

Supporting Information For:

Time Resolved measurements of speciated tailpipe emissions from motor vehicles: trends with emission control technology, cold start effects, and speciation

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Table S1. Vehicle and test information for the current study.

* : Hybrid Vehicle

** : GDI vehicle (otherwise PFI)

*** :CNG vehicle

TEST_ID	VEHICLE_ID	TEST_TYPE	TEST_PHASE	MODEL_YEAR	VEH_CLASS	STANDARD	MILEAGE
1038708	20	UC	2	2012	PC**	SULEV	36733
1038708	20	UC	3	2012	PC**	SULEV	36733
1038708	20	UC	1	2012	PC**	SULEV	36733
1038721	20	US1B	1	2012	PC**	SULEV	36745
1038722	20	US1B	1	2012	PC**	SULEV	36761
1038723	30	UC	1	2014	PC**	L2SUL	11378
1038723	30	UC	2	2014	PC**	L2SUL	11378
1038723	30	UC	3	2014	PC**	L2SUL	11378
1038724	31	UC	3	2012	PC**	SULEV	78310
1038724	31	UC	1	2012	PC**	SULEV	78310
1038724	31	UC	2	2012	PC**	SULEV	78310
1038745	1	UC	1	2013	PC**	PZEV	13452
1038745	1	UC	3	2013	PC**	PZEV	13452
1038745	1	UC	2	2013	PC**	PZEV	13452
1038747	23	UC	3	2013	PC**	PZEV*	8902
1038747	23	UC	2	2013	PC**	PZEV*	8902
1038747	23	UC	1	2013	PC**	PZEV*	8902
1038749	20	MAC4	1	2012	PC**	SULEV	36777
1038750	30	UC	2	2014	PC**	L2SUL	11390
1038750	30	UC	3	2014	PC**	L2SUL	11390
1038750	30	UC	1	2014	PC**	L2SUL	11390
1038755	24	UC	2	2012	PC	PZEV	30832
1038755	24	UC	3	2012	PC	PZEV	30832
1038755	24	UC	1	2012	PC	PZEV	30832
1038757	31	UC	3	2012	PC**	SULEV	78320
1038757	31	UC	2	2012	PC**	SULEV	78320
1038757	31	UC	1	2012	PC**	SULEV	78320
1038760	24	UC	3	2012	PC	PZEV	30858
1038760	24	UC	1	2012	PC	PZEV	30858
1038760	24	UC	2	2012	PC	PZEV	30858
1038763	24	US1B	1	2012	PC	PZEV	30843
1038797	23	UC	2	2013	PC**	PZEV*	8913
1038797	23	UC	3	2013	PC**	PZEV*	8913

1038797	23	UC	1	2013	PC**	PZEV*	8913
1038799	31	MAC4	1	2012	PC**	SULEV	78331
1038801	35	UC	2	2013	PC**	ULEV	18303
1038801	35	UC	3	2013	PC**	ULEV	18303
1038801	35	UC	1	2013	PC**	ULEV	18303
1038820	35	UC	2	2013	PC**	ULEV	18314
1038820	35	UC	3	2013	PC**	ULEV	18314
1038820	35	UC	1	2013	PC**	ULEV	18314

Table S1. Vehicle and test information for the current study, continued.

TEST_ID	TEST_ID	TEST_TYPE	TEST_PHASE	MODEL_YEAR	VEH_CLASS	STANDARD	MILEAGE
1038821	18	UC	1	2008	PC	L2LEV	90406
1038821	18	UC	3	2008	PC	L2LEV	90406
1038821	18	UC	2	2008	PC	L2LEV	90406
1038822	36	UC	3	2013	PC**	L2ULV	19802
1038822	36	UC	1	2013	PC**	L2ULV	19802
1038822	36	UC	2	2013	PC**	L2ULV	19802
1038823	37	UC	2	2013	PC**	ULEV	23468
1038823	37	UC	3	2013	PC**	ULEV	23468
1038823	37	UC	1	2013	PC**	ULEV	23468
1038824	4	UC	3	2013	LDT	ULEV	24110
1038824	4	UC	2	2013	LDT	ULEV	24110
1038824	4	UC	1	2013	LDT	ULEV	24110
1038825	38	UC	3	2012	PC**	L2LEV	12943
1038825	38	UC	1	2012	PC**	L2LEV	12943
1038825	38	UC	2	2012	PC**	L2LEV	12943
1038827	27	UC	2	2013	PC**	L2ULV	21814
1038827	27	UC	1	2013	PC**	L2ULV	21814
1038827	27	UC	3	2013	PC**	L2ULV	21814
1038848	18	UC	2	2008	PC	L2LEV	90417
1038848	18	UC	3	2008	PC	L2LEV	90417
1038848	18	UC	1	2008	PC	L2LEV	90417
1038849	18	UC	1	2008	PC	L2LEV	90429
1038849	18	UC	2	2008	PC	L2LEV	90429
1038849	18	UC	3	2008	PC	L2LEV	90429
1038850	36	UC	3	2013	PC**	L2ULV	19821
1038850	36	UC	1	2013	PC**	L2ULV	19821
1038850	36	UC	2	2013	PC**	L2ULV	19821

1038853	21	UC	1	2014	PC**	PZEV	4483
1038853	21	UC	3	2014	PC**	PZEV	4483
1038853	21	UC	2	2014	PC**	PZEV	4483
1038854	21	MAC4	1	2014	PC**	PZEV	4494
1038862	28	UC	1	2013	PC**	L2SUL	28121
1038862	28	UC	2	2013	PC**	L2SUL	28121
1038862	28	UC	3	2013	PC**	L2SUL	28121
1038864	5	UC	3	2007	PC	L2SUL*	105707
1038864	5	UC	2	2007	PC	L2SUL*	105707
1038864	5	UC	1	2007	PC	L2SUL*	105707

Table S1. Vehicle and test information for the current study, continued.

TEST_ID	TEST_ID	TEST_TYPE	TEST_PHASE	MODEL_YEAR	VEH_CLASS	STANDARD	MILEAGE
1038867	29	UC	1	2012	PC**	PZEV	13405
1038867	29	UC	2	2012	PC**	PZEV	13405
1038867	29	UC	3	2012	PC**	PZEV	13405
1038868	21	UC	3	2014	PC**	PZEV	4508
1038868	21	UC	1	2014	PC**	PZEV	4508
1038868	21	UC	2	2014	PC**	PZEV	4508
1038869	28	UC	2	2013	PC**	L2SUL	28132
1038869	28	UC	3	2013	PC**	L2SUL	28132
1038869	28	UC	1	2013	PC**	L2SUL	28132
1038870	9	MAC4	1	2003	PC	LEV	104571
1038871	9	MAC4	1	2003	PC	LEV	104586
1038883	12	UC	2	2014	M4	ULEV	15087
1038883	12	UC	1	2014	M4	ULEV	15087
1038883	12	UC	3	2014	M4	ULEV	15087
1038884	13	UC	1	2002	M4	TIER1	228442
1038884	13	UC	3	2002	M4	TIER1	228442
1038884	13	UC	2	2002	M4	TIER1	228442
1038885	5	UC	1	2007	PC	L2SUL*	105639
1038885	5	UC	2	2007	PC	L2SUL*	105639
1038885	5	UC	3	2007	PC	L2SUL*	105639
1038889	40	UC	3	2004	M4	ULEV	90432
1038889	40	UC	1	2004	M4	ULEV	90432

1038889	40	UC	2	2004	M4	ULEV	90432
1038890	40	MAC4	1	2004	M4	ULEV	90442
1038891	9	UC	1	2003	M3	LEV	104607
1038891	9	UC	2	2003	M3	LEV	104607
1038891	9	UC	3	2003	M3	LEV	104607
1038894	40	MAC4	1	2004	M4	ULEV	90456
1038901	14	UC	1	1990	PC	TIER0	121473
1038901	14	UC	2	1990	PC	TIER0	121473
1038901	14	UC	3	1990	PC	TIER0	121473
1038902	14	MAC4	1	1990	PC	TIER0	121552
1038903	13	MAC4	1	2002	M4	TIER1	228453
1038909	37	UC	2	2013	PC	ULEV	23514
1038909	37	UC	1	2013	PC	ULEV	23514
1038909	37	UC	3	2013	PC	ULEV	23514
1038911	9	UC	1	2003	M3	LEV	104619
1038912	14	UC	2	1990	PC	TIER0	121567
1038912	14	UC	3	1990	PC	TIER0	121567
1038912	14	UC	1	1990	PC	TIER0	121567

Table S1. Vehicle and test information for the current study, continued.

