SUPPORTING INFORMATION

Reactive oxidative species and speciated particulate light-duty engine emissions from diesel and biodiesel fuel blends

Britt A. Holmén*, Benjamin Rukavina, John Kasumba[&] and Naomi K. Fukagawa[#]

The University of Vermont, 213D Votey Building, 33 Colchester Ave, Burlington, VT 05401

[#] New affiliation: USDA Beltsville Human Nutrition Research Center, Beltsville, MD 20705

[&] New affiliation: Chemistry Department, Western Kentucky University, Bowling Green, KY 42101

* Corresponding Author Email: bholmen@uvm.edu

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I. Fuel Properties & Specifications, Fuel Composition and Driving Cycle

Table S-1. Measured properties of the neat soybean and waste vegetable oil biodiesel fuels, and Trono ULSD fuel.

Property	Units	Soybean	WVO	Trono Fuel[a] (ULSD) Batch1/Batch2	ASTM D6751 Biodiesel (B100) Min	ASTM D6751 Biodiesel (B100) Max	ASTM D975[b] Petrodiesel Min	ASTM D975[b] Petrodiesel Max
Density	kg/m^3	0.876	0.876	0.809/0.812				
Flash point	^oC	167.4	176.5	45.6/ND	130		52	
Kinematic viscosity	mm^2/s	4.166	4.354		1.9	6.0	1.9	4.1
Cloud point	^oC	1.13	-0.15		Report			
Sulfur content	ppm	<1	2.5	1.2/ND		15		10
Carbon residue	wt,%	0.033	0.05	0.003/ND		0.05		0.35
Cetane number		49.9		46.7/ND	47			40
Oxidative stability	h	6.28	11.49		3			
Ash content	wt,%	<0.005	-			0.02		0.01
Cold soak filtration	Sec	86	2058 [c]			360		
Water content	mg/kg	0.01	0.00	0.000/ND		500		500
Acid value	mg KOH/g	0.134	0.196			0.5		
Copper corrosion	Degree of corrosion			1A/ND				No.3A
Phosphorus	wt,%	<0.001	<0.001			0.001		
Sodium and Potassium	ppm	<0.5	30.1[c]			5		
Free glycerol	wt,%	0.007	0.003			0.02		
Total glycerol	wt,%	0.050	0.049			0.24		

[a] The two density values correspond to the densities obtained for the two Trono fuel batches. Batch1 was used to prepare the WVO biodiesel blends and Batch2 was used to prepare the soybean biodiesel blends.

[b] No. 2 diesel fuel. [c] Value exceeded ASTM standard.

Fuel testing was performed at the University of Connecticut's Biofuels Laboratory, Storrs, CT. ND means that No Data was available for that test. Both biodiesel fuels (B100) had antioxidant Naugalube 403 (Chemtura Corporation, Middlebury CT; N,N'-di-sec-butyl-p-phenylenediamine) added at 2000ppm.

Table S-2. Concentrations ($\mu g/gal_{fuel}$) of n-alkanes measured in the WVO and soybean biodiesel fuel blends. SD means one standard deviation. n = 2. No n-alkanes were detected in the neat biodiesel fuels.

WVO								
Compound	**B00**	**SD**	**B10**	**SD**	**B20**	**SD**	**B50**	**SD**
n-Undecane[a]								
n-Dodecane	5.77	0.17	5.17	0.75	4.67	0.08	2.89	0.15
n-Tridecane	5.54	0.04	4.95	0.68	4.49	0.24	2.70	0.00
n-Tetradecane	4.33	0.03	3.89	0.34	3.46	0.06	2.26	0.08
n-Pentadecane	3.98	0.03	3.55	0.35	3.25	0.25	2.10	0.08
n-Hexadecane	3.28	0.04	2.84	0.27	2.70	0.17	1.62	0.06
n-Heptadecane	3.86	0.18	3.31	0.33	3.17	0.29	1.96	0.12
n-Octadecane	3.52	0.04	3.09	0.31	2.94	0.04	2.16	0.09
n-Nonadecane	2.47	0.02	2.20	0.28	2.08	0.01	1.64	0.08
n-Eicosane	1.91	0.00	1.75	0.13	1.70	0.02	1.35	0.04
n-Heneicosane	1.42	0.02	1.34	0.09	1.28	0.06	1.14	0.01
n-Docosane	1.10	0.01	1.06	0.04	1.07	0.00	0.96	0.01
n-Tricosane	0.79	0.01	0.78	0.02	0.77	0.00	0.72	0.00
n-Tetracosane	0.63	0.01	0.62	0.01	0.61	0.01	0.59	0.00
Total	**38.59**	**0.26**	**34.55**	**1.28**	**32.19**	**0.50**	**22.09**	**0.26**
Soybean								
Compounds	**B00**	**SD**	**B10**	**SD**	**B20**	**SD**	**B50**	**SD**
n-Undecane[a]								
n-Dodecane	5.48	0.26	5.12	0.19	5.02	0.17	2.94	0.14
n-Tridecane	5.57	0.06	5.18	0.21	5.08	0.09	2.90	0.17
n-Tetradecane	4.21	0.03	4.11	0.09	3.98	0.03	2.36	0.16
n-Pentadecane	4.01	0.02	3.85	0.07	3.62	0.02	2.34	0.01
n-Hexadecane	3.50	0.02	3.37	0.07	3.34	0.02	1.83	0.11
n-Heptadecane	4.26	0.06	4.07	0.13	4.07	0.08	2.25	0.03
n-Octadecane	3.96	0.16	3.76	0.07	3.42	0.08	2.42	0.10
n-Nonadecane	2.74	0.04	2.65	0.04	2.31	0.11	1.79	0.04
n-Eicosane	1.99	0.10	1.92	0.03	1.62	0.01	1.40	0.04
n-Heneicosane	1.36	0.02	1.35	0.01	1.08	0.01	1.08	0.00
n-Docosane	1.05	0.01	1.05	0.00	0.79	0.01	0.95	0.00
n-Tricosane	0.77	0.01	0.78	0.01	0.56	0.00	0.71	0.01
n-Tetracosane	0.60	0.00	0.61	0.01	0.43	0.00	0.59	0.00
Total	**39.51**	**0.34**	**37.82**	**0.35**	**35.33**	**0.25**	**23.57**	**0.32**

[a] means that the compound was detected but not quantitated

Table S-3. FAMEs concentrations (g/gal$_{fuel}$) of the different blends of WVO and soybean biodiesel fuel blends. SD means one standard deviation, and ND means the compound was not detected. For WVO, n = 2; For Soybean, n = 4. No FAMEs were detected in the petrodiesel fuel.

