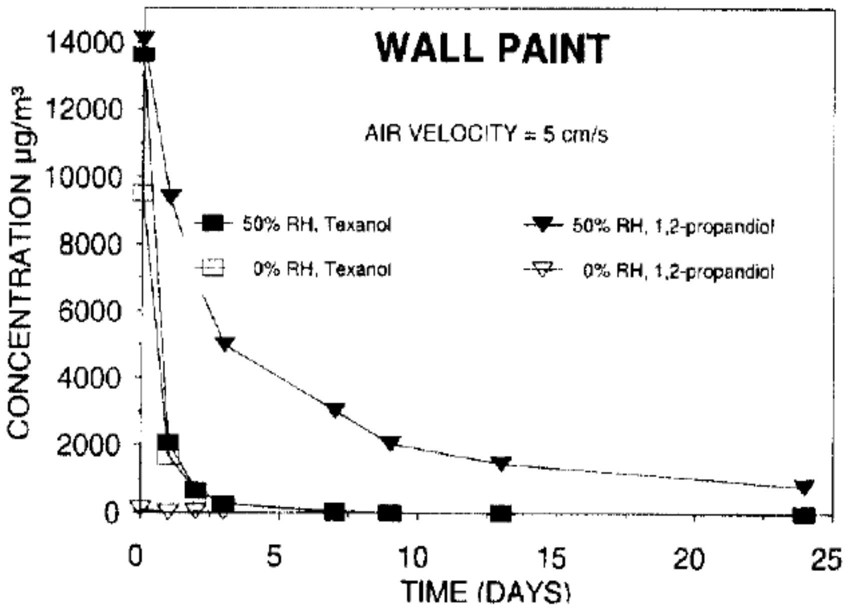


Fig. 6. Concentration/time profiles of 1,2-propandiol and Texanol from a waterborne wall paint on gypsum board, respectively, at 0 and 50% RH, and 23°C, the air velocity = 5 cm s^{-1}. The FLEC data have been converted to standard room concentrations.

Wolkoff, *Atmos Environ* 32 (1998) 2659-2668.

Table 3. Tentative proportionality factors for room concentrations dependent on relative humidity (RH) change.

Concentration change between 30 and 80% RH	17°C	23°C	28°C	Average
Hexanal	+460%	+400%	+210%	+357%
3-Carene	+30%	−15%	−12%	+1%
α-Pinene	−4%	−12%	−8%	−8%
Limonene	0%	−15%	(+78%)	−7%
β-Pinene	+20%	+12%	+15%	+15%

Wood Material Science and Engineering, 2006; 1: 69–75

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Association between temperature, relative humidity and concentration of volatile organic compounds from wooden furniture in a model room

JAN-OLOF FECHTER[1], FINN ENGLUND[2] & ANDERS LUNDIN[3]

[1] *Växjö University, Växjö, Sweden,* [2] *SP Trätek, Swedish National Testing and Research Institute, Stockholm, Sweden, and* [3] *Stockholm County Council, Sweden*

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Fugt og formaldehyd

Formaldehyde in the Indoor Environment

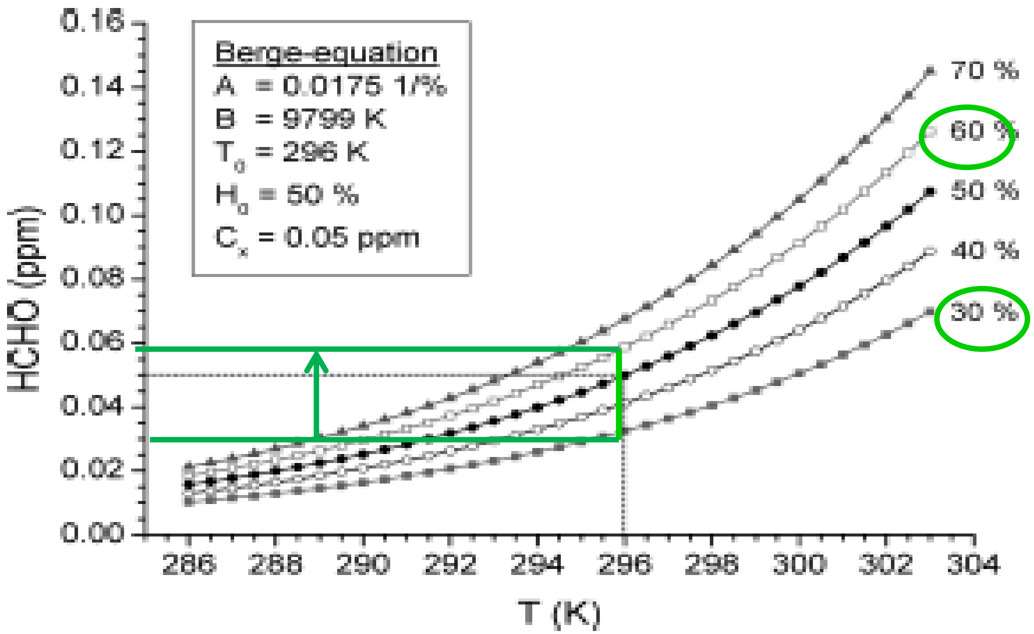

Figure 10. Variation of the formaldehyde concentration as a function of humidity and temperature, calculated with the Berge equation (eq 21). The initial conditions were $T_0 = 296$ K, $H_0 = 50\%$, and $C_x = 0.05$ ppm.

Salthammer et al. *Acc Chem Res* 110 (2010) 2536-2572.

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Fugt og partikel resuspension fra tæpper

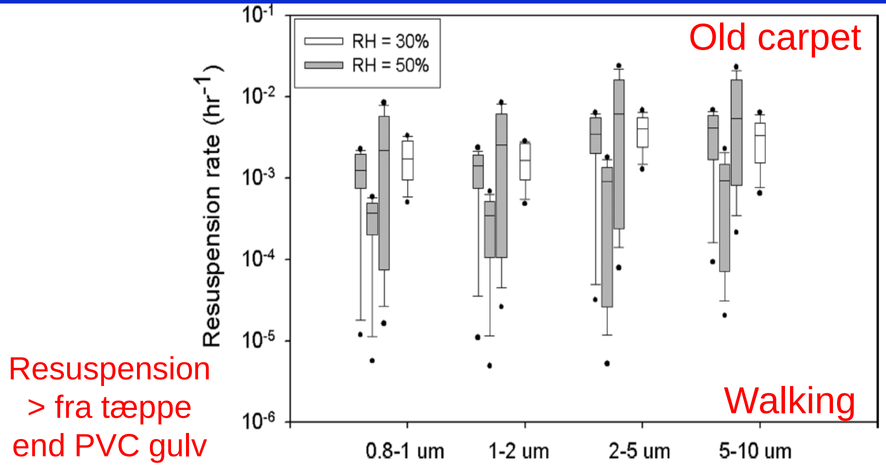

FIG. 8. Box plot of resuspension rates for seeded old carpet under side wall supply system. Three experiments for RH = 30%, and one for RH = 50%. The whiskers show the 5th and 95th percentile. Dots are outliers.

Aerosol Science and Technology

Resuspension of Dust Particles in a Chamber and Associated Environmental Factors Quian/Ferro, 42 (2008) 566-578.

