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Supplement of

Efficient formation of aqueous secondary organic aerosols from the hydroxyl radical reaction with fenchol, borneol, and menthol

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S1. Materials and reagents

Ultratrace H_2O_2 (≥30%), no stabilizers added, (1R,2S,5R)-(−)-Menthol (≥99%), (+)-Borneol (≥98%), and water for LC/MS (gradient-grade) were purchased from Sigma-Merck (Schnelldorf, Germany). (+)-Fenchol was purchased from Alfa Aesar; Chemat (Gdańsk, Poland). (+)-Fenchone (>98%), and (1S,2S,5S)-(-)-2-hydroxy-3-pinanone were purchased from TCI. Camphor (>99.76%), and (±)Camphorquinone (>99.90%) were purchased from Ambeed. Menthone (≥97%), (±)-exo,exo-2,3-Camphanediol (≥97%), Dimethyl phthalate (≥99%) were purchased from Sigma-Merck (Schnelldorf, Germany). Sodium chloride, extra pure, was purchased from Thermo. Ethyl acetate (≥99.5%), was purchased from Honeywell (Avantor Performance Materials, Gliwice, Poland).

Ultra-high purity (UHP) gases: helium (≥ 99.9999%) was supplied by Multax (Stare Babice, Poland), methane (≥ 99.9995%) was purchased from AirProducts (Warsaw, Poland), and ammonia (99.999%) was obtained from Air Liquid (Warsaw, Poland).

S2 Chromatographic analyses

GC/MS analyses were conducted using a GC/MS-2010 Ultra gas chromatograph coupled with a single quadrupole mass spectrometer (Shimadzu) equipped with electron ionization (EI) or negative chemical ionization (NCI) ion sources – see section 2.4.1 in the main text.

S2.1 Gas chromatography coupled with electron-ionization mass spectrometry

Table S1. Retention times and ions monitored in SIM mode for the reactants of R1 analyzed with the GC-EI/MS instrument.

Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
(+)-Fenchol	$C_{10}H_{18}O$	18.16		154, 139, 136, 125, 123, 121, 111, 107, 105, 97, 91, 85, 84, 81, 80, 72, 71, 69, 67, 57, 55, 53		0.984
(+)-Fenchone	$C_{10}H_{16}O$	17.45		153,152,137,134,123,119,109,97,95,91,82,81,80		0.987
(±)-exo,exo-2,3-Camphanediol	$C_{10}H_{18}O_2$	20.84		152,139,137,122,121,119,112,111,110,109,107,99, 96,95,94,85,84,83,82,81		0.989
(±)Camphorquinone	$C_{10}H_{14}O_2$	19.36		167,166,139,138,124,123,111,110,109,105,96,95,9		0.997

Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
			VF-WAX plus	1,84,83	0.038-0.43	
(1S,2S,5S)-(-)-2-hydroxy-3-pinanone	$C_{10}H_{16}O_2$	18.49		168,140,126,125,122,119,111,108,107,100,99,97,93,92,91,85,84,83		0.9974
Product F1	-	18.65		167,164,150,149,139,137,135,127,126,125,124,123,121,111,110,109,108,107,98,97,95,94,93,91,85,84,83,82,8180,79,77		HP
Product F2	-	18.74		139,138,123,110,109,105,97,96,95,94,91,82,81,80,79,77,70,69		HP
Product F3	-	19.12		168,153,150,135,126,125,123,122,113,112,111,109,108,107,100,97,96,95,94,93,91,85,84,83,82,81,80,79		CQ
Product F4	-	19.22		139,136,125,123,122,121,111,108,107,105,100,99,98,97,96,95,94,93,92,91,85,84,83,82,81,80,79,77		CQ
Product F5	-	19.30		139,136,125,123,122,121,111,108,107,105,100,99,98,97,96,95,94,93,92,91,85,84,83,82,81,80,79,77		CQ
Product F6	-	19.38		154,137,136,125,124,123,121,112,111,110,109,108,107,98,97,96,95,94,93,91,85,84,83,82,81,80,79		CQ
Product F7	-	19.54		139,138,124,123,121,109,108,107,105,97,96,95,94,93,92,91,83,82,81,79,77		CQ
Product F8	-	19.73		153,151,150,136,135,125,122,121,111,110,109,108,107,98,97,96,95,94,93,91,84,83,82,81,80,79		CQ
Product F9	-	19.93		154,139,136,123,122,121,112,111,110,109,108,107,106,105,99,97,96,95,94,93,92,91,85,84,83,82,81,8		CQ

Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
				0,79		
Product F10	-	20.54		154,153,139,129,127,123,121,113,112,111,110,105 ,99,98,97,95,94,91,85,83,82,81,80,79,77		CND
Product F11	-	20.66		226,139,137,129,128,123,121,111,110,109,108,107 ,106,105,100,99,98,97,96,95,93,86,85,84,83,82,81, 79		CND
Product F12	-	20.81		184,166,155,138,137,124,123,115,114,113,110,109 ,100,99,97,96,95,85,83,82,81,80,79		CND
Product F13	-	20.91		154,137,136,124,123,122,121,119,113,110,108,107 ,106,105,98,97,96,95,94,93,84,83,82,81,80,79		CND
Product F14	-	21.40		183,182,167,166,154,140,139,126,125,123,121,112 ,111,97,95,85,84,83,77		CND
Dimethyl phthalate	IS	17.75		162,163, 134, 133, 120, 105, 104, 92, 77, 76, 50, 49		-

[a]Surrogate standards used for quantification: HP = 2-hydroxy-3-pinanone, CQ = Camphorquinone, CND= Camphanediol

Table S2. Retention times and ions monitored in SIM mode for the reactants of R2 analyzed with the GC-EI/MS instrument.

Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
(+)-Borneol	$C_{10}H_{18}O$	13.16		140, 139, 136, 121, 111, 110, 96, 95, 83, 81, 82, 83, 79, 77, 71, 69, 67, 57, 55, 53		0.9964
Camphor	$C_{10}H_{16}O$	11.70		153,152,147,137,123,119,110,109,108,107,105,97, 96,95,93,91		0.9961
(±)-exo,exo-2,3-Camphanediol	$C_{10}H_{18}O_2$	20.84		152,139,137,122,121,119,112,111,110,109,107,99, 96,95,94,85,84,83,82,81		0.9899

Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
(±)Camphorquinone	$C_{10}H_{14}O_2$	19.36	VF-WAX plus	167,166,139,138,124,123,111,110,109,105,96,95,91,84,83	0.035-0.37	0.9982
(1S,2S,5S)-(-)-2-hydroxy-3-pinanone	$C_{10}H_{16}O_2$	18.49		168,140,126,125,122,119,111,108,107,100,99,97,93,92,91,85,84,83		0.9974
Product B1	-	16.17		153,152,147,137,123,119,110,109,108,95,93,83,82,81,80		Camphor
Product B2	-	16.59		139,136,121,111,110,105,99,95,93,83,82,81		Camphor
Product B3	-	18.75		167,166,151,138,125,123,110,109,107,106,95,93,83,81,77,70,69		HP
Product B4	-	19.02		139,138,125,123,113,110,109,96,95,91,84,82,81,80,79		HP
Product B5	-	19.22		139,138,124,123,110,109,105,97,96,95,94,93,91,82,81,80,79,77		HP
Product B6	-	19.48		167,166,153,151,140,139,138,135,126,125,124,123,121,111,110,109,107,98,97,96,95,93,91,86,85,84,83,82,81,79		CQ
Product B7	-	19.76		153,150,149,137,136,125,121,112,111,110,109,107,97,96,95		CQ
Product B8	-	19.87		139,138,123,121,109,105,96,95,94,93,91,83,81,79,77		CQ
Product B9	-	20.10		168,154,153,150,137,135,125,124,123,110,109,108,107,106,95,93		CND
Product B10	-	20.27		155,154,150,144,140,139,137,136,126,125,123,122		CND

Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
				,121,119,113,112,111,110,109,108,107,106,105,103,96,95		
Product B11	-	21.05		169,168,153,150,139,135,125,124,123,111,110,109,108,107		CND
Dimethyl phthalate	IS	17.75		162,163, 134, 133, 120, 105, 104, 92, 77, 76, 50, 49		-

[a]Surrogate standards used for quantification: HP = 2-hydroxy-3-pinanone, CQ = Camphorquinone, CND= Camphanediol

Table S3. Retention times and ions monitored in SIM mode for the reactants of R3 analyzed with the GC-EI/MS instrument.

