This supplementary material include five identified emission profiles for specific vehicle category under particular running modes.
Table lists:

Table S1. The identified profile (weight%) of tailpipe exhaust emission for gasoline vehicles without TWC running under the normal mode (47 species), based on a wide literature review.

Table S2. The identified profile (weight%) of tailpipe exhaust emission for gasoline vehicles running under the freeway mode (59 species), based on a wide literature review.

Table S3. The identified profile (weight%) of tailpipe exhaust emission for diesel vehicles running under the normal mode (57 species), based on a wide literature review.

Table S4. The identified profile (weight%) of tailpipe exhaust emission for diesel vehicles running under the freeway mode (57 species), based on a wide literature review.

Table S5. The identified profile (weight%) of tailpipe exhaust emission for motorcycles (59 species), based on a wide literature review.

Table S1. The identified profile (weight%) of tailpipe exhaust emission for gasoline vehicles without TWC running under the normal mode (47 species), based on a wide literature review.

Species	Schauer et al., 2002	Duffy et al., 1999	Schmitz et al., 2000[a]	Schmitz et al., 2000[b]	Normalized averages
isopentane	6.92	Nd	16.33	6.04	11.04
2,3-dimethylbutane	1.20	0.60	0.67	1.54	1.13
ethane	0.15	1.20	4.31	1.52	2.03
pentane	2.16	4.20	7.52	2.74	4.70
isooctane	4.35	0.30	0.66	1.18	1.83
2-methylpentane	3.33	2.60	1.55	2.27	2.75
butane	0.77	2.40	1.98	1.53	1.89
3-methylpentane	2.06	2.20	0.98	1.41	1.88
hexane	1.65	1.90	0.84	1.47	1.66
2,2-dimethylbutane	0.79	Nd	1.06	0.74	0.97
3-methylhexane	1.67	Nd	0.57	1.10	1.26
2,4-dimethylpentane	1.43	0.40	0.65	0.92	0.96
2-methylhexane	1.50	Nd	0.48	0.96	1.11
heptane	1.08	0.60	0.36	0.86	0.82
3-methylheptane	Nd	Nd	0.20	0.62	0.46
2,3-dimethylpentane	2.87	Nd	0.19	0.36	1.29
octane	0.64	Nd	0.15	0.40	0.45
methylcyclohexane	1.10	0.30	0.10	0.34	0.52
propane	0.04	0.20	0.35	0.12	0.20
cyclohexane	0.96	0.20	0.21	0.28	0.46
nonane	0.18	0.10	0.04	0.17	0.14
decane	0.17	Nd	0.00	0.06	0.09
ethene	2.88	7.20	0.75	6.82	4.99
propene	1.76	5.10	0.78	3.35	3.10
1,3-butadiene	Nd	1.00	0.02	0.39	0.53
trans-2-butene	0.28	0.50	0.10	0.36	0.35
cis-2-butene	0.15	0.30	0.07	0.26	0.22
trans-2-pentene	0.31	Nd	0.39	0.30	0.38
1-pentene	0.21	Nd	0.29	0.19	0.26
1-hexene	0.07	Nd	0.03	0.15	0.10
cis-2-pentene	0.17	Nd	0.22	0.15	0.20
1-butene	Nd	2.20	0.00	0.00	0.83
ethyne	3.48	8.40	0.32	4.28	4.66
propyne	Nd	0.50	0.00	0.00	0.19
toluene	9.50	13.80	5.70	17.49	13.14
m,p-xylene	6.92	6.60	3.37	9.96	7.59
benzene	1.90	7.90	3.77	7.17	5.86

1,2,4-trimethylbenzene	2.42	1.20	3.36	4.11	3.13
ethylbenzene	1.75	1.80	1.25	3.94	2.47
o-xylene	2.26	2.50	1.30	3.75	2.77
propylbenzene	0.39	0.40	1.61	3.08	1.55
styrene	Nd	0.30	0.51	1.01	0.68
formaldehyde	3.56	Nd	11.97	0.93	6.20
benzaldehyde	0.64	Nd	2.52	0.65	1.44
acrolein	0.02	Nd	0.86	0.04	0.34
acetaldehyde	1.21	Nd	0.94	0.34	0.94
acetone	0.17	Nd	0.86	0.10	0.42

[a] referred to the warm phase measurements; [b] referred to the cold start phase measurements; and Nd means not detected.