Særlig lav rel fugt "øger" deponering af fine partikler – men, for større partikler, "øges" resuspension ved øget rel fugt (enkelte papers)

Kivistö, Timo und Juha Hakulinen:

Der Staubgehalt der Luft in Räumen mit textilen Fußbodenbelägen

Staub-Reinhalt. Luft 41 (1981) Nr. 9 S. 357/58,

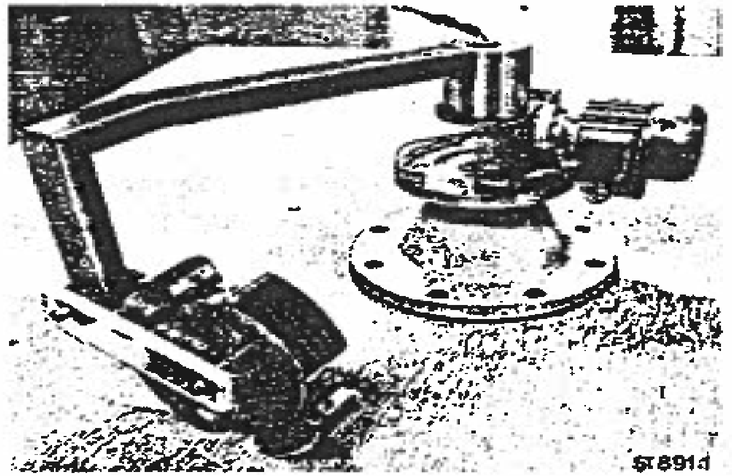

Bild 1: Der Schrittsimulator

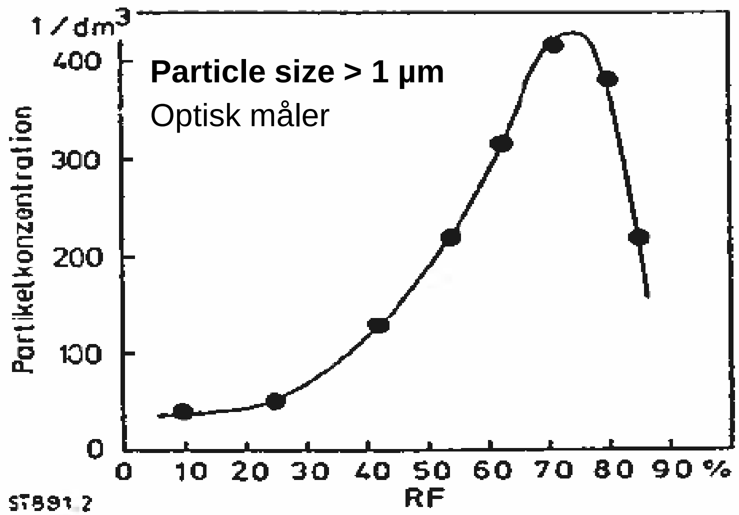

Bild 2: Die Partikelkonzentration als Funktion der relativen Luftfeuchtigkeit (bei einem getufteten Teppich)

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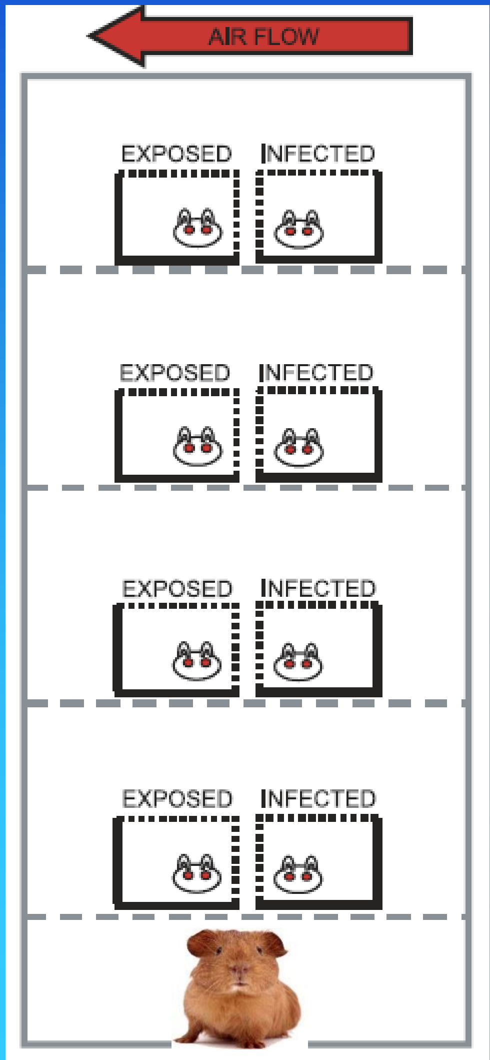
Fugt og virus transmission/overlevelse

OPEN ACCESS Freely available online 2007 PLoS PATHOGENS

Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature

Anice C. Lowen[1*], Samira Mubareka[1], John Steel[1], Peter Palese[1,2*]

1 Department of Microbiology, Mount Sinai School of Medicine, New York, New York, United States of America, 2 Department of Medicine, Mount Sinai School of Medicine, New York, New York, United States of America



humidity. We found that low relative humidities of 20%–35% were most favorable, while transmission was completely blocked at a high relative humidity of 80%. Furthermore, when guinea pigs were kept at 5 °C, transmission occurred with greater frequency than at 20 °C, while at 30 °C, no transmission was detected. Our data implicate low relative humidities produced by indoor heating and cold temperatures as features of winter that favor influenza virus spread.

Vira kan være associeret med astma og allergi-forekomst

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Fugt - virus transmission

OPEN ACCESS Freely available online PLoS PATHOGENS

Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature

Anice C. Lowen[1*], Samira Mubareka[1], John Steel[1], Peter Palese[1,2*]

1 Department of Microbiology, Mount Sinai School of Medicine, New York, New York, United States of America, 2 Department of Medicine, Mount Sinai School of Medicine, New York, New York, United States of America

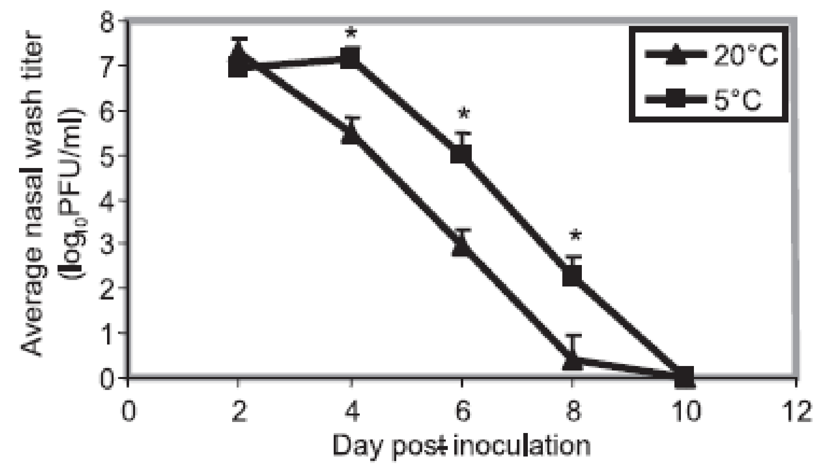

Figure 4. Guinea Pigs Housed at 5 °C Shed Influenza Virus at Higher Titers on Days 4, 6, and 8 p.i. Than Guinea Pigs Housed at 20 °C