TEST_ID	TEST_ID	TEST_TYPE	TEST_PHASE	MODEL_YEAR	VEH_CLASS	STANDARD	MILEAGE
1038915	37	UC	3	2013	PC**	ULEV	23494
1038915	37	UC	2	2013	PC**	ULEV	23494
1038916	37	MAC4	1	2013	PC**	ULEV	23480
1038917	4	UC	2	2013	LDT	ULEV	24182
1038917	4	UC	3	2013	LDT	ULEV	24182
1038918	4	UC	3	2013	LDT	ULEV	24136
1038918	4	UC	2	2013	LDT	ULEV	24136
1038919	4	MAC4	1	2013	LDT	ULEV	24147
1038920	21	UC	1	2014	PC**	PZEV	4526
1038920	21	UC	3	2014	PC**	PZEV	4526
1038920	21	UC	2	2014	PC**	PZEV	4526
1038922	15	MAC4	1	1990	M3	TIER1	59270
1038939	12	UC	2	2014	M4	ULEV	15107
1038939	12	UC	3	2014	M4	ULEV	15107
1038939	12	UC	1	2014	M4	ULEV	15107
1038945	4	UC	2	2013	LDT	ULEV	24170
1038945	4	UC	3	2013	LDT	ULEV	24170

1038945	4	UC	1	2013	LDT	ULEV	24170
1038947	36	UC	3	2013	PC**	L2ULV	19840
1038947	36	UC	1	2013	PC**	L2ULV	19840
1038947	36	UC	2	2013	PC**	L2ULV	19840
1038952	28	UC	3	2013	PC**	L2SUL	28152
1038952	28	UC	1	2013	PC**	L2SUL	28152
1038952	28	UC	2	2013	PC**	L2SUL	28152
1038961	33	UC	1	2007	PC***	L2LEV	19899
1038961	33	UC	2	2007	PC***	L2LEV	19899
1038961	33	UC	3	2007	PC***	L2LEV	19899
1038980	33	UC	1	2007	PC***	L2LEV	19910
1038980	33	UC	3	2007	PC***	L2LEV	19910
1038980	33	UC	2	2007	PC***	L2LEV	19910

Table S2. Composition of calibration standard for PTR-MS, concentrations in pbb.

Compound	Concentration	Compound	Concentration
acetaldehyde	1006	benzene	1027
methanol	951	toluene	989
isoprene	962	m-Xylene	981
acetone	1008	b-pinene	515
acetonitrile	1035	3-carene	237
methacrolein	512	limonene	252
methyl vinyl ketone	482	dichlorobenzene	1012

Table S3. Test information for current study: total volume, CO, CO₂, and THC.

TEST_ID	TEST_PHASE	VMIX [cf]	CO2 [g]	CO [g]	THC [g]
1038708	1	1861	581	1.330	0.140
1038708	2	6948	2684	58.767	0.156
1038708	3	1855	486	0.837	0.012
1038721	1	6459	2191	10.448	0.000
1038722	1	6425	2340	20.320	0.000
1038723	1	1849	794	1.140	0.322
1038723	2	6931	3174	1.168	0.000
1038723	3	1847	654	0.005	0.002
1038724	1	1861	718	3.530	0.312
1038724	2	6938	3030	4.574	0.024
1038724	3	1851	584	0.393	0.004
1038745	1	1857	744	1.136	0.087
1038745	2	6931	3073	9.083	0.000
1038745	3	1846	607	0.005	0.000
1038747	1	1867	501	1.296	0.280
1038747	2	6964	1698	2.501	0.013
1038747	3	1855	284	0.007	0.005
1038749	1	5077	2727	17.608	0.035
1038750	2	1860	854	1.244	0.140
1038750	3	6952	3256	1.223	0.000
1038750	1	1839	631	-0.016	0.002
1038755	2	1858	523	0.448	0.221
1038755	3	6964	1762	0.462	0.000
1038755	1	1855	310	0.004	0.003
1038757	1	1852	721	2.433	0.132
1038757	2	6918	3020	2.194	0.008
1038757	3	1846	593	0.261	0.004
1038760	1	2007	465	0.286	0.105
1038760	2	6965	1853	0.347	0.000
1038760	3	1846	308	0.006	0.002
1038763	1	6499	1879	0.355	0.011
1038797	1	1856	398	1.252	0.112
1038797	2	6959	2076	1.216	0.000

1038797	3	1848	356	0.069	0.003
1038799	1	5069	3263	18.467	0.062
1038801	1	1854	539	1.148	0.347
1038801	2	6931	2332	1.995	0.072
1038801	3	1845	441	0.323	0.028
1038820	1	1855	548	1.768	0.298

Table S3, continued. Test information for current study: total volume, CO, CO₂, and THC.

TEST_ID	TEST_PHASE	VMIX [cf]	CO2 [g]	CO [g]	THC [g]
1038820	2	6929	2288	1.827	0.092
1038820	3	1841	430	0.280	0.029
1038821	1	1851	1010	10.584	1.005
1038821	2	6886	3937	29.958	0.562
1038821	3	1834	784	6.214	0.214
1038822	1	1854	590	2.657	0.525
1038822	2	6909	2726	5.044	0.016
1038822	3	1849	494	0.634	0.016
1038823	1	1854	764	3.441	0.550
1038823	2	6934	3387	80.458	0.403
1038823	3	1842	607	1.426	0.021
1038824	1	1867	1181	8.195	0.841
1038824	2	6863	5006	4.060	0.006
1038824	3	1826	948	0.685	0.026
1038825	1	1848	621	2.648	0.258
1038825	2	6901	2571	32.111	0.151
1038825	3	1834	485	1.302	0.016
1038827	1	1848	559	6.609	0.639
1038827	2	6929	2402	16.466	0.135
1038827	3	1847	455	0.645	0.024
1038848	1	1850	992	10.186	1.091
1038848	2	6877	3929	30.272	0.559
1038848	3	1832	782	6.131	0.164
1038849	1	1848	979	17.659	1.171
1038849	2	6915	3974	37.748	0.607
1038849	3	1838	777	4.988	0.180
1038850	1	1868	637	2.513	0.303
1038850	2	6930	2693	2.718	0.023
1038850	3	1849	545	0.572	0.013

1038853	1	1853	664	2.003	0.141
1038853	2	6526	2641	1.636	0.000
1038854	1	5104	2908	2.342	0.000
1038862	1	1854	944	0.484	0.089
1038862	2	6944	3710	1.010	0.000
1038862	3	1845	726	0.038	0.002
1038864	1	1852	532	0.925	0.133
1038864	2	6926	1998	6.825	0.006
1038864	3	1843	322	0.268	0.010

Table S3. continued. Test information for current study: total volume, CO, CO₂, and THC.

