

CHARACTERIZATION OF TOBACCO ODOR IN SMOKEING ENVIRONMENT

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ABSTRACT

In this study, five different types of smoking spaces and non-smoking spaces were investigated in order to discuss about tobacco odor leakage from smoking area. VVOCs, VOCs and aldehydes were analyzed for characterization of odor. Additionally, the isolation result has been identified by determining ETS markers (nicotine and 3-ethenylpyridine) based on ISO1845.

Determined compounds were quantified and categorized into 13 groups, concentration between the smoking space and non-smoking space was compared. In the most case, the concentration in non-smoking space was lower than smoking space. However, it was observed that the concentration in non-smoking space wasn't so low in stink group (aldehydes, alcohols and organic acids). When it was compared the group composition, the aldehydes group composition in non-smoking space was higher than smoking space. Although the total compounds concentration is lower in non-smoking space, aldehydes might contribute to tobacco odor because of their low odor threshold.

KEYWORDS

Environmental tobacco smoke, odor, actual condition, aldehydes

INTRODUCTION¹⁻⁶⁾

It has been promoting the separation and isolation on smoking space. Tobacco smoke is consisting with numerous chemical compounds, acrolein, acetaldehyde, pyridine (stink), polycyclic aromatic hydrocarbons (carcinogen), nicotine and numerous kind of volatile organic compounds are frequently detected in the side stream. Passive smoking has concerned with health effects due to the annoyance and irritation with those chemicals. Recently, Ministry of Health Labor and Welfare, Japan have released the new guideline for smoking area in the office. It has been allowed to construct the smoking space and install the air cleaner in the office. However, new guideline pointed out that a conventional air cleaner is effective in order to remove particles in smoke, but in most case, not so sufficient for removing smoke odor. Odor from smoking space is still the problem due to leakage on the gaseous in the tobacco smoke from smoking space. Therefore, they recommend eliminating or reducing discomfort by tobacco odor.

In this study, gaseous chemicals were discussed from odor's point of view. Characteristics of tobacco odor were investigated from the comparison between smoking and non-smoking spaces.

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OUTLINE OF THE INVESTIGATION

Investigation points were chosen from five office buildings. Smoking room and the area that allowed smoking was defined as “smoking space”, “non-smoking space” was defined as five meters from the boundary of smoking space.

Table 1 shows the summary of the points investigated. These five points were installed different type of smoking separation. Smoking space and no-smoking space was investigated in each point, and then compared.

In the case of building A, there was the day no use on smoking space (no occupants), residual gaseous chemicals were investigated as same as smoking day.

Table 1 Summary of the points investigated

Building	Date	Time	Smoking space construction
A	2005/10/13	11:00~15:00	Smoking room was divided by partition. Tobacco smoke was exhausted directly from smoking room to outdoor.
B	2005/10/31	11:00~15:00	Smoking room was isolated. Tobacco smoke was exhausted directly from smoking room to outdoor.
C	2005/11/1	11:00~15:00	Smoking space was placed in the outside of office (hallway) but not isolated. Air cleaner was installed.
D	2005/11/2	11:00~15:00	No separation (“smoking time” was placed. Occupants were allowed free smoking during the smoking time). In this case, elevator hall (common in the building) was defined as non-smoking space.
E	2005/12/13	10:00~16:00	Smoking room was divided but no partition. Air flow was designed to flow from non-smoking space to smoking space then exhausted.

AIR SMPLING AND CHEMICAL ANALYSIS

ETS makers⁸⁻¹¹⁾

Nicotine and 3-ethenylpyridine (3-ET) were monitored as environmental tobacco smoke (ETS) maker based on ISO 18145 in order to determine the smoking separation effect. Nicotine and 3-ET were collected with XAD-4 tube (20/40 mesh, 120 mg: Supelco) at a constant rate of 1 L/min for over four hours using Mini-pump Σ-300(SIBATA Scientific Technology LTD).

After the sampling, glass wool filled in the head, collection sorbent and buck up sorbent were taken out from the tube, and transferred to vials for extraction. These were extracted by ultrasonic extraction in 1 mL of ethyl acetate (containing 0.01 % trimethylamine) with 5 µg of internal standard (quinoline).

Analysis for the target compounds was performed using an Agilent 6890/5973 GC/MS system in selected ion monitoring (SIM) mode. A 30m×0.25mm i.d. 0.5µm film thickness DB-WAX column was used as the GC analytical column. The base peak ion was used as the quantification ion for each compound. Quantification was performed using quinoline as internal standard. As 3-ET for standard preparing isn't reasonably available as written in ISO 18145, 4-ET was used for quantification of 3-ET.

