Comparison of Environmental Tobacco Smoke from an Electrically Heated and a Conventional Cigarette

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Abstract

Environmental tobacco smoke (ETS) from an electrically heated cigarette (EHC) (the Accord® smoking system: U.S. test market, 2 mg tar) and a conventional lit-end cigarette (Merit® cigarette: German market, 7 mg tar) was investigated and compared. The EHC produced substantially less ETS than the conventional cigarette as shown for 15 constituents. Concentrations were lower for the EHC than for the conventional cigarette by 93 to 96 % for total particulate matter (TPM), 98 % for nicotine, and at least 94 % for carbon monoxide. Most other constituents were more than 95 % lower.

Introduction

ETS was generated by human smokers in an experimental room under the same conditions for both the EHC and the conventional cigarette. The number of cigarettes was chosen to provide maximum ETS concentration without causing too much discomfort to the smokers.

ETS can be defined as the sum of sidestream smoke (SS) and exhaled mainstream smoke (MS), which has been aged and diluted. Conventional cigarettes, which have very different MS yields (ranging from 1.8 to 16 mg tar), have been shown to produce concentrations of ETS that do not differ greatly (Nelson et al., 1998). For our study, we chose the Merit® cigarette (German market, 7 mg tar) to represent the conventional lit-end cigarette and the Accord® smoking system (U.S. test market, 2 mg tar) to represent the EHC.

The EHC is designed to realize controlled combustion during the puffs instead of allowing the tobacco to burn continuously. Because of the controlled combustion and enclosed aerosol generation, the EHC generates essentially no SS; therefore, a reduction in the amount of ETS compared to conventional cigarettes can be expected. MS from an EHC prototype has been shown to differ substantially in its quantitative chemical composition and its biological activity compared to conventional cigarettes (Rustemeier et al., 2000; Terpstra et al., 1998).

Operation of the EHC

- The EHC, containing tobacco filler wrapped in tobacco mat, is kept in constant contact with 8 electrical heater blades in a microprocessor-controlled lighter.
- One of the 8 blades is triggered by each puff, and an unused section of the cigarette is heated for a defined duration at a defined energy level (2 s/puff, 23 J/puff).
- The electrical heating causes the tobacco under the heater blade to burn at a low temperature during each puff.

Literature

Haussmann, H.-J., Gerstenberg, B., Goecke, W., Kuhl, P., Schepers, G., Stabbert, R., Stinn, W., Turedissai, A., 12-Month inhalation study on room-aged cigarette sidestream smoke in rats, Inhal. Toxicol. 10: 693-697 (1998)

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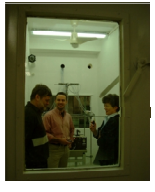
Vonclen, P., Gerstenberg, B., Rustemeier, K., Stabbert, R., Patskan, G., Haussmann, H.-J., Chemical analysis of selected cigarette mainstream smoke constituents for comparative product integrity testing, Tobacco Science Research Conference, Atlanta, U.S.A., 1998

Study Design

General

ETS was generated by 3 smokers, each smoking 2 cigarettes within 15 min in a 22 m³ unventilated room. Tests were performed 3 times with different groups of smokers for both cigarette types. ETS sessions (performed in the afternoon) were preceeded by blank sessions (morning), where the same smokers stood in the room for 15 min without smoking, to establish background concentrations.



- Painted wall paper, PVC flooring, glass windows, and metal-coated plastic foil (bags for sample volume compensation), ceiling fan
- Temperature: 22 to 25 °C, relative humidity: 45 to 60 %, max. CO_2 concentration: 1300 ppm

Fifteen constituents that could be measured with sufficient sensitivity were determined. The constituents were either markers of ETS or taken from a list of approximately 50 toxicologically relevant MS constituents (Voncken et al., 1998). In a prestudy with the EHC, the following constituents were shown to be too close to the detection limit or to the background and were therefore not determined in this study: formaldehyde, acrolein, propionaldehyde, ammonia, vinyl chloride, acrylonitrile, 1,3-butadiene, phenols, aromatic amines, nitrosamines, and several PAHs.