TEST_ID	TEST_PHASE	VMIX [cf]	CO2 [g]	CO [g]	THC [g]
1038867	1	1853	713	1.395	0.137
1038867	2	6902	2876	29.033	0.060
1038867	3	1836	582	1.050	0.011
1038868	1	1852	660	1.361	0.123
1038868	2	6938	2865	1.274	0.000
1038868	3	1843	538	0.028	0.000
1038869	1	1847	962	0.479	0.071
1038869	2	6921	3804	1.931	0.006
1038869	3	1836	719	0.016	0.000
1038870	1	4957	6186	24.044	0.349
1038871	1	5130	6012	6.600	0.114
1038883	1	3243	1503	2.938	0.193
1038883	2	11975	6094	0.451	0.219
1038883	3	3153	1238	0.579	0.104
1038884	1	3231	1330	3.736	0.333
1038884	2	11865	5486	9.053	0.670
1038884	3	3142	1093	2.006	0.153
1038885	1	1829	466	1.442	0.384
1038885	2	6818	1881	6.925	0.010
1038885	3	1793	306	0.203	0.013
1038889	1	3237	1544	3.138	0.224
1038889	2	11747	6867	2.274	0.224
1038889	3	3125	1307	1.045	0.078
1038890	1	8926	6427	2.207	0.168
1038891	1	3317	1237	12.517	1.835
1038891	2	12410	5594	4.892	0.051

1038891	3	3307	1064	2.987	0.183
1038894	1	8900	6324	0.698	0.171
1038901	1	1855	804	9.350	1.982
1038901	2	6904	3644	5.463	0.521
1038901	3	1831	687	3.010	0.687
1038902	1	5160	4323	14.183	0.394
1038903	1	8960	5317	11.846	0.450
1038909	1	1860	785	4.691	0.646
1038909	2	6963	3280	30.574	0.242
1038909	3	1851	609	0.024	0.006
1038911	1	3314	1264	10.845	1.682
1038911	2	12407	5785	34.845	0.208
1038911	3	3304	1073	3.324	0.182

Table S3, continued. Test information for current study: total volume, CO, CO₂, and THC.

TEST_ID	TEST_PHASE	VMIX [cf]	CO2 [g]	CO [g]	THC [g]
1038912	1	1865	818	11.976	1.934
1038912	2	6917	3683	4.423	0.398
1038912	3	1846	684	4.087	0.611
1038915	1	2033	859	4.950	0.509
1038915	1	6961	3347	3.142	0.026
1038915	2	1848	650	1.303	0.013
1038916	3	5085	3424	7.650	0.052
1038917	1	1860	1154	9.236	0.813
1038917	2	6886	4921	5.308	0.040
1038917	3	1831	952	0.700	0.026
1038918	1	1858	1137	11.298	0.991
1038918	2	6894	5052	3.950	0.023
1038918	3	1832	966	1.001	0.024
1038919	1	5023	5314	5.974	0.052
1038920	1	1870	648	0.838	0.204
1038920	1	6974	2743	0.627	0.000
1038920	2	1848	522	0.008	0.000
1038922	3	9099	6046	72.902	3.125
1038939	1	3327	1530	3.685	0.337
1038939	2	12403	6068	0.263	0.153
1038939	3	3292	1198	0.024	0.032
1038945	1	1860	1189	7.731	0.662
1038945	2	6875	5064	6.365	0.072
1038945	3	1829	959	1.043	0.031
1038947	1	1858	613	2.136	0.337
1038947	2	6935	2720	2.544	0.032
1038947	3	1854	514	0.428	0.011
1038952	1	1860	922	0.499	0.152
1038952	2	6957	3596	1.034	0.000
1038952	3	1850	725	0.073	0.001
1038961	1	1855	478	0.277	0.273
1038961	2	6937	1992	5.517	0.000
1038961	3	1847	381	0.366	0.061
1038980	1	1855	489	0.338	0.323
1038980	2	6932	1970	3.887	0.000
1038980	3	1846	390	0.396	0.40

Table S4. Test information for current study: BTEX, ethane, and n-pentane.

TEST_ID	TEST_PHASE	benzene	toluene	m-xylene	o-xylene	p-xylene	Ebenzene	Ethane	n-pentane
1038708	3	0.640	0.120	0.000	0.000	0.000	0.000	0.657	0.158
1038708	1	4.199	5.042	1.946	1.265	0.973	0.973	3.252	1.825
1038708	2	1.494	0.599	0.201	0.151	0.113	0.088	0.485	0.164
1038723	3	0.000	0.000	0.000	0.000	0.000	0.000	0.163	0.052
1038723	1	2.746	5.458	1.938	1.172	0.981	0.742	3.930	2.966
1038723	2	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.027
1038747	1	2.739	7.045	4.237	2.180	2.131	1.470	1.498	1.518
1038747	2	0.099	0.087	0.038	0.000	0.025	0.000	0.014	0.027
1038747	3	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.026
1038755	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027
1038755	1	1.983	4.107	1.388	0.853	0.706	0.658	2.677	3.046
1038755	3	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.053
1038763	1	0.124	0.113	0.000	0.000	0.000	0.000	0.029	0.220
1038799	1	0.401	0.442	0.390	0.204	0.192	0.118	0.105	0.020
1038801	3	1.981	0.797	0.365	0.195	0.170	0.122	1.075	0.556
1038801	1	6.925	12.433	5.428	3.164	2.726	2.410	3.585	4.155
1038801	2	0.283	0.509	0.438	0.225	0.225	0.163	0.128	0.109
1038821	1	34.612	48.803	20.404	11.864	10.214	8.061	29.104	16.022
1038821	2	1.690	1.229	0.607	0.384	0.310	0.198	4.576	0.862
1038821	3	10.736	4.238	1.211	0.760	0.593	0.190	11.349	3.459
1038822	3	0.120	0.049	0.000	0.000	0.000	0.000	0.360	0.133
1038822	1	14.519	17.839	7.449	4.215	3.725	3.308	8.994	4.982
1038822	2	0.049	0.099	0.150	0.063	0.075	0.000	0.057	0.000
1038824	2	0.097	0.197	0.211	0.112	0.112	0.074	0.112	0.000
1038824	1	33.521	47.644	21.555	11.733	10.778	10.263	22.090	9.242
1038824	3	0.259	0.309	0.144	0.000	0.072	0.000	0.950	0.182
1038825	1	5.523	4.872	1.581	0.815	0.791	0.719	3.746	1.798
1038825	2	1.361	0.860	0.372	0.186	0.186	0.087	0.253	0.148
1038825	3	1.337	0.095	0.000	0.000	0.000	0.000	0.867	0.052
1038849	3	7.663	2.774	0.844	0.482	0.434	0.145	10.024	3.355
1038849	1	54.753	59.830	25.387	14.321	12.705	10.198	33.186	17.302
1038849	2	1.692	1.574	0.775	0.475	0.387	0.237	4.644	1.236

1038854	1	0.061	0.031	0.031	0.000	0.019	0.000	0.014	0.007
1038862	1	1.824	2.911	0.758	0.538	0.391	0.391	1.496	1.676
1038862	2	0.086	0.087	0.038	0.000	0.025	0.000	0.043	0.000
1038862	3	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000
1038867	1	2.300	4.941	1.905	1.221	0.952	0.855	1.771	3.505
1038867	2	0.196	0.149	0.100	0.000	0.050	0.000	0.042	0.081
1038867	3	0.000	0.024	0.000	0.000	0.000	0.000	0.303	0.000

Table S4. Test information for current study: BTEX, ethane, and n-pentane.

