The Chemical Mechanism of MECCA

KPP version: `2.2.3_rs3`

MECCA version: `4.4.0.m1`

Date: June 10, 2024

Batch file: `simple.bat`

Integrator: `rosenbrock_posdef`

Gas equation file: `gas.eqn`

Replacement file:

Selected reactions:
"`Tr && G && !C && !Cl && !Br && !I && !Hg`"

Number of aerosol phases: 0

Number of species in selected mechanism:

Gas phase:	54
Aqueous phase:	0
All species:	54

Number of reactions in selected mechanism:

Gas phase (Gnnn):	116
Aqueous phase (Annn):	0
Henry (Hnnn):	0
Photolysis (Jnnn):	21
Aqueous phase photolysis (PHnnn):	0
Heterogeneous (HETnnn):	0
Equilibria (EQnn):	0
Isotope exchange (IEXnnn):	0
Tagging equations (TAGnnn):	0
Dummy (Dnn):	0
All equations:	137

Table 1: Gas phase reactions

#	labels	reaction	rate coefficient	reference
G1000	UpStTrG	$O_2 + O(^1D) \rightarrow O(^3P) + O_2$	3.3E-11*EXP(55./temp)	Burkholder et al. (2015)
G1001	UpStTrG	$O_2 + O(^3P) \rightarrow O_3$	6.0E-34*((temp/300.)**(-2.4)) *cair	Burkholder et al. (2015)
G2100	UpStTrG	$H + O_2 \rightarrow HO_2$	k_3rd(temp,cair,4.4E-32,1.3, 7.5E-11,-0.2,0.6)	Burkholder et al. (2015)
G2104	UpStTrG	$OH + O_3 \rightarrow HO_2 + O_2$	1.7E-12*EXP(-940./temp)	Burkholder et al. (2015)
G2105	UpStTrG	$OH + H_2 \rightarrow H_2O + H$	2.8E-12*EXP(-1800./temp)	Burkholder et al. (2015)
G2107	UpStTrG	$HO_2 + O_3 \rightarrow OH + 2\ O_2$	1.E-14*EXP(-490./temp)	Burkholder et al. (2015)
G2109	UpStTrG	$HO_2 + OH \rightarrow H_2O + O_2$	4.8E-11*EXP(250./temp)	Burkholder et al. (2015)
G2110	UpStTrG	$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$	k_HO2_HO2	Burkholder et al. (2015)*
G2111	UpStTrG	$H_2O + O(^1D) \rightarrow 2\ OH$	1.63E-10*EXP(60./temp)	Burkholder et al. (2015)
G2112	UpStTrG	$H_2O_2 + OH \rightarrow H_2O + HO_2$	1.8E-12	Burkholder et al. (2015)
G2117	UpStTrG	$H_2O + H_2O \rightarrow (H_2O)_2$	6.521E-26*temp*EXP(1851.09/temp) *EXP(-5.10485E-3*temp)	Scribano et al. (2006)*
G2118	UpStTrG	$(H_2O)_2 \rightarrow H_2O + H_2O$	1.E0	see note*
G3101	UpStTrGN	$N_2 + O(^1D) \rightarrow O(^3P) + N_2$	2.15E-11*EXP(110./temp)	Burkholder et al. (2015)
G3103	UpStTrGN	$NO + O_3 \rightarrow NO_2 + O_2$	3.0E-12*EXP(-1500./temp)	Burkholder et al. (2015)
G3106	StTrGN	$NO_2 + O_3 \rightarrow NO_3 + O_2$	1.2E-13*EXP(-2450./temp)	Burkholder et al. (2015)
G3108	StTrGN	$NO_3 + NO \rightarrow 2\ NO_2$	1.5E-11*EXP(170./temp)	Burkholder et al. (2015)
G3109	UpStTrGN	$NO_3 + NO_2 \rightarrow N_2O_5$	k_NO3_NO2	Burkholder et al. (2015)*
G3110	StTrGN	$N_2O_5 \rightarrow NO_2 + NO_3$	k_NO3_NO2/(5.8E-27*EXP(10840./ temp))	Burkholder et al. (2015)*
G3200	TrGN	$NO + OH \rightarrow HONO$	k_3rd(temp,cair,7.0E-31,2.6, 3.6E-11,0.1,0.6)	Burkholder et al. (2015)
G3201	UpStTrGN	$NO + HO_2 \rightarrow NO_2 + OH$	3.3E-12*EXP(270./temp)	Burkholder et al. (2015)
G3202	UpStTrGN	$NO_2 + OH \rightarrow HNO_3$	k_3rd(temp,cair,1.8E-30,3.0, 2.8E-11,0.,0.6)	Burkholder et al. (2015)
G3203	StTrGN	$NO_2 + HO_2 \rightarrow HNO_4$	k_NO2_HO2	Burkholder et al. (2015)*
G3204	TrGN	$NO_3 + HO_2 \rightarrow NO_2 + OH + O_2$	3.5E-12	Burkholder et al. (2015)
G3205	TrGN	$HONO + OH \rightarrow NO_2 + H_2O$	1.8E-11*EXP(-390./temp)	Burkholder et al. (2015)
G3206	StTrGN	$HNO_3 + OH \rightarrow H_2O + NO_3$	k_HNO3_OH	Dulitz et al. (2018)*
G3207	StTrGN	$HNO_4 \rightarrow NO_2 + HO_2$	k_NO2_HO2/(2.1E-27*EXP(10900./ temp))	Burkholder et al. (2015)*
G3208	StTrGN	$HNO_4 + OH \rightarrow NO_2 + H_2O$	1.3E-12*EXP(380./temp)	Burkholder et al. (2015)