WVO								
Compound	**B10**	**SD**	**B20**	**SD**	**B50**	**SD**	**B100**	**SD**
Methyl Myristate (C14:0)	1.6	0	1.9	0.0	2.9	0.0	4.7	0.0
Methyl Palmitate (C16:0)	14.7	4.2	49.1	4.0	183.2	33.7	323.2	30.0
Methyl Linolenate (C18:3n3c)	5.7	0.2	18.6	2.4	85.9	17.9	153.0	20.2
Methyl Linolelaidate (C18:2n6t)	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Linoleate (C18:2n6c)	38.2	11.9	138.8	13.7	545.6	106.2	959.0	99.5
Methyl Elaidate (C18:1n9t)	ND	ND	ND	ND	ND	ND	ND	ND
Methyl Oleate (C18:1n9c)	18.5	4.6	65.5	4.6	269.8	44.4	461.2	47.9
Methyl Stearate (C18:0)	3.9	0.7	10.8	1.1	49.1	9.7	83.3	5.2
Methyl Arachidate (C20:0)	0.3	0.0	0.8	0.2	2.1	0.2	5.0	0.5
Methyl Behenate (C22:0)	1.4	0.2	2.0	0.2	4.2	0.5	7.3	0.9
Total (g/Gal Fuel)	**84.2**	**13.5**	**287.3**	**15.2**	**1142.8**	**121.7**	**1996.6**	**116.3**
Soybean								
Compound			**B20**	**SD**			**B100**	**SD**
Methyl Myristate (C14:0)			3.6	0.0			4.9	0.6
Methyl Palmitate (C16:0)			79.7	10.3			517.3	19.0
Methyl Linolenate (C18:3n3c)			36.2	7.2			312.3	16.6
Methyl Linolelaidate (C18:2n6t)			ND	ND			ND	ND
Methyl Linoleate (C18:2n6c)			286.1	33.6			1833.3	65.1
Methyl Elaidate (C18:1n9t)			ND	ND			ND	ND
Methyl Oleate (C18:1n9c)			94.2	17.3			671.6	32.2
Methyl Stearate (C18:0)			19.8	2.8			152.2	9.6
Methyl Arachidate (C20:0)			1.0	0.3			7.8	0.4
Methyl Behenate (C22:0)			3.3	0.3			11.0	0.4
Total			**523.9**	**39.9**			**3510.3**	**77.5**

ND means that the compound was not detected.

Table S-4. Aromatic hydrocarbons detected in diesel fuel. These compounds were not quantified.

Compound	**Compound**
Benzene, 1-methyl-4-(1-methylethyl)	Benzene, 1,3-bis(1-methylethyl)
Benzene, 1,2,3,5-tetramethyl	1H-Indene, 2,3-dihydro-4,7-dimethyl
Benzene, 1-ethyl-2,5-dimethyl	2H-1-Benzopyran-2-one, 3-methyl
Naphthalene, 1,2,3,4-tetrahydro	1(3H)-Isobenzofuranone, 3-propylidene
Isopropyl phenyl ketone	Naphthalene, 2-chloro
Benzene, pentamethyl	N-Nitrosodiphenylamine
Benzene, 1-ethyl-3-(1-methylethyl)	1(3H)-Isobenzofuranone, 3-butylidene
Benzene, 1-(1,1-dimethylethyl)-3-methyl	Naphthalene, 1,6,7-trimethyl
2(1H)naphtholenone, 3,4-dihydro	1H-Imidazole, 4,5-dihydro-2-(1,2,3,4-tetrahydro-1-naphthalenyl)

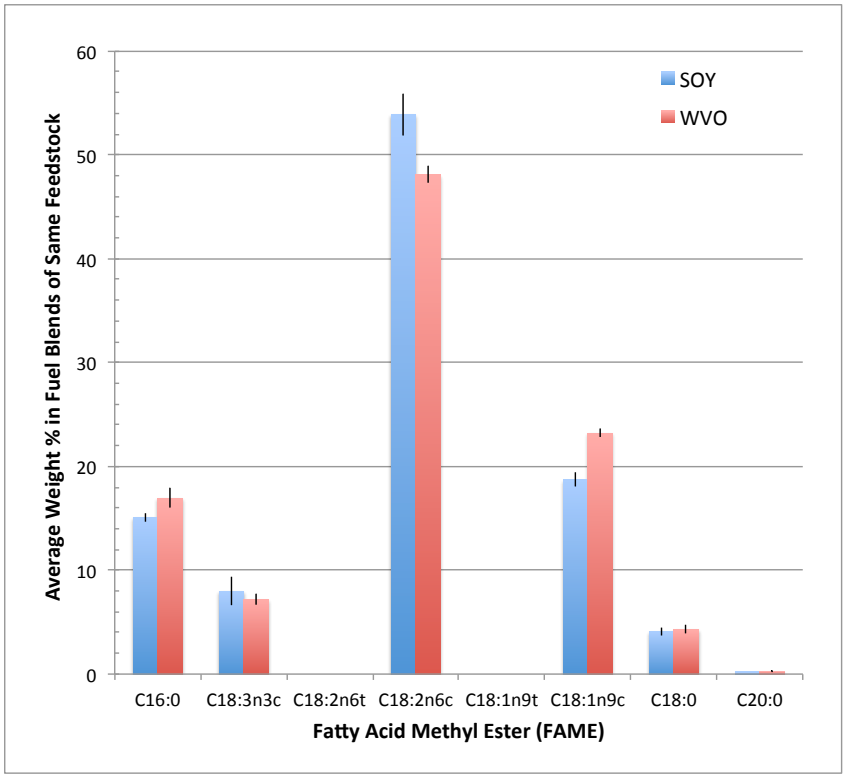


Figure S1. Average (and one standard deviation error bars) FAMEs composition of the WVO and SOY sequence biodiesel blends based on GCMS analysis of diluted fuel. For WVO, results are based on analyses of B10, B20, B50 and B100. For SOY sequence, only B20 and B100 fuels were analyzed.

Table S-5. CM-12 Engine, dynamometer, and lube oil specifications.

Engine	
Bore of cylinder	79.5 mm
Number of cylinders	4
Stroke volume	474 cm^3
Rated speed	95.5 mm
Rated power	60 kW
Maximum torque	130 Nm at 2000 - 2400 RPM
Compression ratio	19.5:1
Power Absorption Unit/ Eddy Current Dynamometer	
Manufacturer	Zelu/ Klam
Model Number	K-40 PAU
Max Power	60kW
Max Torque	145Nm
Lubrication Oil	
Manufacturer	Castrol
Model Number	SAE 5W-40
Part Number	06249
Type	Synthetic

Drive Cycle. Each engine test started after idle and a warm-up period at about 50% load, which ended when the engine coolant temperature reached 90°C. Time zero of the test (**Figure S2**) started the 60-minute transient operation cycle based on data recorded during driving a VW TDI vehicle in downtown Burlington, Vermont. Following the transient cycle were three 10-minute steady-state test phases at increasing percent engine load.