Table S2. The identified profile (weight%) of tailpipe exhaust emission for gasoline vehicles running under the freeway mode (59 species), based on a wide literature review.

Species	Staeheli n et al., 1998	Sagebie l et al., 1996[a]	Sagebie l et al., 1996[b]	Duffy and Nelson , 1996	Schmit z et al., 2000[c]	Schmit z et al., 2000[d]	Roga k et al., 1998	Normalize d averages
isopentane	Nd	8.34	7.90	Nd	4.08	4.94	7.01	6.63
pentane	2.84	2.53	2.98	2.50	1.28	2.23	2.94	2.54
ethane	1.98	1.41	1.90	2.00	1.52	2.72	2.22	2.02
butane	4.47	1.69	2.75	3.90	0.89	1.37	4.39	2.86
2-methylpentane	Nd	2.70	2.60	2.60	0.92	1.54	2.64	2.23
isooctane	Nd	3.02	2.12	Nd	0.96	0.66	2.94	1.99
2,3-dimethylpentane	3.98	0.78	0.66	Nd	0.18	0.18	1.93	1.32
3-methylpentane	Nd	1.52	1.62	1.70	0.53	0.92	1.67	1.36
hexane	0.80	1.23	1.29	1.60	0.48	0.93	1.53	1.15
propane	0.07	0.09	0.32	4.40	0.10	0.15	7.45	1.85
3-methylhexane	Nd	1.28	0.82	Nd	0.38	0.60	0.89	0.82
methylcyclopentane	Nd	0.93	1.04	1.00	Nd	Nd	0.95	1.01
2,3-dimethylbutane	Nd	1.00	0.76	Nd	1.52	0.71	0.81	0.99
2,2-dimethylbutane	Nd	0.73	0.80	Nd	0.44	0.58	0.27	0.58
cyclohexane	2.09	0.16	0.30	0.40	0.10	0.20	0.21	0.51
heptane	0.44	0.64	0.52	0.70	0.27	0.42	0.63	0.53
2,4-dimethylpentane	Nd	0.65	0.53	0.40	0.34	0.64	1.14	0.63
methylcyclohexane	Nd	0.38	0.41	0.50	0.12	0.19	0.28	0.32
2-methylheptane	Nd	0.40	0.43	Nd	0.19	0.59	0.31	0.40
3-methylheptane	Nd	0.42	0.39	Nd	0.23	0.29	0.35	0.35
isobutane	Nd	0.20	0.52	Nd	0.62	0.85	-0.07	0.43
octane	0.18	0.28	0.23	0.30	0.13	0.17	0.26	0.23
nonane	0.16	0.20	0.05	Nd	0.05	0.05	0.17	0.12
decane	0.01	0.20	0.02	Nd	0.02	0.01	0.17	0.08
ethene	11.12	5.73	7.90	6.30	13.56	12.95	Nd	9.86
propene	6.42	2.18	3.16	5.20	7.25	5.65	Nd	5.11
1-butene	0.88	1.46	2.87	2.70	0.00	0.00	Nd	1.36
2-methyl-2-butene	0.95	Nd	Nd	Nd	Nd	Nd	Nd	0.97
1,3-butadiene	Nd	0.46	0.69	1.10	0.50	0.52	Nd	0.67
2-methyl-1-butene	0.74	Nd	Nd	Nd	Nd	Nd	Nd	0.76
trans-2-pentene	0.56	0.56	0.58	Nd	0.16	0.08	Nd	0.40
trans-2-butene	Nd	0.33	0.29	0.70	0.44	0.24	Nd	0.41
cis-2-butene	Nd	0.24	0.43	0.60	0.31	0.18	Nd	0.36
cis-2-pentene	0.36	0.33	0.37	Nd	0.09	0.04	Nd	0.25
isoprene	Nd	0.28	0.34	Nd	0.03	0.17	Nd	0.21