TEST_ID	TEST_PHASE	benzene	toluene	m-xylene	o-xylene	p-xylene	Ebenzene	Ethane	n-pentane
1038870	1	1.649	1.559	0.613	0.364	0.303	0.219	1.018	0.574
1038891	2	0.373	0.377	0.157	0.000	0.090	0.000	0.304	0.122
1038891	1	40.224	104.897	58.947	33.764	29.473	25.399	21.360	20.360
1038891	3	24.682	7.486	1.952	1.345	0.954	0.000	6.782	3.302
1038901	3	15.134	28.419	13.394	7.964	6.697	5.955	17.639	13.471
1038901	2	1.455	1.682	0.860	0.548	0.424	0.386	2.768	0.962
1038901	1	37.994	101.668	53.304	30.734	26.652	23.026	26.876	24.489
1038902	1	1.045	1.169	0.624	0.378	0.309	0.265	1.093	0.425
1038909	2	1.979	1.305	0.501	0.238	0.251	0.188	0.227	0.041
1038909	3	0.047	0.024	0.000	0.000	0.000	0.000	0.136	0.000
1038909	1	20.634	35.506	18.395	10.650	9.197	6.995	9.597	7.527
1038916	1	0.104	0.123	0.124	0.062	0.062	0.043	0.035	0.000
1038917	3	0.475	0.360	0.169	0.000	0.073	0.000	0.904	0.263
1038917	2	0.293	0.358	0.274	0.137	0.137	0.100	0.169	0.095
1038917	1	34.118	53.432	23.834	14.276	11.917	11.941	21.078	7.801
1038919	1	0.187	0.262	0.215	0.117	0.104	0.061	0.202	0.060
1038920	2	0.049	0.050	0.063	0.000	0.025	0.000	0.000	0.000
1038920	1	5.671	7.775	3.723	1.911	1.862	1.396	1.832	3.809
1038920	3	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1038922	1	10.580	16.293	8.363	4.665	4.187	4.076	6.065	3.080
1038945	1	26.592	38.828	16.606	9.451	8.303	8.034	19.118	5.948
1038945	3	0.427	0.432	0.169	0.000	0.097	0.000	1.371	0.211
1038945	2	0.427	0.456	0.261	0.149	0.137	0.099	0.366	0.095
1038947	1	6.448	7.726	2.702	1.655	1.339	1.217	7.115	2.488

1038947	2	0.086	0.111	0.137	0.075	0.075	0.000	0.099	0.000
1038947	3	0.118	0.000	0.000	0.000	0.000	0.000	0.327	0.000
1038952	1	1.765	2.387	0.875	0.486	0.438	0.340	1.129	1.427
1038952	3	0.000	0.000	0.000	0.000	0.000	0.000	0.219	0.000
1038952	2	0.074	0.037	0.000	0.000	0.000	0.000	0.028	0.000
1038980	1	0.119	0.000	0.000	0.000	0.000	0.000	8.545	0.000
1038980	2	0.000	0.025	0.000	0.000	0.000	0.000	0.071	0.000
1038980	3	0.000	0.000	0.000	0.000	0.000	0.000	0.109	0.000

Table S5. BTEX Composition Data from a previous study¹ used in combination with current data for Figure 2.

Test ID num.	Vehicle name	benzene	toluene	m-xylene	p-xylene	o-xylene
<u>1027872</u>	PreLEV-14	<u>5.04E-02</u>	<u>1.04E-01</u>	<u>2.93E-02</u>	<u>1.46E-02</u>	<u>1.52E-02</u>
1028029	PreLEV-10	1.56E-02	4.02E-02	1.68E-02	8.38E-03	8.39E-03
1027921	PreLEV-11	2.28E-02	4.39E-02	1.73E-02	8.63E-03	8.94E-03
1027920	PreLEV-8	1.02E-03	6.20E-04	1.35E-04	1.26E-04	5.80E-04
1032320	PreLEV-5	2.37E-02	6.12E-02	2.84E-02	1.42E-02	1.66E-02
1032392	PreLEV-4	4.82E-02	7.39E-02	3.49E-02	1.74E-02	1.95E-02
1032426	PreLEV-3	5.28E-02	5.91E-02	2.26E-02	1.13E-02	1.36E-02
1032444	PreLEV-2	1.75E-02	5.73E-02	2.76E-02	1.38E-02	1.63E-02
1032440	PreLEV-2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032389	PreLEV-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032442	PreLEV-1	4.29E-02	6.73E-02	2.97E-02	1.48E-02	1.64E-02
1032443	PreLEV-9	2.22E-02	6.55E-02	3.91E-02	1.96E-02	2.26E-02
1032303	PreLEV-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032445	PreLEV-15	3.09E-02	6.27E-02	2.97E-02	1.49E-02	1.68E-02
1028023	LEV1-25	5.30E-02	7.72E-02	2.56E-02	1.28E-02	1.21E-02
1027859	LEV1-1	1.45E-05	1.07E-03	2.14E-04	7.39E-05	1.72E-04
1027976	LEV1-8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1027970	LEV1-26	7.94E-03	2.49E-02	1.18E-02	5.92E-03	6.05E-03
1027969	LEV1-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1027975	LEV1-17	2.20E-02	4.81E-02	2.06E-02	1.03E-02	1.06E-02
1028027	LEV1-16	7.37E-03	1.50E-02	7.65E-03	3.83E-03	4.20E-03
1027837	LEV1-1	1.28E-02	4.03E-02	2.10E-02	1.05E-02	1.23E-02
1028075	LEV1-19	8.09E-03	1.17E-02	5.05E-03	2.52E-03	2.54E-03
1027918	LEV1-6	1.61E-02	3.05E-02	1.38E-02	6.93E-03	8.18E-03
1032302	LEV1-2	4.33E-02	6.77E-02	3.12E-02	1.56E-02	1.73E-02
1032304	LEV1-2	3.98E-02	6.98E-02	3.15E-02	1.57E-02	1.71E-02
1032348	LEV1-3	6.81E-02	6.51E-02	3.36E-02	1.68E-02	1.79E-02
1032388	LEV1-21	3.63E-02	6.41E-02	3.12E-02	1.56E-02	1.75E-02
1032346	LEV1-3	3.26E-02	6.85E-02	3.10E-02	1.54E-02	1.76E-02
1032347	LEV1-3	8.56E-02	5.30E-02	3.47E-02	1.78E-02	2.25E-02
1023424	LEV1-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032428	LEV1-9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032394	LEV1-24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032393	LEV1-4	2.93E-02	5.74E-02	2.63E-02	1.31E-02	1.46E-02
1032473	LEV1-2	5.54E-02	5.50E-02	4.18E-02	2.09E-02	2.43E-02

Table S5 continued.