Table 1: Gas phase reactions (... continued)

#	labels	reaction	rate coefficient	reference
G3209	TrGN	$NH_3 + OH \rightarrow NH_2 + H_2O$	1.7E-12*EXP(-710./temp)	Kohlmann and Poppe (1999)
G3210	TrGN	$NH_2 + O_3 \rightarrow NH_2O + O_2$	4.3E-12*EXP(-930./temp)	Kohlmann and Poppe (1999)
G3211	TrGN	$NH_2 + HO_2 \rightarrow NH_2O + OH$	4.8E-07*EXP(-628./temp)*(temp)**(-1.32)	Kohlmann and Poppe (1999)
G3212	TrGN	$NH_2 + HO_2 \rightarrow HNO + H_2O$	9.4E-09*EXP(-356./temp)*(temp)**(-1.12)	Kohlmann and Poppe (1999)
G3213	TrGN	$NH_2 + NO \rightarrow HO_2 + OH + N_2$	1.92E-12*((temp/298.)**(-1.5))	Kohlmann and Poppe (1999)
G3214	TrGN	$NH_2 + NO \rightarrow N_2 + H_2O$	1.41E-11*((temp/298.)**(-1.5))	Kohlmann and Poppe (1999)
G3215	TrGN	$NH_2 + NO_2 \rightarrow N_2O + H_2O$	1.2E-11*((temp/298.)**(-2.0))	Kohlmann and Poppe (1999)
G3216	TrGN	$NH_2 + NO_2 \rightarrow NH_2O + NO$	0.8E-11*((temp/298.)**(-2.0))	Kohlmann and Poppe (1999)
G3217	TrGN	$NH_2O + O_3 \rightarrow NH_2 + O_2$	1.2E-14	Kohlmann and Poppe (1999)
G3218	TrGN	$NH_2O \rightarrow NHOH$	1.3E3	Kohlmann and Poppe (1999)
G3219	TrGN	$HNO + OH \rightarrow NO + H_2O$	8.0E-11*EXP(-500./temp)	Kohlmann and Poppe (1999)
G3220	TrGN	$HNO + NHOH \rightarrow NH_2OH + NO$	1.66E-12*EXP(-1500./temp)	Kohlmann and Poppe (1999)
G3221	TrGN	$HNO + NO_2 \rightarrow HONO + NO$	1.0E-12*EXP(-1000./temp)	Kohlmann and Poppe (1999)
G3222	TrGN	$NHOH + OH \rightarrow HNO + H_2O$	1.66E-12	Kohlmann and Poppe (1999)
G3223	TrGN	$NH_2OH + OH \rightarrow NHOH + H_2O$	4.13E-11*EXP(-2138./temp)	Kohlmann and Poppe (1999)
G3224	TrGN	$HNO + O_2 \rightarrow HO_2 + NO$	3.65E-14*EXP(-4600./temp)	Kohlmann and Poppe (1999)
G4101	StTrG	$CH_4 + OH \rightarrow CH_3 + H_2O$	1.85E-20*EXP(2.82*LOG(temp)-987./temp)	Atkinson (2003)
G4102	TrG	$CH_3OH + OH \rightarrow .85\ HCHO + .85\ HO_2 + .15\ CH_3O + H_2O$	6.38E-18*((temp)**2)*EXP(144./temp)	Atkinson et al. (2006)
G4103a	StTrG	$CH_3O_2 + HO_2 \rightarrow CH_3OOH + O_2$	3.8E-13*EXP(780./temp)/(1.+1./498.*EXP(1160./temp))	Atkinson et al. (2006)
G4103b	StTrG	$CH_3O_2 + HO_2 \rightarrow HCHO + H_2O + O_2$	3.8E-13*EXP(780./temp)/(1.+498.*EXP(-1160./temp))	Atkinson et al. (2006)
G4104a	StTrGN	$CH_3O_2 + NO \rightarrow CH_3O + NO_2$	2.3E-12*EXP(360./temp)*(1.-beta_CH3NO3)	Atkinson et al. (2006), Butkovskaya et al. (2012), Flocke et al. (1998)
G4104b	StTrGN	$CH_3O_2 + NO \rightarrow CH_3ONO_2$	2.3E-12*EXP(360./temp)*beta_CH3NO3	Atkinson et al. (2006), Butkovskaya et al. (2012), Flocke et al. (1998)*
G4105	TrGN	$CH_3O_2 + NO_3 \rightarrow CH_3O + NO_2 + O_2$	1.2E-12	Atkinson et al. (2006)
G4106a	StTrG	$CH_3O_2 \rightarrow CH_3O + .5\ O_2$	7.4E-13*EXP(-520./temp)*RO2*2.	Atkinson et al. (2006)