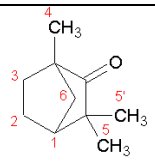
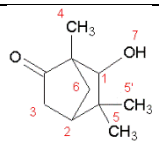
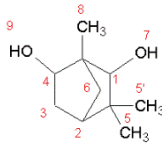
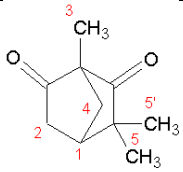
Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
(−)-Menthol	$C_{10}H_{20}O$	12.53	VF-WAX plus	139, 138, 123, 110, 109, 96, 95, 83, 82, 81, 80, 71, 69, 68, 67, 57, 56, 55	0.034-0.36	0.9952
Menthone	$C_{10}H_{18}O$	11.07		155,154,140,139,125,121,113,112,111,110,109,98,97,96,95,94,93		0.9951
(±)-exo,exo-2,3-Camphanediol	$C_{10}H_{18}O_2$	20.84		152,139,137,122,121,119,112,111,110,109,107,99,96,95,94,85,84,83,82,81		0.9784
(1S,2S,5S)-(-)-2-hydroxy-3-pinanone	$C_{10}H_{16}O_2$	18.49		168,140,126,125,122,119,111,108,107,100,99,97,93,92,91,85,84,83		0.9974
Product M1	-	19.04		170,152,140,137,126,125,124,123,110,109,98,97,96,95,91,86,85,84,83,82,81,79		HP
Product M2	-	19.40		169,168,167,153,139,138,137,127,126,125,124,123,113,112,111,110,109,107,99,98,97,96,95,93,85,84,83,82,81,80,79		HP
Product M3	-	19.96		172,154,141,140,139,136,129,125,122,121,112,111		HP

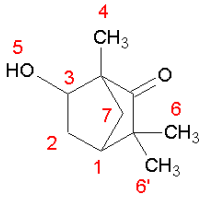
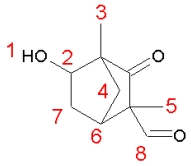
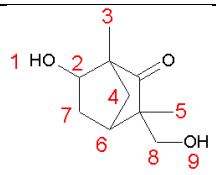
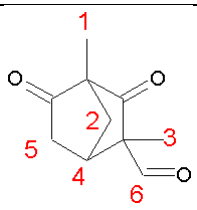
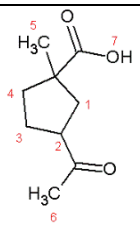
Name	Elemental composition	Retention time (min)	Column	Ions monitored in selected SIM mode (m/z)	Concentration range (µg/L)	$R^{2,a}$
				,107,99,98,97,96,95,93,87,85,84,81,71,70,69		
Product M4	-	20.84		152,142,139,137,126,124,123,122,121,119,113,112 ,111,110,109,107,99,97,96,95,94,85,84,83,82,81		CND
Dimethyl phthalate	IS	17.75		162,163,134,133, 120, 105, 104, 92, 77, 76, 50, 49		-

[a]Surrogate standards used for quantification: HP = 2-hydroxy-3-pinanone, CND= Camphanediol

S3. Total and partial $k_{OH_{aq}}$ values for products of R1-R3 predicted with SAR

Table S4. Total and partial $k_{OH_{aq}}$ values for products of aqueous OH oxidation of fenchol (R1).

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
Fenchone	152		1	3.8	14%	2.7
			2	3.4	12%	
			3	3.6	13%	
			4	3.7	13%	
			5	4.5	16%	
			5	4.5	16%	
			6	4.0	15%	
F1	168		1	5.1	17%	3.0
			2	4.0	13%	
			3	0.5	2%	
			4	3.8	13%	
			5	5.2	18%	
			5	5.2	18%	
			6	4.2	14%	
			7	1.6	5%	
F2	170		1	5.9	14%	4.2
			2	4.6	11%	
			3	2.6	6%	
			4	5.9	14%	
			5	5.2	12%	
			5	5.2	12%	
			6	5.0	12%	
			7	1.6	4%	
			8	4.5	11%	
			9	1.6	4%	
F3	166		1	3.4	17%	2.0
			2	0.5	3%	
			3	3.3	17%	
			4	3.6	18%	
			5	4.5	23%	
			5	4.5	23%	

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
F4	168		1	4.0	14%	2.8
			2	1.5	5%	
			3	5.0	18%	
			4	3.8	14%	
			5	1.6	6%	
			6	4.5	16%	
			6	4.5	16%	
			7	2.8	10%	
F5	182		1	1.6	7%	2.4
			2	4.8	20%	
			3	3.8	16%	
			4	3.9	17%	
			5	3.8	16%	
			6	3.1	13%	
			7	1.5	6%	
			8	1.0	4%	
F6	184		1	1.7	4%	4.0
			2	5.0	13%	
			3	3.7	9%	
			4	4.2	11%	
			5	3.8	10%	
			6	5.0	13%	
			7	1.5	4%	
			8	13.3	33%	
			9	2.1	5%	
F7	180		1	3.3	14%	1.5
			2	3.5	15%	
			3	4.0	17%	
			4	3.1	13%	
			5	0.5	2%	
			6	1.0	4%	
F8	170		1	2.4	16%	1.5
			2	1.1	7%	
			3	4.7	30%	
			4	3.6	24%	
			5	2.4	16%	
			6	0.9	6%	

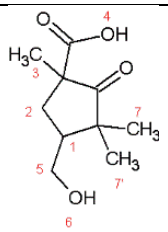
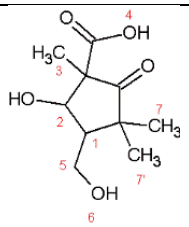
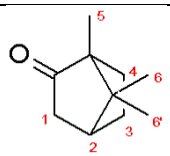
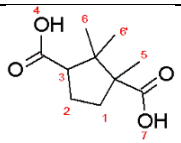
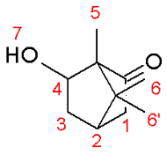
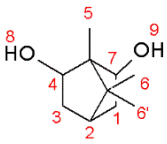
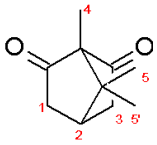
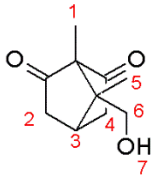
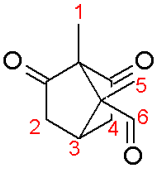
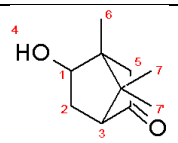
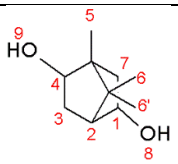
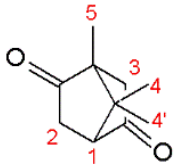
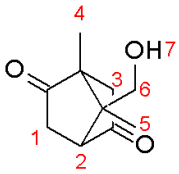
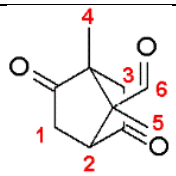
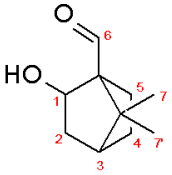
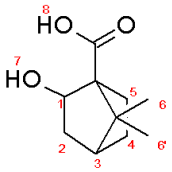
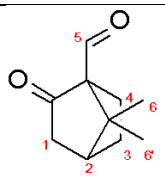
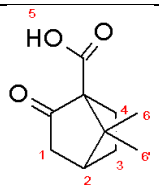
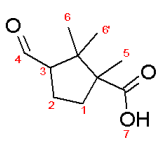
Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
			7	0.3	2%	
F9	200		1	1.8	6%	3.0
			2	2.4	8%	
			3	2.2	7%	
			4	0.3	1%	
			5	12.5	41%	
			6	2.2	7%	
			7	4.5	15%	
			7	4.5	15%	
F10	216		1	2.5	8%	3.3
			2	3.4	10%	
			3	2.3	7%	
			4	0.3	1%	
			5	13.1	40%	
			6	2.2	7%	
			7	4.5	14%	
			7	4.5	14%	

Table S5. Total and partial $k_{OH_{aq}}$ values for products of aqueous OH oxidation of borneol (R2).

