

Supplementary Information: Characterization and Biological Removal of Organic Compounds from Hydraulic Fracturing Produced Water

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Table S1. Linear regression of the first order biodegradation reaction rate with chemical characteristics of the samples

Regression Statistics			
Multiple R			0.78
R Square			0.61
Adjusted R Square			-0.23
Standard Error			0.01
Observations			18.00
	Coefficients	Standard Error	P-value
Intercept	-0.07	0.05	0.17
Initial TOC	0.00	0.00	0.07
Linear HCs	0.00	0.00	NA
Branched HCs	0.00	0.00	NA
Cyclic HCs	0.00	0.00	NA
Avg. carbon count	0.01	0.00	NA
O-heteroatoms	0.04	0.04	0.35
N-heteroatoms	0.00	0.00	NA
Other heteroatoms	0.00	0.00	NA
PEG	0.00	0.00	NA
PPG	0.00	0.00	NA
AEO	-0.01	0.00	NA
NPEO	0.00	0.00	0.98
Acids	0.00	0.00	0.99

Table S2. Analysis of variance (ANOVA) of the first order biodegradation reaction rate with chemical characteristics of the samples

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Linear HCs	1	0	0	0.01	0.942
Branched HCs	1	0.00008	0.00008	1.13	0.309
Avg. carbon count	1	0	0	0	0.955
O-heteroatoms	1	0.000104	0.000104	1.46	0.25
N-heteroatoms	1	0.000017	0.000017	0.24	0.63
Error	12	0.000856	0.000071		
Total	17	0.001636			

Table S3. Reported chemicals in FracFocus for the studied samples.

Sample Name	Chemicals
Bakken	Aluminum oxide, Crystalline Silica - SiO ₂ , Amorphous silica, Titanium dioxide, Silicon dioxide, Iron (III) oxide, Guar Gum, Ethylene Glycol, Isopropal Alcohol, Diethylenetriamine Alkylbenzene Sulfate, Diatomaceous Earth, Calcined, Boric Acid- sodium salt, Potassium Hydroxide, Potassium Carbonate, Sodium Hydroxide, Benzene 1-1-oxybis-tetrapropylene, Isoparaffinic Solvent, Polyethylene glycol, Organo Phosphorus Salt, Tert-Butyl Hydroperoxide, Heavy Aromatic Solvent Naphtha, Diethylenetriamine, 2-Ethylhexanol, 2,2-Dibromo-3-Nitrilopropionamide, Sodium Chloride, Naphthalene, Sodium bromide, Dibromoacetone, Citric Acid
Utica1	Hydrochloric Acid, Citric Acid, Methanol (Methyl Alcohol), Propargyl Alcohol (2-Propynol), Crystalline Silica, Petroleum Distillate Blend, Polysaccharide Blend, Ethoxylated Nonyl Phenol, Petroleum Distillate Hydrotreated Light, Boric Acid, Glutaraldehyde, Didecyl Dimethyl Ammonium Chloride, Quaternary Ammonium Compound, Ethanol, Ethylene Glycol, Diethylene Glycol, Potassium Hydroxide, Ammonium Persulfate, Calcium Chloride
Utica2	Hydrogen chloride, Cholinium chloride, Guar gum, Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid (sodium salt polymer), Ammonium sulfate, Potassium borate, Glutaraldehyde, sodium sulfate, Potassium hydroxide, Glycerol, Ethanol, 2,2,2-nitrilotris-, 1,1,1-tris(dihydrogen phosphate) (sodium salt), Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate, Diammonium peroxodisulphate, Urea, Trisodium ortho phosphate, Sodium erythorbate, Methanol, Fatty acids, tall oil, Thiourea, polymer with formaldehyde and 1-phenylethanone, Ethane-1,2-diol, Vinylidene chloride/methylacrylate copolymer, Alcohols, C14-15, ethoxylated(7EO), Prop-2-yn-1-ol, Alkenes, C>10 a-, Tetrasodium ethylenediaminetetraacetate, Dimethyl siloxanes and silicones, Magnesium silicate hydrate (talc), Decamethyl cyclopentasiloxane, Siloxanes and Silicones, di-Me, reaction products with silica, Octamethylcyclotetrasiloxane, poly(tetrafluoroethylene), Sodium hydroxide
Utica3	Hydrochloric Acid, Proprietary Alkyl Alcohol, Sodium Hydroxide, Proprietary Inorganic Salt, Proprietary Aliphatic Hydrocarbon, Proprietary Oxyalkylated Alcohol, Glutaraldehyde (Pentenediol), Ammonium Persulfate, Isopropanol, Proprietary Fatty Alcohol Ethoxylate, Proprietary Aromatic Aldehyde, Proprietary Ethoxylated Alcohol Blend, Proprietary Alkyl Amine Surfactant, Citric Acid, Proprietary Surfactant, Petroleum Distillate, Guar Gum, Proprietary Clay, Proprietary Vinyl Copolymer, Sodium Chloride, Proprietary Aliphatic Alcohol, Tetrasodium Ethylenediaminetetraacetate, Proprietary Substituted Fatty Acid Ester, Proprietary Oxyalkylated Fatty Acid Derivative, Proprietary Polycarboxylic Acid Polymer, Proprietary Fatty Amino Adduct, Copper Sulfate, Methanol, Proprietary Polyether, Proprietary Oxyalkylated Alcohol
Utica4	Proprietary Water-Soluble Polymer, Hydrochloric Acid, Sodium Hydroxide, Proprietary Alkyl Alcohol, Proprietary Inorganic Salt, Proprietary Aliphatic Hydrocarbon, Proprietary Oxyalkylated Alcohol, Glutaraldehyde (Pentenediol), Ammonium Persulfate, Isopropanol, Proprietary Fatty Alcohol Ethoxylate, Proprietary Aromatic Aldehyde, Proprietary Ethoxylated Alcohol Blend, Proprietary Alkyl Amine Surfactant, Guar Gum, Petroleum Distillate, Proprietary Clay, Proprietary Vinyl Copolymer, Proprietary Aliphatic Alcohol, Proprietary Substituted Fatty Acid Ester, Proprietary Oxyalkylated Fatty Acid Derivative, Sodium Chloride, Tetrasodium Ethylenediaminetetraacetate, Proprietary Polycarboxylic Acid Polymer, Sodium Erythorbate, Proprietary Fatty Amino Adduct, Copper Sulfate, Proprietary Polyether, Proprietary Oxyalkylated Alcohol, Methanol

Utica5 Crystalline silica, Hydrogen chloride, Cholinium chloride, Guar gum, Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer, Ammonium sulfate, Potassium borate, Glutaraldehyde, Sodium sulfate, Potassium hydroxide, Glycerol, Ethanol, 2,2,2-nitrotris-, 1,1,1-tris(dihydrogen phosphate), sodium salt, Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate, urea, Trisodium ortho phosphate, Sodium erythorbate, methanol, fatty acids (tall oil), Thiourea, polymer with formaldehyde and 1-phenylethanone, Non-crystalline silica, Ethane-1,2-diol, Vinylidene chloride/methylacrylate copolymer, Alcohols, C14-15, ethoxylated(7EO), Prop-2-yn-1-ol, Alkenes, C>10 a-, Diammonium peroxidisulphate (other trade name: ammonium persulfate), Sodium hydroxide, Tetrasodium ethylenediaminetetraacetate, Dimethyl siloxanes and silicones, Magnesium silicate hydrate (talc), Decamethyl cyclopentasiloxane, Siloxanes and Silicones, di-Me, reaction products with silica, Octamethylcyclotetrasiloxane, poly(tetrafluoroethylene),

Utica6 Water, Hydrochloric Acid, Tetrasodium Ethylenediaminetetraacetate, Trisodium Nitrilotriacetate, Sodium Hydroxide, Isopropanol (Isopropyl Alcohol, Propan-2-ol), Proprietary Organic Amine Resin Salt, Dimethyl Formamide, Proprietary Aromatic Aldehyde, Proprietary Quaternary Ammonium Compound, Crystalline Silica (Quartz Sand, Silicon Dioxide), Crystalline Silica (Quartz Sand, Silicon Dioxide), Petroleum Distillate Hydrotreated Light, Guar Gum, Ammonium Persulfate, Crystalline Silica (Quartz Sand, Silicon Dioxide), Proprietary Cured Acrylic Resin, Petroleum Distillate Hydrotreated Light, 2-Butoxyethanol (Ethylene Glycol Monobutyl Ether), Isopropanol (Isopropyl Alcohol, Propan-2-ol), Dodecylbenzenesulfonic Acid, Sodium Metaborate Tetrahydrate, Boric Acid, Potassium Hydroxide, Potassium Carbonate, Potassium Hydroxide, Ammonium Persulfate, Glutaraldehyde (Pentanediol), Quaternary Ammonium Compound, Ethanol