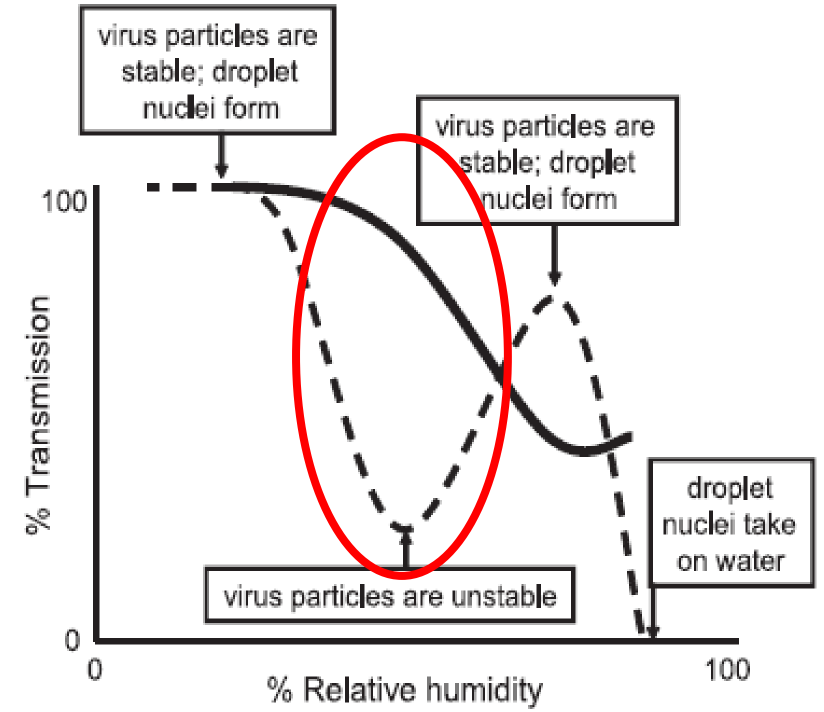

Figure 6. Variation of Transmission Efficiency with Relative Humidity: A Model

NATIONAL RESEARCH CENTRE FOR THE WORKING ENVIRONMENT

Fugt - virus transmission – søvnkvalitet

Myatt *et al. Environmental Health* 2010, **9**:55
http://www.ehjournal.net/content/9/1/55

ENVIRONMENTAL HEALTH

RESEARCH **Open Access**

Modeling the airborne survival of influenza virus in a residential setting: the impacts of home humidification

Theodore A Myatt[1*], Matthew H Kaufman[1], Joseph G Allen[1], David L MacIntosh[1], M Patricia Fabian[2], James J McDevitt[2]

Results: The presence of a portable humidifier with an output of 0.16 kg water per hour in the bedroom resulted in an increase in median sleeping hours AH/RH levels of 11 to 19% compared to periods without a humidifier present. The associated percent decrease in influenza virus survival was 17.5 - 31.6%. Distribution of water vapor through a residence was estimated to yield 3 to 12% increases in AH/RH and 7.8-13.9% reductions in influenza virus survival.

Conclusion: This modeling analysis demonstrates the potential benefit of portable residential humidifiers in reducing the survival of aerosolized influenza virus by controlling humidity indoors.

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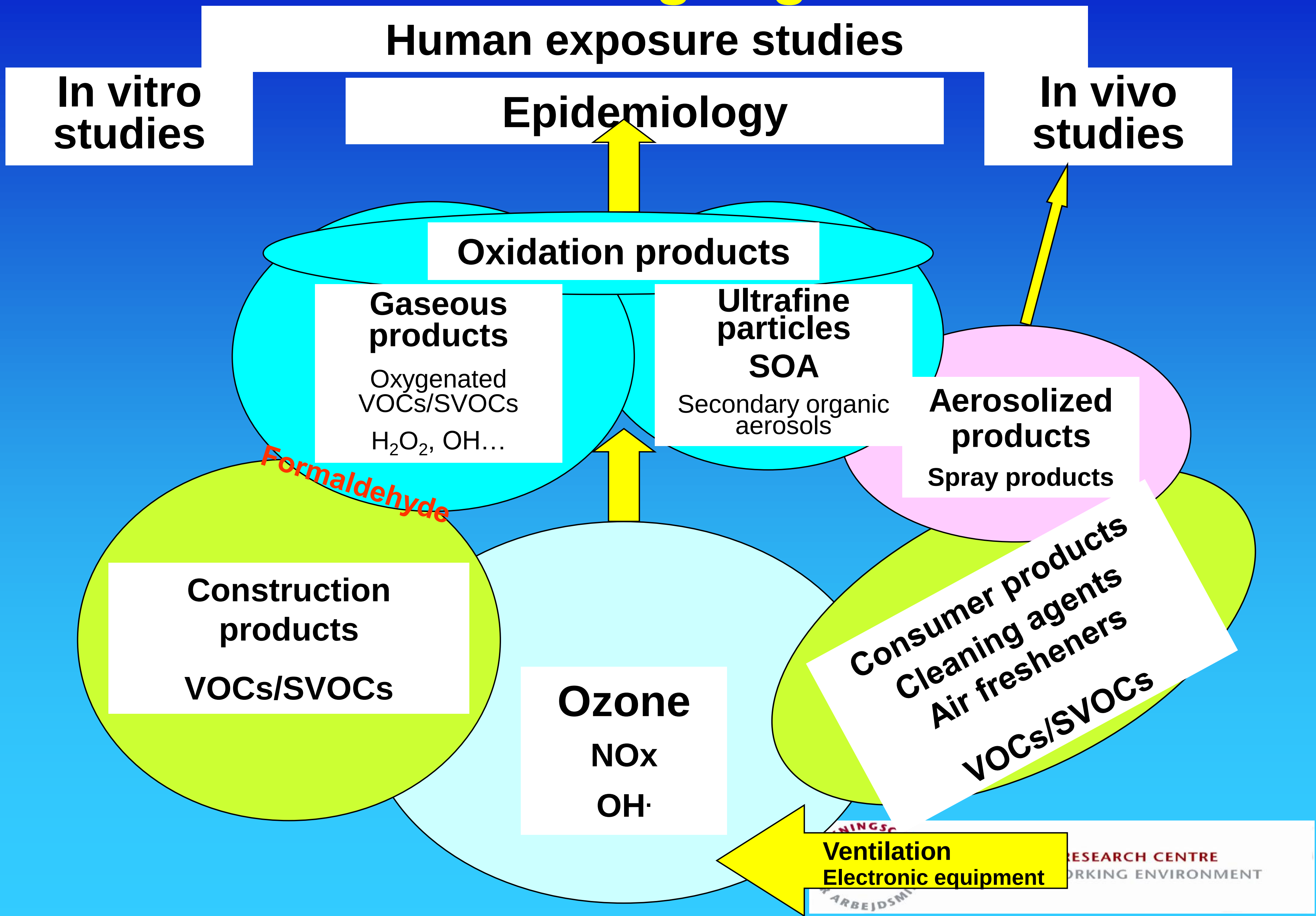
Hvorfor fokusere på ozon?