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
Camphor	152		1	0.5	2%	2.5
			2	3.8	15%	
			3	3.4	14%	
			4	3.6	14%	
			5	3.7	15%	
			6	4.9	20%	
			6'	4.9	20%	
Camphoric acid	200		1	3.6	18%	2.0
			2	3.1	15%	
			3	0.8	4%	
			4	0.3	2%	
			5	2.4	12%	
			6	4.9	24%	
			6'	4.9	24%	
			7	0.3	2%	

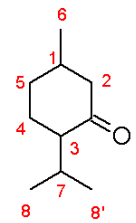
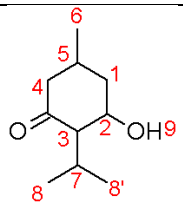
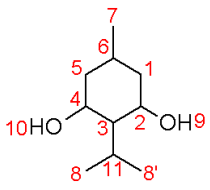
Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
B1	168		1	0.5	2%	2.6
			2	4.0	15%	
			3	1.5	6%	
			4	5.0	19%	
			5	3.8	15%	
			6	4.9	19%	
			6'	4.9	19%	
			7	1.6	6%	
B2	170		1	1.5	4%	3.7
			2	4.6	13%	
			3	1.5	4%	
			4	5.9	16%	
			6	4.9	13%	
			5	4.5	12%	
			6'	4.9	13%	
			7	5.9	16%	
			8	1.6	4%	
			9	1.6	4%	
B3	166		1	0.5	3%	1.8
			2	3.4	19%	
			3	0.5	3%	
			4	3.3	19%	
			5	4.9	28%	
			5'	4.9	28%	
B4	182		1	3.3	12%	2.8
			2	0.5	2%	
			3	2.9	10%	
			4	0.5	2%	
			5	4.3	15%	
			6	14.8	52%	
			7	2.1	7%	
B5	180		1	3.3	28%	1.2
			2	0.5	4%	
			3	2.6	22%	
			4	0.5	4%	
			5	3.8	32%	
			6	1.1	9%	

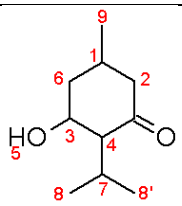
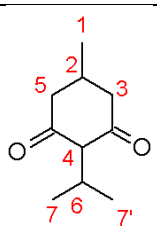
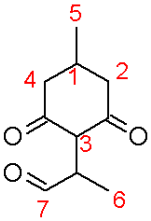
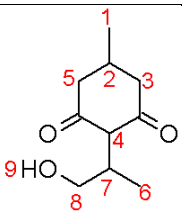
Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
B6	168		1	5.6	23%	2.4
			2	1.3	5%	
			3	0.7	3%	
			4	1.6	7%	
			5	0.6	3%	
			6	4.3	18%	
			7	4.9	21%	
			7’	4.9	21%	
B7	170		1	4.7	14%	3.3
			2	1.9	6%	
			3	1.5	5%	
			4	5.9	18%	
			5	4.3	13%	
			6	4.9	15%	
			6’	4.9	15%	
			7	1.8	5%	
			8	1.6	5%	
			9	1.7	5%	
B8	166		1	0.6	4%	1.5
			2	0.5	3%	
			3	0.5	4%	
			4	4.9	33%	
			4’	4.9	33%	
			5	3.7	24%	
B9	182		1	0.5	2%	2.6
			2	0.5	2%	
			3	0.5	2%	
			4	3.7	14%	
			5	4.3	16%	
			6	14.8	56%	
			7	2.1	8%	
B10	180		1	0.5	5%	1.0
			2	0.5	5%	
			3	0.5	5%	
			4	3.7	36%	
			5	3.8	38%	
			6	1.1	11%	

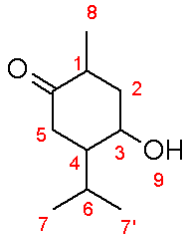
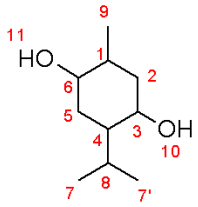
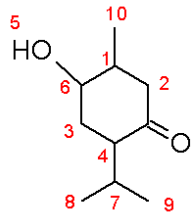
Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
B11	168		1	4.4	15%	2.9
			2	1.5	5%	
			3	4.4	15%	
			4	3.4	12%	
			5	3.3	11%	
			6	0.9	3%	
			7	4.9	17%	
			7'	4.9	17%	
			8	1.6	5%	
B12	184		1	2.9	11%	2.6
			2	1.5	6%	
			3	4.4	17%	
			4	3.4	13%	
			5	2.1	8%	
			6	4.9	19%	
			6'	4.9	19%	
			7	1.6	6%	
			8	0.3	1%	
B13	166		1	0.8	2%	3.7
			2	9.6	26%	
			3	8.5	23%	
			4	7.0	19%	
			5	0.8	2%	
			6	4.9	13%	
			6'	4.9	13%	
B14	182		1	0.5	3%	2.0
			2	3.8	19%	
			3	3.4	17%	
			4	1.8	9%	
			5	0.3	2%	
			6	4.9	25%	
			6'	4.9	25%	
B15	184		1	3.6	19%	1.9
			2	4.7	24%	
			3	1.0	5%	
			4	0.9	5%	
			5	2.4	12%	
			6			

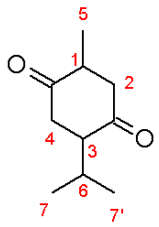
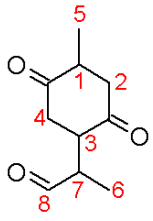
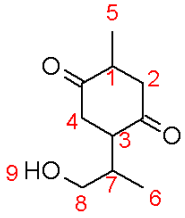
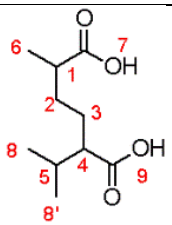
Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
			6'	4.9	26%	
			7	4.9	26%	
				0.4	2%	

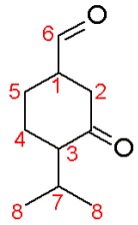
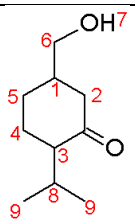
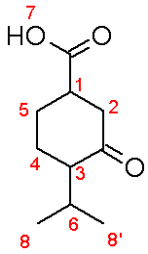
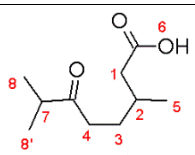
Table S6. Total and partial $k_{OH_{aq}}$ values for products of aqueous OH oxidation of menthol (R3).

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
Menthone	154		1	6.5	15%	4.3
			2	1.0	2%	
			3	1.1	2%	
			4	5.5	13%	
			5	6.7	16%	
			6	4.2	10%	
			7	8.0	19%	
			8	5.1	12%	
			8’	5.1	12%	
M1	170		1	2.9	7%	4.3
			2	7.7	18%	
			3	0.5	1%	
			4	1.0	2%	
			5	6.8	16%	
			6	4.2	10%	
			7	8.4	19%	
			8	5.1	12%	
			8'	5.1	12%	
			9	1.7	4%	
M2	172		1	2.9	5%	6.2
			2	9.0	15%	
			3	2.4	4%	
			4	9.0	15%	
			5	2.9	5%	
			6	7.9	13%	
			7	4.2	7%	
			8	5.1	8%	
			8'	5.1	8%	
			9	1.7	3%	

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
			10	1.7	3%	
			11	9.8	16%	
M3	170		1	6.8	16%	4.3
			2	1.0	2%	
			3	7.7	18%	
			4	0.5	1%	
			5	1.7	4%	
			6	2.9	7%	
			7	8.4	19%	
			8	5.1	12%	
			8'	5.1	12%	
			9	4.2	10%	
M4	168		1	4.2	21%	2.0
			2	5.8	30%	
			3	1.0	5%	
			4	0.2	1%	
			5	1.0	5%	
			6	7.2	37%	
			7	5.1	26%	
			7	5.1	26%	
M5	182		1	5.8	34%	1.7
			2	1.0	6%	
			3	0.1	1%	
			4	1.0	6%	
			5	4.2	24%	
			6	4.0	23%	
			7	1.1	6%	
M6	184		1	4.2	11%	3.7
			2	5.8	15%	
			3	1.0	3%	
			4	0.1	0%	
			5	1.0	3%	
			6	4.4	12%	
			7	3.9	10%	
			8	15.2	40%	
			9	2.2	6%	