Table S4. Surfactant accurate mass tables from LC/Q-ToF/MS measurements

Products	Retention Time(min)	Base Peak	Base Peak Formula	Observed m/z	Theoretical m/z	Error (ppm)
<i>PEG-COOH (Polyethylene glycol carboxylate derivatives)</i>						
COOH of PEG-EO8	4.31	[M+Na] ⁺	C ₁₆ H ₃₂ O ₁₀ Na ⁺	407.1890	407.1888	0.5
COOH of PEG-EO9	4.32	[M+Na] ⁺	C ₁₈ H ₃₆ O ₁₁ Na ⁺	451.2154	451.2150	0.9
COOH of PEG-EO10	4.33	[M+Na] ⁺	C ₂₀ H ₄₀ O ₁₂ Na ⁺	495.2423	495.2412	2.2
COOH of PEG-EO11	4.33	[M+Na] ⁺	C ₂₂ H ₄₄ O ₁₃ Na ⁺	539.2685	539.2674	2.0
COOH of PEG-EO12	4.34	[M+Na] ⁺	C ₂₄ H ₄₈ O ₁₄ Na ⁺	583.2947	583.2936	1.9
COOH of PEG-EO13	4.34	[M+Na] ⁺	C ₂₆ H ₅₂ O ₁₅ Na ⁺	627.3207	627.3198	1.4
COOH of PEG-EO14	4.35	[M+Na] ⁺	C ₂₈ H ₅₆ O ₁₆ Na ⁺	671.3462	671.3461	0.1
<i>PEGs (Polyethylene glycols)</i>						
PEG-EO8	4.30	[M+Na] ⁺	C ₁₆ H ₃₄ O ₉ Na ⁺	393.2087	393.2095	2.0
PEG-EO9	4.60	[M+NH ₄] ⁺	C ₁₈ H ₃₈ O ₁₀ NH ₄ ⁺	432.2804	432.2803	-0.2
PEG-EO10	4.70	[M+NH ₄] ⁺	C ₂₀ H ₄₂ O ₁₁ NH ₄ ⁺	476.3074	476.3065	-1.9
PEG-EO11	4.80	[M+NH ₄] ⁺	C ₂₂ H ₄₆ O ₁₂ NH ₄ ⁺	520.3330	520.3328	-0.4
PEG-EO12	5.10	[M+NH ₄] ⁺	C ₂₄ H ₅₀ O ₁₃ NH ₄ ⁺	564.3580	564.3590	1.8
PEG-EO13	5.60	[M+NH ₄] ⁺	C ₂₆ H ₅₄ O ₁₄ NH ₄ ⁺	608.3846	608.3852	1.0
PEG-EO8	4.30	[M+Na] ⁺	C ₁₆ H ₃₄ O ₉ Na ⁺	393.2087	393.2095	2.0
<i>PPGs (polypropylene glycols)</i>						
PPG-PO4	7.60	[M+Na] ⁺	C ₁₂ H ₂₆ O ₅ Na ⁺	273.1675	273.1672	-1.1
PPG-PO5	8.50	[M+Na] ⁺	C ₁₅ H ₃₂ O ₆ Na ⁺	331.2093	331.2091	-0.6
PPG-PO6	9.50	[M+Na] ⁺	C ₁₈ H ₃₈ O ₇ Na ⁺	389.2516	389.2510	-1.5
PPG-PO7	10.30	[M+Na] ⁺	C ₂₁ H ₄₄ O ₈ Na ⁺	447.2937	447.2928	-2.0
PPG-PO8	11.10	[M+NH ₄] ⁺	C ₂₄ H ₅₀ O ₉ NH ₄ ⁺	500.3802	500.3793	-1.8
PPG-PO9	12.00	[M+NH ₄] ⁺	C ₂₇ H ₅₆ O ₁₀ NH ₄ ⁺	558.4220	558.4212	-1.4
PPG-PO10	12.80	[M+NH ₄] ⁺	C ₃₀ H ₆₂ O ₁₁ NH ₄ ⁺	616.4635	616.4630	-0.8
PPG-PO11	13.60	[M+NH ₄] ⁺	C ₃₃ H ₆₈ O ₁₂ NH ₄ ⁺	674.5052	674.5049	-0.4
PPG-PO12	14.40	[M+NH ₄] ⁺	C ₃₆ H ₇₄ O ₁₃ NH ₄ ⁺	732.5472	732.5468	-0.5
<i>C10-EOs (C₁₀ ethoxylates)</i>						
C ₁₀ EO ₅	16.65	[M+NH ₄] ⁺	C ₂₀ H ₄₂ O ₆ NH ₄ ⁺	396.3324	396.3320	-1.0

Products	Retention Time(min)	Base Peak	Base Peak Formula	Observed <i>m/z</i>	Theoretical <i>m/z</i>	Error (ppm)
C ₁₀ EO ₆	16.50	[M+NH ₄] ⁺	C ₂₂ H ₄₆ O ₇ NH ₄ ⁺	440.3588	440.3582	-1.4
C ₁₀ EO ₇	16.30	[M+NH ₄] ⁺	C ₂₄ H ₅₀ O ₈ NH ₄ ⁺	484.3849	484.3844	-1.0
C ₁₀ EO ₈	16.10	[M+NH ₄] ⁺	C ₂₆ H ₅₄ O ₉ NH ₄ ⁺	528.4113	528.4106	-1.3
C ₁₀ EO ₉	15.90	[M+NH ₄] ⁺	C ₂₈ H ₅₈ O ₁₀ NH ₄ ⁺	572.4376	572.4368	-1.4
C ₁₀ EO ₁₀	15.75	[M+NH ₄] ⁺	C ₃₀ H ₆₂ O ₁₁ NH ₄ ⁺	616.4637	616.4630	-1.1
C ₁₀ EO ₁₁	15.55	[M+NH ₄] ⁺	C ₃₂ H ₆₆ O ₁₂ NH ₄ ⁺	660.4900	660.4893	-1.1
C ₁₀ EO ₁₂	15.40	[M+NH ₄] ⁺	C ₃₄ H ₇₀ O ₁₃ NH ₄ ⁺	704.5157	704.5155	-0.3
<i>C12-EOs (C₁₂ ethoxylates)</i>						
C ₁₂ EO ₆	17.90	[M+NH ₄] ⁺	C ₂₄ H ₅₀ O ₇ NH ₄ ⁺	468.3891	468.3895	0.9
C ₁₂ EO ₇	17.75	[M+NH ₄] ⁺	C ₂₆ H ₅₄ O ₈ NH ₄ ⁺	512.4160	512.4157	-0.6
C ₁₂ EO ₈	17.55	[M+NH ₄] ⁺	C ₂₈ H ₅₈ O ₉ NH ₄ ⁺	556.4420	556.4419	-0.2
C ₁₂ EO ₉	17.40	[M+NH ₄] ⁺	C ₃₀ H ₆₂ O ₁₀ NH ₄ ⁺	600.4680	600.4681	0.2
C ₁₂ EO ₁₀	17.20	[M+NH ₄] ⁺	C ₃₂ H ₆₆ O ₁₁ NH ₄ ⁺	644.4942	644.4943	0.2
C ₁₂ EO ₁₁	17.05	[M+NH ₄] ⁺	C ₃₄ H ₇₀ O ₁₂ NH ₄ ⁺	688.5210	688.5206	-0.6
C ₁₂ EO ₁₂	16.85	[M+NH ₄] ⁺	C ₃₆ H ₇₄ O ₁₃ NH ₄ ⁺	732.5461	732.5468	1.0
C ₁₂ EO ₁₃	16.65	[M+NH ₄] ⁺	C ₃₈ H ₇₈ O ₁₄ NH ₄ ⁺	776.5736	776.5730	-0.8
C ₁₂ EO ₁₄	16.50	[M+NH ₄] ⁺	C ₄₀ H ₈₂ O ₁₅ NH ₄ ⁺	820.5986	820.5992	0.7
<i>C13-EOs (C₁₃ ethoxylates)</i>						
C ₁₃ EO ₅	19.10	[M+NH ₄] ⁺	C ₂₃ H ₄₈ O ₆ NH ₄ ⁺	438.3796	438.3789	-1.6
C ₁₃ EO ₆	18.90	[M+NH ₄] ⁺	C ₂₅ H ₅₂ O ₇ NH ₄ ⁺	482.4059	482.4051	-1.7
C ₁₃ EO ₇	18.75	[M+NH ₄] ⁺	C ₂₇ H ₅₆ O ₈ NH ₄ ⁺	526.4324	526.4313	-2.1
C ₁₃ EO ₈	18.60	[M+NH ₄] ⁺	C ₂₉ H ₆₀ O ₉ NH ₄ ⁺	570.4575	570.4576	0.2
C ₁₃ EO ₉	18.45	[M+NH ₄] ⁺	C ₃₁ H ₆₄ O ₁₀ NH ₄ ⁺	614.4833	614.4838	0.8
C ₁₃ EO ₁₀	18.25	[M+NH ₄] ⁺	C ₃₃ H ₆₈ O ₁₁ NH ₄ ⁺	658.5105	658.5100	-0.8
C ₁₃ EO ₁₁	18.10	[M+NH ₄] ⁺	C ₃₅ H ₇₂ O ₁₂ NH ₄ ⁺	702.5358	702.5362	0.6
C ₁₃ EO ₁₂	17.95	[M+NH ₄] ⁺	C ₃₇ H ₇₆ O ₁₃ NH ₄ ⁺	746.5614	746.5624	1.3
C ₁₃ EO ₁₃	17.75	[M+NH ₄] ⁺	C ₃₉ H ₈₀ O ₁₄ NH ₄ ⁺	790.5879	790.5886	0.9
C ₁₃ EO ₁₄	17.55	[M+NH ₄] ⁺	C ₄₁ H ₈₄ O ₁₅ NH ₄ ⁺	834.6135	834.6148	1.6