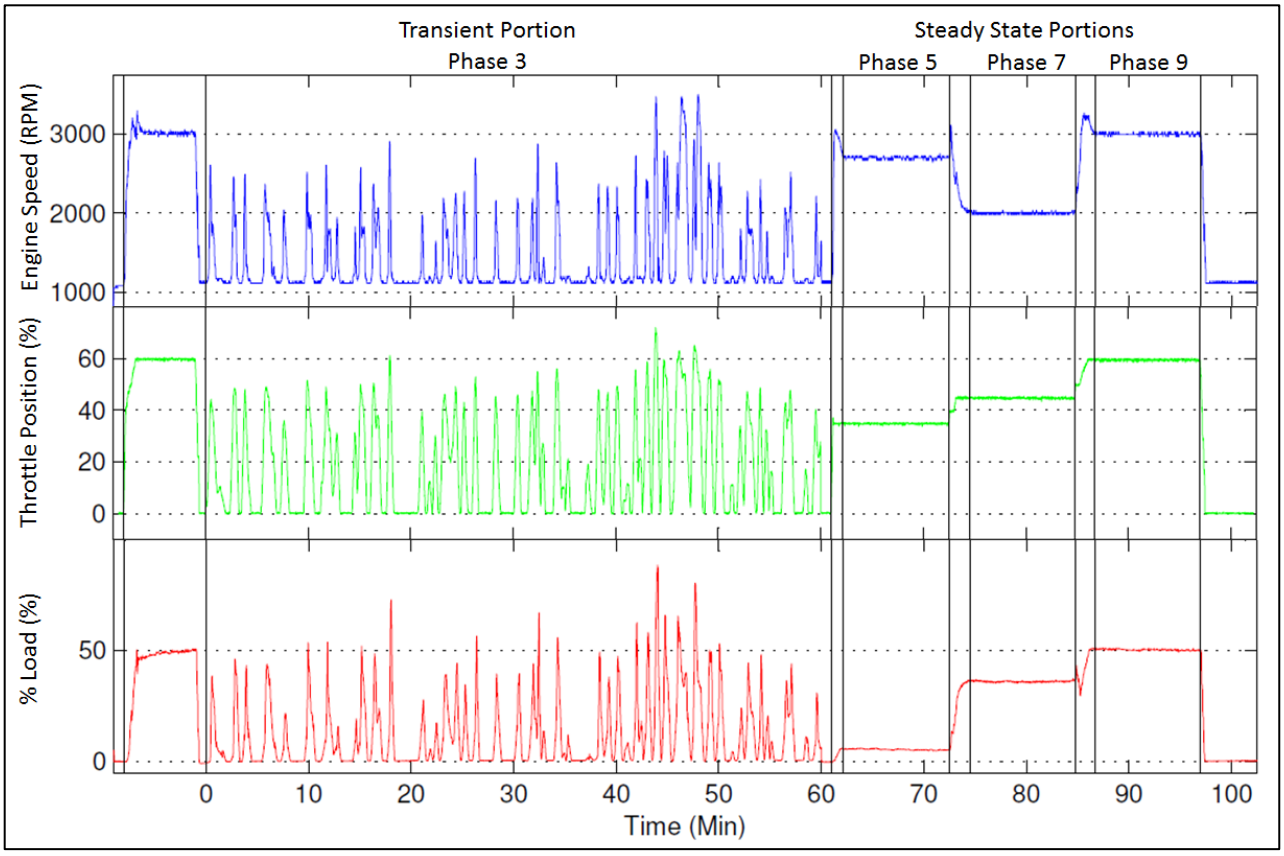


Figure S2. Drive cycle used during engine testing (Feralio and Holmén 2015).

II. Detailed Results from DTT Assay.

Table S-6. Raw Impinger Data: Mean and Standard Deviation of Drop Method PM Concentration (ug/mL_{EtOH}), DTT Rate (nmol/min) and PM-normalized DTT Activity ($nmol/min/mg_{PM}$)

Fuel Feedstock	Bxx	PM Concentration (ug/mL)		DTT Rate (nmol/min)		DTT Activity (nmol/min/mgPM)	
		Mean	StDev	Mean	StDev	Mean	StDev
SOY	0	18.0	3.7	0.37	0.05	20.9	4.2
SOY	10	22.3	1.7	0.35	0.10	15.3	3.6
SOY	20	21.0	2.6	0.22	0.07	10.9	4.6
SOY	50	21.4	1.0	0.26	0.06	12.4	2.7
SOY	100	20.4	4.1	0.27	0.06	13.6	3.8
WVO	0	24.9	1.7	0.56	0.13	22.6	4.5
WVO	10	21.5	1.0	0.39	0.12	17.7	4.8
WVO	20	19.3	6.0	0.35	0.22	16.9	5.8
WVO	50	26.1	7.4	0.24	0.17	8.6	4.0
WVO	100	21.2	0.6	0.18	0.06	8.5	2.8

III. Extraction of Organic Chemical Compounds

Before extraction, all filters were weighed to ensure that mass change during storage was ±5% of the mass recorded prior to storage. For extraction, a ¼-inch punch was cut from each filter using a punch bore and placed in a 180 μL glass thermal desorption vial (glass TD-vial) to which 70 μL of DCM/Hexanes (1:1, v/v) solvent mixture was added to extract the nonpolar compounds by sonicating for 5 minutes. The punch was extracted two more times, and all three extracts were combined in a separate 180 μL glass TD-vial. Polar analytes were then extracted three times with 70 μL aliquots of MeOH and sonicating for 5 minutes each time. The three MeOH extracts were combined in a separate 180 μL glass TD-vial. Both the polar and nonpolar extracts were then gently blown down with N_2 gas to about 60 μL each. The two extracts were then combined in a new 180 μL glass TD-vial, and the combined extract was blown down to 100 μL. An aliquot (2 μL for Blanks, B00, B10, and B20 filter extracts; 1 μL for B50 filter extracts; for the B100 extracts, 5 μL of the extract was diluted with 15 μL of DCM:Hexanes:MeOH (1:1:2) and 2 μL of the diluted extract was used for GC/MS analysis) was then taken from the 100 μL final combined extract and injected in a gas chromatography/mass spectrometer (5890GC/5972MSD, Agilent Technologies, Wilmington, DE) equipped with a thermal desorption syringeless injector (Lavigne Laboratories, Storrs Mansfield, CT) for analysis of nonpolar compounds such as PAHs and n-alkanes. Given that the laboratory did not have authentic standards for the odd-numbered n-alkanes, such compounds (odd-numbered n-alkanes) were identified and confirmed using the NIST Library (NIST 2008). For the analysis of polar compounds (carbonyls and quinones), an aliquot (2 μL for Blanks, B00, B10,

