October 2, 2018

Japan Tobacco Inc.

The Effects of T-Vapor products on Indoor Air Quality

Study on the Impact of T-Vapor products on Indoor Air Quality

Study Conductor	Japan Tobacco Inc.
Test tobacco product	○T-Vapor product A ‣ JT product ○T-Vapor product B ‣ Competitor's product ○Combustible cigarette ‣ JT's leading brand (Tar 6mg)
Study Overview	Investigation of effects on indoor air quality in the designated smoking area and the non-smoking area in a restaurant

- Investigating the effects of using combustible cigarettes or T-Vapor products for 15 minutes on indoor air quality in the designated smoking area and the non-smoking area.
- Restaurant: Total of 28 seats (15 seats in the smoking area, and 13 seats in the non-smoking area)
- The smoking area is surrounded on all sides by walls and partitions, and the automatic sliding door with 1.3m^2 opening area is located at the boundary between the smoking and non-smoking area.
- For ventilation in the smoking area, the ventilation rate is by mechanical facilities (286 m^3 /hour*), and air is supplied naturally through the boundary from the non-smoking area. (The average boundary airflow velocity is 0.06 m/s)
  *In order to set the severe conditions, some of the actual exhaust facilities were closed to reduce the exhaust air volume.
- In the smoking area, 10 smokers used combustible cigarettes or T-Vapor products only.(one cigarette or one T-vapor unit for 15 minutes per a person)
- Total of 10 combustible cigarettes or 10 T-Vapor products used for 15 minutes, and total of three people entered or left the smoking area (6 times opening and closing doors) to evaluate the leakage of the constituents from the smoking area.
- Measurement points were one point in the designated smoking area and 2 points in the non-smoking area. (Both points in the non-smoking area were at 1meter from the boundary.)
- Measured constituents were 15 items
- The research terms used: "During use" (the average of the constituents measured for 15 minutes during use of test tobacco product), "Before use" (the environment where test tobacco product is not used)

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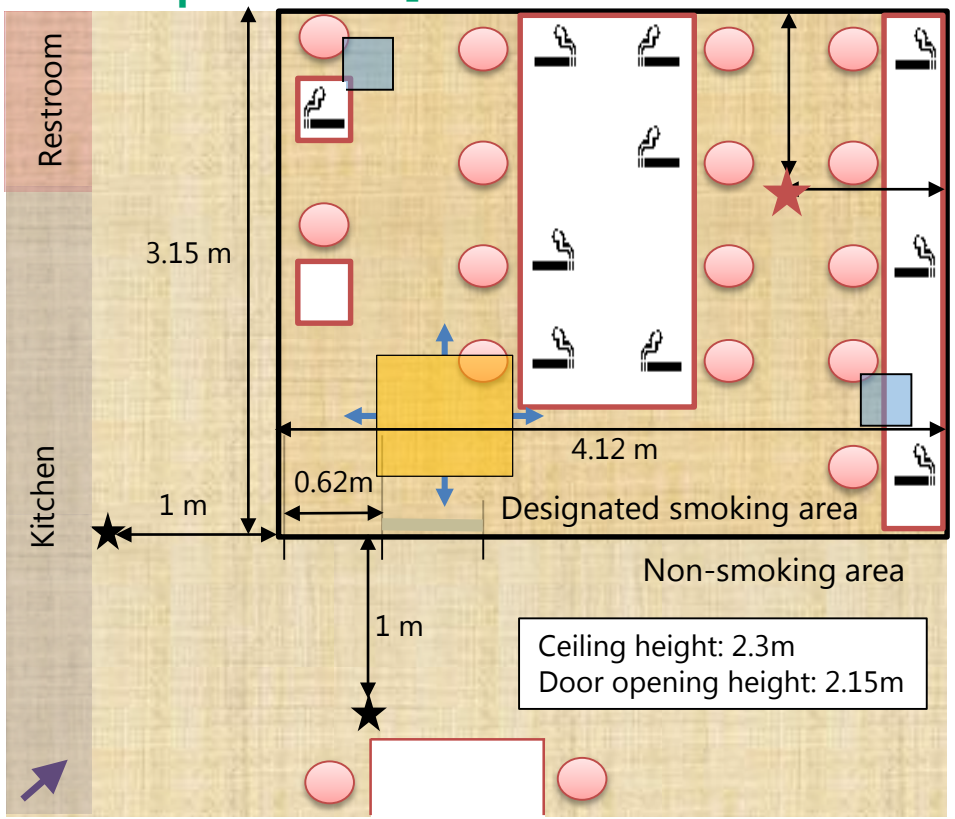
Constituents Measured