Products	Retention Time(min)	Base Peak	Base Peak Formula	Observed <i>m/z</i>	Theoretical <i>m/z</i>	Error (ppm)
C ₁₃ EO ₁₅	17.40	[M+NH ₄] ⁺	C ₄₃ H ₈₈ O ₁₆ NH ₄ ⁺	878.6411	878.6411	0.0
<i>C14-EOs (C₁₄ ethoxylates)</i>						
C ₁₄ EO ₈	19.40	[M+NH ₄] ⁺	C ₃₀ H ₆₂ O ₉ NH ₄ ⁺	584.4736	584.4732	-0.7
C ₁₄ EO ₉	19.20	[M+NH ₄] ⁺	C ₃₂ H ₆₆ O ₁₀ NH ₄ ⁺	628.4996	628.4994	-0.3
C ₁₄ EO ₁₀	19.00	[M+NH ₄] ⁺	C ₃₄ H ₇₀ O ₁₁ NH ₄ ⁺	672.5256	672.5256	0.0
C ₁₄ EO ₁₁	18.90	[M+NH ₄] ⁺	C ₃₆ H ₇₄ O ₁₂ NH ₄ ⁺	716.5512	716.5519	1.0
C ₁₄ EO ₁₂	18.70	[M+NH ₄] ⁺	C ₃₈ H ₇₈ O ₁₃ NH ₄ ⁺	760.5787	760.5781	-0.8
C ₁₄ EO ₁₃	18.55	[M+NH ₄] ⁺	C ₄₀ H ₈₂ O ₁₄ NH ₄ ⁺	804.6052	804.6043	-1.1
<i>NPEOs (Nonylphenol ethoxylates)</i>						
NP-EO15	16.55	[M+NH ₄] ⁺	C ₄₅ H ₈₄ O ₁₆ NH ₄ ⁺	898.6107	898.6098	-1.0
NP-EO14	16.70	[M+NH ₄] ⁺	C ₄₃ H ₈₀ O ₁₅ NH ₄ ⁺	854.5849	854.5835	-1.6
NP-EO13	16.85	[M+NH ₄] ⁺	C ₄₁ H ₇₆ O ₁₄ NH ₄ ⁺	810.5584	810.5573	-1.4
NP-EO12	17.00	[M+NH ₄] ⁺	C ₃₉ H ₇₂ O ₁₃ NH ₄ ⁺	766.5317	766.5311	-0.8
NP-EO11	17.15	[M+NH ₄] ⁺	C ₃₇ H ₆₈ O ₁₂ NH ₄ ⁺	722.5047	722.5049	0.3
NP-EO10	17.30	[M+NH ₄] ⁺	C ₃₅ H ₆₄ O ₁₁ NH ₄ ⁺	678.4786	678.4787	0.1
NP-EO9	17.50	[M+NH ₄] ⁺	C ₃₃ H ₆₀ O ₁₀ NH ₄ ⁺	634.4528	634.4525	-0.5
NP-EO8	17.65	[M+NH ₄] ⁺	C ₃₁ H ₅₆ O ₉ NH ₄ ⁺	590.4269	590.4263	-1.0
NP-EO7	17.80	[M+NH ₄] ⁺	C ₂₉ H ₅₂ O ₈ NH ₄ ⁺	546.4004	546.4000	-0.7
NP-EO6	17.90	[M+NH ₄] ⁺	C ₂₇ H ₄₈ O ₇ NH ₄ ⁺	502.3734	502.3738	0.8

Table S5. The four eigenvectors of the principal component analysis (PCA).*

Variable	PC1	PC2	PC3	PC4
Initial TOC	-0.176	-0.005	-0.363	-0.124
Linear HCs	0.313	0.092	-0.331	0.416
Branched HCs	0.328	-0.159	0.288	-0.297
Cyclic HCs	-0.422	0.062	-0.014	-0.028
Avg. carbon count	0.399	-0.001	-0.213	-0.119
O-heteroatoms	-0.375	-0.197	0.046	0.200
N-heteroatoms	-0.385	-0.134	-0.190	0.156
Other heteroatoms	-0.060	0.391	0.166	0.451
PEG	0.020	-0.476	-0.121	0.109
PPG	0.020	-0.476	-0.121	0.109
AEO	0.313	0.059	-0.394	0.166
NPEO	0.161	-0.139	0.427	0.602
Acids	-0.020	0.476	0.121	-0.109
Rxn. Rate	0.093	-0.224	0.427	-0.126

*“Avg.”: Average; “AEO”: Alkyl ethoxylates; “HCs”: Hydrocarbons; “Acids”: Long-Chain Fatty (stearic acid, nonadecanoic acid, docosanoic acid); “N-, O-Heteroatoms”: heteroatoms containing nitrogen and oxygen; “Other heteroatoms”: heteroatoms containing bromine, sulfur, iodine, or chlorine; “Rxn Rate”: first order biodegradation rate.

Table S6. Additional characteristics of the produced water samples used for the statistical analysis.*

Sample	Linear HCs	Branched HCs	Cyclic HCs	Avg. carbon count	O-H-atoms	N-H-atoms	Other H-atoms	PEG	PPG	AEO	NPEO	Acids
Utica - S1 - 50k	51.5%	33.3%	15.2%	15.70	27.3%	0.0%	3.0%	2	1	0	1	0
Utica - S2 - 50k	54.2%	8.3%	37.5%	14.21	54.2%	12.5%	4.2%	2	1	0	0	0
Utica - S3 - 50k	64.7%	26.5%	8.8%	19.50	2.9%	0.0%	0.0%	2	1	3	0	0
Utica - S1 - 100k	51.5%	33.3%	15.2%	15.70	27.3%	0.0%	3.0%	2	1	0	1	0
Utica - S2 - 100k	54.2%	8.3%	37.5%	14.21	54.2%	12.5%	4.2%	2	1	0	0	0
Utica - S3 - 100k	64.7%	26.5%	8.8%	19.50	2.9%	0.0%	0.0%	2	1	3	0	0
Utica - S4 - 100k	70.6%	11.8%	17.6%	16.35	23.5%	5.9%	5.9%	2	1	3	1	0
Utica - S6 - 100k	40.0%	6.7%	53.3%	10.83	50.0%	16.7%	0.0%	2	1	0	0	0
Bakken - S7 - 100k	57.1%	10.7%	32.1%	15.04	7.1%	0.0%	10.7%	1	0	1	0	3

*“Avg.”: Average; “AEO”: Alkyl ethoxylates; “HCs”: Hydrocarbons; “Acids”: Long-Chain Fatty (stearic acid, nonadecanoic acid, docosanoic acid); “N-, O-H-atoms”: heteroatoms containing nitrogen and oxygen; “Other h-atoms”: heteroatoms containing bromine, sulfur, iodine, or chlorine.