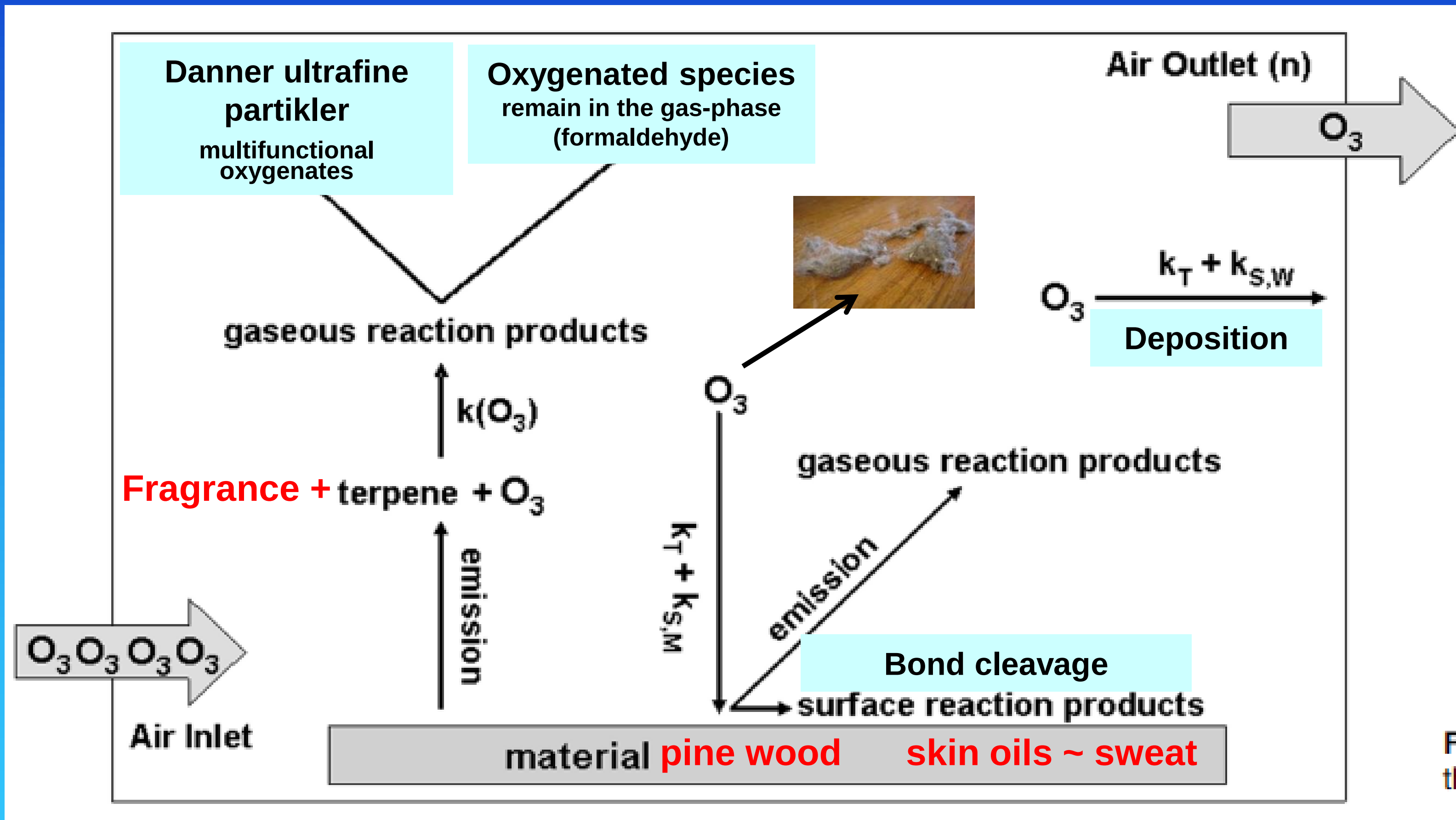
- Forventet stigning i koncentration pga klimaændringer
- De fleste (daglige) forbrugerprodukter indeholder duftstoffer, som ozon reagerer med, og..
- Der dannes en række nye stoffer, som kan være forbundet med en sundhedsrisiko (oxidationsprodukter og aerosoler)
- Ozon + gulvstøv har tidligere vist effekter på lungefunktionen

- Mange duftstoffer (parfumer) er ”implicit” forbundet med risiko for luftvejsproblemer eller forværring deraf

Indeklima ”smog” og sundhed



Ozon gasfase og overflade-reaktioner



Modified from: Salthammer and Bahadir *Clean* **37** (2009) 417-435.

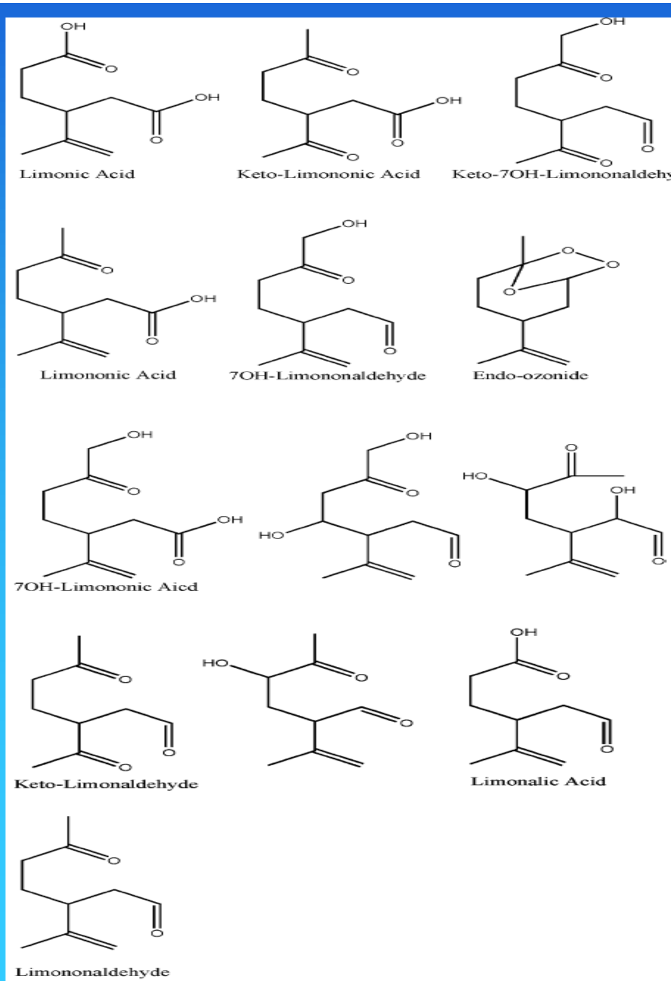
Ozonolysis products in ozone+limonene

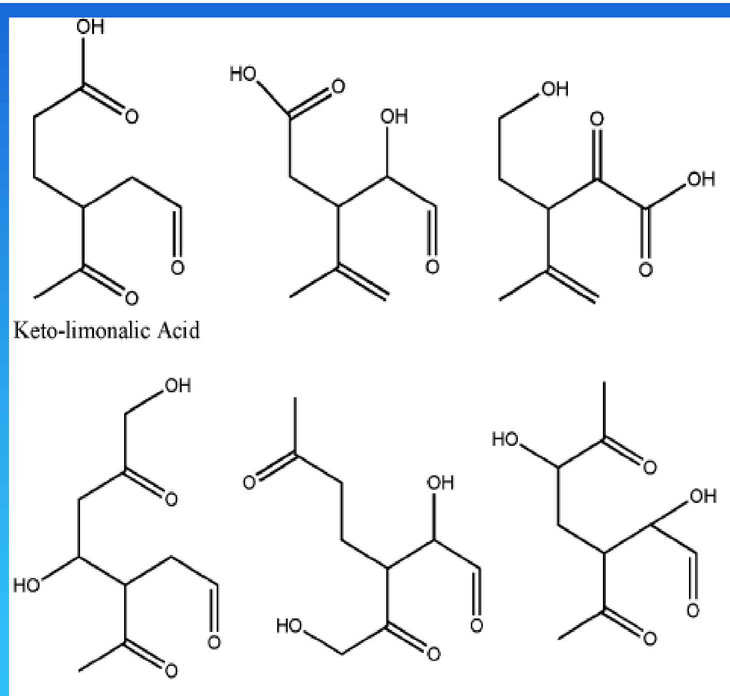
PAPER www.rsc.org/pccp | Physical Chemistry Chemical Physics