Items defined in the Japan act on Maintenance of Sanitation in Buildings	Suspended Particulate Matter (SPM), Carbon monoxide, Formaldehyde	SPM: LD3-K2 Digital Dust Indicator (light scattering measurement, K=0.00052 mg/m^3/CPM), SHIBATA SCIENTIFIC TECHNOLOGY LTD. Carbon monoxide: CO/CO_2 meter (constant potential electrolysis method), SHIBATA SCIENTIFIC TECHNOLOGY LTD. Formaldehyde: adsorbent Collection-Extraction-LC-UV Analytical Method (according to ISO16000-3)
Indicator for indoor air quality	TVOC(Total volatile organic compounds)	GX-6000 TVOC Monitoring (PID detector) ,Riken Trading Co., Ltd.
VOC(Volatile organic compounds)	1,3-Butadiene, Isoprene, Benzene, Toluene	adsorbent Collection-ATD-GC-MS Analytical Method (SIM) (according to ISO16000-6)
Carbonyls	Acetaldehyde, Acrolein, Crotonaldehyde	adsorbent Collection-Extraction-LC-UV Analytical Method (according to ISO16000-3)
Marker compounds of environmental tobacco smoke	3-Ethenylpyridine, Nicotine	adsorbent collection-Extraction-GC-MS (SIM) Analytical Method (according to ISO18145)
Major ingredients of T-Vapor products	Propylene glycol(PG), Glycerin	adsorbent collection-Extraction-GC-MS Analysis (SIM)

【In-store plain view】



: Opening for exhaust air

★ : Measurement points in the non-smoking area (at 1m from the door)

★ : Measurement point in the smoking area (at 1m from the wall)

: Position of using tobacco products

: Automatic Sliding door

: Air conditioning unit (ceiling mounted)

: Camera position and direction for photo

【Inside the store】

Study on the Impact of T-Vapor products on Indoor Air Quality

Study Conditions

	Restaurant (type: cafe)	Notes
Smoking area[m^2]	13.0	
Number of smokers staying in the smoking area[N]	10	Number of seats in smoking area [seats] × percentage of smokers [%] is rounded to the nearest whole number
Number of cigarettes used[units／15minutes･person]	1	The number of cigarettes per 15 minutes is rounded up from the number of cigarettes (units/person･hour)
Number of puffs[puff／15minutes･person]	14	Combustible cigarettes: the number of aspirations per cigarette is free.
Total Number of cigarettes used[units／15minutes]	10	Number of smokers staying × Number of cigarettes used [units/15 minutes per person]
Ventilation rate[m^3／h]	286	Measured value by airflow meter
Entry and exit from smoking area [times/15minutes]	6 (3 times entrances and 3 times exits)	10 smokers staying (assuming 10 groups of smokers staying) Calculated from 10 times(entry and exit)/46 minutes (average stay time of cafe (* Cross-marketing Co., Ltd.)) × 15 minutes (test time))
Entrance/Exit Interval [minutes]	2	Every 2-minute after starting smoking (2, 4, 6, 8, 10, 12 minutes after starting test: total 6 times)