Table 1: Gas phase reactions (... continued)

#	labels	reaction	rate coefficient	reference
G4106b	StTrG	$CH_3O_2 \rightarrow .5\ HCHO + .5\ CH_3OH + .5\ O_2$	(k_CH3O2-7.4E-13*EXP(-520./temp)) *RO2*2.	Atkinson et al. (2006)
G4107	StTrG	$CH_3OOH + OH \rightarrow .6\ CH_3O_2 + .4\ HCHO + .4\ OH + H_2O$	k_CH3OOH_OH	Wallington et al. (2018)
G4108	StTrG	$HCHO + OH \rightarrow CO + H_2O + HO_2$	9.52E-18*EXP(2.03*LOG(temp) +636./temp)	Sivakumaran et al. (2003)
G4109	TrGN	$HCHO + NO_3 \rightarrow HNO_3 + CO + HO_2$	3.4E-13*EXP(-1900./temp)	Burkholder et al. (2015)*
G4110	UpStTrG	$CO + OH \rightarrow H + CO_2$	(1.57E-13+cair*3.54E-33)	McCabe et al. (2001)
G4111	TrG	$HCOOH + OH \rightarrow CO_2 + HO_2 + H_2O$	2.94E-14*exp(786./temp) +9.85E-13*EXP(-1036./temp)	Paulot et al. (2011)
G4114	StTrGN	$CH_3O_2 + NO_2 \rightarrow CH_3O_2NO_2$	k_NO2_CH3O2	Burkholder et al. (2015)
G4115	StTrGN	$CH_3O_2NO_2 \rightarrow CH_3O_2 + NO_2$	k_NO2_CH3O2/(9.5E-29*EXP(11234./ temp))	Burkholder et al. (2015)*
G4116	StTrGN	$CH_3O_2NO_2 + OH \rightarrow HCHO + NO_3 + H_2O$	3.00E-14	see note*
G4117	StTrGN	$CH_3ONO_2 + OH \rightarrow H_2O + HCHO + NO_2$	4.0E-13*EXP(-845./temp)	Atkinson et al. (2006)
G4118	StTrG	$CH_3O \rightarrow HO_2 + HCHO$	1.3E-14*exp(-663./temp)*c(ind_O2)	Chai et al. (2014)
G4119a	StTrGN	$CH_3O + NO_2 \rightarrow CH_3ONO_2$	k_3rd_iupac(temp,cair,8.1E-29, 4.5,2.1E-11,0.,0.44)	Atkinson et al. (2006)
G4119b	StTrGN	$CH_3O + NO_2 \rightarrow HCHO + HONO$	9.6E-12*EXP(-1150./temp)	Atkinson et al. (2006)
G4120a	StTrGN	$CH_3O + NO \rightarrow CH_3ONO$	k_3rd_iupac(temp,cair,2.6E-29, 2.8,3.3E-11,0.6,REAL(EXP(-temp/ 900.),SP))	Atkinson et al. (2006)
G4120b	StTrGN	$CH_3O + NO \rightarrow HCHO + HNO$	2.3E-12*(temp/300.)**(0.7)	Atkinson et al. (2006)
G4121	StTrG	$CH_3O_2 + O_3 \rightarrow CH_3O + 2\ O_2$	2.9E-16*exp(-1000./temp)	Burkholder et al. (2015)
G4122	StTrGN	$CH_3ONO + OH \rightarrow H_2O + HCHO + NO$	1.E-10*exp(-1764./temp)	Nielsen et al. (1991)
G4123	StTrG	$HCHO + HO_2 \rightarrow HOCH_2O_2$	9.7E-15*EXP(625./temp)	Atkinson et al. (2006)
G4124	StTrG	$HOCH_2O_2 \rightarrow HCHO + HO_2$	2.4E12*EXP(-7000./temp)	Atkinson et al. (2006)
G4125	StTrG	$HOCH_2O_2 + HO_2 \rightarrow .5\ HOCH_2OOH + .5\ HCOOH + .2\ OH + .2\ HO_2 + .3\ H_2O + .8\ O_2$	5.6E-15*EXP(2300./temp)	Atkinson et al. (2006)
G4126	StTrGN	$HOCH_2O_2 + NO \rightarrow NO_2 + HO_2 + HCOOH$	0.7275*2.3E-12*EXP(360./temp)	Atkinson et al. (2006)*
G4127	StTrGN	$HOCH_2O_2 + NO_3 \rightarrow NO_2 + HO_2 + HCOOH$	1.2E-12	see note*
G4129a	StTrG	$HOCH_2O_2 \rightarrow HCOOH + HO_2$	(k_CH3O2*5.5E-12)**(0.5)*RO2*2.	Atkinson et al. (2006)
G4129b	StTrG	$HOCH_2O_2 \rightarrow .5\ HCOOH + .5\ HOCH_2OH + .5\ O_2$	(k_CH3O2*5.7E-14*EXP(750./temp)) **(0.5)*RO2*2.	Atkinson et al. (2006)
G4130a	StTrG	$HOCH_2OOH + OH \rightarrow HOCH_2O_2 + H_2O$	k_ROOHRO	Taraborrelli (2010)*
G4130b	StTrG	$HOCH_2OOH + OH \rightarrow HCOOH + H_2O + OH$	k_ROHRO + k_s*f_sOOH*f_sOH	Taraborrelli (2010)*