and B20 filter extract; 1 μL for B50 filter extracts; 5 μL of the extract was diluted with 15 μL of DCM:Hexanes:MeOH (1:1:2) and 2 μL of the diluted extract was derivatized) was then taken from the 100 μL final extract and derivatized with excess (pentafluorobenzylhydroxylamine) PFBHA in a 180 μL TD-vial**.** This was performed by adding 1 μL of a 2.4 ppm solution of 6-fluoro-4-chromanone (6F4C) quantitation standard to the aliquot followed by 1.5 μL of a 25 mg/mL PFBHA (in MeOH) solution.[2] Acetonitrile/dichloromethane (ACN/DCM) solvent mixture (9:1, v/v) was then added to the vial to target a final solution volume of 30 μL and a PFBHA concentration of 5 mM. The sample was then derivatized at 35 ºC for 24 hours. At the end of the 24 hour derivatization period, the excess PFBHA was quenched by adding 11 μL of acetone, and the quenching reaction let to proceed for at least 1 hour at room temperature. The derivatized extract was blown down to dryness and then heated at 80 ºC for 10 minutes so as to let the excess PFBHA-acetone oxime volatilize. The derivatized sample was then analyzed on the TD-GC/MS. Note that 1 μL of a 2 ppm solution containing 6 deuterated PAH internal standards (2.65 ng of, 1,4-dichlorobenzene-D4, naphthalene-D8, acenaphthene-D10, phenanthrene-D10, chrysene-D12, and perylene-D12) in DCM was added to each sample's nonpolar extract just before TD-GC/MS analysis for quantitation of the nonpolar compounds. The internal standard eluting closest to a given target analyte was used to quantify that particular analyte. 6-Fluoro-4-chromanone, added to the polar fraction extract just before the derivatization reaction, was used as the internal standard to quantify all the derivatized POCs.[2]

The TD-GC/MS system operated in splitless mode using 99.999% helium carrier gas flowing at 1.6 mL/min, and a Rxi-XLB 30 m, 0.25 mm ID, and 0.25 μm film thickness (Restek, Bellefonte, PA) column. The injector temperature was 295 ºC, while the detector temperature was 290 ºC. The oven program used for analysis of all extracts on the TD-GC/MS was as follows: 65 ºC initial temperature held for 12 min, 10 ºC/min ramp to 180 ºC and held for 3 min, 2.5 ºC/min ramp to 300 ºC and held for 15 min. The MSD was operated with electron ionization (EI), and the EI mass spectra were acquired in scan mode (m/z 50 - 650 amu).

The Rxi-XLB column could not resolve the unsaturated FAMEs, and this made the analysis/quantitation of FAMEs simultaneously with the PAHs and n-alkanes on the TD-GC/MS impossible. Therefore, FAMEs were separately analyzed on a 6890GC/5973MSD system equipped with a polar column, SLB-IL 100, 30 m length, 0.25 mm ID, and 0.20 μm film thickness (Sigma Aldrich, Milwaukee, WI) and a 7683 Series liquid autosampler (Agilent). A 1 μL aliquot was drawn from the 100 μL final extract and diluted with 50 μL of hexanes for the Blanks, B00, B10, and B20 filter extracts. The 1 μL aliquot from the B50 extracts was diluted with 100 μL of hexanes, while that from the B100 extracts was diluted with 200 μL of hexanes. An appropriate amount of a 100 ppm standard of 6F4C internal standard was then added to each extract just before GC/MS analysis to target a 6F4C concentration of 2 ppm for quantitation of all FAMEs. The 6890/5973 GC/MS system also operated in splitless mode using helium carrier gas flowing at 1 mL/min. The injector and detector temperatures were 240 ºC and 280 ºC, respectively. The oven program used for analysis of all extracts on the 6890/5973 GC/MS system was as follows: 50 ºC initial temperature held for 13.5 min, 3 ºC/min ramp to 200 ºC and held for 30 min. The MSD was also operated in EI mode (m/z 50 - 500 amu).

Fuel samples collected from the fuel tank were analyzed for FAMEs after dilution with hexanes to achieve 50-100ppm concentration of which 1 μL was injected using the 6890/5973 autosampler. GCMS analysis was performed on the polar SLB-IL 100 column, as for the PM extracts, and similarly quantified based on authentic standards in a 10-FAME mix from Supelco.

IV. Determination of Organic Compound Detection Limits

Method detection limit (MDL) is defined as the amount of analyte that can be identified, measured, and reported with 99% confidence that the amount of analyte in a sample is greater than zero (Method 556, US EPA[1]). The method detection limits were estimated according to Method 556 (US EPA[1]) using the equation below:

$$Method\ Detection\ Limit\ (MDL) = St_{(n-1,\ 1-alpha\ =\ 0.99)} \qquad Eq\ (S-1)$$

where S = standard deviation of n runs for a sample whose concentration of the analyte is about 5 times the noise level, n = number of replicate, and $t_{(n-1,\ 1-alpha\ =\ 0.99)}$ is the Student's t-value for the 99% confidence level with n-1 degrees of freedom.

MDL for the PAHs were determined by analyzing a 0.125 ppm PAHs standard (number of runs, $n = 7$, $t_{n-1} = 3.143$) on the TD-GC/MS, while the detection limits for the n-alkanes were determined using a 0.7 ppm standard ($n=7$, $t_{n-1} = 3.143$. The MDLs for the FAMEs were determined by analyzing a 5 ppm standard of the 10 FAMEs mix seven times ($n=7$, $t_{n-1} = 3.143$) on the 6890/5973 GC/MS. Table S3 below shows the MDLs of the n-alkanes, PAHs, and FAMEs.