Study on the Impact of T-Vapor products on Indoor Air Quality

Reference Conditions

	Restaurant (type: cafe)	Notes
Number of seats in smoking area［seats］	**15**	Actual number of the seats in smoking area
Percentage of smokers in smoking area［%］	**68.7**	The smoker prevalence in FY2017 (18.2%) (Since the percentage of smoking seats is 53%, 0.182/0.53=34.3, in addition, it is doubled to 34.3×2 in order to conduct tests under severe conditions.)
Operation rate［%］	**100**	Setting the severe conditions
Number of cigarettes used［units/h･person］	**3.8**	See Number of cigarettes used in a restaurant (The survey by Cross Marketing, Inc. (2016))

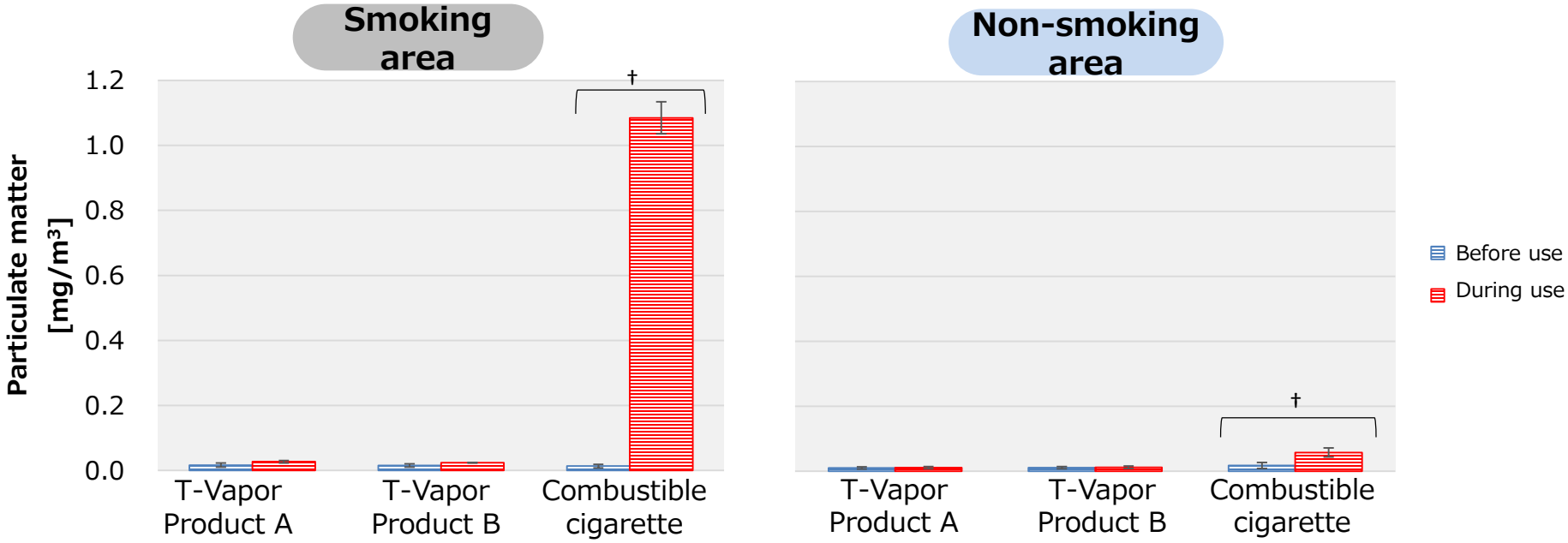
The result of the concentration of particulate matter

The concentration of particulate matter in the smoking area by the use of T-Vapor products greatly differed from that of combustible cigarettes.

- The concentration of particulate matter was increased when combustible cigarettes were used, while in terms of T-Vapor products, it was almost unchanged* before and during use.

The concentration of particulate matter in the non-smoking area also differed between the use of T-Vapor products and combustible cigarette smoking.

- The concentration of particulate matter was increased when combustible cigarettes were used, while in terms of T-Vapor products, it was almost unchanged* before and during use.