Volatile Organic Compounds⁷⁾

Volatile organic compounds (VOCs) were determined by solid-phase collection- thermal desorption –GC-MS method. VOCs in air were collected using Tenax-TA plus Carboxene1000 backup (100mg each) at a constant rate of 0.2 L/min for over four hours using Mini-pump Σ-50(SIBATA Scientific Technology LTD).

Chemical analysis was performed using an Agilent 6890/5973 GC-MS system with thermal desorption system (GESTEL TDSA) in scanning mode. A 60m×0.25mm i.d. 1.4µm film thickness DB-624 column was used as the GC analytical column. Quantification was performed using 52 component indoor air standards (SUPELCO). The base peak ion was selected as the quantification ion for each compound. Extra compounds were identified by mass spectrum library search. Then identified compounds were quantified as hexane conversion (till heptane's retention time) or toluene conversion (after heptane's retention time).

Aldehydes

Aldehydes were analyzed by HPLC method. Aldehydes in air were collected using DNPH cartridge (AERO DNPH Cartridge: G L Sciences) as DNPH derivatives at a constant rate of 0.5 L/min for over four hours using Mini-pump Σ-300(SIBATA Scientific Technology LTD).

Chemical analysis was performed using a Shimadzu LC-VP HPLC system. A 250cm×0.46cm i.d. 5µm particle diameter Discovery RP-Amide C16 column was used as the HPLC analytical column. Quantification was performed using mixture of TO11/IP-6A aldehyde / ketone-DNPH, methacrolein-DNPH, 2-butanone-DNPH stock solutions (SUPELCO). Aldehydes and ketone –DNPH derivatives were detected UV detector at 360nm wavelength.

RESULTS AND DISCUSSION

Smoking separation result

Table 2 shows both the result of 3-ET and nicotine concentration in smoking and non-smoking spaces and leakage. Leakage was evaluated using smoking space and non-smoking space result on table 2 as shown in equation 1.

$$\text{Leakage(\%)} = \text{non-smoking space concentration} \times 100 / \text{smoking space concentration (1)}$$

It seems that there is a relationship between smoking space construction (isolation) and smoking separation result. There was observed that nicotine leakage was lower than 3-ET in majority case. It might suggest that nicotine concentration is quickly decreased as a result of oxidization, sticking on the surface of wall and particulate and so on.

Table 2 Result of ETS markers concentration and their leakage to non-smoking space

Building	Space	3-ET		nicotine		Smoking separation
		Concentration (µg/m ³)	Leakage (%)	Concentration (µg/m ³)	Leakage (%)	
A	Smoking	0.94	9	7.7	1	○
	Non-smoking	0.09		0.11		
B	Smoking	4.1	7	42	1	◎
	Non-smoking	0.27		0.38		
C	Smoking	1.0	45	4.9	29	×
	Non-smoking	0.45		1.4		
D	Smoking	1.4	38	4.1	9	×
	Non-smoking	0.52		0.36		
E	Smoking	5.2	6	15	9	△
	Non-smoking	0.34		1.4		

Gaseous chemicals

Determined compounds in smoking space and non-smoking space were categorized into 13 chemical groups and totaled. 13 chemical groups were categorized as follows; saturated hydrocarbons, unsaturated hydrocarbons, cyclic hydrocarbons, alcohols, aldehydes, ketones, organic acids, aromatic hydrocarbons, terpens, chlorinated organic compounds, N-containing compounds, O-containing compounds and esters. A group total concentration between the smoking space and non-smoking space was compared.

Figure 1-1~1-5 shows the result of group total. In most case, the total concentration in non-smoking space was lower than smoking space.

Leakage on 13 chemical groups were evaluated as same as ETS markers using equation 1 and shown in Table 3. In the case of building A, gaseous chemical residue was measured in no-use day. Residue was evaluated using equation 2.

$$\text{Residue(\%)} = \text{no-use day concentration} \times 100 / \text{use day concentration (2)}$$

Saturated hydrocarbons and aromatic hydrocarbons are frequently observable in air due to the emission from construction materials, it is difficult to discuss about relationship of tobacco smoke leakage. Therefore, aldehydes, alcohols, organic acids and N-containing compounds groups were aimed at discussion due to chemical characteristics in tobacco smoke.

In the case of total concentrating of N-containing group that include nicotine and 3-ET, leakage was very similar with ETS markers. It because nicotine and 3-ET was major component of N-containing compounds group total.