Test ID num.	Vehicle name	benzene	toluene	m-xylene	p-xylene	o-xylene
1032436	LEV1-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032435	LEV1-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032434	LEV1-24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032472	LEV1-24	3.84E-02	6.71E-02	3.51E-02	1.75E-02	1.83E-02
1027977	LEV2-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1027973	LEV2-11	1.28E-02	4.14E-02	1.50E-02	7.51E-03	8.16E-03
1027905	LEV2-19	1.98E-02	2.77E-02	1.09E-02	5.40E-03	6.18E-03
1027978	LEV2-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1027908	LEV2-8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1027906	LEV2-16	2.98E-02	4.50E-02	2.15E-02	1.07E-02	1.03E-02
1027852	LEV2-4	3.79E-02	7.32E-02	1.87E-02	9.36E-03	1.09E-02
1027867	LEV2-9	9.68E-03	2.11E-02	6.91E-03	3.45E-03	3.46E-03
1027907	LEV2-20	1.95E-02	4.46E-02	2.05E-02	1.03E-02	1.11E-02
1028021	LEV2-18	3.50E-03	5.99E-03	2.31E-03	1.14E-03	1.68E-03
1028022	LEV2-2	4.73E-02	7.65E-02	3.36E-02	1.67E-02	1.74E-02
1027863	LEV2-13	1.71E-02	3.18E-02	1.49E-02	7.58E-03	8.22E-03
1027971	LEV2-4	4.75E-02	6.36E-02	2.51E-02	1.27E-02	1.49E-02
1032282	LEV2-6	2.99E-02	4.54E-02	1.27E-02	1.27E-02	1.02E-02
1023305	LEV2-25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1032310	LEV2-23	6.41E-02	6.38E-02	3.46E-02	1.71E-02	2.11E-02
1032309	LEV2-6	4.77E-02	7.71E-02	3.20E-02	1.61E-02	1.80E-02
1032321	LEV2-6	4.93E-02	8.11E-02	3.90E-02	1.94E-02	2.19E-02
1032342	LEV2-5	4.83E-02	7.34E-02	3.55E-02	1.77E-02	1.94E-02
1032351	LEV2-5	2.76E-02	4.89E-02	2.10E-02	1.06E-02	1.35E-02
1032345	LEV2-6	3.75E-02	5.82E-02	3.38E-02	1.70E-02	1.84E-02
1032360	LEV2-3	2.20E-02	4.71E-02	2.65E-02	1.36E-02	1.75E-02
1032343	LEV2-6	3.83E-02	5.32E-02	2.76E-02	1.38E-02	1.75E-02
1032383	LEV2-24	5.76E-02	6.57E-02	3.25E-02	1.62E-02	1.82E-02
1032359	LEV2-3	1.74E-02	7.33E-02	7.65E-02	3.84E-02	4.90E-02
1032283	LEV2-3	2.54E-02	3.96E-02	8.34E-03	8.34E-03	8.24E-03

Table S6. Vehicle data and emissions from a previous study¹ used in combination with current data for for Figure 4.

TEST_ID	Class	TEST_PHASE	MODEL_YEAR	MPG	HC_GM_MILE
1032302	LEV	1	1997	12.69	0.97
1032302	LEV	2	1997	22.12	0.02
1032302	LEV	3	1997	15.46	0.16
1032304	LEV	1	1997	11.95	1.20
1032304	LEV	2	1997	22.17	0.02
1032304	LEV	3	1997	15.25	0.13
1032309	LEV2	1	2011	10.36	0.49
1032309	LEV2	2	2011	17.98	0.04
1032309	LEV2	3	2011	12.78	0.06
1032310	LEV2	1	2011	12.93	0.31
1032310	LEV2	2	2011	23.70	0.00
1032310	LEV2	3	2011	15.29	0.02
1032320	T0	1	1990	12.57	1.70
1032320	T0	2	1990	22.18	0.06
1032320	T0	3	1990	15.48	0.38
1032321	LEV2	1	2011	10.29	0.71
1032321	LEV2	2	2011	18.46	0.02
1032321	LEV2	3	2011	11.92	0.05
1032322	LEV2	1	2012	10.84	0.12
1032322	LEV2	2	2012	20.04	0.01
1032322	LEV2	3	2012	13.91	0.01
1032342	LEV2	1	2011	14.22	0.30
1032342	LEV2	2	2011	24.03	0.02
1032342	LEV2	3	2011	16.84	0.01
1032346	LEV	1	1998	12.21	1.00
1032346	LEV	2	1998	21.49	0.01
1032346	LEV	3	1998	15.14	0.05
1032351	LEV2	1	2011	14.28	0.29
1032351	LEV2	2	2011	25.52	0.03
1032351	LEV2	3	2011	18.15	0.02
1032362	LEV	1	1998	11.83	1.09
1032362	LEV	2	1998	20.88	0.01
1032362	LEV	3	1998	14.96	0.07
1032382	LEV2	1	2012	17.47	0.10

1032382	LEV2	2	2012	29.16	0.00
1032382	LEV2	3	2012	21.02	0.01
1032383	LEV2	1	2012	9.71	0.46
1032383	LEV2	2	2012	17.36	0.02
1032383	LEV2	3	2012	12.75	0.01

TableS6.Continued.

TEST_ID	Class	TEST_PHASE	MODEL_YEAR	MPG	HC_GM_MILE
1032388	LEV	1	2001	13.79	0.71
1032388	LEV	2	2001	24.91	0.01
1032388	LEV	3	2001	18.08	0.13
1032392	T0	1	1989	18.78	2.51
1032392	T0	2	1989	30.09	0.27
1032392	T0	3	1989	24.74	0.41
1032393	LEV	1	1999	14.87	0.57
1032393	LEV	2	1999	27.14	0.03
1032393	LEV	3	1999	18.79	0.06
1032428	LEV	1	1994	8.92	6.53
1032428	LEV	2	1994	17.22	2.31
1032428	LEV	3	1994	10.73	3.11
1032435	LEV	1	1996	11.64	5.24
1032435	LEV	2	1996	19.79	1.87
1032435	LEV	3	1996	13.83	0.33
1032442	T0	1	1987	8.77	6.21
1032442	T0	2	1987	16.95	0.82
1032442	T0	3	1987	11.42	1.50
1032443	T0	1	1991	9.53	4.69
1032443	T0	2	1991	18.87	0.12
1032443	T0	3	1991	14.18	0.35
1032444	T0	1	1988	15.81	6.46
1032444	T0	2	1988	26.71	2.81
1032444	T0	3	1988	20.65	4.57

1032445	T0	1	1993	10.18	7.79
1032445	T0	2	1993	16.99	1.28
1032445	T0	3	1993	12.17	2.85
1032472	LEV	1	2002	6.70	2.20
1032472	LEV	2	2002	10.99	0.03
1032472	LEV	3	2002	7.94	0.14

Table S7. Vehicle data and emissions from a previous study¹ used in combination with current data for for Figure 6.