※There was no significant difference in the concentration of particulate matter between before and during use of T-Vapor products

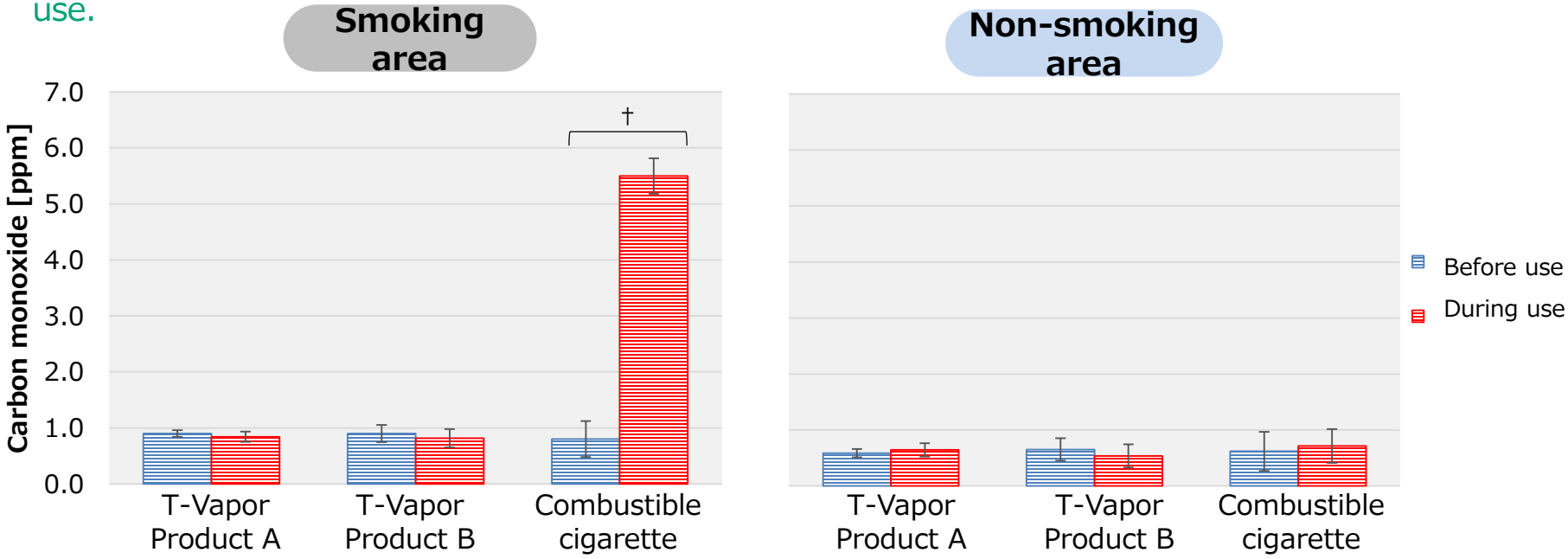
† : A significant difference is found out (One-tailed test: $p < 0.05$)

The result of carbon monoxide concentration

The concentration of carbon monoxide in the smoking area by the use of T-Vapor products greatly differed from that of combustible cigarettes.

- The concentration of carbon monoxide was increased when combustible cigarettes were used, while in terms of T-Vapor products, it was almost unchanged* before and during use.

Carbon monoxide concentrations in the non-smoking area was almost unchanged* before and during use of either combustible cigarettes or T-Vapor products.