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
M7	170		1	1.1	3%	4.1
			2	2.6	6%	
			3	8.6	21%	
			4	2.8	7%	
			5	1.0	2%	
			6	9.3	23%	
			7	5.1	12%	
			7'	5.1	12%	
			8	3.8	9%	
			9	1.7	4%	
M8	172		1	3.2	6%	5.8
			2	3.0	5%	
			3	8.6	15%	
			4	3.2	6%	
			5	2.8	5%	
			6	9.5	16%	
			7	5.1	9%	
			7'	5.1	9%	
			8	9.3	16%	
			9	4.4	8%	
			10	1.7	3%	
			11	1.7	3%	
M9	170		1	2.8	7%	4.1
			2	1.1	3%	
			3	2.4	6%	
			4	1.1	3%	
			5	1.7	4%	
			6	9.5	23%	
			7	8.0	19%	
			8	5.1	12%	
			9	5.1	12%	
			10	4.4	11%	

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
M10	168		1	1.0	4%	2.6
			2	0.9	4%	
			3	1.0	4%	
			4	0.8	3%	
			5	3.8	15%	
			6	8.0	31%	
			7	5.1	20%	
			7'	5.1	20%	
M11	182		1	1.0	7%	1.3
			2	0.9	7%	
			3	0.7	6%	
			4	0.8	6%	
			5	3.8	29%	
			6	4.0	30%	
			7	0.8	6%	
			8	1.1	8%	
M12	184		1	1.5	4%	3.4
			2	0.9	3%	
			3	0.8	2%	
			4	0.8	2%	
			5	3.8	11%	
			6	4.4	13%	
			7	4.3	13%	
			8	15.2	45%	
			9	2.2	6%	
M13	202		1	1.3	4%	3.3
			2	6.1	19%	
			3	5.5	17%	
			4	1.3	4%	
			5	5.2	16%	
			6	2.5	8%	
			7	0.3	1%	
			8	5.1	16%	
			8'	5.1	16%	
			9	0.3	1%	

Name	Nominal mass (Da)	Structure	H-atom position	Partial $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-8}	Relative contribution (%)	Total $k_{OH_{aq}}$ ($M^{-1}s^{-1}$)×10^{-9}
M14	168		1	0.9	3%	3.2
			2	0.8	2%	
			3	0.9	3%	
			4	5.5	17%	
			5	5.2	16%	
			6	0.9	3%	
			7	8.0	25%	
			8	5.1	16%	
			8'	5.1	16%	
M15	170		1	2.6	5%	4.9
			2	0.9	2%	
			3	1.1	2%	
			4	5.5	11%	
			5	5.8	12%	
			6	12.5	26%	
			7	2.2	4%	
			8	8.0	16%	
			9	5.1	10%	
			9	5.1	10%	
M16	184		1	1.1	3%	3.6
			2	0.8	2%	
			3	1.6	5%	
			4	8.4	24%	
			5	5.3	15%	
			6	8.0	22%	
			7	0.3	1%	
			8	5.1	14%	
			8'	5.1	14%	
M17	186		1	1.2	4%	3.2
			2	5.0	16%	
			3	8.9	28%	
			4	1.8	6%	
			5	4.2	13%	
			6	0.3	1%	
			7	1.7	5%	
			8	4.4	14%	
			8'	4.4	14%	

S4. Kinetic models

Reactions 1-5 in Tables S7-S9 describe the generation of OH via photolysis of H_2O_2 (Tan et al., 2009). The k values of Reactions 1-5 in Tables S7-S9 reflect the first-order rate of disappearance of H_2O_2. This value was obtained by fitting the model data to the experimentally measured rate of H_2O_2 photolysis, obtained by titration with potassium permanganate. The majority of k values used in the models were predicted with the structure-activity relationship (SAR) (Witkowski et al., 2024).

Table S7. Reactions used in the model for the aqueous OH oxidation of fenchol (R1).

Reaction number	Reaction	k ($M^{-1}s^{-1}$)
1	H2O2 = OH + OH	5.4×10^{-6}
2	OH + H2O2 = HO2 + H2O	2.7×10^{7}
3	HO2+H2O2=OH + H2O	3.7
4	HO2 + HO2 = H2O2 + O2	8.3×10^{5}
5	OH + HO2 = H2O+O2	7.1×10^{9}
6	FCH + OH = Pr1	8.0×10^{7}
7	FCH + OH = Fenchone	5.6×10^{8}
8	FCH + OH = F1	3.8×10^{8}
9	FCH + OH = F2	2.0×10^{9}
10	F1 + OH = Fr2	6.0×10^{7}
11	F1 + OH = F3	2.9×10^{9}
12	F3 + OH = Fr3	2.0×10^{9}
13	F2 + OH = Fr4	5.0×10^{7}
14	F2 + OH = F4	4.1×10^{9}
15	F4 + OH = Fr5	2.0×10^{8}
16	F4 + OH = F6	1.2×10^{9}
17	F4 + OH = F5	1.4×10^{9}
18	F6 + OH = Fr6	6.0×10^{7}
19	F6 + OH = F7	2.8×10^{9}
20	F5 + OH = Fr7	1.8×10^{9}
21	F7 + OH = Fr8	1.6×10^{9}
22	Fenchone + OH = Fr9	1.9×10^{9}
23	Fenchone + OH = F8	3.2×10^{8}
24	Fenchone + OH = F10	2.1×10^{8}
25	Fenchone + OH = F9	2.7×10^{8}
26	F8 + OH = Fr10	1.5×10^{9}
27	F10 + OH = Fr11	3.3×10^{9}
28	F9 + OH = Fr12	3.0×10^{9}

Table S8. Reactions used in the model for the aqueous OH oxidation of borneol (R2).

Reaction number	Reaction	k ($M^{-1}s^{-1}$)
1	H2O2 = OH + OH	5.3×10^{-6}
2	OH + H2O2 = HO2 + H2O	2.7×10^{7}
3	HO2+H2O2=OH + H2O	3.7
4	HO2 + HO2 = H2O2 + O2	8.3×10^{5}
5	OH + HO2 = H2O+O2	7.1×10^{9}
6	BNL+ OH = Br1	9.0×10^{7}
7	BNL + OH = Camphor	6.6×10^{8}
8	BNL + OH = B1	5.3×10^{8}
9	BNL + OH = B2	4.9×10^{8}
10	BNL + OH = B6	1.2×10^{9}
11	BNL + OH = B7	3.3×10^{8}
12	BNL + OH = B12	6.0×10^{7}
13	B12 + OH = Br2	2.6×10^{9}
14	B1 + OH = Br3	2.6×10^{9}
15	B6 + OH = Br4	2.4×10^{9}
16	B2 + OH = Br5	8.0×10^{7}
17	B2 + OH = B3	3.6×10^{9}
18	B7 + OH = Br6	1.0×10^{8}
19	B7 + OH = B8	3.2×10^{9}
20	B3 + OH = Br7	9.0×10^{7}
21	B3 + OH = B4	8.8×10^{8}
22	B3 + OH = B5	7.9×10^{8}
23	B4 + OH = Br8	1.7×10^{9}
24	B5 + OH = Br9	1.4×10^{9}
25	B8 + OH = Br10	9.0×10^{7}
26	B8 + OH = B9	7.5×10^{8}
27	B8 + OH = B10	6.7×10^{8}
28	B9 + OH = Br11	1.7×10^{9}
29	B10 + OH = Br12	1.4×10^{9}
30	Camphor + OH = Br13	1.9×10^{9}
31	Camphor + OH = CA	2.4×10^{8}
32	Camphor + OH = B14	2.9×10^{8}
33	CA + OH = Br14	2.0×10^{9}
34	B14 + OH = Br15	2.0×10^{9}

15

Table S9. Reactions used in the model for the aqueous OH oxidation of menthol (R3).