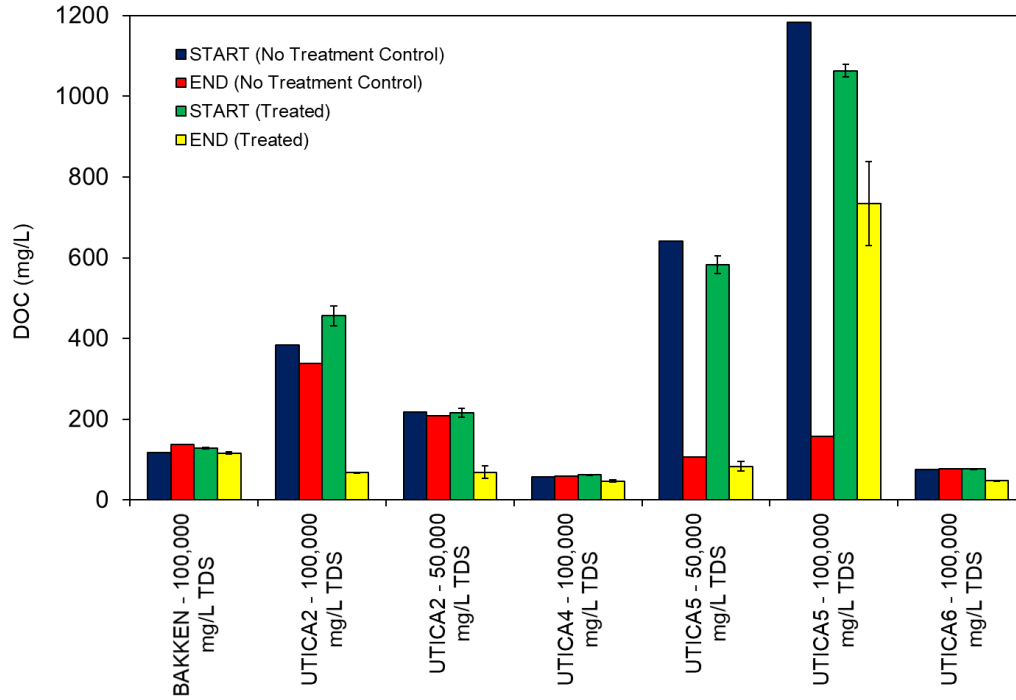


Figure S1. Comparison of no biofilm controls and biofilm treated samples for dilutions at 50,000 and 100,000 mg/L TDS of the produced water samples at the start and end of treatment.

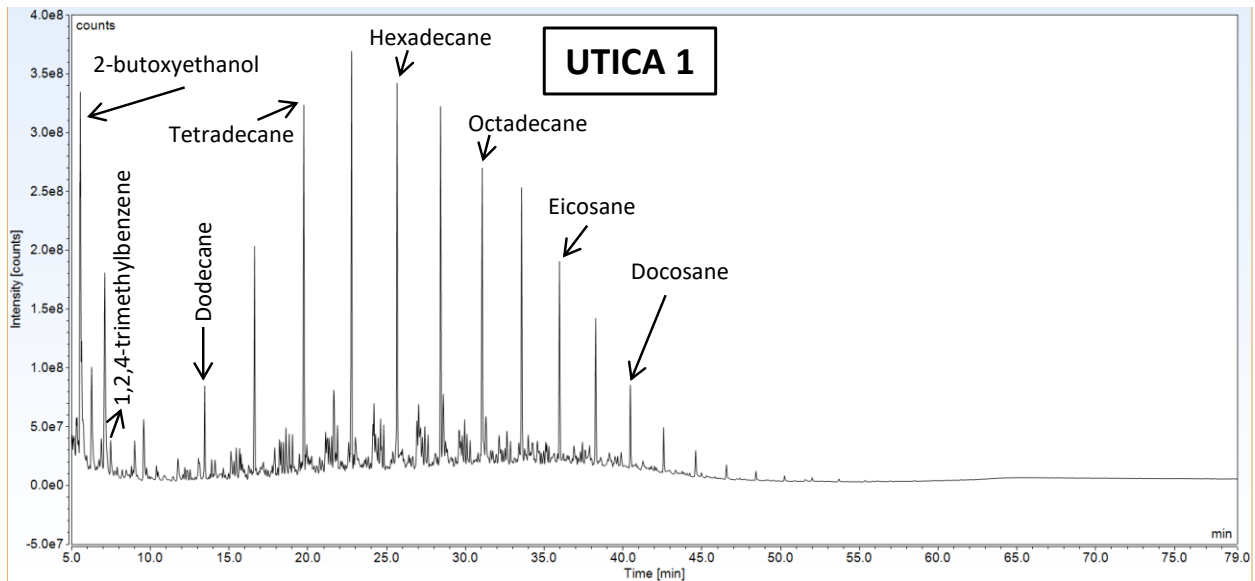


Figure S2. GCMS chromatogram of Utica1 sample.

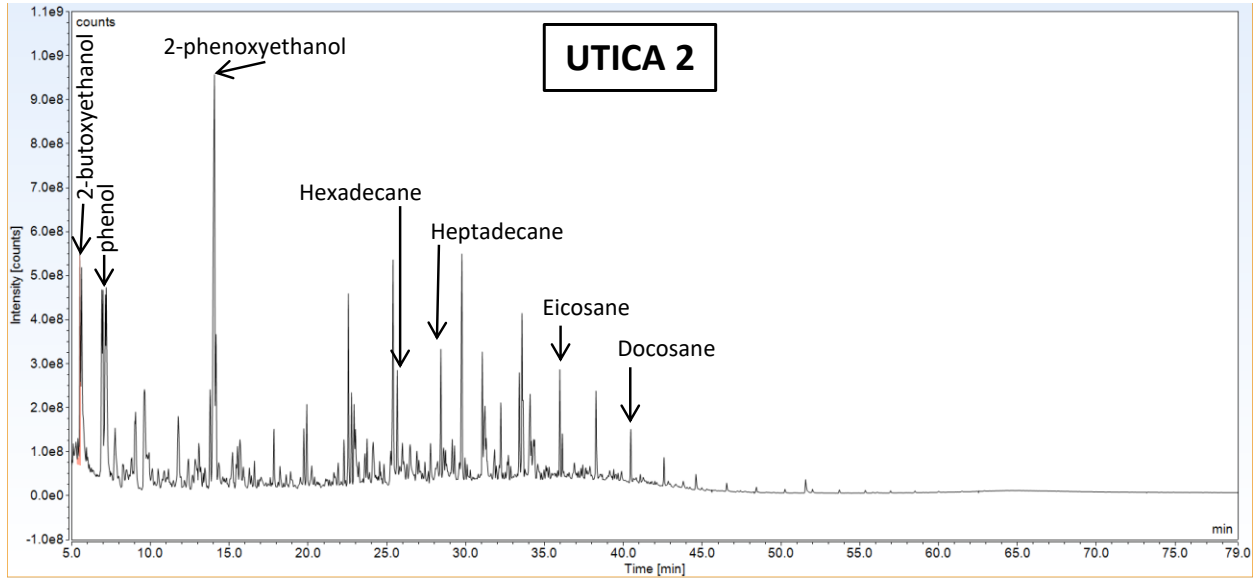


Figure S3. GCMS chromatogram of Utica2 sample.

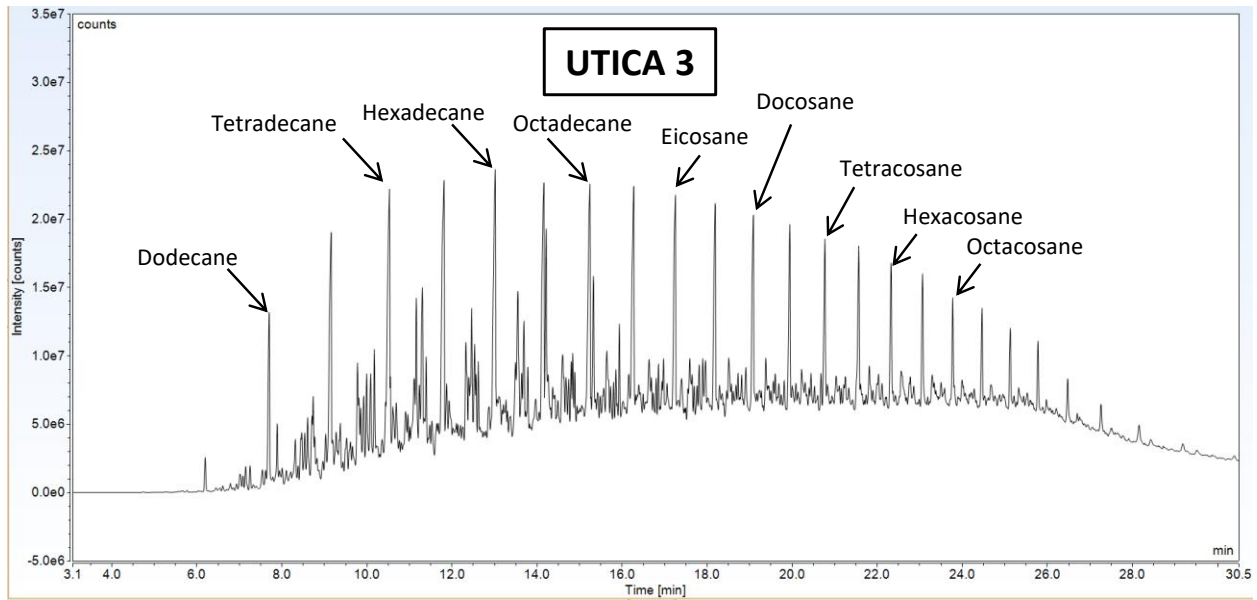


Figure S4. GCMS chromatogram of Utica3 sample.