Duplicate samples were taken during the first hour after smoking. Sample volumes were compensated for by pumping an equivalent volume into bags inside the room.

Evaluation

- ETS tested vs background (t-test, Mann-Whitney U-test when data below detection limit)
- Comparison of background-corrected concentrations when ETS ≠ background, otherwise direct comparison
- Comparison expressed as reduction (calculated for each group of smokers)
  - mean reduction (N = 3, M + SD)
  - maximum possible reduction - uncertain because EHC not different from background

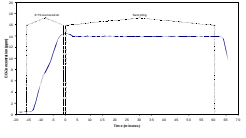
Analytical Methods

	Principle
	online, TEOM-ambient particulate monitor
	Cambridge filter, UV absorption (325 nm)
	Cambridge filter, fluorescence (300/420 nm)
	Cambridge filter, HPLC with UV detection (205 nm)
	online, nondispersive IR photometry
	XAD-4, GC/NPD
	dinitrophenyl-hydrazine solution, HPLC/UV detection (365 nm)
	cool traps with methanol (-78 °C), GC/MSD
	Cambridge filter, GC/MSD

References: Haussmann et al. (1998), Ogden et al. (1996)

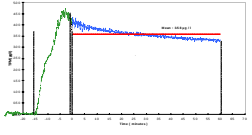
Time Course of ETS

CO Concentration



CO concentration drops by 5 % when smokers leave the room and then stays constant.

TPM Concentration



TPM concentration drops by approximately 20 % within the 1 h of sampling due to deposition of the particulate matter.

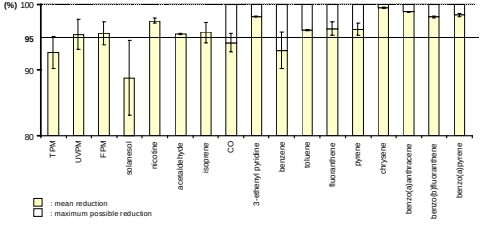
Results

ETS and Background Concentrations in the Room

Parameter	Unit	Concentration Background	EHC	Conventional Cigarette	Stat. Test EHC vs Background
TPM	µg/l	<0.02	0.23 + 0.07	3.16 + 0.31	+++
UVPM	ng THBP/l	<2	21 + 10	486 + 78	+
FPM	ng scop./l	0.18 + 0.03	2.8 + 1.1	60 + 7	+
solanesol	ng/l	<0.30	9.5 + 4.2	87 + 22	+
nicotine	"	<0.30	0.67 + 0.16	28 + 3	+
acetaldehyde	"	8 + 2	31 + 4	508 + 43	+++
isoprene	"	6 + 1	27 + 3	524 + 154	+++
carbon monoxide	ppm	0.7 + 0.2	0.8 + 0.2	12.9 + 0.8	=
3-ethenyl pyridine	ng/l	<0.3	<0.3	17 + 1	=
benzene	"	<4	<4	63 + 21	=
toluene	"	4.6 [a]	5.6 [a]	123 + 38	=
fluoranthene	pg/l	<0.3	<0.3	11 + 2	=
pyrene	"	<0.3	<0.3	10 + 2	=
chrysene	"	0.36 [a]	0.36 + 0.06	67 + 5	=
benz(a)anthracene	"	<0.3	<0.3	27 + 2	=
benzo(b)fluoran-thene	"	<0.3	<0.3	16 + 2	=
benzo(a)pyrene	"	<0.3	<0.3	19 + 2	=

N = 3; for TPM and CO N = 6
concentrations: mean + S.D or [a] median in case 1 single value is below detection limit
THBP: 2,2',4,4'-tetrahydroxy benzophenone, scop.: scopoletin
=: p >0.05, not statistically significant; +: p < 0.05; +++: p <0.001

Reduction of Concentrations in ETS by the EHC Compared to a Conventional Cigarette



Conclusion

- In ETS generated with the EHC, most constituents were lower by more than 95 % compared to ETS from a conventional lit-end cigarette.
- Results indicate the composition of ETS from the EHC and a conventional cigarette to be similar.

INBIFO is a research laboratory of Philip Morris International.