※There was no significant difference in carbon monoxide concentration between before and during use

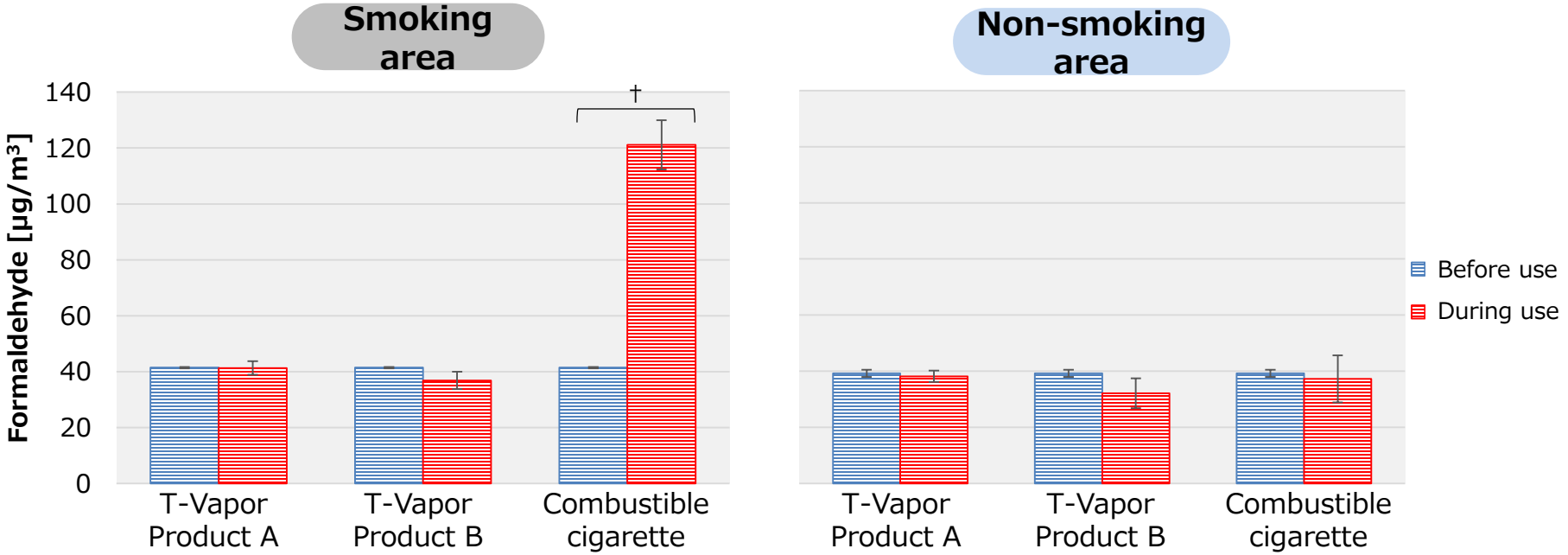
† : A significant difference is found out (One-tailed test: $p < 0.05$)

The results of formaldehyde concentration

The concentration of formaldehyde in the smoking area by the use of T-Vapor products greatly differed from that of combustible cigarettes.

- The concentration of formaldehyde was increased when combustible cigarettes were used, while in terms of T-Vapor products, it was almost unchanged* before and during use.

Formaldehyde concentrations in the non-smoking area was almost unchanged* before and during use of either combustible cigarettes or T-Vapor products.