Table 1: Gas phase reactions (... continued)

#	labels	reaction	rate coefficient	reference
G4132	StTrG	$HOCH_2OH + OH \rightarrow HO_2 + HCOOH + H_2O$	2.*k_ROHRO + k_s*f_sOH*f_sOH	Taraborrelli (2010)*
G4133	StTrG	$CH_3O_2 + OH \rightarrow CH_3O + HO_2$	1.4E-10	Bossolasco et al. (2014)*
G4134	StTrG	$CH_2OO \rightarrow CO + HO_2 + OH$	1.124E+14*EXP(-10000./temp)	see note*
G4135	StTrG	$CH_2OO + H_2O \rightarrow HOCH_2OOH$	k_CH2OO_NO2*3.6E-6	Ouyang et al. (2013)*
G4136	StTrG	$CH_2OO + (H_2O)_2 \rightarrow HOCH_2OOH + H_2O$	5.2E-12	Chao et al. (2015), Lewis et al. (2015)*
G4137	StTrGN	$CH_2OO + NO \rightarrow HCHO + NO_2$	6.E-14	Welz et al. (2012)*
G4138	StTrGN	$CH_2OO + NO_2 \rightarrow HCHO + NO_3$	k_CH2OO_NO2	Welz et al. (2012), Stone et al. (2014)*
G4140	StTrG	$CH_2OO + CO \rightarrow HCHO + CO_2$	3.6E-14	Vereecken et al. (2012)
G4141	StTrG	$CH_2OO + HCOOH \rightarrow 2\ HCOOH$	1.E-10	Welz et al. (2014)*
G4142	StTrG	$CH_2OO + HCHO \rightarrow 2$ LCARBON	1.7E-12	Stone et al. (2014)*
G4143	StTrG	$CH_2OO + CH_3OH \rightarrow 2$ LCARBON	5.E-12	Vereecken et al. (2012)*
G4144	StTrG	$CH_2OO + CH_3O_2 \rightarrow 2$ LCARBON	5.E-12	Vereecken et al. (2012)*
G4145	StTrG	$CH_2OO + HO_2 \rightarrow$ LCARBON	5.E-12	Vereecken et al. (2012)
G4146	StTrG	$CH_2OO + O_3 \rightarrow HCHO + 2\ O_2$	1.E-12	Vereecken et al. (2014)
G4147	StTrG	$CH_2OO + CH_2OO \rightarrow 2\ HCHO + O_2$	6.E-11	Buras et al. (2014)
G4148	StTrGN	$HOCH_2O_2 + NO_2 \rightarrow HOCH_2O_2NO_2$	k_NO2_CH3O2	see note*
G4149	StTrGN	$HOCH_2O_2NO_2 \rightarrow HOCH_2O_2 + NO_2$	k_NO2_CH3O2/(9.5E-29*EXP(11234./temp))	Barnes et al. (1985)*
G4150	StTrGN	$HOCH_2O_2NO_2 + OH \rightarrow HCOOH + NO_3 + H_2O$	9.50E-13*EXP(-650./temp)*f_sOH	see note*
G4151	StTrG	$CH_3 + O_2 \rightarrow CH_3O_2$	k_3rd_iupac(temp,cair,7.0E-31,3.,1.8E-12,-1.1,0.33)	Atkinson et al. (2006)
G4152	StTrG	$CH_3 + O_3 \rightarrow .956\ HCHO + .956\ H + .044\ CH_3O + O_2$	5.1E-12*exp(-210./temp)	Albaladejo et al. (2002), Ogryzlo et al. (1981)
G4153	StTrG	$CH_3 + O(^3P) \rightarrow .83\ HCHO + .83\ H + .17\ CO + .17\ H_2 + .17\ H$	1.3E-10	Atkinson et al. (2006)
G4154	StTrG	$CH_3O + O_3 \rightarrow CH_3O_2 + O_2$	2.53E-14	Albaladejo et al. (2002)*
G4155	StTrG	$CH_3O + O(^3P) \rightarrow .75\ CH_3 + .75\ O_2 + .25\ HCHO + .25\ OH$	2.5E-11	Baulch et al. (2005)
G4156	StTrG	$CH_3O_2 + O(^3P) \rightarrow CH_3O + O_2$	4.3E-11	Zellner et al. (1988)
G4157	StTrG	$HCHO + O(^3P) \rightarrow .7\ OH + .7\ CO + .3\ H + .3\ CO_2 + HO_2$	3.4E-11*EXP(-1600./temp)	Burkholder et al. (2015)
G4158	TrG	$CH_2OO^* \rightarrow .37\ CH_2OO + .47\ CO + .47\ H_2O + .16\ HO_2 + .16\ CO + .16\ OH$	KDEC	Atkinson et al. (2006)