1-pentene	0.28	0.28	0.28	Nd	0.16	0.07	Nd	0.22
cyclopentene	Nd	0.20	0.18	0.20	Nd	Nd	Nd	0.20
1-hexene	Nd	0.05	0.29	Nd	0.14	0.05	Nd	0.13
ethyne	5.91	1.96	2.14	6.70	8.27	0.38	Nd	4.34
propyne	Nd	Nd	Nd	0.50	0.00	0.00	Nd	0.17
toluene	7.38	7.46	7.80	9.30	18.00	17.94	Nd	11.62
m,p-xylene	4.97	6.25	5.77	4.90	7.46	6.41	Nd	6.12
benzene	4.76	3.87	5.03	5.20	7.10	20.91	Nd	8.03
1,2,4-trimethylbenzene	2.11	3.95	2.90	Nd	3.31	1.53	Nd	2.84
ethylbenzene	1.66	1.84	1.54	1.30	3.31	1.88	Nd	1.97
o-xylene	2.20	2.29	2.20	1.80	2.80	2.00	Nd	2.27
propylbenzene	0.31	0.58	0.45	Nd	2.30	0.77	Nd	0.91
1,2,3-trimethylbenzene	0.45	0.95	0.76	Nd	1.04	0.44	Nd	0.75
styrene	Nd	0.82	0.87	Nd	0.67	0.90	Nd	0.84
m,p-ethyltoluene	2.16	3.19	2.42	1.30	Nd	Nd	Nd	2.33
o-ethyltoluene	0.61	0.91	0.74	0.40	Nd	Nd	Nd	0.68
1,3,5-trimethylbenzene	0.70	1.06	0.91	1.10	Nd	Nd	Nd	0.97
formaldehyde	4.85	1.13	2.13	Nd	2.11	0.47	Nd	2.20
benzaldehyde	Nd	Nd	Nd	Nd	0.90	0.72	Nd	0.83
acrolein	0.59	Nd	Nd	Nd	0.36	0.13	Nd	0.37
acetaldehyde	1.07	Nd	Nd	Nd	0.33	0.38	Nd	0.61
acetone	0.51	Nd	Nd	Nd	0.06	0.13	Nd	0.24
propionaldehyde	0.08	Nd	Nd	Nd	0.05	0.00	Nd	0.04
methylethylketone	0.04	Nd	Nd	Nd	0.04	0.00	Nd	0.03

a referred to the Fort McHenry Tunnel measurements; b referred to the Tuscarora Mountain Tunnel measurements; c referred to the measurements for gasoline vehicles without TWC; d referred to the measurements for gasoline vehicles with TWC; and Nd means not detected.

Table S3. The identified profile (weight%) of tailpipe exhaust emission for diesel vehicles running under the normal mode (57 species), based on a wide literature review.

Species	Schmitz et al., 2000[a]	Schmitz et al., 2000[b]	Liu et al., 2008[c]	Normalized averages
isopentane	3.80	3.00	0.71	2.67
2,3-dimethylbutane	0.45	0.52	0.00	0.35
ethane	1.06	1.24	1.04	1.19
pentane	0.74	0.56	0.17	0.52
isooctane	0.03	0.04	0.00	0.03
2-methylpentane	0.12	0.14	1.60	0.66
butane	0.16	0.12	0.13	0.15
isobutane	0.03	0.03	0.11	0.06
3-methylpentane	0.01	0.01	0.25	0.10
hexane	0.02	0.03	0.19	0.08
2,2-dimethylbutane	0.42	0.47	0.00	0.32
3-methylhexane	0.28	0.33	0.00	0.22
2,4-dimethylpentane	0.05	0.04	0.00	0.03
2-methylhexane	0.12	0.18	0.30	0.21
heptane	0.07	0.07	0.33	0.16
3-methylheptane	0.06	0.06	Nd	0.07
2-methylheptane	0.07	0.08	0.29	0.16
2,3-dimethylpentane	0.00	0.02	0.95	0.34
octane	0.11	0.11	0.75	0.35
methylcyclohexane	0.07	0.08	0.33	0.17
propane	0.16	0.19	0.18	0.19
cyclohexane	0.05	0.17	0.00	0.08
nonane	0.46	0.46	3.64	1.62
decane	1.14	1.32	5.22	2.74
ethene	26.40	28.02	6.67	21.73
propene	7.99	9.10	7.69	8.82
1,3-butadiene	1.11	1.08	0.00	0.78
trans-2-butene	0.31	0.33	0.43	0.38
cis-2-butene	0.21	0.21	0.26	0.24
trans-2-pentene	0.18	0.18	0.22	0.21
1-pentene	0.97	1.30	1.27	1.26
1-hexene	0.96	1.40	Nd	1.26
cis-2-pentene	0.11	0.11	0.13	0.12
isoprene	0.12	0.19	0.00	0.11
1-butene	0.00	0.00	3.15	1.12
ethyne	7.00	8.80	0.52	5.81
propyne	0.00	0.00	0.54	0.19