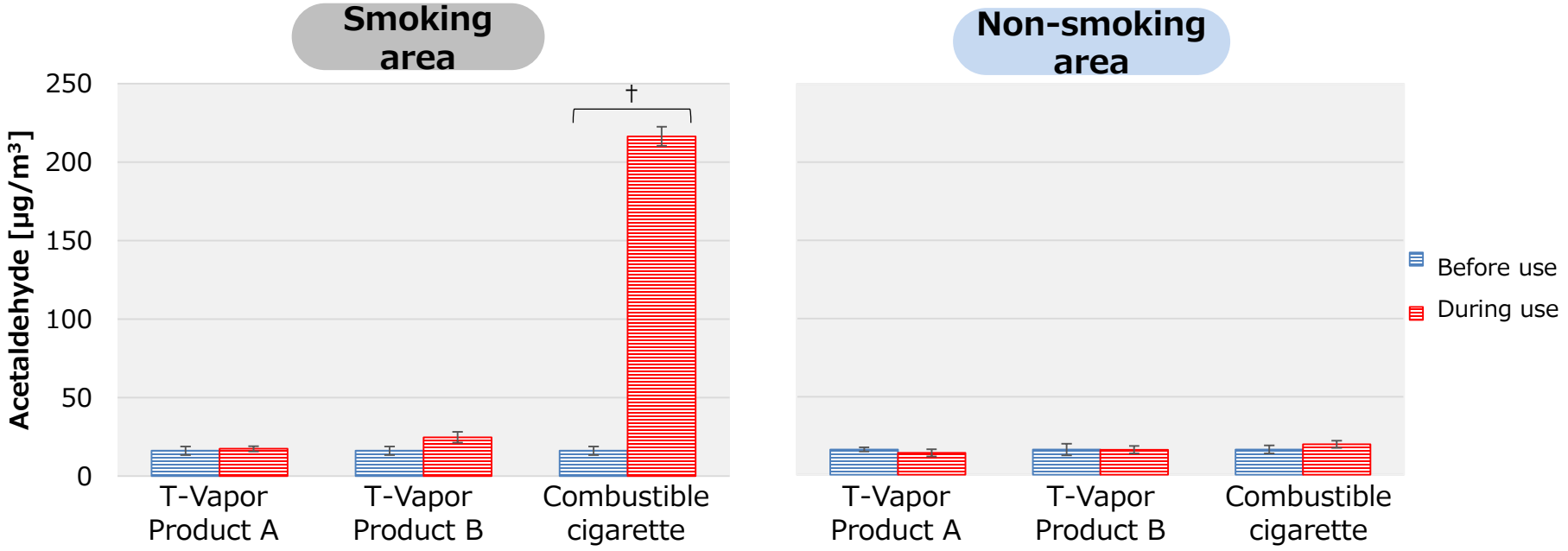
※There was no significant difference in formaldehyde concentration between before and during use

† : A significant difference is found out (One-tailed test: $p < 0.05$)

The concentration of acetaldehyde in the smoking area by the use of T-Vapor products greatly differed from that of combustible cigarettes.

- The concentration of acetaldehyde was increased when combustible cigarettes were used, while in terms of T-Vapor products, it was almost unchanged* before and during use.

Acetaldehyde concentrations in the non-smoking area was almost unchanged* before and during use of either combustible cigarettes or T-Vapor products.



※There was no significant difference in acetaldehyde concentration between before and during use

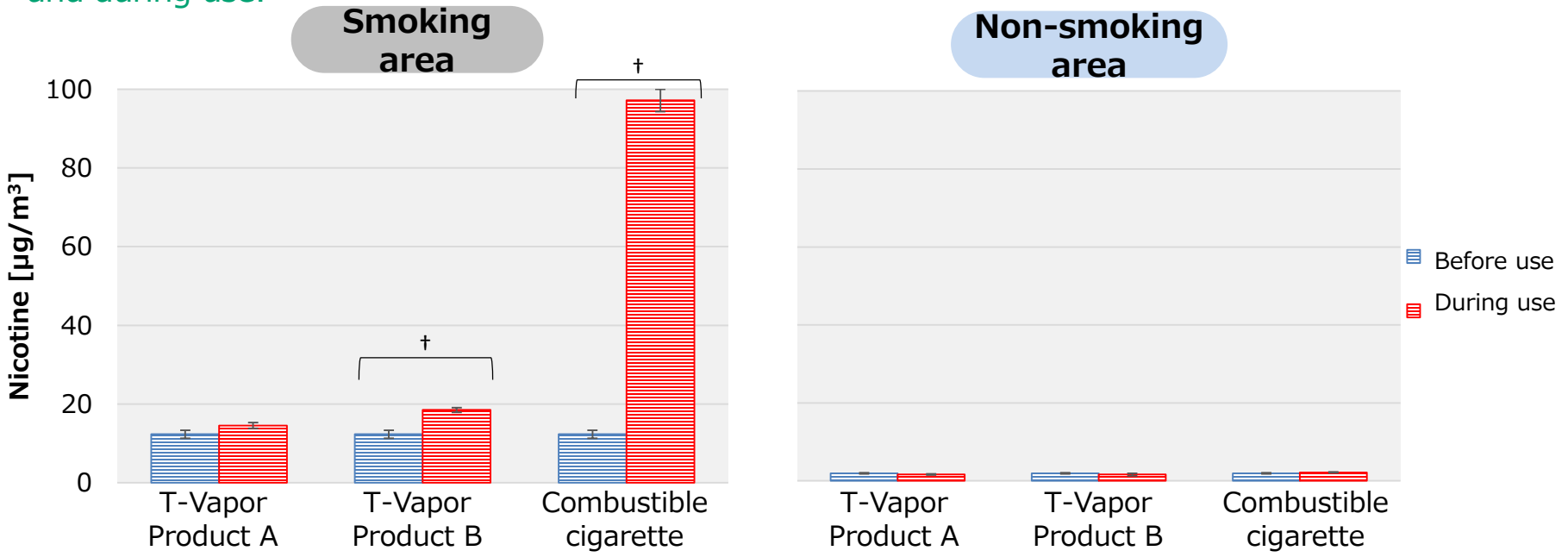
† : A significant difference is found out (One-tailed test: $p < 0.05$)