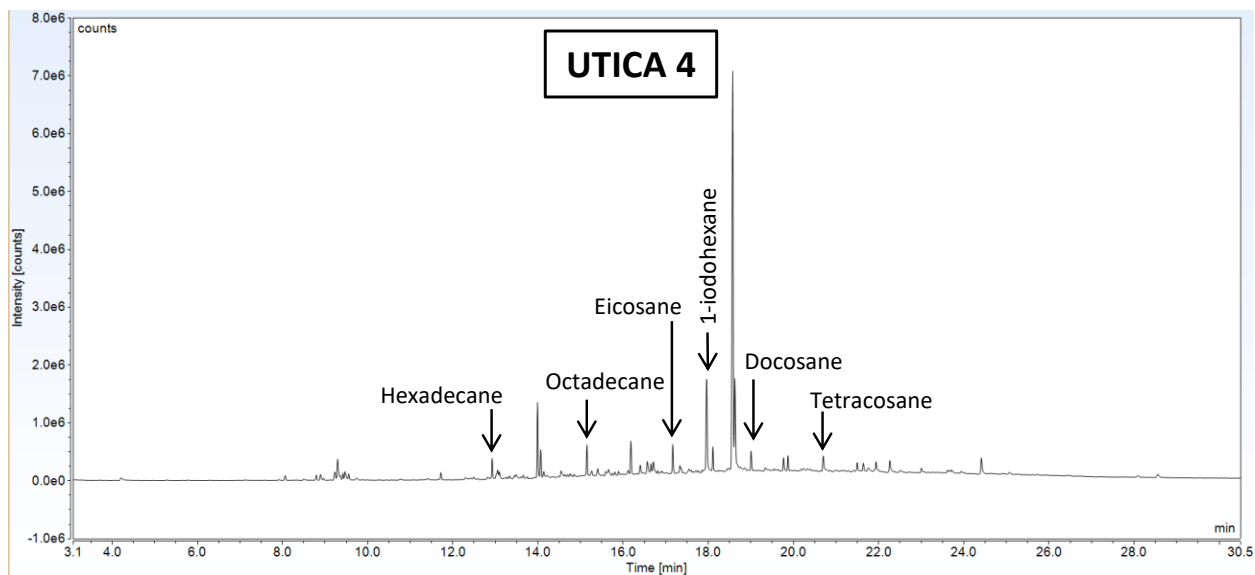


Figure S5. GCMS chromatogram of Utica4 sample.

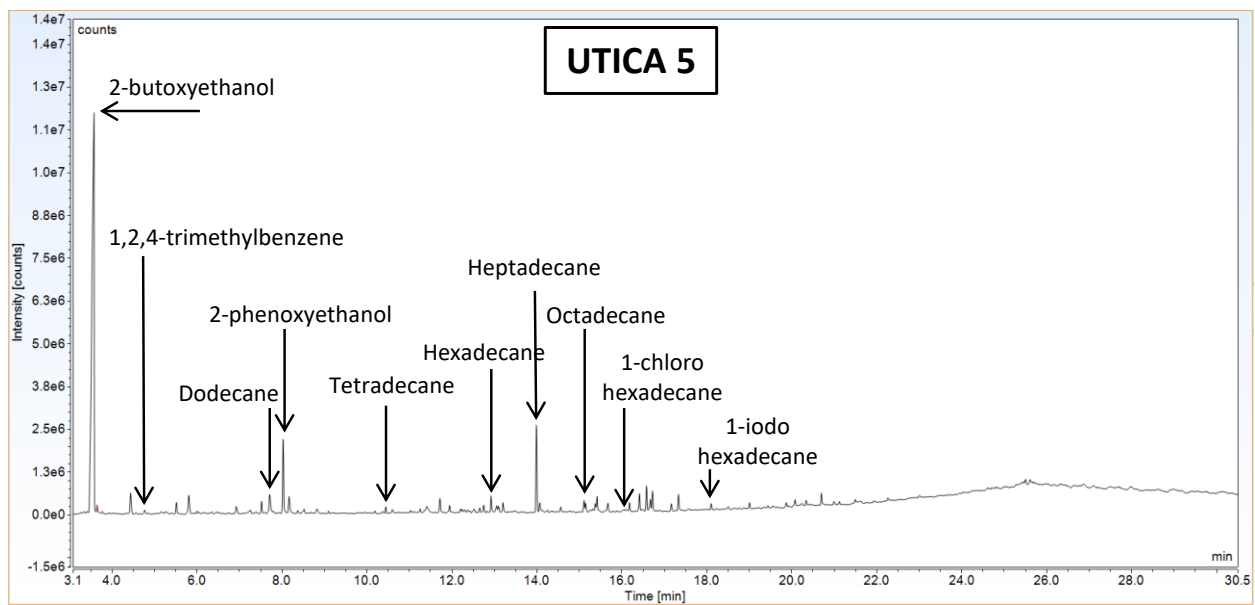


Figure S6. GCMS chromatogram of Utica5 sample.

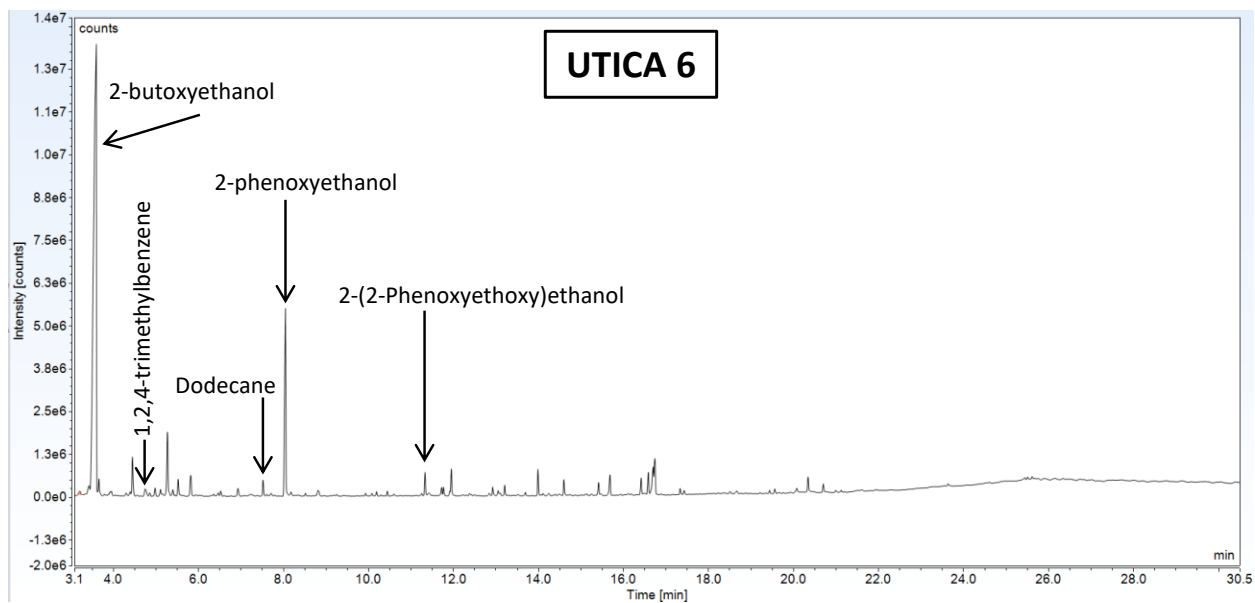


Figure S7. GCMS chromatogram of Utica6 sample.