TEST_ID	TEST_PHASE	benzene	toluene	m-xylene	p-xylene	o-xylene	ethane	n-pentane
1032302	1	30.46	63.64	29.63	14.80	16.49	20.82	17.98
1032302	2	0.48	0.92	0.56	0.28	0.30	0.24	0.11
1032302	3	14.31	5.74	1.82	0.88	0.93	10.54	3.63
1032304	1	37.07	83.43	37.26	18.64	19.98	27.91	21.85
1032304	2	0.78	0.62	0.45	0.22	0.28	0.22	0.11
1032304	3	10.17	2.32	0.80	0.39	0.52	8.60	3.01
1032309	1	19.42	35.69	14.52	7.28	7.92	11.55	6.09
1032309	2	1.58	2.28	1.06	0.53	0.65	1.20	0.61
1032309	3	3.39	2.22	0.76	0.40	0.49	2.79	0.78
1032310	1	17.54	17.64	9.51	4.73	5.78	6.42	3.91
1032310	2	0.12	0.19	0.15	0.07	0.11	0.03	0.01
1032310	3	0.91	0.44	0.12	0.05	0.00	1.05	0.43
1032320	1	38.12	110.32	51.53	25.78	29.67	25.76	26.10
1032320	2	1.18	1.62	0.77	0.38	0.53	2.25	0.73
1032320	3	8.32	15.25	6.58	3.28	3.92	13.00	8.45
1032321	1	33.25	56.83	27.41	13.69	15.29	17.29	6.62
1032321	2	0.48	0.89	0.45	0.22	0.27	0.70	0.31
1032321	3	2.29	1.30	0.44	0.22	0.29	2.47	0.60
1032322	1	4.03	5.84	2.21	1.07	1.36	3.39	2.01
1032322	2	0.14	0.32	0.20	0.09	0.16	0.08	0.06
1032322	3	0.07	0.18	0.00	0.00	0.11	0.18	0.05
1032342	1	13.51	21.30	9.93	4.97	5.43	6.35	4.03
1032342	2	0.47	0.52	0.32	0.16	0.17	0.22	0.16
1032342	3	0.17	0.26	0.22	0.11	0.13	0.22	0.17
1032346	1	28.60	64.76	29.24	14.60	16.60	22.60	19.71
1032346	2	0.44	0.38	0.23	0.10	0.14	0.50	0.05
1032346	3	1.72	0.98	0.32	0.16	0.18	4.80	1.42
1032351	1	9.25	16.80	6.77	3.41	4.14	6.10	3.61
1032351	2	0.25	0.35	0.26	0.13	0.20	0.09	0.09
1032351	3	0.22	0.34	0.18	0.09	0.18	0.38	0.12
1032359	1	2.04	9.45	10.72	5.35	6.93	1.07	0.47

1032359	2	0.14	0.40	0.24	0.13	0.17	0.54	0.16
1032359	3	0.13	0.36	0.20	0.11	0.00	2.07	0.49
1032360	1	0.31	1.12	0.78	0.40	0.44	1.06	0.22
1032360	2	0.26	0.43	0.22	0.12	0.14	0.87	0.16
1032360	3	0.09	0.25	0.07	0.02	0.14	1.66	0.32
1032362	1	35.66	69.90	31.59	15.78	17.28	26.84	18.20
1032362	2	0.19	0.40	0.24	0.12	0.16	0.47	0.06
1032362	3	5.74	1.68	0.33	0.16	0.25	6.68	1.53

Table S7. Continued.

TEST_ID	TEST_PHASE	benzene	toluene	m-xylene	p-xylene	o-xylene	ethane	n-pentane
1032382	1	3.03	7.14	4.68	2.33	0.00	2.72	1.40
1032382	2	0.09	0.17	0.14	0.06	0.00	0.01	0.01
1032382	3	0.13	0.13	0.05	0.02	0.00	0.05	0.00
1032383	1	25.02	27.38	12.93	6.46	7.18	7.77	4.25
1032383	2	0.43	0.72	0.47	0.23	0.28	0.26	0.11
1032383	3	0.18	0.44	0.38	0.20	0.22	0.13	0.07
1032388	1	22.45	42.57	21.17	10.58	11.77	19.83	8.67
1032388	2	0.41	0.45	0.26	0.13	0.17	0.22	0.10
1032388	3	4.40	5.87	2.23	1.12	1.27	4.85	3.30
1032392	1	85.93	180.46	93.20	46.60	51.96	32.00	35.41
1032392	2	17.15	16.15	6.02	3.00	3.43	9.51	4.07
1032392	3	17.90	18.16	6.87	3.43	3.85	14.57	10.14
1032393	1	15.57	35.75	16.30	8.15	9.08	10.87	11.59
1032393	2	0.39	0.28	0.19	0.09	0.10	0.18	0.14
1032393	3	2.20	0.95	0.27	0.13	0.13	2.23	1.31
1032426	1	53.63	77.61	32.55	16.28	18.10	46.05	24.27
1032426	2	24.16	20.52	7.27	3.64	4.61	10.91	9.01
1032426	3	31.07	42.51	15.57	7.81	9.87	33.06	23.70
1032428	1	205.29	413.16	188.13	94.07	89.82	65.96	76.47
1032428	2	110.15	135.10	46.61	23.31	20.90	35.36	32.66
1032428	3	157.46	199.19	71.09	35.57	31.15	36.42	32.43

1032434	1	7.08	16.71	6.05	3.02	3.64	61.22	15.85
1032434	2	0.21	0.10	0.00	0.00	0.00	0.39	0.00
1032434	3	0.00	0.00	0.00	0.00	0.00	9.25	0.00
1032435	1	132.56	278.98	169.73	84.86	91.00	92.94	47.68
1032435	2	93.51	46.75	24.17	12.08	12.23	37.21	5.24
1032435	3	16.37	14.70	7.86	4.00	4.21	19.99	4.42
1032436	1	2.89	10.38	3.95	2.00	2.38	27.11	9.26
1032436	2	0.07	0.17	0.10	0.07	0.22	0.41	0.00
1032436	3	0.09	0.32	0.19	0.09	0.33	6.06	0.05
1032442	1	185.97	402.14	193.57	96.74	106.84	63.87	91.83
1032442	2	47.08	46.82	17.69	8.82	9.76	21.08	14.28
1032442	3	59.49	87.06	34.11	17.01	19.04	40.27	31.56
1032443	1	91.22	298.26	180.21	90.15	104.63	62.29	53.48
1032443	2	3.36	6.35	4.09	2.05	2.26	2.70	1.10
1032443	3	11.00	17.17	6.98	3.54	3.77	14.28	7.89

Table S7. Continued.

TEST_ID	TEST_PHASE	benzene	toluene	m-xylene	p-xylene	o-xylene	ethane	n-pentane
1032443	1	91.22	298.26	180.21	90.15	104.63	62.29	53.48
1032443	2	3.36	6.35	4.09	2.05	2.26	2.70	1.10
1032443	3	11.00	17.17	6.98	3.54	3.77	14.28	7.89
1032444	1	110.56	384.77	199.08	99.54	119.34	39.61	79.77
1032444	2	51.93	160.90	74.99	37.49	43.88	26.42	44.87
1032444	3	77.87	267.07	124.49	62.24	73.96	31.06	85.51
1032445	1	189.59	473.43	238.24	119.19	135.37	67.83	108.05
1032445	2	41.19	76.65	35.67	17.87	20.29	22.71	23.39
1032445	3	114.15	169.50	68.62	34.31	38.45	47.66	54.90
1032472	1	73.41	135.12	69.95	34.96	36.08	47.18	33.78
1032472	2	0.89	1.51	1.04	0.52	0.61	0.45	0.22
1032472	3	4.98	2.20	0.81	0.40	0.53	7.77	0.31

1032473	1	1.71	5.45	4.75	2.38	2.61	0.80	0.41
1032473	2	0.51	0.93	0.71	0.35	0.42	0.17	0.16
1032473	3	7.45	1.99	0.89	0.45	0.62	6.43	1.94

Table S8. Contribution of cold start for US drivers assuming driving patterns similar to the UC protocol.

% Contribution of Cold Start Emissions to the Average Driving Trip						
	THC	Benzene	Toluene	Xylenes	Ethane	n-Pentane
Average	0.94	0.93	0.94	0.94	0.93	0.96
Lower Quartile	0.72	0.8	0.87	0.77	0.83	0.87
Worst-Emitters	0.16	0.08	0.17	0.22	0.11	0.12

Table S9. Gasoline composition analysis.