The results of nicotine concentration

The concentration of nicotine in the smoking area by the use of T-Vapor products greatly differed from that of combustible cigarettes.

- The concentration of nicotine was increased when combustible cigarettes or T-Vapor product B were used, while in terms of T-Vapor products A, it was almost unchanged* before and during use.

Nicotine concentrations in the non-smoking area was almost unchanged* before and during use of either combustible cigarettes or T-Vapor products.



※There was no significant difference in nicotine concentration between before and during use

† : A significant difference is found out (One-tailed test: $p < 0.05$)

Table of the measurements

Constituents		Designated smoking area: Before use	Designated smoking area: T-Vapor Product A	Designated smoking area: T-Vapor Product B	Designated smoking area: Combustible Cigarette	Non-smoking area: Before use	Non-smoking area: T-Vapor Product A	Non-smoking area: T-Vapor Product B	Non-smoking area: Combustible Cigarette	LOQ	LOD
Marker compounds of environmental tobacco smoke											
(Vapor phase)											
Nicotine	($\mu g/m^3$)	12.3 ± 1.1	14.6 ± 0.7	18.5 ± 0.6 †	97.1 ± 2.8 †	1.93 ± 0.16	1.64 ± 0.13	1.63 ± 0.33	2.17 ± 0.12	0.847	0.254
3-Ethenylpyridine	($\mu g/m^3$)	0.658 ± 0.116	0.502*	0.541 ± 0.032	23.3 ± 0.7 †	<0.478	<0.478	<0.478	<0.478	0.478	0.143
Carbonyls											
Formaldehyde	($\mu g/m^3$)	41.4 ± 0.2	41.3 ± 2.4	36.9 ± 3.1	121 ± 9 †	39.3 ± 1.3	38.2 ± 2.0	32.1 ± 5.3	37.3 ± 8.4	2.34	0.703
Acetaldehyde	($\mu g/m^3$)	16.2 ± 2.7	17.4 ± 1.6	24.7 ± 3.5	216 ± 6 †	13.4 ± 2.3	14.0 ± 1.3	16.1 ± 3.7	19.5 ± 2.5	2.58	0.773
Crotonaldehyde	($\mu g/m^3$)	<1.76	<1.76	<1.76	7.85 ± 0.27	<1.76	<1.76	<1.76	<1.76	5.86	1.76
Acrolein	($\mu g/m^3$)	<1.24	<1.24	<1.24	7.96 ± 0.36	<1.24	<1.24	<1.24	<1.24	4.13	1.24
VOCs											
1,3-butadiene	($\mu g/m^3$)	<2.68	<2.68	<2.68	35.7 ± 3.2	<0.804	<0.804	<0.804	<2.68	2.68	0.804
Isoprene	($\mu g/m^3$)	<1.87	<1.87	<1.87	10.9 ± 0.6	<0.560	<0.560	<0.560	<1.87	1.87	0.560
Benzene	($\mu g/m^3$)	<0.492	<0.492	<0.492	26.4 ± 1.2	<0.492	<0.492	<0.492	<0.492	1.64	0.492
Toluene	($\mu g/m^3$)	<1.43	<1.43	<1.43	55.4 ± 10.6	<0.428	<0.428	<0.428	<1.43	1.43	0.428
Major ingredients of T-Vapor products											
Propylene glycol	($\mu g/m^3$)	4.33 ± 0.90	4.77 ± 0.21	17.3 ± 0.9 †	9.62 ± 0.21 †	<2.66	<2.66	<2.66	<2.66	2.66	0.799
Glycerin	($\mu g/m^3$)	<1.67	25.1 ± 2.4	20.1 ± 3.1	30.3 ± 1.9	<5.57	<5.57	<1.67	<5.57	5.57	1.67