High-resolution mass spectrometric analysis of secondary organic aerosol produced by ozonation of limonene†

Phys. Chem. Chem. Phys., 2008, **10**, 1009–1022

Maggie L. Walser,[a] Yury Desyaterik,[b] Julia Laskin,[c] Alexander Laskin[b] and Sergey A. Nizkorodov*[a]





Gas-phase and particle-phaseproducts (secondary organic aerosols)

Sundhedseffekter – epidemiologi
ozon i kontorer

Indoor Air 2008; 18: 156–170
www.blackwellpublishing.com/ina

INDOOR AIR
doi:10.1111/j.1600-0668.2008.00521.x

Outdoor ozone and building-related symptoms in the BASE study

Abstract Reactions between ozone and indoor contaminants may influence human health and indoor air quality. The U.S. EPA Building Assessment Survey and Evaluation (BASE) study data were analyzed for associations between ambient ozone concentrations and building-related symptom (BRS) prevalence. Multiple logistic regression (MLR) models, adjusted for personal, workplace, and environmental variables, revealed positive relationships ($P < 0.05$) between ambient ozone concentrations and upper respiratory (UR), dry eyes, neurological and headache BRS (odds ratios ranged from 1.03 to 1.04 per 10 $\mu g/m^3$ increase in ambient ozone concentrations). Other BRS had marginally significant relationships with ambient ozone ($P < 0.10$). A linear dose–response in UR symptoms was observed with increasing ambient ozone ($P = 0.03$); most other symptoms showed similar but not statistically significant trends. Ambient ozone correlated with indoor concentrations of some aldehydes, a pattern suggesting the occurrence of indoor ozone chemistry. Coupled with the MLR ambient ozone-BRS analysis, this correlation is consistent with the hypothesis that ozone-initiated indoor reactions play an important role in indoor air quality and building occupant health. Replication with increased statistical power and with longitudinal data is needed. If the observed associations are confirmed as causal, ventilation system ozone removal technologies could reduce UR BRS prevalence when higher ambient ozone levels are present.

M. G. Apte, I. S. H. Buchanan, M. J. Mendell
Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Key words: Ozone Initiated Chemistry; Sick Building Syndrome; Aldehydes; Dose Response; Multiple Logistic Regression; National Ambient Air Quality Standard.

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Practical Implications
This paper provides strong statistical evidence that supports (but does not prove) the hypothesis that ozone entrained into buildings from the outdoor air is involved in increasing the frequency that occupants experience and a range of upper and lower respiratory, mucosal and neurological symptoms by as much as a factor of 2 when ambient ozone levels increase from those found in low-ozone regions to those typical of high-ozone regions. Although replication is needed, the implication is that reducing the amount of ozone entrained into building ventilation systems, either by ambient pollution reduction or engineered gas-phase filtration, may substantially reduce the prevalence of these symptoms experienced by occupants.

Sen eftermiddag ambient ozon koncentration

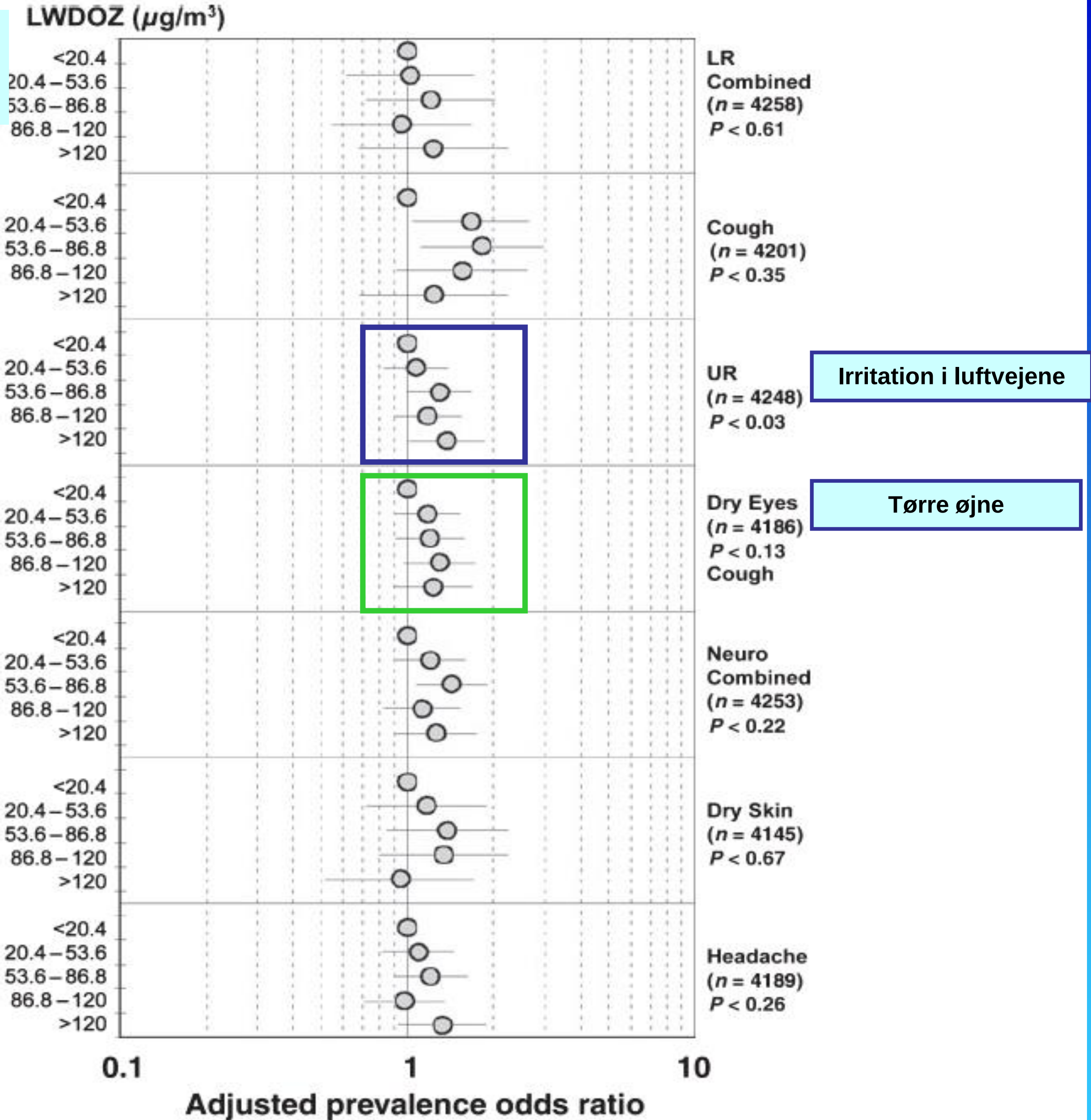
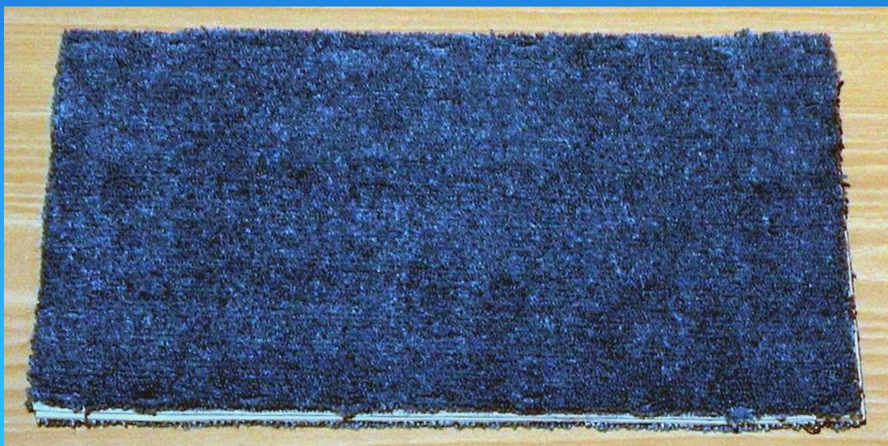
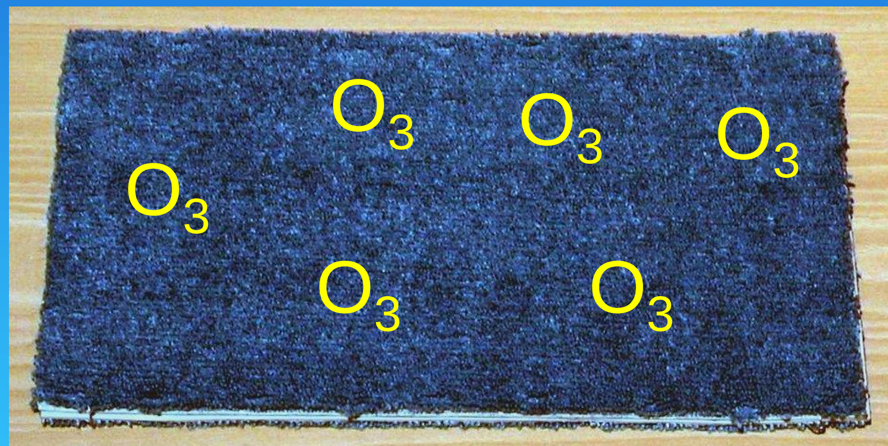