Fraction		frac C	frac H		mass %		wt. C	wt. H
C4 P		0.827	0.173		0.5		0.4133	0.0867
C5 P		0.832	0.168		10.31		8.5814	1.7286
C6 P		0.836	0.164		9.86		8.2453	1.6147
C7 P		0.839	0.161		10.42		8.7428	1.6772
C8 P		0.841	0.159		10.41		8.7564	1.6536
C9 P		0.843	0.157		3.47		2.9245	0.5455
C10 P		0.844	0.156		1.37		1.1565	0.2135
C11+ P		0.845	0.155		2.4		2.0285	0.3715
C6 A		0.923	0.077		0.74		0.6827	0.0573
C7 A		0.912	0.088		5.13		4.6810	0.4490
C8 A		0.905	0.095		8		7.2404	0.7596
C9 A		0.899	0.101		6.65		5.9807	0.6693
C10 A		0.895	0.105		3.61		3.2304	0.3796
C11+ A		0.891	0.109		0.93		0.8288	0.1012
O/N		0.856	0.144		14.34		12.2789	2.0611
C5 cyc O		0.882	0.118		0.06		0.0529	0.0071
C6 cyc O		0.877	0.123		0.32		0.2807	0.0393
C7 cyc O		0.874	0.126		0.43		0.3759	0.0541
C8 cyc O		0.872	0.128		0.23		0.2005	0.0295
C9 cyc O		0.870	0.130		0.05		0.0435	0.0065
poly-N		0.869	0.131		0		0.0000	0.0000
MTBE		0.681	0.137		0		0.0000	0.0000
Ethanol		0.521	0.131		10.77		5.6155	1.4139
TAME		0.705	0.138		0		0.0000	0.0000
		Total %			100		82.3407	13.9187
					C/H Ratio		5.92	
					Wt% O		3.74	
RON	87-88							

Supplemental Figures

Comparison of PTR-MS and ARB-GC Results:

Bag 1 of UC Coldstart Tests

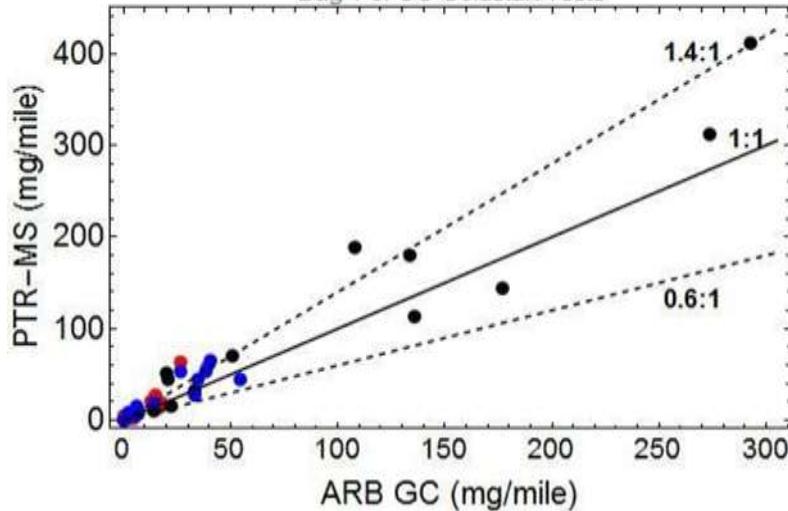


Figure S1. Comparisons of cold-start total BTEX (black), benzene (blue), and acetaldehyde (red) emissions as measured by PTR-MS and GC-FID. PTR-MS measurements for individual compounds are within 50% and BTEX as a group within 30% of GC-MS emissions.

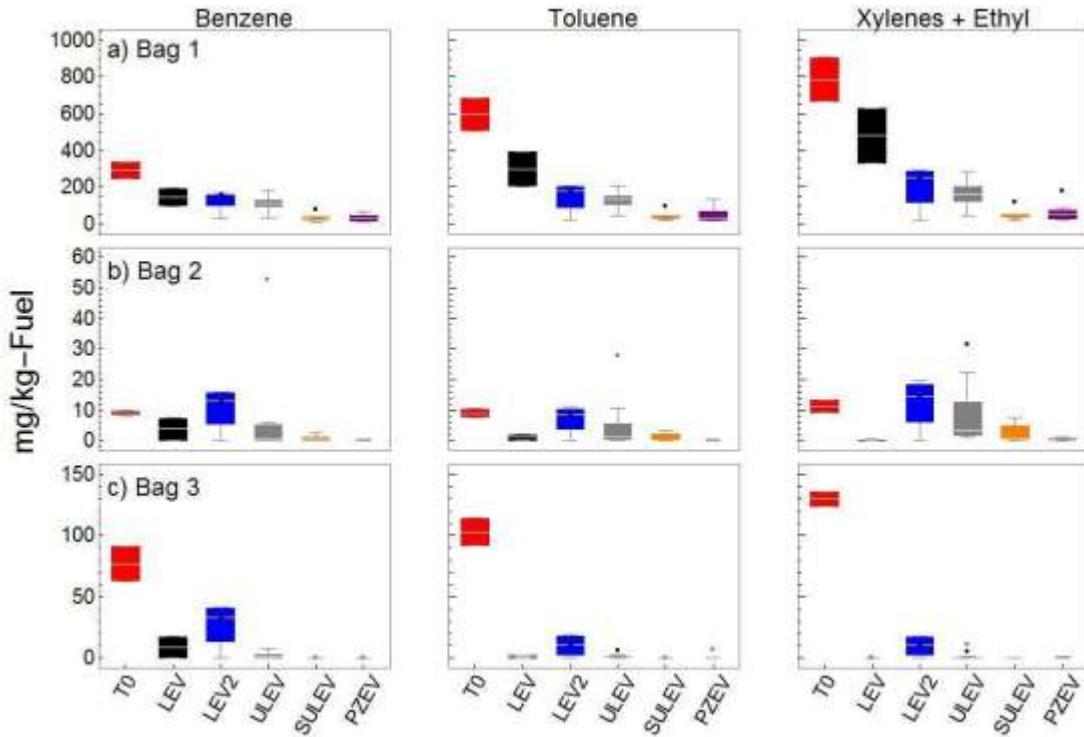


Figure S2. BTEX emission factors for all vehicle classes for bag 1 (a), bag 2 (b), and bag 3 (c) of the UC protocol, as measured by PTR-MS. Ethyl benzene is grouped with the xylenes. The central white lines on

the box plots are median values; the edges of the boxes are the 25th and 75th percentiles; the whiskers extend to the most extreme data not considered outliers; and the solid black points are outliers.