Suspended particulate matter (SPM: <10um)	(mg/m^3)	Before use	0.016 ± 0.006	0.015 ± 0.005	0.013 ± 0.005		0.011 ± 0.00	0.011 ± 0.003	0.018 ± 0.009		
		After use	0.027 ± 0.004	0.024 ± 0.001	1.085 ± 0.049 †		0.012 ± 0.004	0.012 ± 0.004	0.058 ± 0.014 †		
TVOC	(ppm)	Before use	1.8 ± 0.1	1.9 ± 0.1	1.6 ± 0.0		0.6 ± 0.1	0.8 ± 0.2	0.7 ± 0.3	※Minimum measurable concentration: 0.1	
		After use	1.8 ± 0.1	1.9 ± 0.1	2.1 ± 0.0		0.6 ± 0.0	0.8 ± 0.2	0.8 ± 0.2		
CO	(ppm)	Before use	0.9 ± 0.1	0.9 ± 0.2	0.8 ± 0.3		0.6 ± 0.1	0.7 ± 0.2	0.6 ± 0.3	※Minimum measurable concentration: 0.1	
		After use	0.8 ± 0.1	0.8 ± 0.2	5.5 ± 0.3 †		0.6 ± 0.1	0.5 ± 0.2	0.7 ± 0.3		

† : A significant difference is found out (One-tailed test: $p < 0.05$)

* : Median

LOQ: Limit Of Quantitation, LOD: Limit Of Detection

The summary of the results

T-Vapor product A:

In the both smoking area and non-smoking area, concentrations of all target constituents quantified* did not show the significant increases between before and during use.

T-Vapor product B:

In the smoking area, concentrations of PG and nicotine were increased, while other target constituents quantified* did not show the significant increases before and during use.

In the non-smoking area, no significant increases were observed among all constituents quantified.

Combustible cigarette:

In the smoking area, the concentration of almost all constituents measured were increased.

In the non-smoking area, the concentration of particulate matter was significantly increased.

*except Glycerin, which was not quantified in the “before use” conditions

- From the above, if **T-Vapor products are used in smoking area (with doors and exhaust facilities)**, the constituents derived from T-Vapor products **will not have an effect on indoor air quality in the non-smoking area.**
- On the other hand, when smoking combustible cigarettes in a smoking area (boundary airflow velocity 0.06 m/sec) as in this study, it is necessary to secure a certain boundary airflow velocity* in order to prevent unintended passive smoking because it affects indoor air quality in the non-smoking area.

※According to Ministry of Health, Labor and Welfare in “the Report on Study Committee on Determination of Smoking Effect Standards Determination”, boundary wind speed of 0.2 m/s or more is preferable

Based on this study, we believe that the designated smoking area for T-Vapor products with door and common ventilation facility have no effects on indoor air quality in non-smoking area.