Fig. 2 Dose–response graph for late workday (15:00–18:00 hours) ambient ozone concentrations (LWDOZ). ORs and their 95% confidence interval are shown for each of the BRS symptoms at the given LWDOZ concentrations, relative to the lowest ozone exposure cohort (< 20.4 μg/m³). N is the sample size in the models. The *P*-values were obtained assuming a linear dose-response relationship between LWDOZ and BRS in a MLR model using a single five-part categorical ozone variable that represented the five ozone ranges on the left of the figure

Does O_3 removal induce changes in secondary VOC emissions from materials that are perceivable by the human nose



Sample A



Sample B

Knudsen et al. *Indoor Air* 13 (2003) 223-231.

Preference of odour

- Intensity
- Acceptability
- Preference

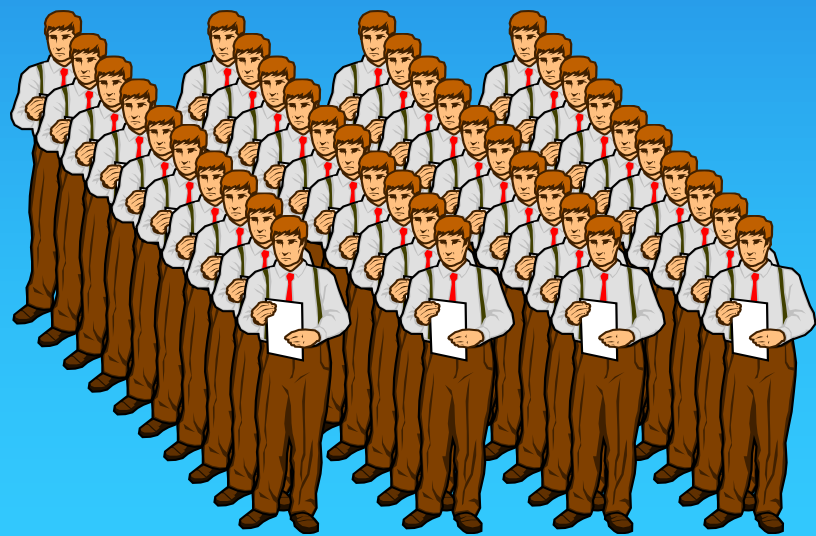
Which odor do you prefer?