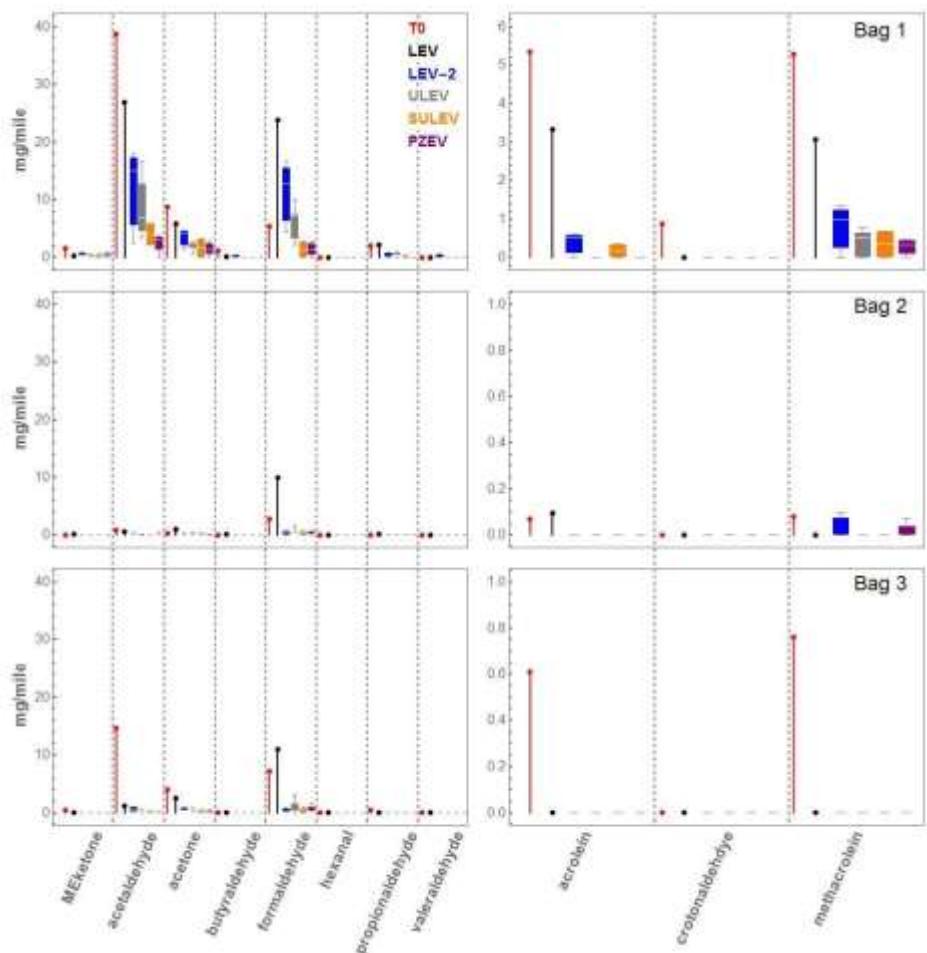


Figure S3. Emissions of ketones and aldehydes, measured by LC-MS in mg/mile.

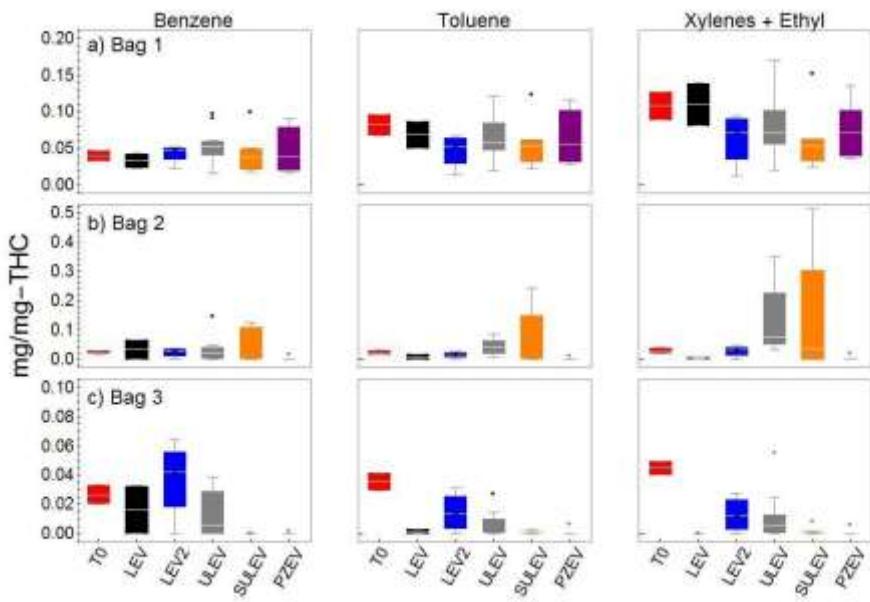


Figure S4. BTEX emissions normalized to NMOG emissions.

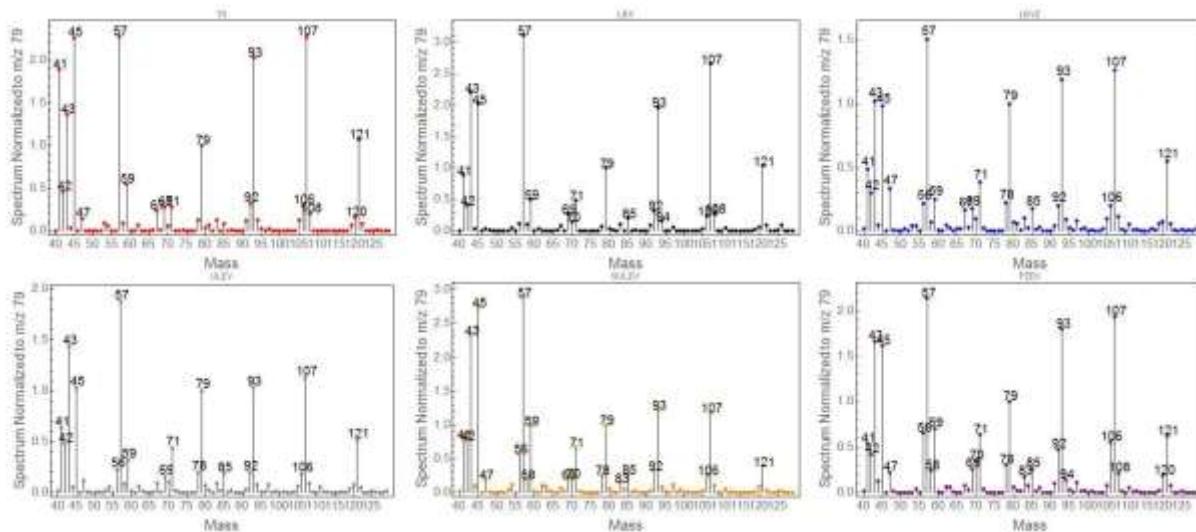


Figure S5. Average mass spectra for all classes of vehicles.

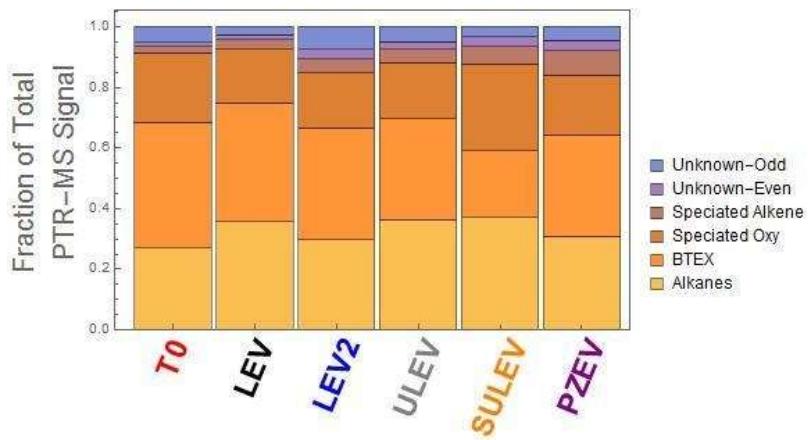


Figure S6. Total PTR-MS signal for bag 1 averaged by vehicle class and divided into chemical categories. The unknown category has been sub-divided into even and odd masses, showing dominance of oddmasses.