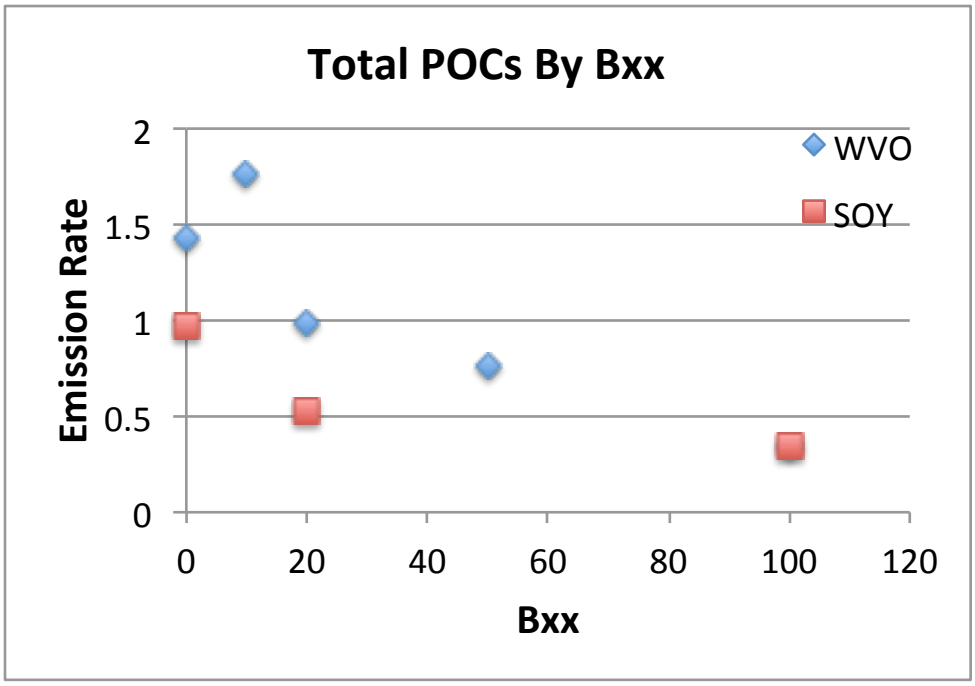
Percent Recoveries and Reproducibility. Before extraction, each ¼-inch filter punch was spiked with 200 ng of tetracosane-d50 and 100 ng of 2-fluoro-9-fluorenone (2F9F) to assess the extraction efficiencies of the nonpolar and polar compounds in the PM, respectively. The average recovery of tetracosane-d50 was 80.1±23.0%, while that of 2F9F was 109.6±58.4%. Also, two to four punches were separately extracted from select filters in order to assess the reproducibility of the extraction and GC/MS analysis procedure. Good reproducibility (at least 75% of the extracts had %RSD values less than 20%; Average±SD values for %RSDs of all target analyte groups were as follows: 8.5±8.1 for the PAHs, 11.1±14.3 for the n-alkanes, and 16.0±13.4 for the FAMEs, see Kasumba [3] for details) was obtained for most of the exhaust PM filters where multiple one-punch extractions were performed. Further, good reproducibility was also achieved for the triplicate and duplicate filters extracted for WVO and soybean blends, respectively, as about 71% of the data had %RSD values less than 20%. Percent RSD values greater than 30% were observed for the high volatility compounds (compounds with less than 14 carbon atoms), and such variability was probably caused by losses during extract blowdown. No corrections for percent recoveries were performed, and all data, including those with high variability, were used for data analysis. Average emission rates (ng/μg) of all target analytes for each biodiesel blend are in Kasumba (2015).

V. Emission Rates of Polar Organic Compounds by Functional Group by Blend

The *eight panels* below (**Figure S3**) show the average emission rate of the sum of target analytes in each functional group class (ng/ug PM) as a function of biodiesel blend volume percent (x-axis) with different plots for WVO and SOY feedstocks. The following table summarizes the target polar organic compounds quantified in this study based on use of authentic standards.

Target Polar Analytes By Functional Group Class

Aliphatic Aldehydes	Aromatic Aldehydes	
Hexanal	Benzaldehyde	
Heptanal	m-Tolualdehyde	
Octanal	o-Tolualdehyde	
Nonanal	p-Tolualdehyde	
Decanal		
Undecanal		
Dodecanal		
Aliphatic Ketones	**Aromatic Ketones**	**Quinones**
2-Pentanone	Acetophenone	1,4-Benzoquinone
3-Pentanone	1-Indanone	1,4-Naphthoquinone
2-Nonanone	9-Fluorenone	Acenaphthoquinone
2-Hexanone	Perinaphthenone	Anthraquinone
2-Heptanone	Benzophenone	
2-Octanone		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Emission Rate
Bxx
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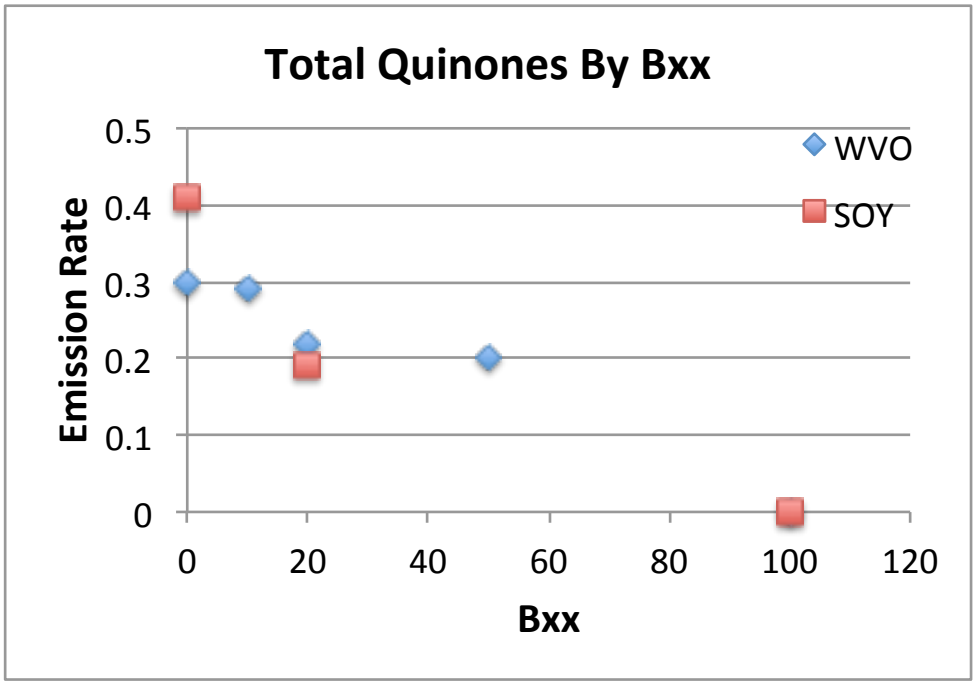
1.5
2
0
20
40
60
80
100
120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Emission Rate
Bxx
WVO
SOY
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0.4
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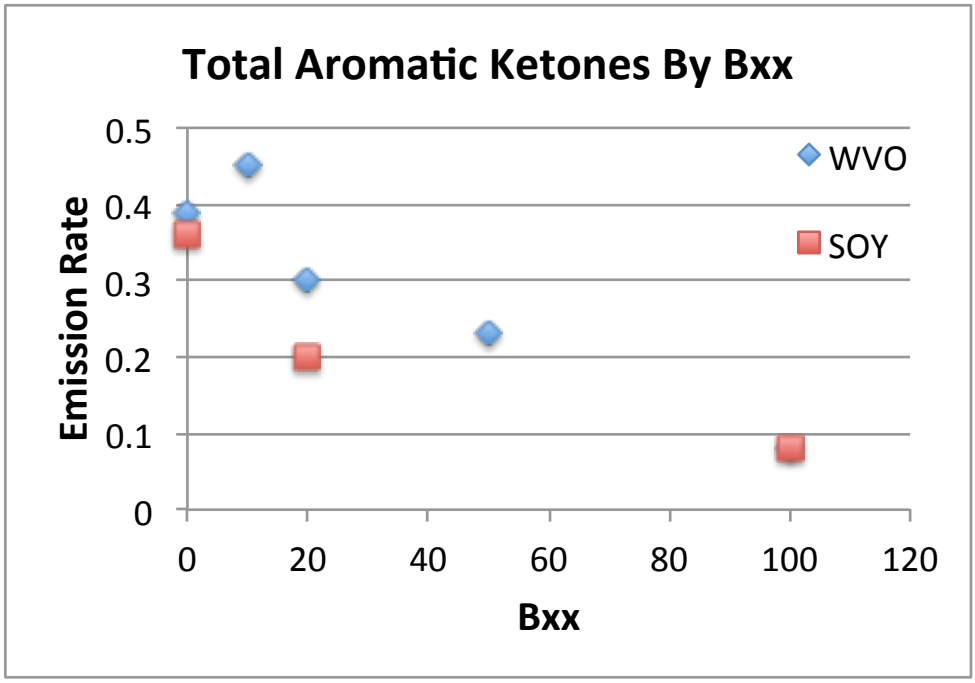
60
80
100
120