X ☐

Y ☐

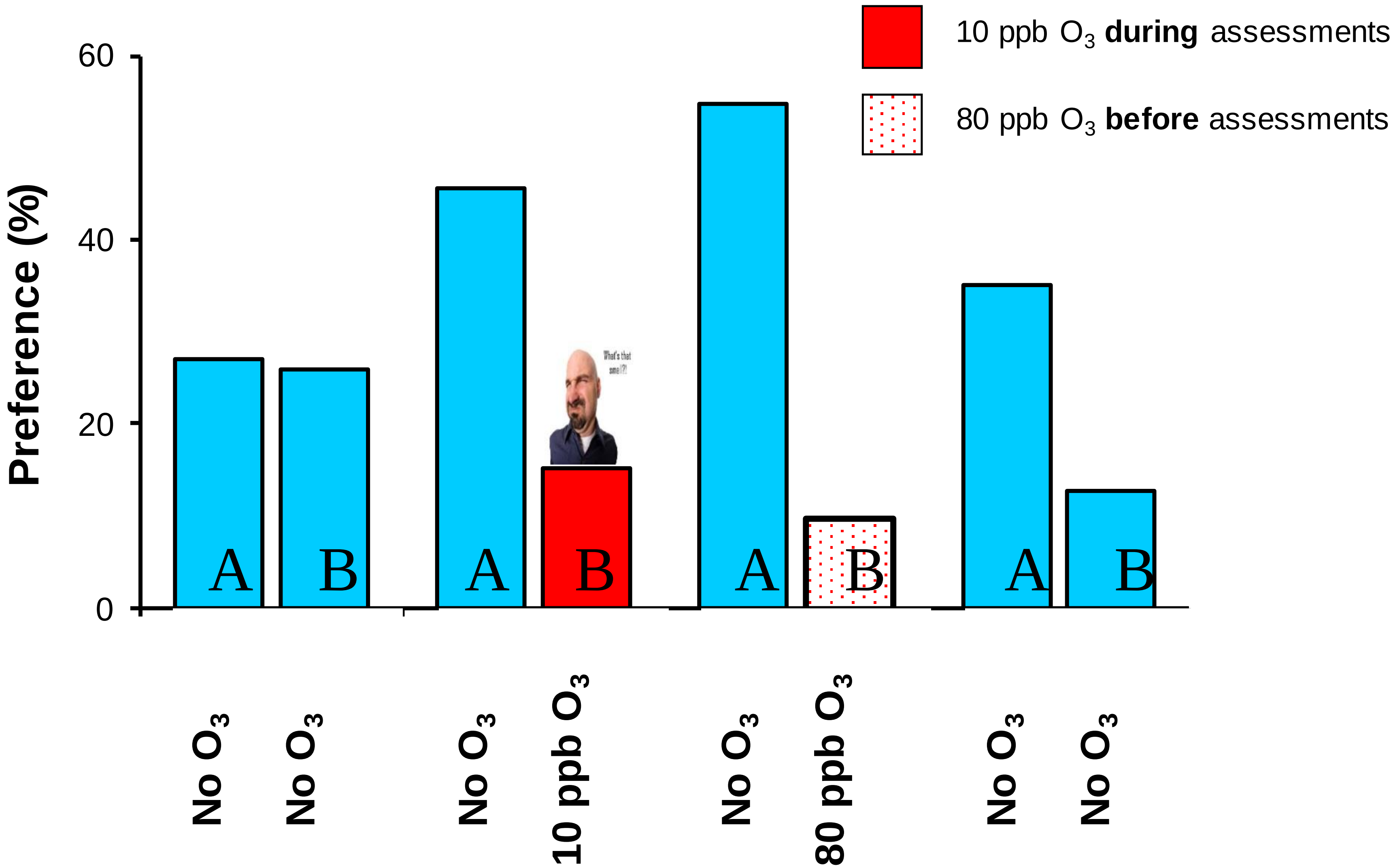
Do not ☐w

35 subjects



Knudsen et al. *Indoor Air* 13 (2003) 223-231.

Latex carpet



Knudsen et al. *Indoor Air* 13 (2003) 223-231.

Ozon/terpen-kemi's effekter på luftvejene

terpener = duftstoffer

1. Terpen-oxidationsprodukters påvirkning af luftvejene

2. Kan ozon/terpen blandinger have en adjuvans effekt eller inducere allergisk sensitisering og inflammation?

3. Hvordan påvirker ozon/terpen blandinger påvirke allerede ”allergiske” mus?

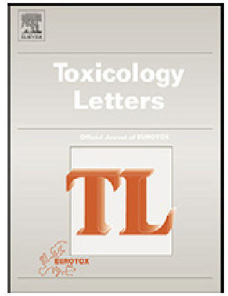
4. Hvordan påvirkes luftvejene af tør luft, når de udsættes for formaldehyd?

Toxicology Letters 216 (2013) 54–64

Contents lists available at SciVerse ScienceDirect

Toxicology Letters

journal homepage: www.elsevier.com/locate/toxlet



Human reference values for acute airway effects of five common ozone-initiated terpene reaction products in indoor air

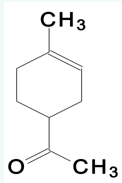
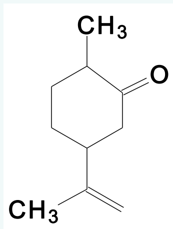
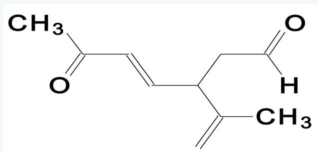
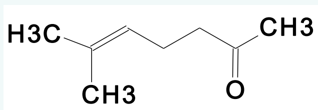
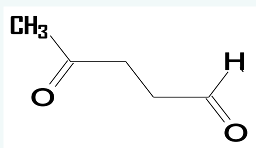
Peder Wolkoff*, Søren T. Larsen, Maria Hammer, Vivi Kofoed-Sørensen, Per A. Clausen, Gunnar D. Nielsen

National Research Centre for the Working Environment, Denmark

HIGHLIGHTS

- Airway effects of ozone-initiated terpene reaction products were assessed in mice.
- Sensory irritation, airway limitation, and pulmonary effects were observed.
- 3-Isopropyl-6-oxo-heptanal may be a sensory irritant of concern.
- 4-Oxopentanal may be of concern due to air-flow limitation.

Ozon/terpen oxidationsprodukter

Ozone-initiated reaction products	Structure	Limonene	α-terpineol	Geraniol	Squalene	Cabin air/ Office air	Ventilation filters
4-AMCH 4-acetyl-1-methyl cyclohexene		+					
DHC: dihydrocarvone 2-methyl-5-isopropenyl-cyclohexan-1-one		+					
IPOH 3-isopropenyl-6-oxo-heptanal		+				+	
6-MHO 6-methyl-5-heptene-2-one		+		+	+	+	
4-OPA 4-oxopentanal		+	+	+	+	+	+

Wolkoff et al., *Toxicol Lett* 216 (2013) 54-64.

Human reference værdier for ozon/terpen oxidations-produkter*

Life-long exposure

Ozone/terpene reaction products	Human reference values ppm	
	Sensory irritation	Airflow limitation
IPOH	0.16	-
DHC	9	9
4-AMCH	1.3	0.2
4-OPA	0.3	0.03
6-MHO	0.3	0.5
Formaldehyde**	0.08	
Ozone**		0.08

Field campaigns required

*) Wolkoff et al. *Toxicol Lett* 216 (2013) 54-64.

**) Nielsen et al. *Hum Exp Toxicol* 19 (1999) 400-409.

Toxicology and Applied Pharmacology 268 (2013) 294–299

Contents lists available at SciVerse ScienceDirect

Toxicology and Applied Pharmacology

journal homepage: www.elsevier.com/locate/ytaap

Acute airway effects of airborne formaldehyde in sensitized and non-sensitized mice housed in a dry or humid environment

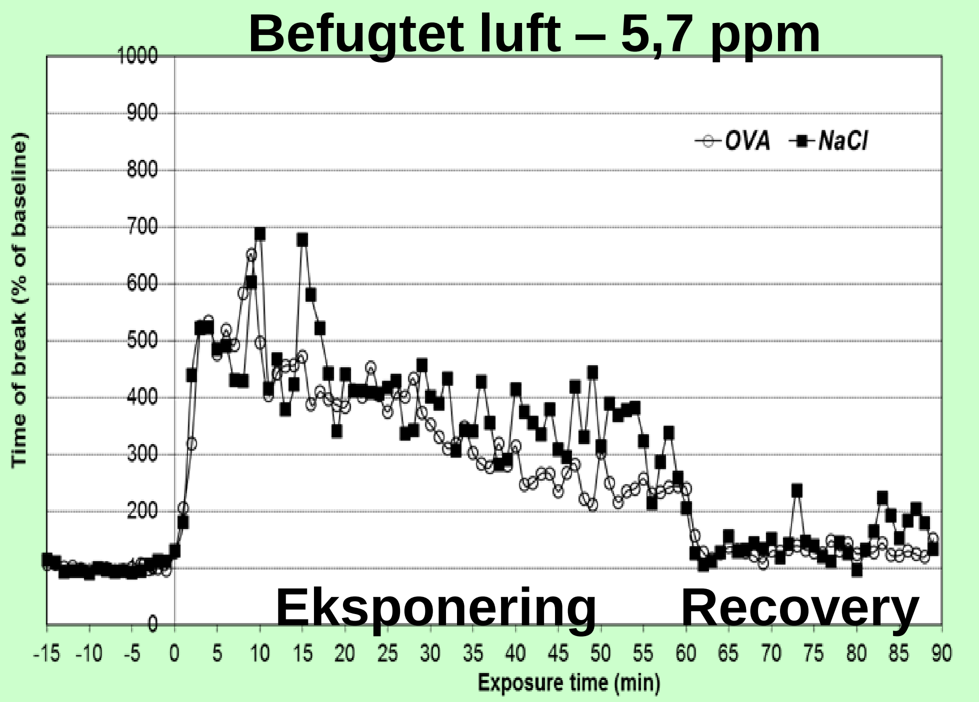
Søren Thor Larsen *, Peder Wolkoff, Maria Hammer, Vivi Kofoed-Sørensen, Per Axel Clausen, Gunnar Damgård Nielsen