Reaction number	Reaction	k ($M^{-1}s^{-1}$)
1	H2O2 = OH + OH	4.0×10^{-6}
2	OH + H2O2 = HO2 + H2O	2.7×10^{7}
3	HO2+H2O2=OH + H2O	3.7
4	HO2 + HO2 = H2O2 + O2	8.3×10^{5}
5	OH + HO2 = H2O+O2	7.1×10^{9}
6	MTH + OH = Mr1	1.6×10^{8}
7	MTH + OH = Menthone	2.7×10^{8}
8	MTH + OH = M1	2.3×10^{9}
9	MTH + OH = M2	5.9×10^{8}
10	MTH + OH = M7	3.5×10^{8}
11	MTH + OH = M8	3.1×10^{8}
12	M1 + OH = Mr2	4.3×10^{9}
13	M2 + OH = Mr3	3.5×10^{8}
14	M2 + OH = M3	4.0×10^{9}
15	M3 + OH = Mr4	4.4×10^{8}
16	M3 + OH = M4	4.0×10^{9}
17	M4 + OH = Mr5	1.5×10^{8}
18	M4 + OH = M6	1.5×10^{9}
19	M4 + OH = M5	1.3×10^{9}
20	M6 + OH = Mr6	2.8×10^{9}
21	M5 + OH = Mr7	2.3×10^{9}
22	M7+ OH = Mr8	4.1×10^{9}
23	M8 + OH = Mr9	1.2×10^{8}
24	M8 + OH = M9	5.6×10^{9}
25	M9 + OH = Mr10	2.1×10^{8}
26	M9 + OH = M10	4.0×10^{9}
27	M10 + OH = Mr11	1.3×10^{8}
28	M10 + OH = M12	1.3×10^{9}
29	M10 + OH = M11	1.1×10^{9}
30	M12 + OH = Mr12	2.7×10^{10}
31	M11 + OH = Mr13	2.3×10^{10}
32	Menthone + OH = Mr14	2.9×10^{9}
33	Menthone + OH = M13	4.3×10^{8}

34	Menthone + OH = M16	6.4×10^{8}
35	Menthone + OH = M17	3.0×10^{8}
36	M13 + OH = Mr15	3.3×10^{9}
37	M16 + OH = Mr16	3.6×10^{9}
38	M17 + OH = Mr17	3.2×10^{9}

Table S10. Henry's Law constants for the reactants of R1.

Name	**M×atm^{-1}**	**H^{cc}**
Fenchol	21.0×10^{2}	5.14×10^{3}
Fenchone	14.3	3.50×10^{2}
F1	3.91×10^{5}	9.57×10^{6}
F2	4.08×10^{3}	9.98×10^{4}
F6	2.51×10^{3}	6.14×10^{4}
F5	1.30×10^{8}	3.18×10^{9}
F3	3.75×10^{4}	9.17×10^{5}
F8	1.49×10^{6}	3.65×10^{7}
F10	8.40×10^{11}	2.06×10^{13}
F9	3.08×10^{10}	7.54×10^{11}
F4	3.91×10^{5}	9.57×10^{6}
F7	1.25×10^{7}	3.06×10^{8}

Table S11. Henry's Law constants for the reactants of R2.

Name	**M×atm^{-1}**	**H^{cc}**
Borneol	46.0	1.13×10^{3}
Camphor	14.3	3.50×10^{2}
B1	3.91×10^{5}	9.57×10^{6}
B3	3.75×10^{4}	9.17×10^{5}
B2	4.08×10^{3}	9.98×10^{4}
B4	2.40×10^{5}	5.87×10^{6}
B5	1.25×10^{7}	3.06×10^{8}
B6	3.91×10^{5}	9.57×10^{6}
B8	3.75×10^{4}	9.17×10^{5}
B7	4.08×10^{3}	9.98×10^{4}
B9	2.40×10^{5}	5.87×10^{6}
B10	1.25×10^{7}	3.06×10^{8}
B12	2.66×10^{7}	6.51×10^{8}
B14	2.55×10^{6}	6.24×10^{7}

CA	7.63×10^{7}	1.87×10^{9}

Table S12. Henry's Law constants for the reactants of R3.

Name	**M×atm^{-1}**	**H^{cc}**
Menthol	66.9	1.64×10^{3}
Menthone	6.29	1.54×10^{2}
M1	1.72×10^{5}	4.21×10^{6}
M2	1.80×10^{3}	4.40×10^{4}
M3	1.72×10^{5}	4.21×10^{6}
M4	1.65×10^{4}	4.04×10^{5}
M6	1.06×10^{5}	2.59×10^{6}
M5	5.49×10^{6}	1.34×10^{8}
M7	1.72×10^{5}	4.21×10^{6}
M8	1.80×10^{3}	4.40×10^{4}
M9	1.72×10^{5}	4.21×10^{6}
M10	1.65×10^{4}	4.04×10^{5}
M12	1.06×10^{5}	2.59×10^{6}
M11	5.49×10^{6}	1.34×10^{8}
M16	1.13×10^{6}	2.76×10^{7}
M17	4.95×10^{5}	1.21×10^{7}
M13	3.38×10^{7}	8.27×10^{8}

S5 Chromatograms of products of aqueous OH reactions with borneol (R2) and menthol (R3)

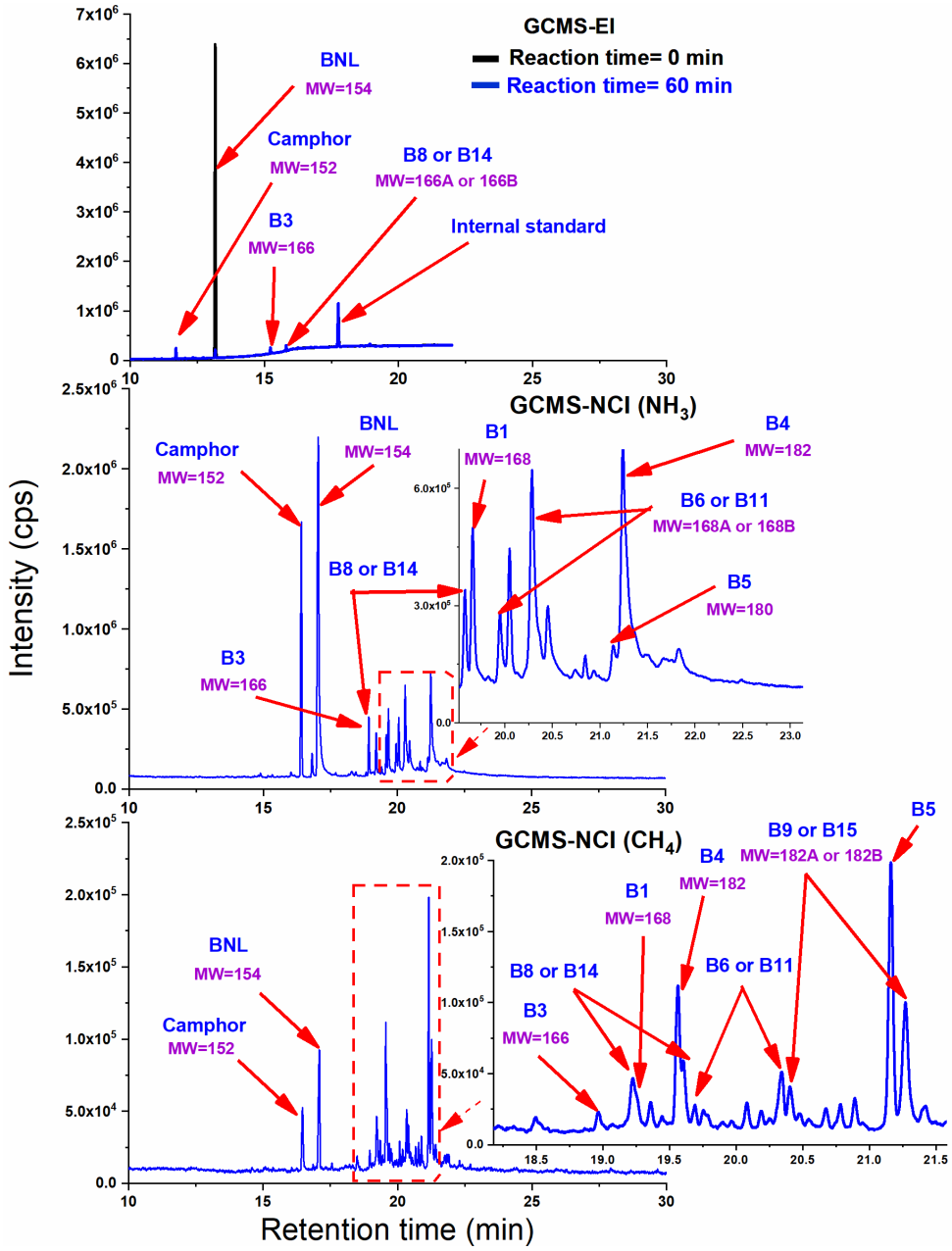


Figure S1: GC/MS chromatograms of the non-acidic products of borneol + OH reaction (R2) detected with EI (A) and (-)NCI using NH_3 (B), and CH_4 (C) as reagent gases. Note that different chromatographic columns were used for GC-EI/MS and GC-NCI/MS analyses (section 2.4.1), resulting in different retention times between panel (A) and panels (B) and (C).