Table 1: Gas phase reactions (... continued)

#	labels	reaction	rate coefficient	reference
G4159	TrGN	$HCN + OH \rightarrow H_2O + CN$	k_3rd(temp,cair,4.28E-33,1.0, REAL(4.25E-13*EXP(-1150./temp) ,SP),1.0,0.8)	Kleinböhl et al. (2006)
G4160a	TrGN	$HCN + O(^1D) \rightarrow O(^3P) + HCN$	1.08E-10*EXP(105./temp) *0.15*EXP(200./temp)	Strekowski et al. (2010)
G4160b	TrGN	$HCN + O(^1D) \rightarrow H + NCO$	1.08E-10*EXP(105./temp)*0.68/2.	Strekowski et al. (2010)*
G4160c	TrGN	$HCN + O(^1D) \rightarrow OH + CN$	1.08E-10*EXP(105./temp)*(1.-(0.68/ 2.+0.15*EXP(200./temp)))	Strekowski et al. (2010)*
G4161	TrGN	$HCN + O(^3P) \rightarrow H + NCO$	1.0E-11*EXP(-4000./temp)	Burkholder et al. (2015)*
G4162	TrGN	$CN + O_2 \rightarrow NCO + O(^3P)$	1.2E-11*EXP(210./temp)*0.75	Baulch et al. (2005)
G4163	TrGN	$CN + O_2 \rightarrow CO + NO$	1.2E-11*EXP(210./temp)*0.25	Baulch et al. (2005)
G4164	TrGN	$NCO + O_2 \rightarrow CO_2 + NO$	7.E-15	Becker et al. (2000)*
G9200	StTrGS	$SO_2 + OH \rightarrow H_2SO_4 + HO_2$	k_3rd(temp,cair,3.3E-31,4.3, 1.6E-12,0.,0.6)	Burkholder et al. (2015)
G9403	TrGS	$CH_3SO_2 \rightarrow SO_2 + CH_3$	1.8E13*EXP(-8661./temp)	Barone et al. (1995)
G9404	TrGS	$CH_3SO_2 + O_3 \rightarrow CH_3SO_3$	3.E-13	Barone et al. (1995)
G9405	TrGS	$CH_3SO_3 + HO_2 \rightarrow CH_3SO_3H$	5.E-11	Barone et al. (1995)
G9408	StTrGS	$CH_2OO + SO_2 \rightarrow H_2SO_4 + HCHO$	k_CH2OO_SO2	Welz et al. (2012), Stone et al. (2014)*

General notes

Three-body reactions

Rate coefficients for three-body reactions are defined via the function `k_3rd`(T, M, k_0^{300}, n, k_{inf}^{300}, m, f_c). In the code, the temperature T is called `temp` and the concentration of "air molecules" M is called `cair`. Using the auxiliary variables $k_0(T)$, $k_{\mathrm{inf}}(T)$, and k_{ratio}, `k_3rd` is defined as:

$$k_0(T) = k_0^{300} \times \left(\frac{300\mathrm{K}}{T}\right)^n \quad (1)$$

$$k_{\mathrm{inf}}(T) = k_{\mathrm{inf}}^{300} \times \left(\frac{300\mathrm{K}}{T}\right)^m \quad (2)$$

$$k_{\mathrm{ratio}} = \frac{k_0(T)M}{k_{\mathrm{inf}}(T)} \quad (3)$$

$$\texttt{k\_3rd} = \frac{k_0(T)M}{1+k_{\mathrm{ratio}}} \times f_\mathrm{c}^{\left(\frac{1}{1+(\log_{10}(k_{\mathrm{ratio}}))^2}\right)} \quad (4)$$