toluene	1.26	1.42	1.40	1.45
m,p-xylene	0.53	0.63	1.64	1.00
benzene	5.07	5.07	2.89	4.64
1,2,4-trimethylbenzene	0.73	0.87	3.75	1.91
ethylbenzene	0.22	0.28	0.62	0.40
o-xylene	0.24	0.34	0.82	0.50
propylbenzene	0.24	0.33	0.46	0.36
1,2,3-trimethylbenzene	0.11	0.14	1.69	0.69
styrene	0.41	0.47	0.24	0.40
o-ethyltoluene	Nd	Nd	0.56	0.60
m-ethyltoluene	Nd	Nd	2.83	3.02
formaldehyde	19.18	13.14	Nd	17.25
benzaldehyde	0.66	0.75	Nd	0.75
acrolein	1.13	1.23	Nd	1.26
acetaldehyde	6.04	6.09	Nd	6.48
acetone	1.93	1.50	Nd	1.83
butyraldehyde	0.63	0.74	Nd	0.73
propionaldehyde	1.12	1.45	Nd	1.37
methylethylketone	0.00	0.00	Nd	0.00
valeraldehyde	0.88	0.77	Nd	0.88

[a] referred to the warm phase measurements; [b] referred to the cold start phase measurements; c means that the results from Liu et al. (2008) were revised by mutiplying a factor of 0.74 to be comparable with other measurements, because the original measurements by Liu et al. (2008) did not include carbonyls, which were considered to account for 26% of diesel NMVOC emissions; and Nd means not detected.

Table S4. The identified profile (weight%) of tailpipe exhaust emission for diesel vehicles running under the freeway mode (57 species), based on a wide literature review.

Species	Sagebiel et al., 1996[a]	Sagebiel et al., 1996[b]	Schmitz et al., 2000	Staehelin et al., 1998	Normalized averages
ethane	0.46	0.23	1.55	0.62	0.99
propane	0.87	0.46	0.17	1.12	0.90
butane	0.25	1.37	0.53	5.31	2.57
pentane	0.60	1.34	2.20	3.07	2.48
hexane	0.38	0.89	0.04	0.55	0.64
heptane	0.23	0.44	0.04	1.03	0.60
octane	0.12	0.35	0.08	0.26	0.28
nonane	0.44	0.31	0.37	0.33	0.50
decane	1.03	0.79	0.37	1.50	1.27
isobutane	0.11	0.44	0.09	Nd	0.29
isopentane	0.52	4.44	6.28	Nd	5.17
2,2-dimethylbutane	1.03	1.76	0.68	Nd	1.60
cyclopentane	0.12	0.13	Nd	Nd	0.17
2,3-dimethylbutane	0.13	0.46	0.15	Nd	0.34
2-methylpentane	0.78	1.44	0.41	Nd	1.21
3-methylpentane	0.36	0.88	0.00	Nd	0.57
2,4-dimethylpentane	0.14	0.17	0.21	Nd	0.24
cyclohexane	0.09	0.19	0.08	1.19	0.54
2,3-dimethylpentane	0.36	0.27	0.01	3.20	1.32
3-methylhexane	0.91	0.59	0.18	Nd	0.77
isooctane	0.58	0.95	0.03	Nd	0.72
methylcyclohexane	0.17	0.23	0.05	Nd	0.21
2-methylheptane	-0.03	0.37	0.11	Nd	0.21
3-methylheptane	0.17	0.26	0.07	Nd	0.23
ethene	3.88	5.09	20.37	8.79	13.15
ethyne	1.00	0.92	7.97	3.08	4.48
propene	1.57	2.34	5.43	4.37	4.73
1-butene	1.16	1.69	Nd	0.97	1.32
1,3-butadien	0.12	0.58	0.21	Nd	0.42
trans-2-butene	0.10	0.00	0.15	Nd	0.11
cis-2-butene	0.12	0.21	0.10	Nd	0.19
3-methyl-l-butene	0.11	0.20	Nd	0.38	0.32
1-pentene	0.35	0.46	0.64	0.67	0.73
2-methyl-l-butene	0.22	0.37	Nd	0.78	0.63
isoprene	-0.03	0.25	0.07	Nd	0.14
trans-2-pentene	0.14	0.40	0.04	0.68	0.43
cis-2-pentene	0.11	0.15	0.03	0.40	0.24