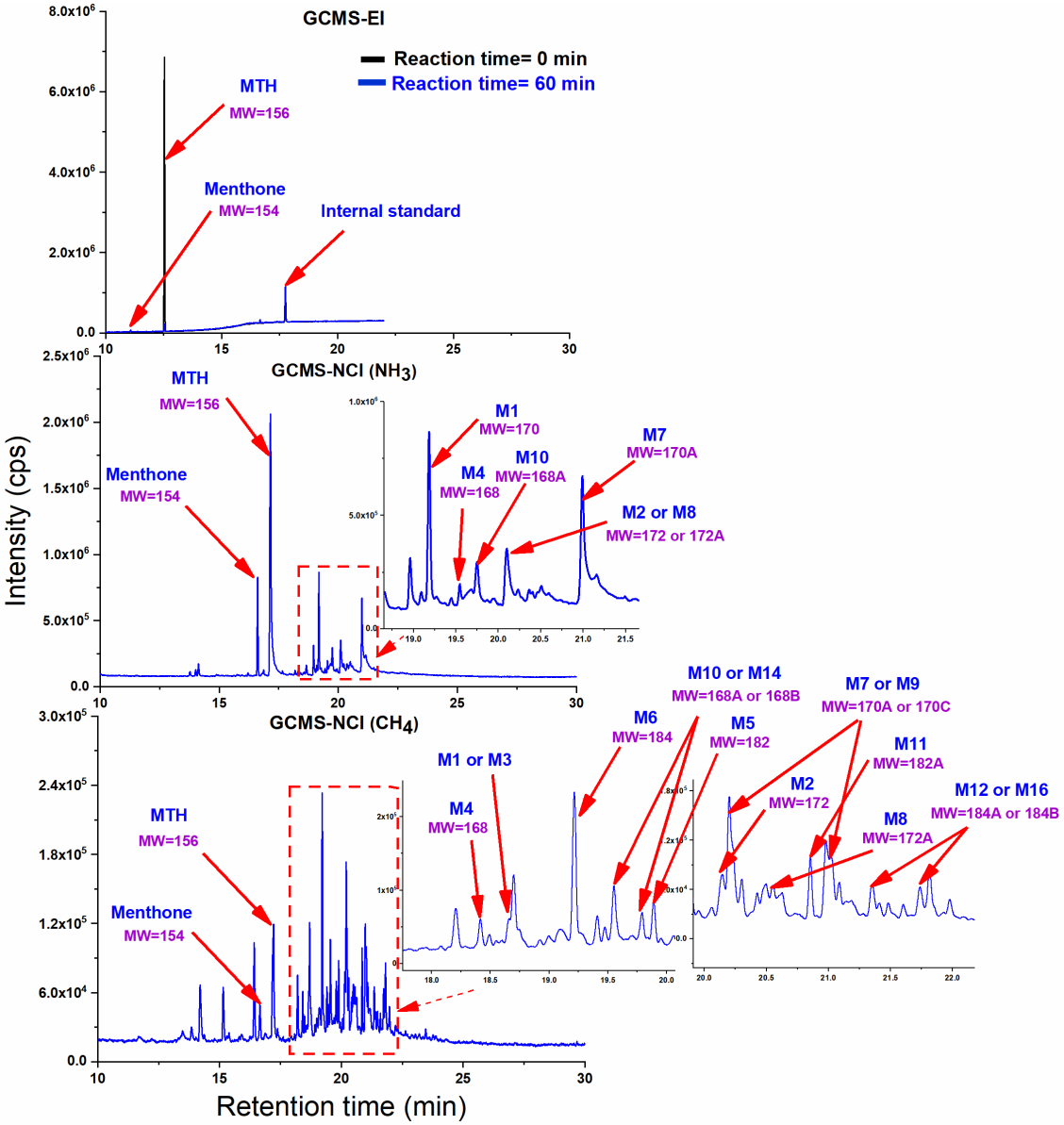


Figure S2: GC/MS chromatograms of the non-acidic products of menthol + OH reaction (R3) detected with EI (A) and (-)NCI using NH3 (B), and CH4 (C) as reagent gases. Note that different chromatographic columns were used for GC-EI/MS and GC-NCI/MS analyses (section 2.4.1), resulting in different retention times between panel (A) and panels (B) and (C).

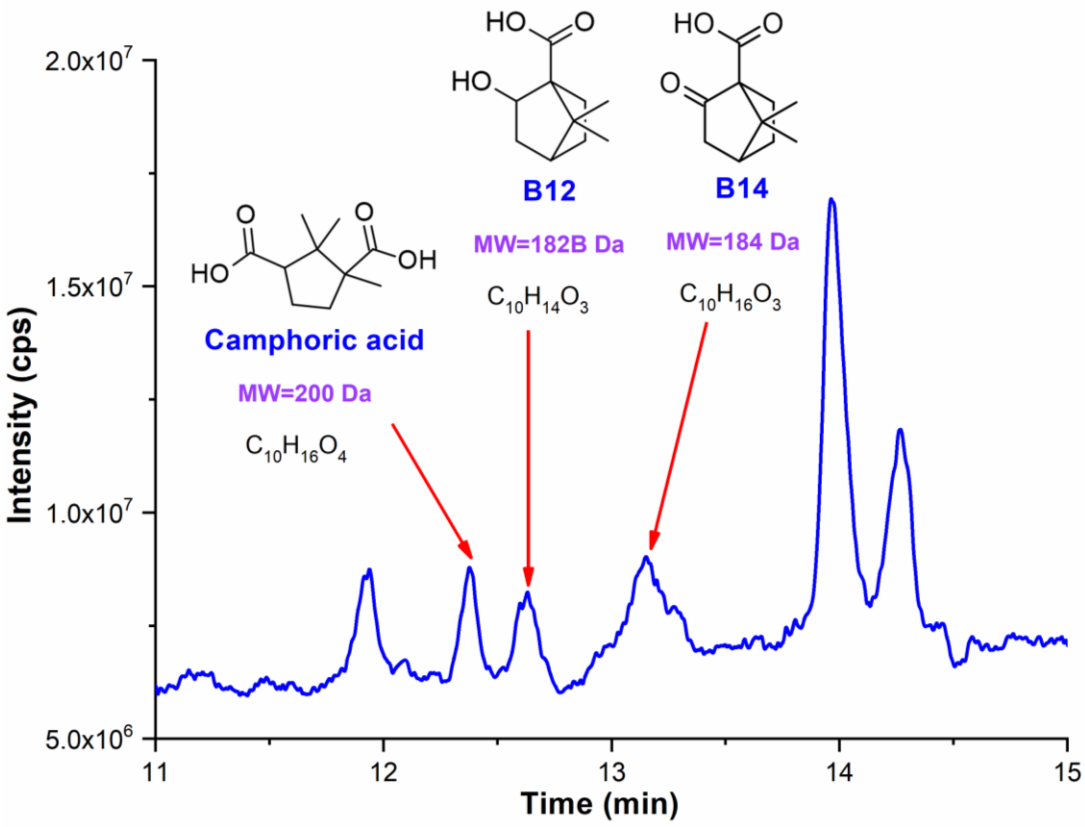


Figure S3: LC-ToF/MS chromatogram of TACs formed from OH reaction with borneol – R2 in Fig.1.