A similar function, called `k_3rd_iupac` here, is used by Wallington et al. (2018) for three-body reactions. It has the same function parameters as `k_3rd` and it is defined as:

$$k_0(T) = k_0^{300} \times \left(\frac{300\mathrm{K}}{T}\right)^n \quad (5)$$

$$k_{\mathrm{inf}}(T) = k_{\mathrm{inf}}^{300} \times \left(\frac{300\mathrm{K}}{T}\right)^m \quad (6)$$

$$k_{\mathrm{ratio}} = \frac{k_0(T)M}{k_{\mathrm{inf}}(T)} \quad (7)$$

$$N = 0.75 - 1.27 \times \log_{10}(f_\mathrm{c}) \quad (8)$$

$$\texttt{k\_3rd\_iupac} = \frac{k_0(T)M}{1+k_{\mathrm{ratio}}} \times f_\mathrm{c}^{\left(\frac{1}{1+(\log_{10}(k_{\mathrm{ratio}})/N)^2}\right)} \quad (9)$$

Structure-Activity Relationships (SAR)

Some unmeasured rate coefficients are estimated with structure-activity relationships, using the following parameters and substituent factors:

k for H-abstraction by OH in $\mathrm{cm^{-3}s^{-1}}$	
`k_p`	$4.49 \times 10^{-18} \times (T/\mathrm{K})^2 \exp(-320\,\mathrm{K}/T)$
`k_s`	$4.50 \times 10^{-18} \times (T/\mathrm{K})^2 \exp(253\,\mathrm{K}/T)$
`k_t`	$2.12 \times 10^{-18} \times (T/\mathrm{K})^2 \exp(696\,\mathrm{K}/T)$
`k_ROHRO`	$2.1 \times 10^{-18} \times (T/\mathrm{K})^2 \exp(-85\,\mathrm{K}/T)$
`k_CO2H`	$0.7 \times k_{\mathrm{CH_3CO_2H+OH}}$
`k_ROOHRO`	$0.6 \times k_{\mathrm{CH_3OOH+OH}}$
`f_alk`	1.23
`f_sOH`	3.44
`f_tOH`	2.68
`f_sOOH`	8.
`f_tOOH`	8.
`f_ONO2`	0.04
`f_CH2ONO2`	0.20
`f_cpan`	0.25
`f_allyl`	3.6
`f_CHO`	0.55
`f_CO2H`	1.67
`f_CO`	0.73
`f_O`	8.15
`f_pCH2OH`	1.29
`f_tCH2OH`	0.53

k for OH-addition to double bonds in $\mathrm{cm^{-3}s^{-1}}$	
`k_adp`	$4.5 \times 10^{-12} \times (T/300\,\mathrm{K})^{-0.85}$
`k_ads`	$1/4 \times (1.1 \times 10^{-11} \times \exp(485\,\mathrm{K}/T) + 1.0 \times 10^{-11} \times \exp(553\,\mathrm{K}/T))$
`k_adt`	$1.922 \times 10^{-11} \times \exp(450\,\mathrm{K}/T) - k_{\mathrm{ads}}$
`k_adsecprim`	3.0×10^{-11}
`k_adtertprim`	5.7×10^{-11}
`a_PAN`	0.56
`a_CHO`	0.31
`a_COCH3`	0.76
`a_CH2OH`	1.7
`a_CH2OOH`	1.7
`a_COH`	2.2
`a_COOH`	2.2
`a_CO2H`	0.25
`a_CH2ONO2`	0.64

RO_2 self and cross reactions

The self and cross reactions of organic peroxy radicals are treated according to the permutation reaction formalism as implemented in the MCM (Rickard and Pascoe, 2009), as decribed by Jenkin et al. (1997). Every organic peroxy radical reacts in a pseudo-first-order reaction with a rate constant that is expressed as $k^{1\mathrm{st}} = 2 \times \sqrt{k_{\mathrm{self}} \times \texttt{k\_CH3O2}} \times [\mathrm{RO_2}]$ where k_{self} = second-order rate coefficient of the self reaction of the organic peroxy radical, `k_CH3O2` = second-order rate coefficient of the self reaction of CH_3O_2, and $[\mathrm{RO_2}]$ = sum of the concentrations of all organic peroxy radicals.

Specific notes

G2110: The rate coefficient is: k_HO2_HO2 = (3.0E-13*EXP(460./temp)+2.1E-33*EXP(920./temp) *cair)*(1.+1.4E-21*EXP(2200./temp)*C(ind_H2O)).

G2117: Converted to Kc [molec-1 cm3]= Kp*R*T/NA, where R is 82.05736 [cm3atmK1mol1].

G2118: Assuming fast equilibrium.

G3109: The rate coefficient is: k_NO3_NO2 = k_3rd(temp,cair,2.4E-30,3.0,1.6E-12,-0.1,0.6).

G3110: The rate coefficient is defined as backward reaction divided by equilibrium constant.

G3203: The rate coefficient is: k_NO2_HO2 = k_3rd(temp,cair,1.9E-31,3.4,4.0E-12,0.3,0.6).