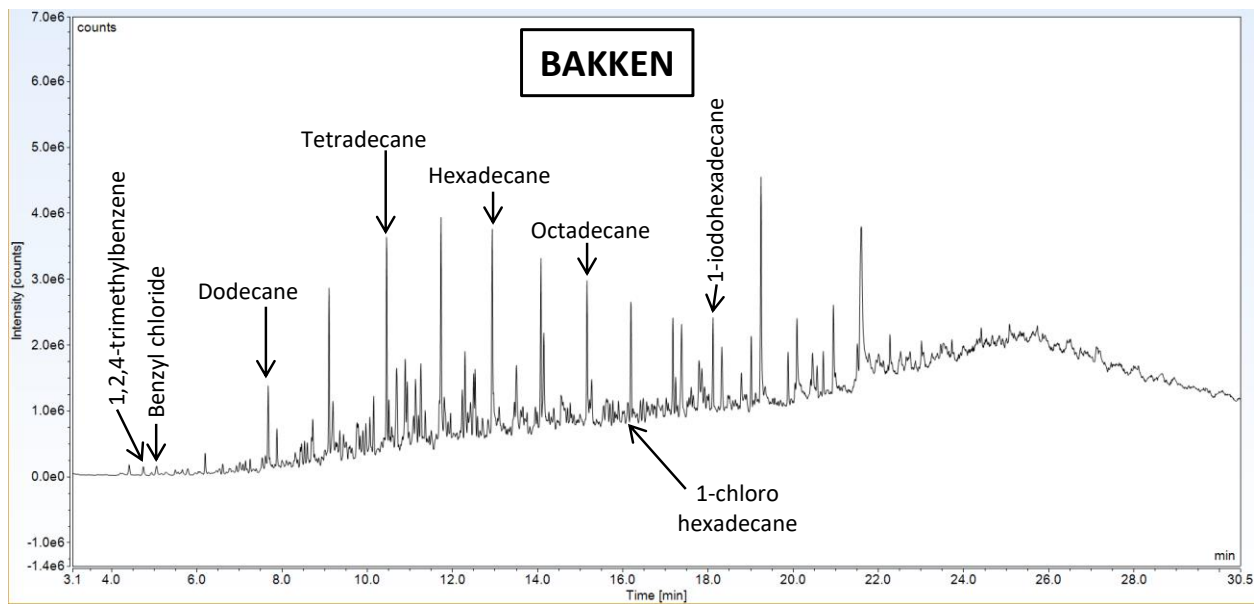


Figure S8. GCMS chromatogram of Bakken sample.

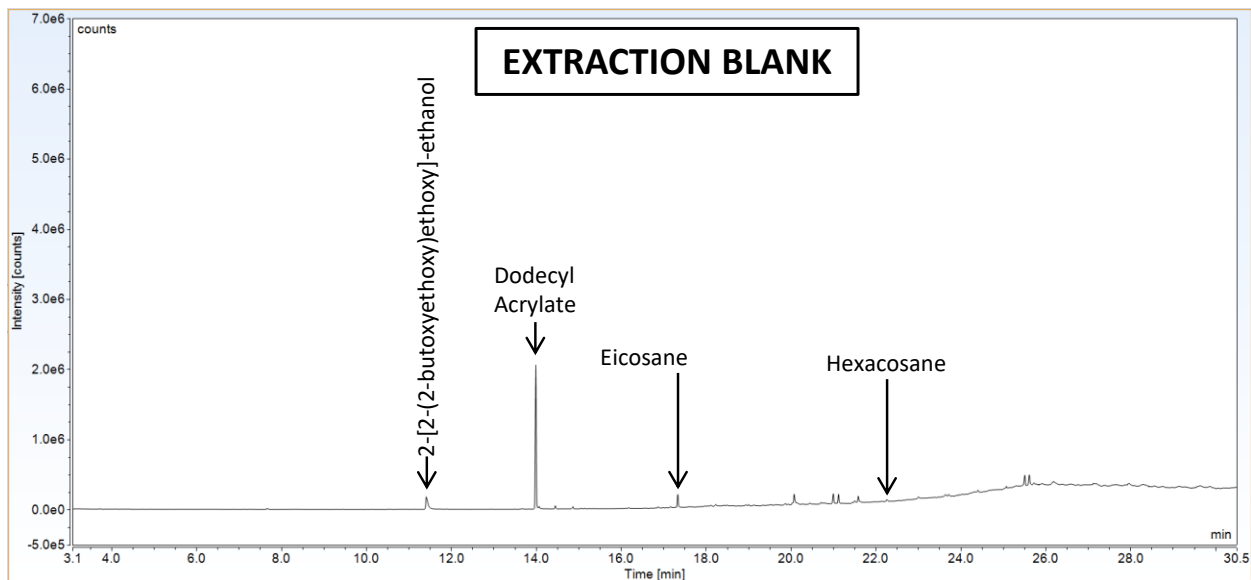


Figure S9. GCMS chromatogram of extraction blank. Positive detection in samples was only reported if abundances were higher than the extraction blank by at least a factor of 20.

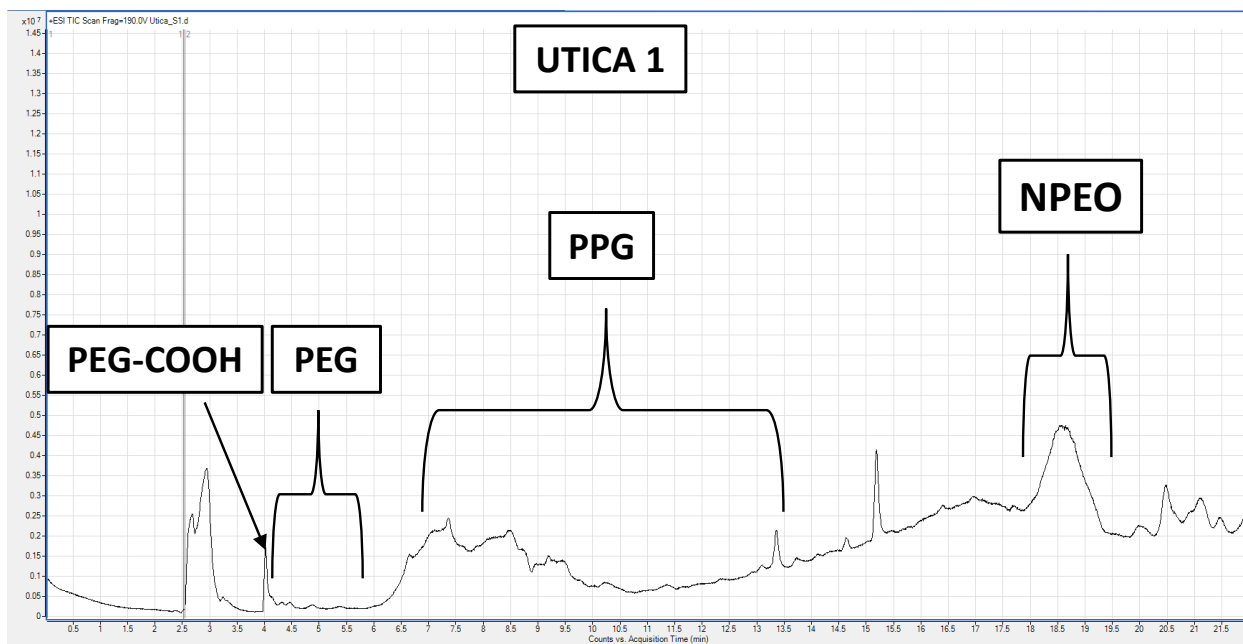


Figure S10. LCMS chromatogram of Utica1 sample.