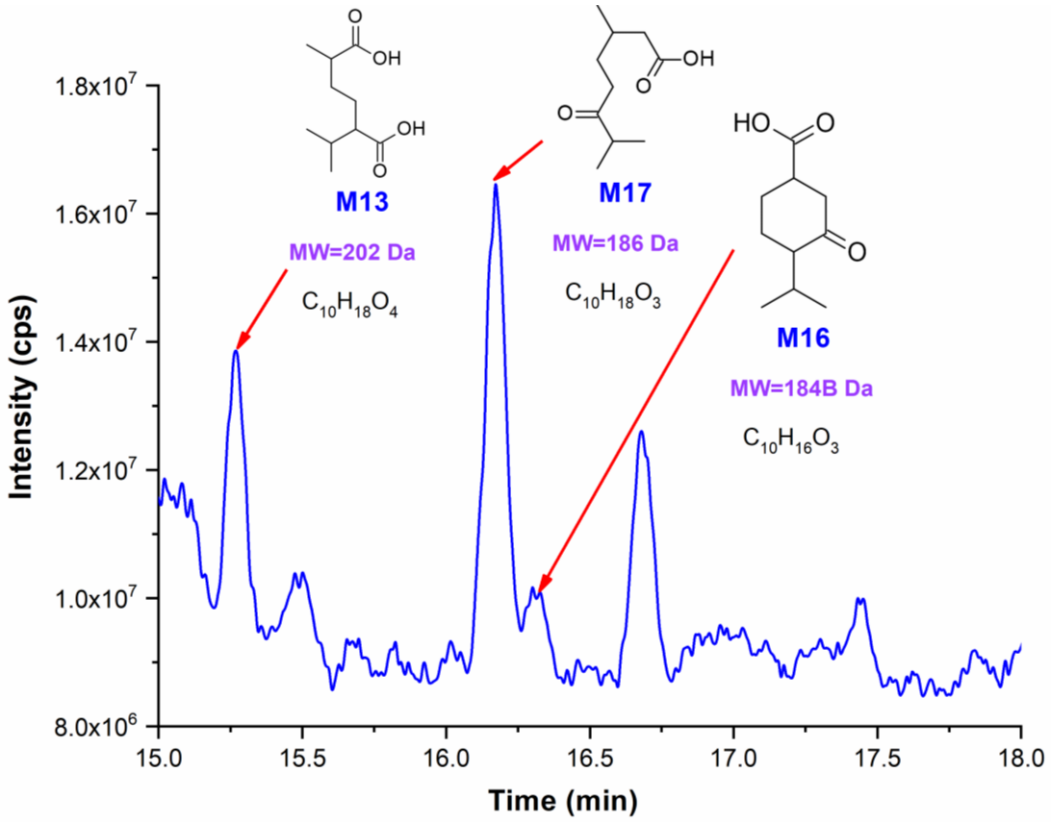


Figure S4: LC-ToF/MS chromatogram of TACs formed from OH reaction with menthol – R3 in Fig. 1.

Table S13. Retention times with the elemental composition for TACs formed in FCH+OH reaction (R1) obtained from the LC-ToF/MS analysis.

t_r (min)	Name	m/z (Da)	Elemental composition	Difference (Da)
9.93	F10	215.0920	$C_{10}H_{16}O_5$	0.0001
12.10	F8	169.0868	$C_9H_{14}O_3$	0.0003
13.15	F9	199.0971	$C_{10}H_{16}O_4$	0.0001

Table S14. Retention times with their elemental composition for TACs formed from BNL + $_{aq}$OH (R2) obtained from the LC-ToF/MS analysis.

t_r (min)	Name	m/z (Da)	Elemental composition	Difference (Da)
12.38	Camphoric acid	199.0970	$C_{10}H_{16}O_4$	0.0000
13.15	B14	181.0864	$C_{10}H_{14}O_3$	-0.0001
13.96	B12	183.1022	$C_{10}H_{16}O_3$	0.0001

Table S15. Retention times with the elemental composition for TACs formed from MTH + $_{aq}$OH reaction (R3) obtained from the LC-ToF/MS analysis.

t_r (min)	Name	m/z (Da)	Elemental composition	Difference (Da)
15.27	M13	201.1130	$C_{10}H_{18}O_4$	0.0003
16.17	M17	185.1184	$C_{10}H_{18}O_3$	0.0006
16.33	M16	183.1024	$C_{10}H_{16}O_3$	0.0003

S6 Yields of products of aqueous OH reactions with fenchol (R1), borneol (R2), and menthol (R3)

Table S16. The yields of the products from the reactions R1 - R3.

Molar yields of first-generation products					
Products formed directly from FCH (R1)		***Products formed directly from BNL (R2)***		***Products formed directly from MTH (R3)***	
Fenchone[a]	0.11±0.01	Camphor[a]	0.12±0.02	Menthone[a]	0.03±0.003
F1[b]	0.05±0.02	B1[b]	0.1±0.03	M1[b]	0.17±0.05
F2[b]	0.22±0.07	B2[c]	0.15±0.08	M2[b]	0.02±0.006
F3[b]	0.07±0.02	B3[b]	0.1±0.03	M3[b]	0.16±0.05
F4[b]	0.12±0.04	B4[c]	0.03±0.02	M4[b]	0.04±0.01
F5[b]	0.16±0.05	B5[b]	0.02±0.01	M5[b]	0.04±0.01
F6[b]	0.16±0.05	B6[b]	0.15±0.05	M6[b]	0.04±0.01
F7[b]	0.02±0.006	B7[c]	0.1±0.05	M7[b]	0.19±0.06
		B8[b]	0.16±0.05	M8[c]	0.08±0.04
		B9[c]	0.005±0.003	M9[c]	0.08±0.04
		B10[c]	0.0045±0.002	M10[b]	0.02±0.006
		B12[c]	0.02±0.010	M11[c]	0.0002±0.0001
				M12[c]	0.0002±0.0001

[a]Experimental uncertainties represent 2σ values obtained from triplicate measurements using authentic standards [b]Values derived using surrogate standards and adjusted with the kinetic model [c]Values derived only from the kinetic model

Table S17. The modelled yields of terpenoic acids formed from fenchone, camphor, and menthone.

Terpenoic acids formed from:								
Fenchone			***Camphor***			***Menthone***		
Name	**Yield (effective, from FCH)[a]**	**Yield (from fenchone)[a]**	**Name**	**Yield (effective, from BNL)[a]**	**Yield (from camphor)[a]**	**Name**	**Yield (effective, from MTH)[a]**	**Yield (from menthone)[a]**
F8	0.01±0.005	0.12±0.06	B13	0.01±0.005	0.1±0.05	M13	0.003±0.001	0.1±0.05
F9	0.01±0.005	0.1±0.04	B14	0.01±0.005	0.12±0.06	M16	0.004±0.002	0.15±0.07
F10	0.01±0.005	0.08±0.04	Camphoric acid	0.0004±0.0002	0.004±0.002	M17	0.002±0.001	0.07±0.03