Total Aromatic Ketones By Bxx
Emission Rate
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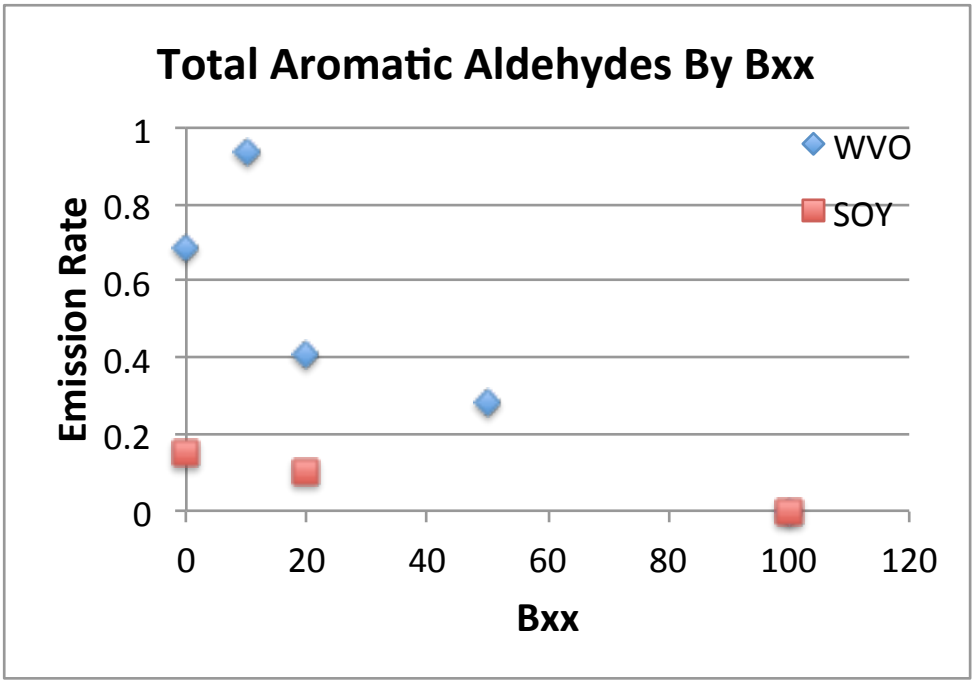
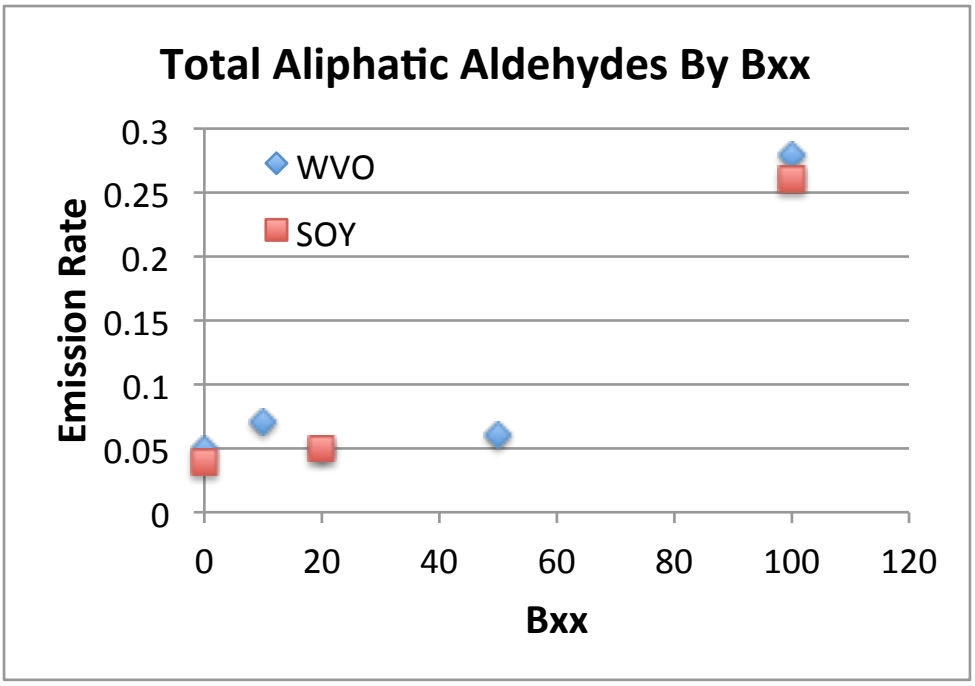
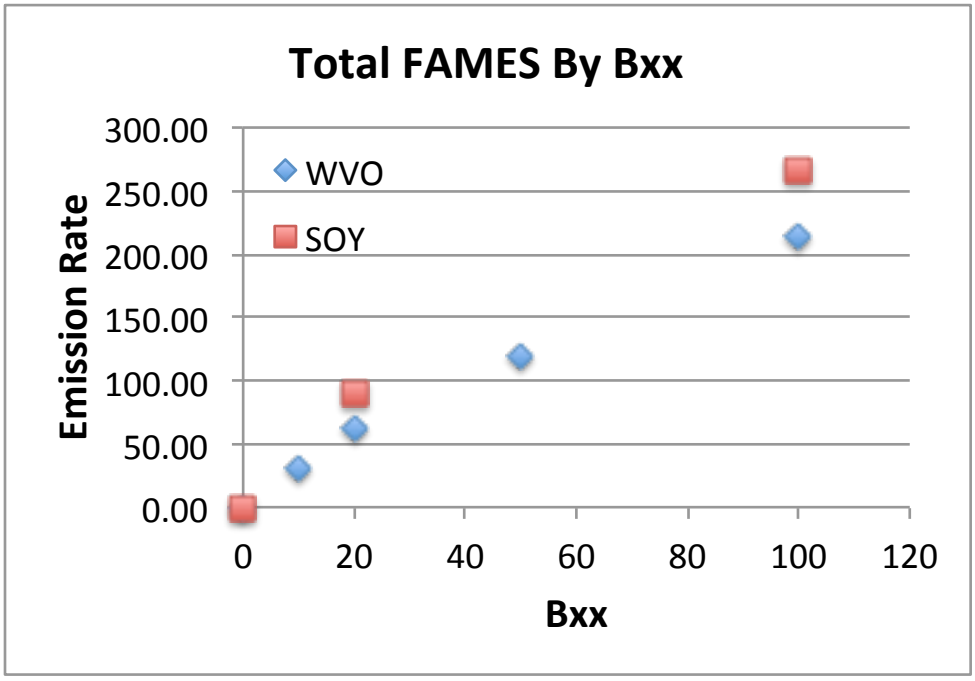
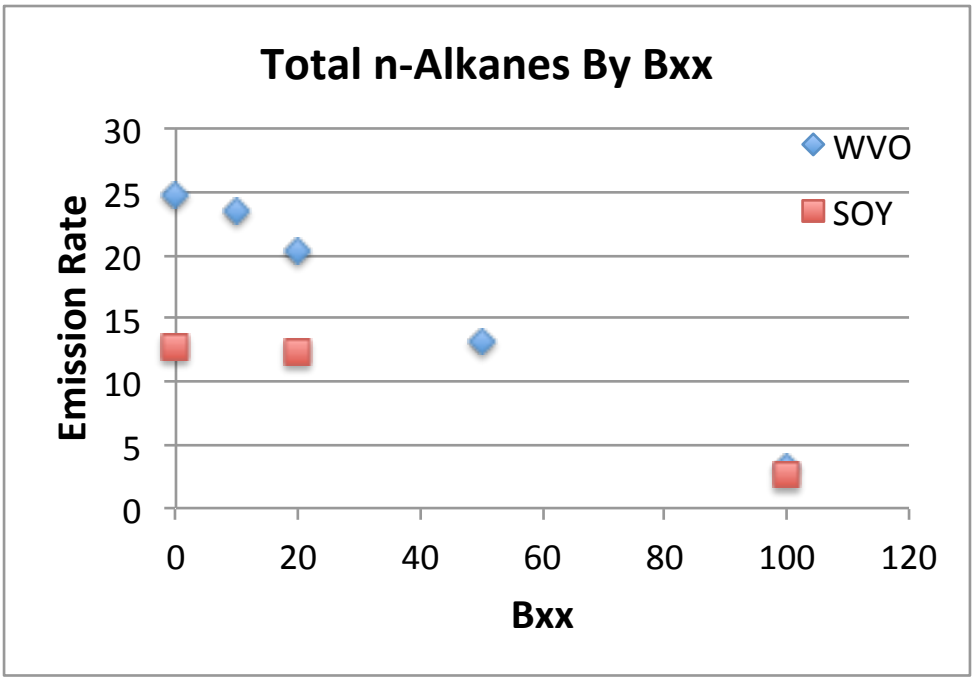
0.3
0.2
0.1
0
0
20
40
60
80
100
120
Bxx
WVO
SOY