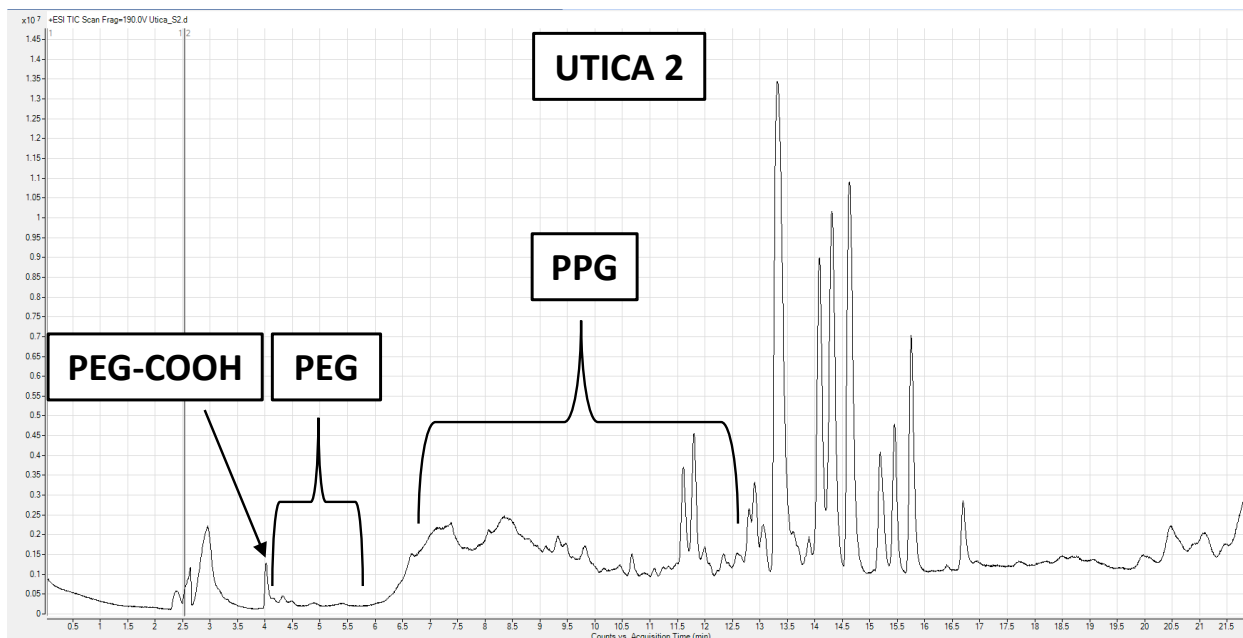


Figure S11. LCMS chromatogram of Utica2 sample.

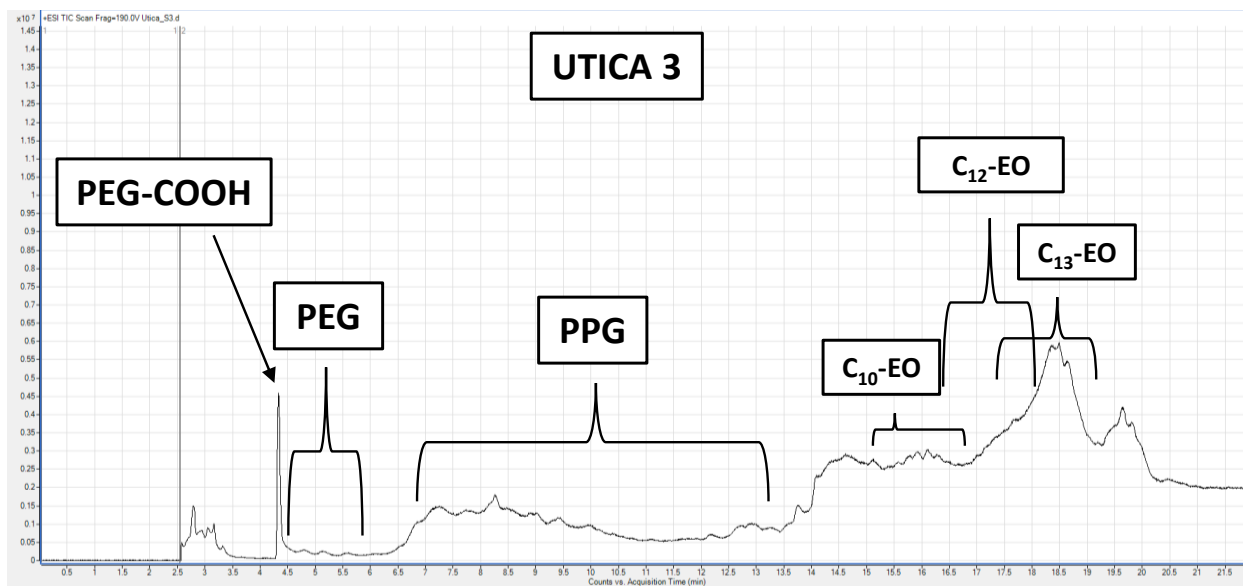


Figure S12. LCMS chromatogram of Utica3 sample.

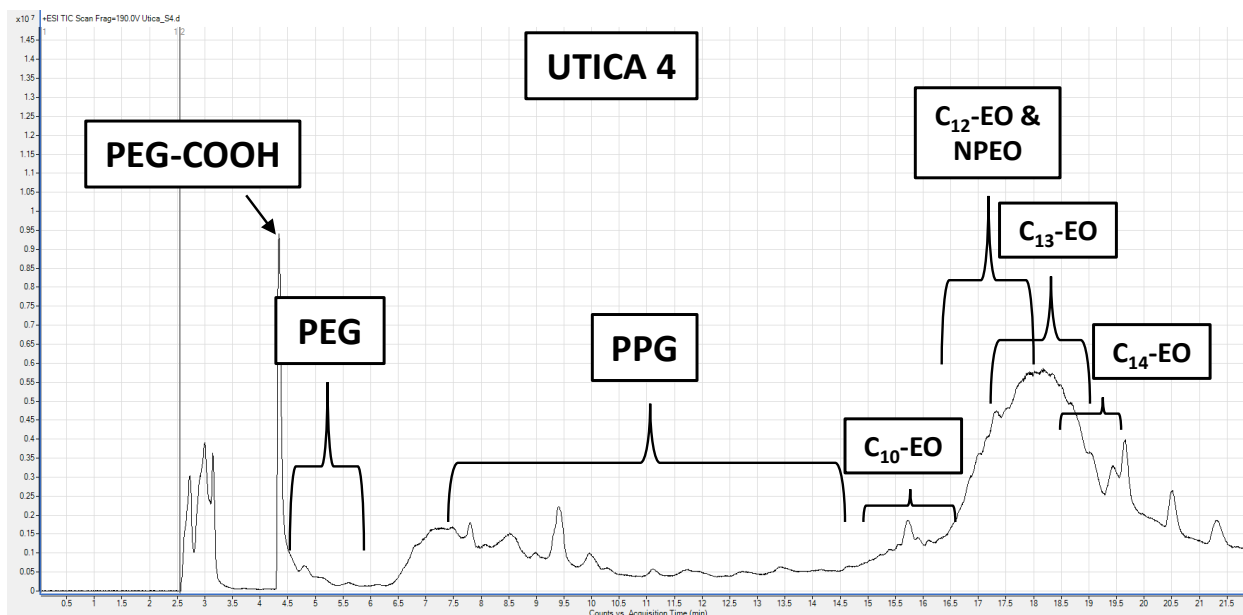


Figure S13. LCMS chromatogram of Utica4 sample.

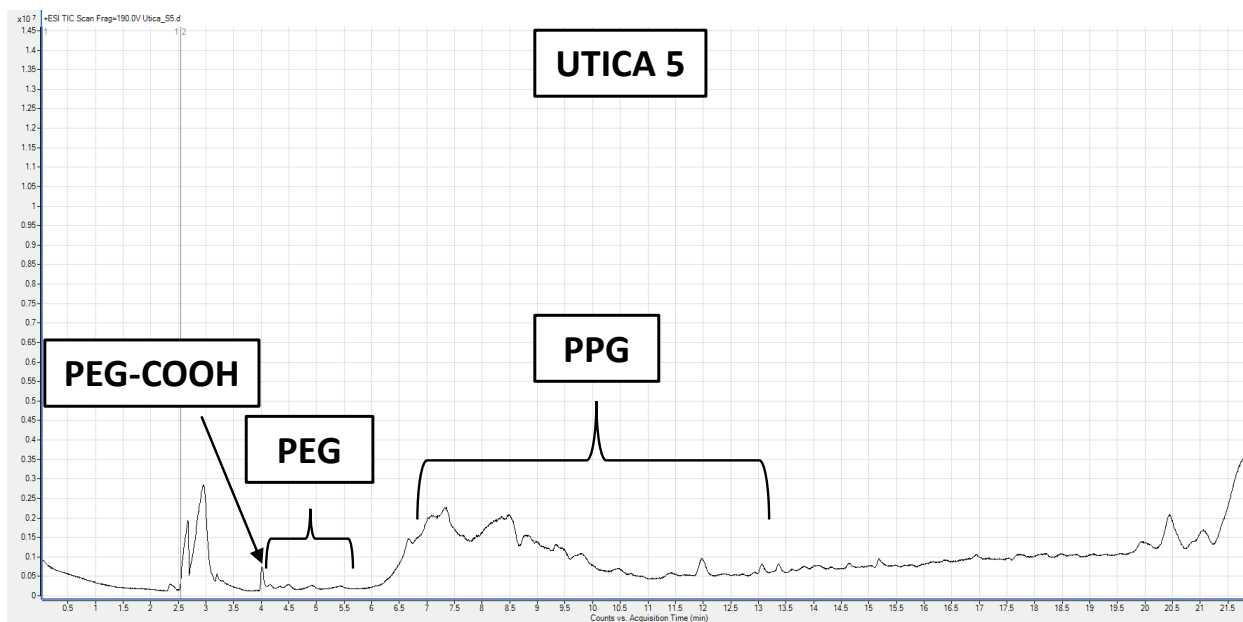


Figure S14. LCMS chromatogram of Utica5 sample.