2-methyl-2-butene	0.25	0.26	Nd	0.89	0.65
1-hexene	0.30	0.37	0.78	Nd	0.66
benzene	1.26	2.00	6.65	4.07	4.82
toluene	1.77	3.22	4.25	6.44	5.41
ethylbenzene	1.12	0.58	0.23	1.40	1.15
m,p-xylene	4.33	2.51	0.80	5.29	4.46
styrene	0.73	0.67	0.28	Nd	0.77
o-xylene	1.47	1.00	0.04	1.22	1.29
propylbenzene	0.13	0.17	0.04	0.05	0.14
n-propylbenzene	0.42	0.24	Nd	0.36	0.47
m,p-ethyltoluene	2.19	1.31	Nd	1.56	2.32
1,3,5-trimethylbenzene	0.82	0.52	Nd	0.53	0.86
o-ethyitoluene	0.79	0.72	Nd	0.31	0.84
1,2,4-trimethylbenzene	2.94	1.55	0.29	1.87	2.29
1,2,3-trimethylbenzene	0.68	0.54	0.06	0.47	0.60
formaldehyde	3.42	6.31	11.81	13.19	11.98
acetaldehyde	Nd	Nd	5.84	2.85	5.99
acetone	Nd	Nd	2.11	1.55	2.53
acrolein	Nd	Nd	0.98	1.41	1.65
propionaldehyde	Nd	Nd	Nd	0.61	0.42

a referred to the Fort McHenry Tunnel measurements; b referred to the Tuscarora Mountain Tunnel measurements; and Nd means not detected.

Table S5. The identified profile (weight%) of tailpipe exhaust emission for motorcycles (59 species), based on a wide literature review.

Species	Liu et al., 2008	Schmitz et al., 2000[a]	Schmitz et al., 2000[b]	Rogak et al., 1998	Normalized averages
ethane	1.12	0.16	0.16	0.35	0.68
isopentane	7.92	23.86	23.83	Nd	12.04
2,3-dimethylbutane	1.15	0.74	0.74	0.37	1.14
pentane	1.76	6.85	6.84	8.55	9.12
isooctane	0.60	0.38	0.39	0.62	0.76
2-methylpentane	5.65	0.32	0.32	4.12	3.96
butane	0.51	14.00	13.98	0.81	2.01
isobutane	0.55	5.83	5.82	Nd	0.84
3-methylpentane	3.52	0.19	0.19	2.77	2.53
hexane	1.56	0.17	0.17	5.01	2.63
2,2-dimethylbutane	0.16	0.15	0.15	0.29	0.28
3-methylhexane	2.76	0.13	0.14	Nd	1.54
2,4-dimethylpentane	0.76	0.11	0.11	0.40	0.52
2-methylhexane	3.20	0.12	0.12	Nd	1.74
heptane	1.08	0.11	0.11	2.94	1.61
3-mehtylheptane	1.57	0.10	0.11	1.69	1.32
2-methylheptane	1.42	0.07	0.07	1.29	1.08
2,3-dimethylpentane	0.75	0.07	0.07	0.76	0.63
octane	0.81	0.05	0.05	1.43	0.89
methylcyclohexane	1.44	0.04	0.04	0.13	0.63
propane	0.09	0.83	0.82	0.13	0.71
cyclohexane	0.37	0.03	0.04	0.89	0.51
nonane	0.40	0.02	0.02	0.36	0.30
decane	0.22	0.01	0.01	0.10	0.13
ethene	5.79	1.21	1.20	3.10	4.30
propene	2.04	0.73	0.72	1.59	1.93
1,3-butadiene	0.38	0.11	0.08	Nd	0.29
trans-2-butene	0.90	0.09	0.07	Nd	0.54
cis-2-butene	0.78	0.06	0.05	Nd	0.45
trans-2-pentene	2.34	0.07	0.06	Nd	1.25
1-pentene	0.88	0.04	0.04	Nd	0.49
cis-2-pentene	1.28	0.04	0.03	Nd	0.68
isoprene	0.00	0.03	0.02	0.09	0.05
1-butene	2.16	0.00	0.00	Nd	1.09
2-methyl-2-butene	3.61	Nd	Nd	Nd	5.49
cis-3-heptene	1.47	Nd	Nd	Nd	2.24
2-methyl-1-butene	1.27	Nd	Nd	Nd	1.93
ethyne	0.56	0.87	1.06	3.38	2.23
propyne	0.26	0.00	0.00	0.20	0.17