Total Aromatic Aldehydes By Bxx
Emission Rate
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
Bxx
WVO
SOY


Total Aliphatic Aldehydes By Bxx
Emission Rate
0.3
0.25
0.2
0.15
0.1
0.05
0
WVO
SOY
0
20
40
60
80
100
120
Bxx


Total FAMES By Bxx
Emission Rate
300.00
250.00
200.00
150.00
100.00
50.00
0.00
WVO
SOY
0
20
40
60
80
100
120
Bxx



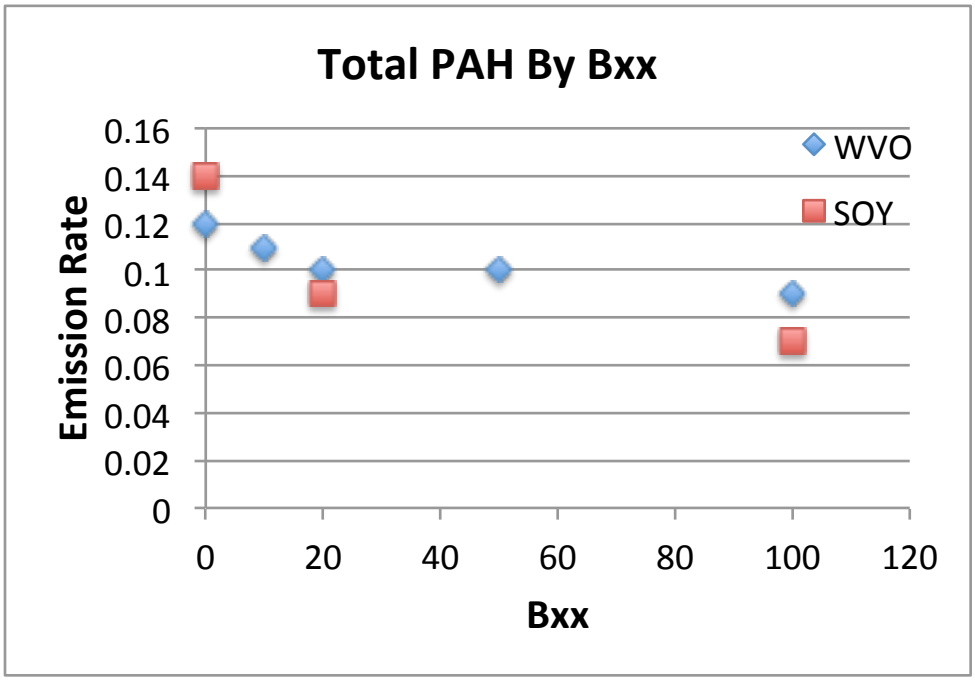


Figure S3. Mean organic compound class emission rate (ng/ug of PM) as a function of biodiesel blend % (x-axis) for both feedstocks.