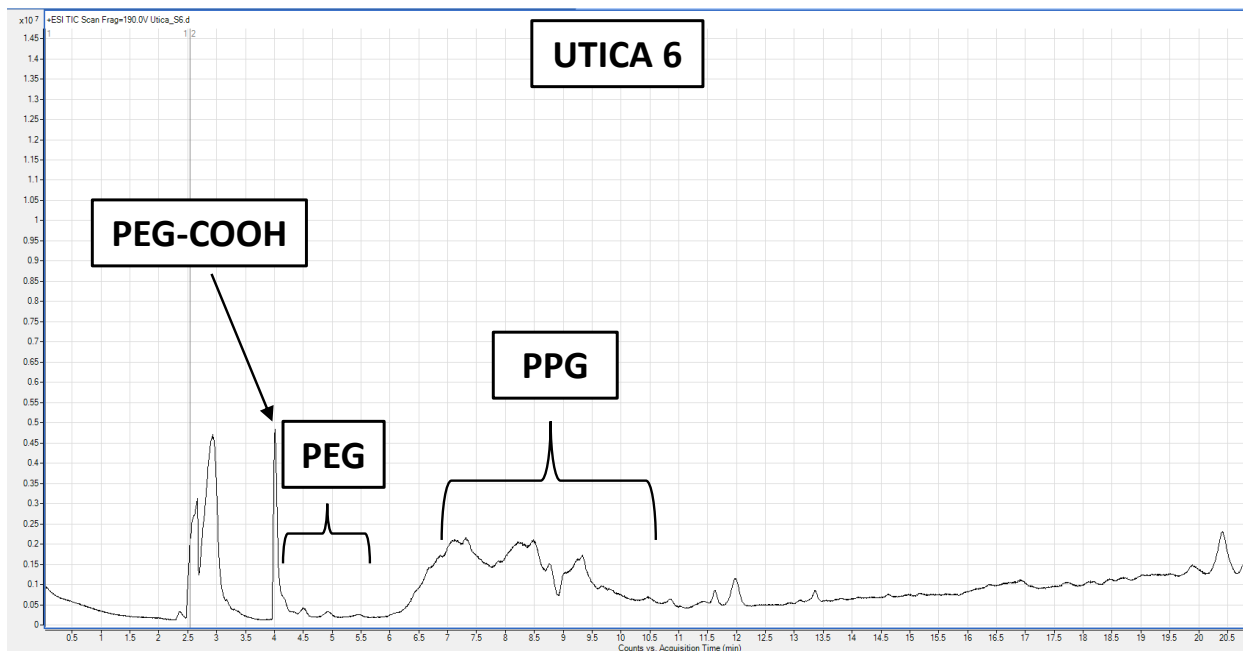


Figure S15. LCMS chromatogram of Utica6 sample.

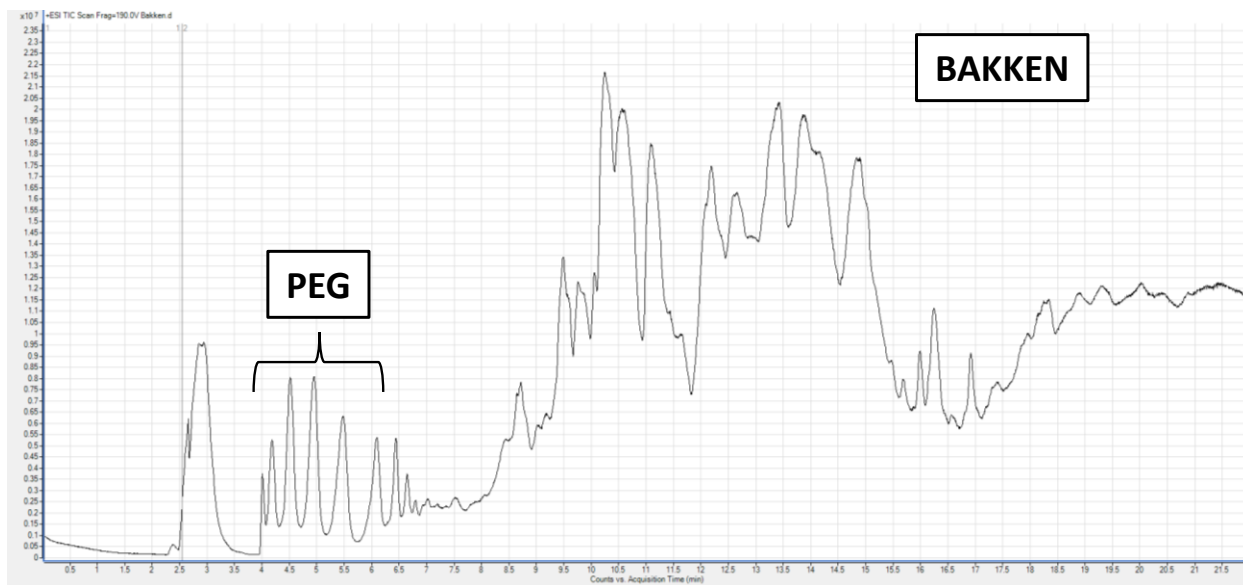


Figure S16. LCMS chromatogram of Bakken sample.

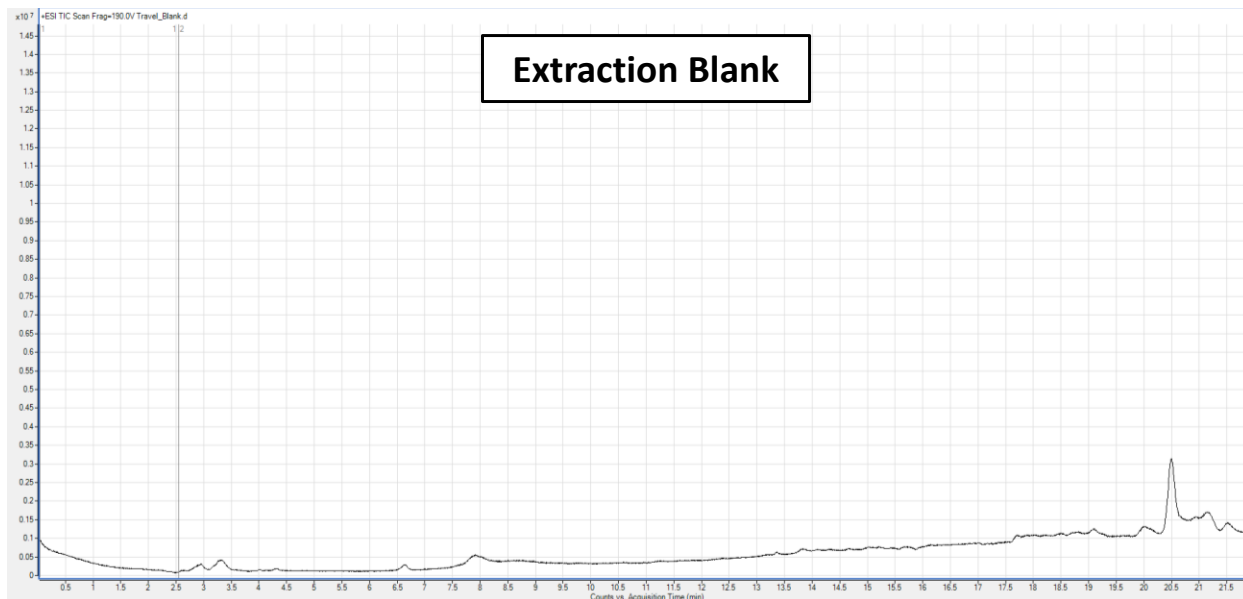


Figure S17. LCMS chromatogram of extraction blank. Positive detection in samples was only reported if abundances were higher than the extraction blank by at least a factor of 20.