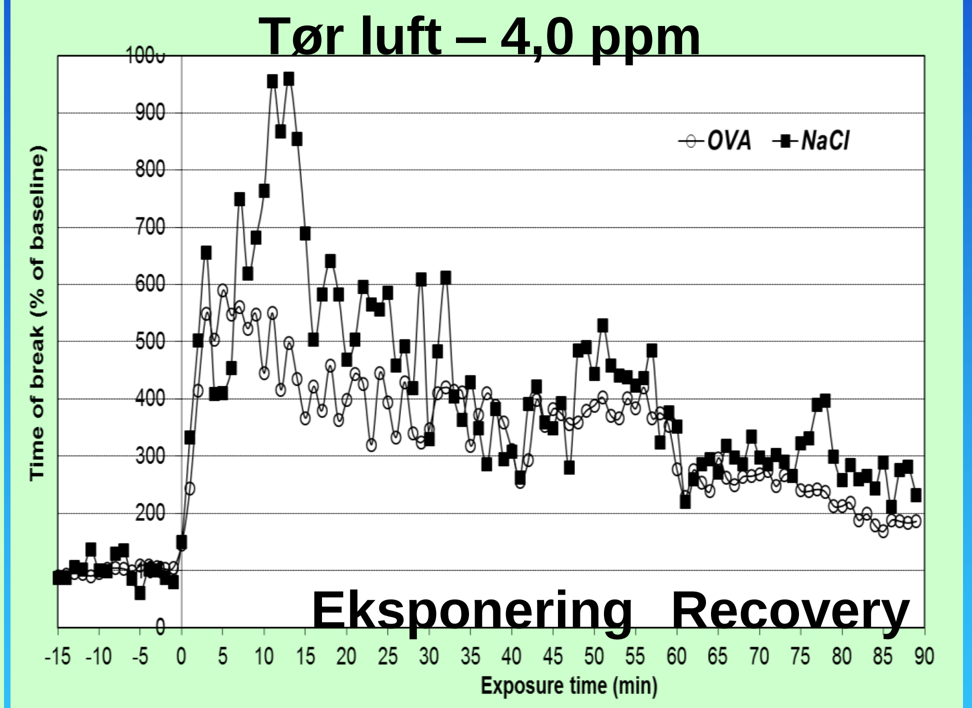
The National Research Centre for the Working Environment, Lersø Parkalle 105, DK-2100 Copenhagen, Denmark

Formaldehyd - høj vs lav rel fugtighed

Time of brake (tilbageholde respirationen)

Sensibiliserede vs ikke-sensibiliserede mus





Lav RF eller sensibilisering øger ikke sensorisk irritation over for formaldehyd

Sensibiliserede mus er mindre følsomme i de nedre luftveje over for formaldehyd

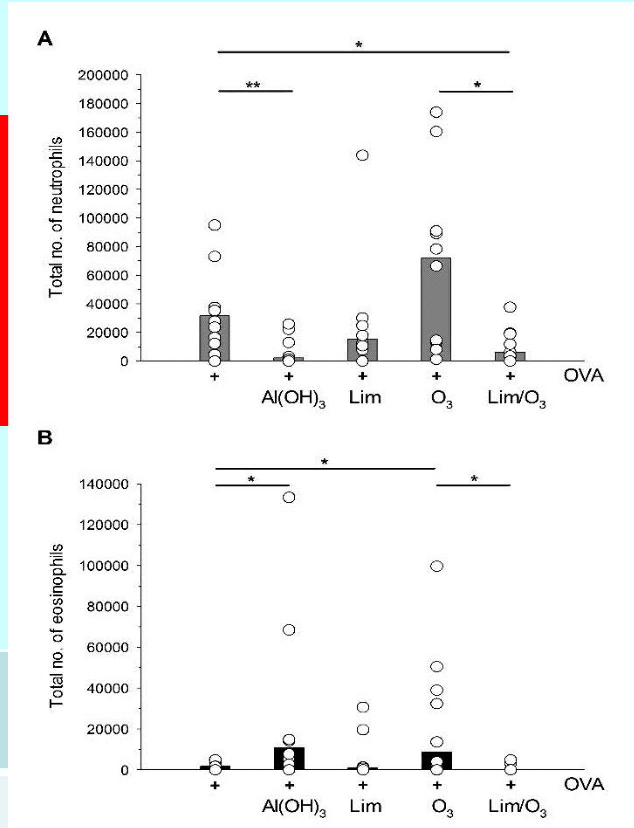
FORSKNINGSCENTER FOR ARBEJDSMILJØ

Adjuvans effekt af reaktiv kemi?

At undersøge effekten af gentagen inhalativ sub-kronisk eksponering af ozon, limonen and reaktionsblandingen sammen med aerosoliseret ovalbumin (OVA) på immun-respons i mus

Lav O_3 promoverede eosinophil inflammation I luftvejene, men ingen OVA-specifik IgE dannelse. Reaktionsprodukterne promoverede specifik IgE, men inflammation, som er karakteristisk for allergisk astma, blev <u>ikke</u> observeret.

Limonen så ud til at have anti-inflammatorisk effekt



Nebulized ovalbumin exposure/weeks			/Days	mg/L
20 min/day	2			46
20 min/week		12		
20 min/day			3	100

Hansen et al. *J Toxicol Environ Health Part A*, 76 (2013) 1085-1095.

Ozon-kemi

Reaktionsprodukterne ”kan have” sundhedseffekter, der er værre end udgangsstofferne! ?

Guidelines (indoor) mg/m^3

	NOAEL Wolkoff, 2013	AgBB	G.V. (I)	LCI P	SMAC	ECHA	Effect H=hum; A=rodent
+-Limonene	**8.5**	**1.5**	**1**	**4**	**450/115**		Sensory irritation, H OEL/100 Neuropathy+precaution; A
(+)-α-Pinene	**14**	**1.5**	**0.2**	**2.5**			Sensory irritation; H OEL/100 Sensory irritation; H; precaution Bladder epithelial changes; A
3-Carene	**9.5**	**1.5**	**0.2**				Sensory irritation; H OEL/100 Sensory irritation; H; precaution
Linalool						**4.1** **0.7**	Acute effect: Motility, A Long-term effect: Motility; A
Citronellol						**47.8**	Long-term systemic
Geraniol						**47.8**	Long-term systemic
Toluene	**22**	**1.9**	**0.3**	**2.9**			Sensory irritation, A OEL/100 Neurotoxicity Neuropathy+precaution; A
Formaldehyde	**~ 0.8**						Sensory irritation, H

AgBB: German LCI for material emissions , 2012
G.V. (I) German Indoor Climate Commission, 2003-2010.
LCI: Lowest concentration of interest. ECA harmonization work; material emission, 2013.
SMAC: Space maximum Allowed Concentration, NASA, 2008.
ECHA: DNEL (gen. popu.); European Chemicals Agency, 2010.