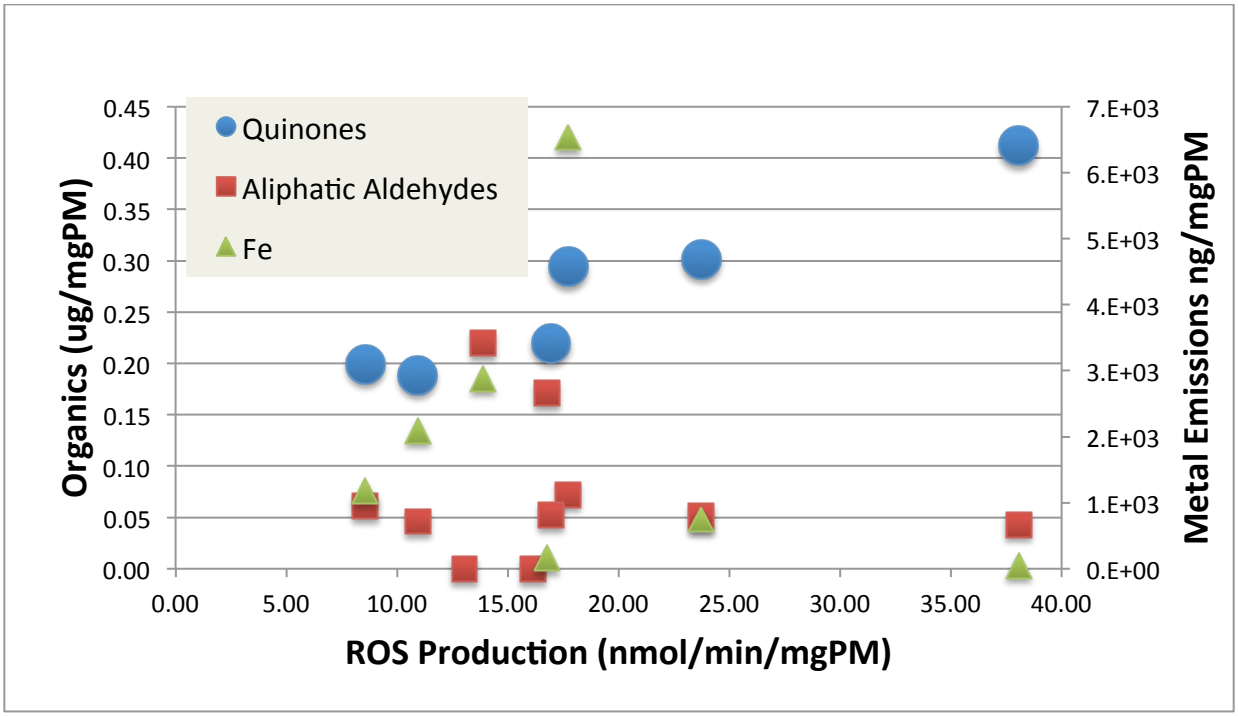


Figure S4. Relationship between ROS production measured by DTT Assay (x-axis) and total quinones (blue circles), total aliphatic aldehydes (red squares) and total iron (green triangles, right-hand y-axis scale) for SOY and WVO emissions tests combined.

VI. Elemental Data from ICP-MS Analysis of Diluted PM Filters

Blank Fiberfilm filter Raw Metals Mass.

BLANK FILTER - ICP/MS	
raw ng/filter	
5824.23	Al
369.71	Fe
1195.76	Ca
215353.02	Na
624.29	Mg
49497.03	K
14102.65	Ba
1.60	Cd
1.23	Co
27.26	Cr
407.52	Cu
213.60	Hg
9.59	Mn
2.76	Mo
83.09	Ni
53.32	Pb
26.89	Ti
35.55	V
14496.60	Zn

Elemental data from ICP-MS analysis of the diluted filters were highly variable due to high background of many elements in the Fiberfilm filter material. Future studies should seek alternative filter materials with low blanks to enable improved interpretation of elemental data.

Table S-7. Emission rates ($\mu g/mg_{PM}$) for elements analyzed by ICP-MS*.

	WASTE VEGETABLE OIL					SOYBEAN			
	B0	B10	B20	B50	B100	B0	B20	B100_1	B100_2
Crustal Elements									
Al	ND	22435	ND	17810	35765	ND	ND	ND	ND
Fe	748	6533	ND	1173	2881	47	2094	162	118
Ca	660	10944	ND	7351	18318	ND	ND	ND	ND
Na	ND	440271	ND	333775	804491	ND	ND	10230	ND
Mg	ND	4787	ND	3849	8842	ND	ND	ND	ND
K	ND	125459	ND	96915	249684	ND	ND	4203	ND
Anthropogenic Elements									
Ba	ND	116862	ND	102344	279918	ND	ND	ND	ND
Cd	18	52	ND	13	40	30	2	1	80
Co	4	11	5	33	2	ND	5	3	ND
Cr	45	4597	ND	118	2229	ND	998	103	70
Cu	2586	189503	868	ND	220038	1324	16864	6046	2586
Hg	825	693	503	225	ND	ND	ND	ND	ND
Mn	2	97	ND	38	110	ND	26	2	1
Mo	55	38	25	22	5	ND	9	4	2
Ni	1169	52963	ND	566	19547	582	5500	1826	514
Pb	483	7002	ND	248	8256	564	1742	222	1836
Sr	ND	805	ND	645	1635	ND	ND	ND	ND
Ti	ND	190	ND	28	38	ND	ND	ND	2
V	59	ND	48	43	ND	35	68	6	8
Zn	ND	235013	ND	122696	464465	ND	ND	ND	ND

* Blank-subtracted values. Replicate filters were analyzed for SOY B100 only as indicated by underscore. Color bars indicate relative magnitude of emission rates by blend (column-wise). ND = not detected after blank subtraction.

VII. References Cited

(1) Munch, J.; Munch, D.; Winslow, S.; Wendelken, S.; Pepich, B. Determination of carbonyl compounds in drinking water by pentafluorobenzylhydroxylamine derivatization and capillary gas chromatography with electron capture detection; Method 556; National Exposure Research Laboratory, Office of Research and Development, US Environmental Protection Agency, Cincinnati, OH, 1998.

(2) Jakober, C. A.; Robert, M. A.; Riddle, S. G.; Destaillats, H.; Charles, M. J.; Green, P. G.; Kleeman, M. J. Carbonyl Emissions from Gasoline and Diesel Motor Vehicles. Environ. Sci. Technol. 2008, 42 (13), 4697–4703.

(3) Kasumba, J. Organic Chemical Characterization Of Primary And Secondary Biodiesel Exhaust Particulate Matter. Ph.D. Dissertation, Civil & Environmental Engineering, The University of Vermont, Graduate College Dissertations and Theses 2015.