In the case of good smoking separation building (A and B), leakage was lower however, it was observed that the concentration in non-smoking space wasn't so low in stink chemical groups (aldehydes, alcohols, ketones and organic acids). In the case of no smoking separation building(C), total concentration of smoking and non-smoking space was approximately same. Especially, aldehyde and organic acids was highly leaked. In the case of building D, there wasn't placed smoking space; elevator hall was measured as non-smoking space. It is interesting that aldehydes concentration in elevator hall was higher than room, highly leaked. Although the stink chemical group concentration is lower in good smoking separation building, aldehydes, organic acids, alcohols and ketones might contribute to tobacco odor because of their low odor threshold.

Table 3 Leakage from smoking space on 13 chemical groups

Building No. Area	A		B	C	D	E
	Leakage %	Residue %	Leakage %	Leakage %	Leakage %	Leakage %
saturated hydrocarbons	81	85	42	58	65	136
unsaturated hydrocarbons	28	13	8	81	47	85
cyclic hydrocarbons	139	55	41	99	64	430
alcohols	80	59	93	81	38	89
aldehydes	73	58	27	92	131	54
ketones	76	22	26	73	13	50
organic acids	62	28	24	137	49	18
aromatic hydrocarbons	76	50	58	84	105	100
terpens	34	87	0	60	54	64
chlorinated organic compounds	136	89	44	96	69	93
N-containing compounds	8	5	1	42	48	35
O-containing compounds	13	432	14	44	97	812
estres	89	0	121	227	73	88
Total	72	52	35	79	60	86

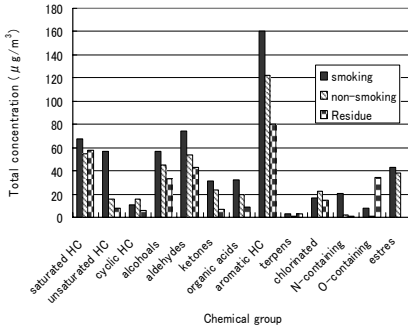


Figure 1-1 Result of measurement (Building A)

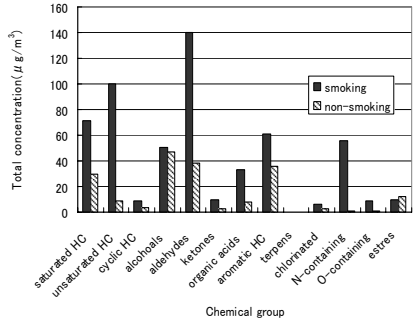


Figure 1-2 Result of measurement (Building B)

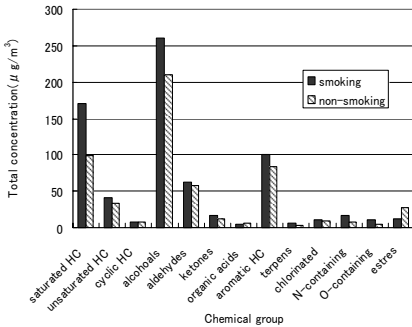


Figure 1-3 Result of measurement (Building C)

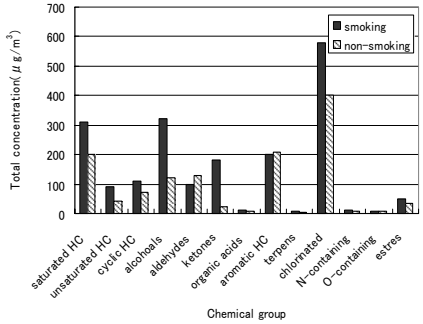


Figure 1-4 Result of measurement (Building D)

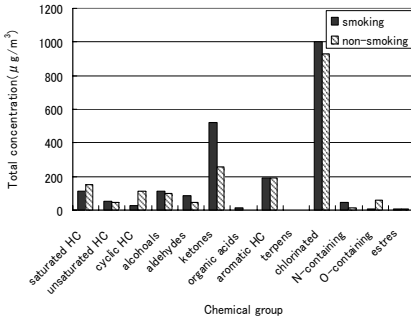


Figure 1-5 Result of measurement (Building E)

CONCLUSIONS

Smoking separation and isolation has been promoting however, tobacco odor leaked out from smoking space, there clearly exist the problem. In this study, five different types of smoking spaces were investigated in order to characterize tobacco odor. Hydrocarbons were difficult to discuss as tobacco odor, but aldehydes, alcohols, organic acids, ketones were highly leaked from smoking space. These chemicals were might contribute to tobacco odor because of their low odor threshold.

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