[a]Yields derived from the kinetic model

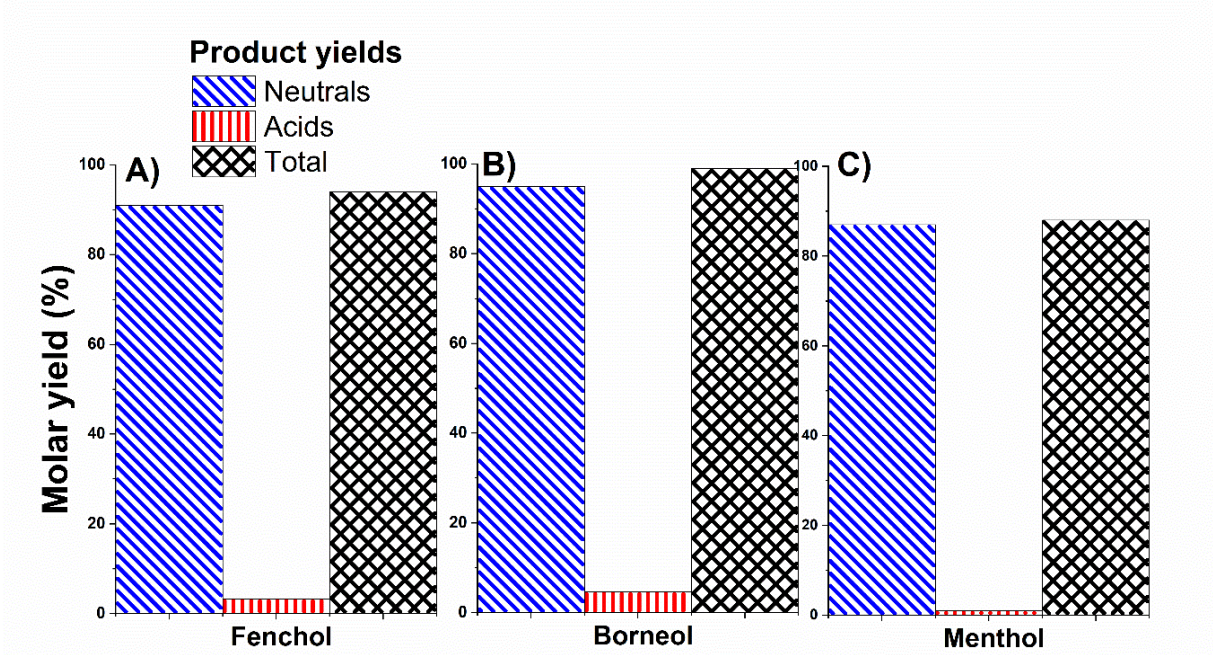


Figure S5. Yields of non-acidic and acidic products formed in reactions R1 – R3

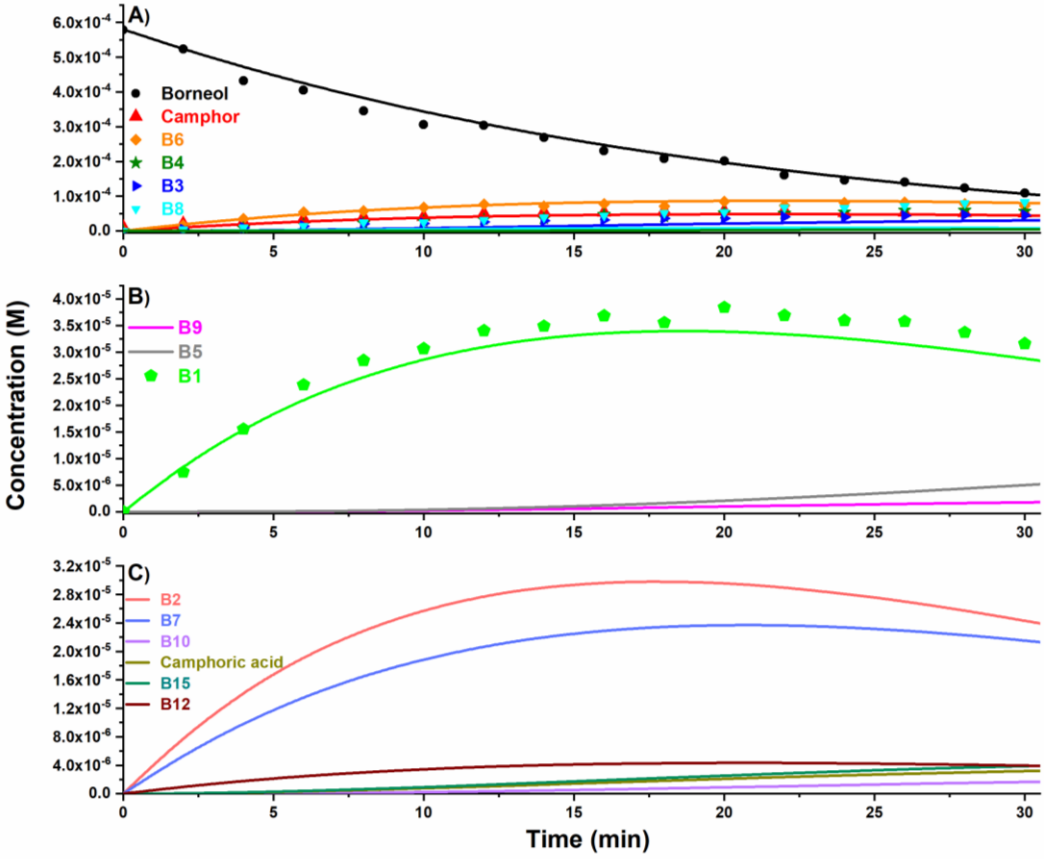


Figure S6: Temporal concentration profiles of the BNL and products of R2: points - experiment, and lines – kinetic model. Structures of products listed are shown in Schemes 3-5 in the main text.

For R2, the temporal profiles of some of the products were also reproduced accurately by the box model - Fig. S6. For the products camphor, B1, B3, B4, B6, and B8, the experimental results agree well with those generated by the model (Fig. S6A, B). However, for products B2, B5, B7, B9, B10, B12, B14, and camphoric acid, only the model-generated data are presented in Figs. S6B and C (section 3.4). For R2, the yield of acidic products was approx. 5%, and the yield of non-acidic products was 95 ± 30% – Table 1 and Figure S5. Similar results were obtained for R3 – Fig. S7.

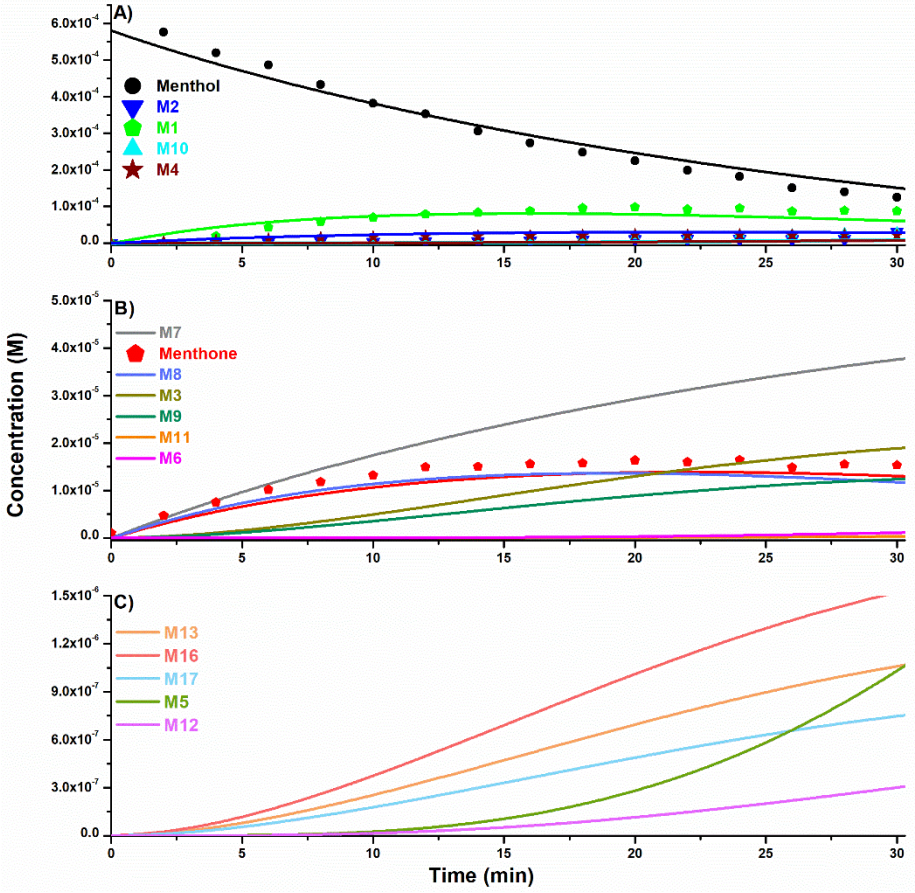


Figure S7: Temporal concentration profiles of the MTH and products of R3: points - experiment, and lines – kinetic model. Structures of products listed are shown in Schemes 6 and 7 in the main text.

The box model for R3 accurately reproduced the temporal evolution of products menthone, M1, M2, M4, and M10 - Fig. S7A and B. For products M3, M5-M9, M11-M13, M16, and M17, only data generated by the model are presented- Figs. S7B and C (section 3.4). For R3, the yields of acidic and non-acidic products were 1% and 87 ± 25%, respectively - Table 1 and Fig. S5.

References

Tan, Y., Perri, M. J., Seitzinger, S. P., and Turpin, B. J.: Effects of Precursor Concentration and Acidic Sulfate in Aqueous Glyoxal–OH Radical Oxidation and Implications for Secondary Organic Aerosol, Environ. Sci. Technol., 43, 8105-8112, https://doi.org/10.1021/es901742f, 2009.

Witkowski, B., Jain, P., Wileńska, B., and Gierczak, T.: Temperature-dependent aqueous OH kinetics of C_2–C_{10} linear and terpenoid alcohols and diols: new rate coefficients, structure–activity relationship, and atmospheric lifetimes, Atmos. Chem. Phys., 24, 663-688, 10.5194/acp-24-663-2024, 2024.