toluene	4.48	4.76	4.93	9.06	8.83
m,p-xylene	5.31	1.58	1.67	6.24	5.62
benzene	1.46	1.63	1.65	2.77	2.86
1,2,4-trimethylbenzene	2.02	0.88	0.90	1.15	1.88
ethylbenzene	1.06	0.73	0.76	1.81	1.66
o-xylene	1.97	0.63	0.67	2.04	2.02
propylbenzene	0.24	0.60	0.63	0.04	0.57
1,2,3-trimethylbenzene	0.45	0.27	0.28	0.16	0.44
styrene	0.00	0.16	0.15	Nd	0.16
m,p-ethyltoluene	2.09	Nd	Nd	1.32	2.59
1,3,5-trimetylbenzene	1.06	Nd	Nd	0.58	1.25
formaldehyde	Nd	0.61	0.39	Nd	0.76
benzaldehyde	Nd	0.20	0.18	Nd	0.29
acrolein	Nd	0.05	0.05	Nd	0.07
acetaldehyde	Nd	0.08	0.07	Nd	0.12
acetone	Nd	0.02	0.02	0.04	0.04
butyraldehyde	Nd	0.02	0.01	Nd	0.02
propionaldehyde	Nd	0.01	0.01	Nd	0.02
methylethylketone	Nd	0.04	0.03	Nd	0.05
valeraldehyde	Nd	0.01	0.01	Nd	0.01

[a] referred to the warm phase measurements; [b] referred to the cold start phase measurements; and Nd means not detected.

References

Duffy, B. L., and Nelson, P. F.: Non-methane exhaust composition in the sydney harbour tunnel: A focus on benzene and 1,3-butadiene, Atmos. Environ., 30, 2759-2768, 1996.

Duffy, B. L., Nelson, P. F., Ye, Y., and Weeks, I. A.: Speciated hydrocarbon profiles and calculated reactivities of exhaust and evaporative emissions from 82 in-use light-duty australian vehicles, Atmos. Environ., 33, 291-307, 1999.

Liu, Y., Shao, M., Fu, L. L., Lu, S. H., Zeng, L. M., and Tang, D. G.: Source profiles of volatile organic compounds (VOCs) measured in china: Part i, Atmos. Environ., 2008.

Rogak, S. N., Pott, U., Dann, T., and Wang, D.: Gaseous emissions from vehicles in a traffic tunnel in vancouver, british columbia, J. Air Waste Manage. Assoc., 48, 604-615, 1998.

Sagebiel, J. C., Zielinska, B., Pierson, W. R., and Gertler, A. W.: Real-world emissions and calculated reactivities of organic species from motor vehicles, Atmos. Environ., 30, 2287-2296, 1996.

Schauer, J. J., Kleeman, M. J., Cass, G. R., and Simoneit, B. R. T.: Measurement of emissions from air pollution sources. 5. C-1-c-32 organic compounds from gasoline-powered motor vehicles, Environ. Sci. Technol., 36, 1169-1180, Doi 10.1021/Es0108077, 2002.

Schmitz, T., Hassel, D., and Weber, F. J.: Determination of voc-components in the exhaust of gasoline and diesel passenger cars, Atmos. Environ., 34, 4639-4647, 2000.

Staehelin, J., Keller, C., Stahel, W., Schlapfer, K., and Wunderli, S.: Emission factors from road traffic from a tunnel study (gubrist tunnel, switzerland). Part iii: Results of organic compounds, so2 and speciation of organic exhaust emission, Atmos. Environ., 32, 999-1009, 1998.