G3206: The rate coefficient is: k_HNO3_OH = 1.32E-14 * EXP(527/temp) + 1 / (1 / (7.39E-32 * EXP(453/temp)*cair) + 1 / (9.73E-17 * EXP(1910/temp)))

G3207: The rate coefficient is defined as backward reaction divided by equilibrium constant.

G4104b: Methyl nitrate yield according to Banic et al. (2003) but reduced by a factor of 10 according to the upper limit derived from measurements by Munger et al. (1999).

G4109: Same temperature dependence as for CH_3CHO+NO_3 assumed.

G4115: The rate coefficient is defined as backward reaction divided by equilibrium constant.

G4116: Same value as for PAN + OH.

G4126: Same as for G4104 but scaled to match the recommeded value at 298K.

G4127: Same as for CH3O2 + NO3 in G4105.

G4130a: SAR for H-abstraction by OH.

G4130b: SAR for H-abstraction by OH.

G4132: SAR for H-abstraction by OH.

G4133: Lower limit of the rate constant. Products uncertain but CH_3OH can be excluded because of a likely high energy barrier (L. Vereecken, pers. comm.). CH_2OO production cannot be excluded.

G4134: Estimate based on the decomposition lifetime of 3 s (Olzmann et al., 1997) and a 20 kcal/mol energy barrier (Vereecken and Francisco, 2012).

G4135: Rate constant for $CH_2OO + NO_2$ (G4138) multiplied by the factor from Ouyang et al. (2013).

G4136: Average of two measurements.

G4137: Upper limit.

G4138: Average of 7.E-12 and 1.5E-12.

G4141: $HOOCH_2OCHO$ forms and then decomposes to formic anhydride (Gruzdev et al., 1993) which hydrolyses in the humid atmosphere (Conn et al., 1942).

G4142: High-pressure limit.

G4143: Generic estimate for reaction with alcohols.

G4144: Generic estimate for reaction with RO_2.

G4148: Same value as for NO_2+CH_3O_2.

G4149: Barnes et al. (1985) estimated a decomposition rate equal to that of $CH_3O_2NO_2$.

G4150: Value for $CH_3O_2NO_2$ + OH, H-abstraction enhanced by the HO-group by f_sOH.

G4154: Products assumed to be $CH_3O_2 + O_2$ (could also be $HCHO + O_2 + OH$).

G4160b: Half of the H-yield is attributed to fast secondary chemistry.

G4160c: The NH + CO channel is also significant but neglected here.

G4161: No studies below 450 K and only the major channel is considered.

G4164: Upper limit. Dominant pathway under atmospheric conditions.

G9408: Average of 3.9E-11 and 3.42E-11.

Table 2: Photolysis reactions

#	labels	reaction	rate coefficient	reference
J (gas)				
J1000a	UpStTrGJ	$O_2 + h\nu \rightarrow O(^3P) + O(^3P)$	jx(ip_O2)	Sander et al. (2014)
J1001a	UpStTrGJ	$O_3 + h\nu \rightarrow O(^1D) + O_2$	jx(ip_O1D)	Sander et al. (2014)
J1001b	UpStTrGJ	$O_3 + h\nu \rightarrow O(^3P) + O_2$	jx(ip_O3P)	Sander et al. (2014)
J2101	UpStTrGJ	$H_2O_2 + h\nu \rightarrow 2\ OH$	jx(ip_H2O2)	Sander et al. (2014)
J3101	UpStTrGJN	$NO_2 + h\nu \rightarrow NO + O(^3P)$	jx(ip_NO2)	Sander et al. (2014)
J3103a	UpStTrGJN	$NO_3 + h\nu \rightarrow NO_2 + O(^3P)$	jx(ip_NO2O)	Sander et al. (2014)
J3103b	UpStTrGJN	$NO_3 + h\nu \rightarrow NO + O_2$	jx(ip_NOO2)	Sander et al. (2014)
J3104	StTrGJN	$N_2O_5 + h\nu \rightarrow NO_2 + NO_3$	jx(ip_N2O5)	Sander et al. (2014)
J3200	TrGJN	$HONO + h\nu \rightarrow NO + OH$	jx(ip_HONO)	Sander et al. (2014)
J3201	StTrGJN	$HNO_3 + h\nu \rightarrow NO_2 + OH$	jx(ip_HNO3)	Sander et al. (2014)
J3202	StTrGJN	$HNO_4 + h\nu \rightarrow .667\ NO_2 + .667\ HO_2 + .333\ NO_3 + .333\ OH$	jx(ip_HNO4)	Sander et al. (2014)
J41000	StTrGJ	$CH_3OOH + h\nu \rightarrow CH_3O + OH$	jx(ip_CH3OOH)	Sander et al. (2014)
J41001a	StTrGJ	$HCHO + h\nu \rightarrow H_2 + CO$	jx(ip_COH2)	Sander et al. (2014)
J41001b	StTrGJ	$HCHO + h\nu \rightarrow H + CO + HO_2$	jx(ip_CHOH)	Sander et al. (2014)
J41004	StTrGJN	$CH_3ONO + h\nu \rightarrow CH_3O + NO$	jx(ip_CH3ONO)	Sander et al. (2014)
J41005	StTrGJN	$CH_3ONO_2 + h\nu \rightarrow CH_3O + NO_2$	jx(ip_CH3NO3)	Sander et al. (2014)
J41006	StTrGJN	$CH_3O_2NO_2 + h\nu \rightarrow .667\ NO_2 + .667\ CH_3O_2 + .333\ NO_3 + .333\ CH_3O$	jx(ip_CH3O2NO2)	Sander et al. (2014)*
J41007	StTrGJ	$HOCH_2OOH + h\nu \rightarrow HCOOH + OH + HO_2$	jx(ip_CH3OOH)	Sander et al. (2014)
J41008	StTrGJ	$CH_3O_2 + h\nu \rightarrow HCHO + OH$	jx(ip_CH3O2)	Sander et al. (2014)
J41009	StTrGJ	$HCOOH + h\nu \rightarrow CO + HO_2 + OH$	jx(ip_HCOOH)	Sander et al. (2014)
J41010	StTrGJN	$HOCH_2O_2NO_2 + h\nu \rightarrow .667\ NO_2 + .667\ HOCH_2O_2 + .333\ NO_3 + .333\ HCOOH + .333\ HO_2$	jx(ip_CH3O2NO2)	Sander et al. (2014)
PH (aqueous)				

General notes

j-values are calculated with an external module (e.g., JVAL) and then supplied to the MECCA chemistry.

Values that originate from the Master Chemical Mechanism (MCM) by Rickard and Pascoe (2009) are translated according in the following way:
j(11) → jx(ip_COH2)
j(12) → jx(ip_CHOH)
j(15) → jx(ip_HOCH2CHO)
j(18) → jx(ip_MACR)
j(22) → jx(ip_ACETOL)
j(23)+j(24) → jx(ip_MVK)
j(31)+j(32)+j(33) → jx(ip_GLYOX)
j(34) → jx(ip_MGLYOX)
j(41) → jx(ip_CH3OOH)
j(53) → j(isopropyl nitrate)
j(54) → j(isopropyl nitrate)
j(55) → j(isopropyl nitrate)
j(56)+j(57) → jx(ip_NOA)

Specific notes

J41006: product distribution as for HNO4

Table 3: Reversible (Henry's law) equilibria and irreversible ("heterogenous") uptake

#	labels	reaction	rate coefficient	reference

General notes

The forward (`k_exf`) and backward (`k_exb`) rate coefficients are calculated in subroutine `mecca_aero_calc_k_ex` in the file `messy_mecca_aero.f90` using accommodation coefficients and Henry's law constants from chemprop (see `chemprop.pdf`).

For uptake of X (X = N_2O_5, $ClNO_3$, or $BrNO_3$) and subsequent reaction with H_2O, Cl^-, and Br^- in H3201, H6300, H6301, H6302, H7300, H7301, H7302, H7601, and H7602, we define:

$$k_{\mathrm{exf}}(\mathrm{X}) = \frac{k_{\mathrm{mt}}(\mathrm{X}) \times \mathrm{LWC}}{[\mathrm{H_2O}] + 5 \times 10^2 [\mathrm{Cl^-}] + 3 \times 10^5 [\mathrm{Br^-}]}$$

Here, k_{mt} = mass transfer coefficient, and LWC = liquid water content of the aerosol. The total uptake rate of X is only determined by k_{mt}. The factors only affect the branching between hydrolysis and the halide reactions. The factor $5{\times}10^2$ was chosen such that the chloride reaction dominates over hydrolysis at about $[Cl^-] > 0.1$ M (see Fig. 3 in Behnke et al. (1997)), i.e. when the ratio $[H_2O]/[Cl^-]$ is less than $5{\times}10^2$. The ratio $5{\times}10^2/3{\times}10^5$ was chosen such that the reactions with chloride and bromide are roughly equal for sea water composition (Behnke et al., 1994). These ratios were measured for uptake of N_2O_5. Here, they are also used for $ClNO_3$ and $BrNO_3$.

Table 4: Heterogeneous reactions

#	labels	reaction	rate coefficient	reference

General notes

Heterogeneous reaction rates are calculated with an external module (e.g., MECCA_KHET) and then supplied to the MECCA chemistry (see `www.messy-interface.org` for details)

Table 5: Acid-base and other equilibria

#	labels	reaction	$K_0[M^{m-n}]$	-$\Delta H/R[K]$	reference

Specific notes

Table 6: Aqueous phase reactions

#	labels	reaction	k_0 $[M^{1-n}s^{-1}]$	$-E_a/R[K]$	reference

Specific notes

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