Supporting Information

Progress and Prospective of Nitrogen-based Alternative Fuels

Oren Elishav[†], Bar Mosevitzky Lis[‡], Elisa M. Miller[§], Douglas J. Arent[¶], Agustin Valera-Medina[‖], Alon Grinberg Dana[⊥], Gennady E. Shter[‡], Gideon S. Grader[*,‡,†]

[†] The Nancy and Stephen Grand Technion Energy Program, Technion – Israel Institute of Technology, Haifa 3200003, Israel.
[‡] The Wolfson Department of Chemical Engineering, Technion – Israel Institute of Technology, Haifa 3200003, Israel.
[§] Materials and Chemical Science and Technology Directorate, National Renewable Energy Laboratory, 15013 Denver West Parkway, Golden, Colorado 80401, United States
[¶] National Renewable Energy Laboratory, 15013 Denver West Parkway, Golden, Colorado 80401, United States
[‖] College of Physical Sciences and Engineering, Cardiff University, Wales, United Kingdom.
[⊥] Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, United States.

*E-mail: grader@technion.ac.il

1. Reaction Rate Coefficient Tables

A complete list of the modified Arrhenius expression kinetic parameters used to produce Figures 20-34 is provided in the tables below, detailing for each dataset its source, intended temperature range and experimental gas concentrations for three-body reactions. Where neccessary, the van 't Hoff equation and the species thermodynamic data were used to calculate the forward rate coefficient aprameters from the reverse kinetics. In cases where only a graphical representation was available, the kinetic data was extracted using a generic image processing software. Otherwise, the data below was adapted as is from the sources detailed below. The full references for this data are avialble under the “Reference” section in the paper.

Table S1. Modified Arrhenius expression kinetic parameters for eq 27 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm^3, mole, s)	β	E_a ($kcal\cdot mol^{-1}$)	T range (K)	[M] ($mol\cdot cm^{-3}$)
Roose (1979)[303]	2.56E+16	0	93.796	2200-3450	$9.5\cdot10^{-7}$-$2.6\cdot10^{-6}$
Dove (1979)[299]	8.00E+15	0	89.500	2500-3000	$1.7\cdot10^{-6}$
$Yumura_1$ (1980)[304]	1.35E+16	0	90.600	2050-3070	$5.0\cdot10^{-7}$-$9.0\cdot10^{-6}$
$Yumura_2$ (1981)[305]	1.73E+16	0	92.100	1740-3050	$4.0\cdot10^{-7}$-$2.0\cdot10^{-5}$
Holzrichter (1981)[306]				2200-3300	$9.0\cdot10^{-7}$-$2.0\cdot10^{-4}$
k_∞	4.00E+16	0	93.929		
k_0	5.50E+15	0	107.792		
Davidson (1990)[308]	2.20E+16	0	93.468	1740-3300	$2.8\cdot10^{-6}$-$5.7\cdot10^{-6}$
Altinay (2015)[311]				292-533	$3.8\cdot10^{-7}$-$2.3\cdot10^{-5}$
k_∞	1.73E+14	0.484	106.855		
k_0	3.89E+22	-1.276	106.855		
	Troe parameters: α=0.5, $T_1=10^{30}$, $T_2=10^{30}$ and $T_3=10^{-30}$				
Present Work				-	-
k_∞	2.63E+08	2.671	106.500		
k_0	1.55E+09	1.65	96.680		

Table S2. Modified Arrhenius expression kinetic parameters for eq 29 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a ($kcal\cdot mol^{-1}$)	T range (K)
Ogamesyan (1965)[316]	4.10E+13	0	13.700	570-690
$Michael_1$ (1985)[319]	6.87E+13	0	13.216	900-1850
Marshall (1986)[320]	3.43E+14	0	17.249	660-1136

Michael$_2$ (1986)[321]	6.38E+05	2.39	10.172	908-1777
Sutherland (1988)[322]	1.82E+14	0	16.029	900-1620
Ko (1990)[323]	5.42E+05	2.4	9.918	490-1780
Zavitsas (2015)[333]	8.31E+06	2	9.575	500-2000
Nguyen (2019)[334]	2.89E+06	2.23	10.407	300-2500

Table S3. Modified Arrhenius expression kinetic parameters for eq 30 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Oganesyan (1965)[316]	1.90E+13	0	10.000	570-690
Salimian (1984)[341]	2.19E+13	0	8.883	1750-2060
Fujii (1986)[342]	3.16E+12	0	6.095	1700-2300
Perry (1984)[343]	2.06E+13	0	9.000	448-841
Cohen (1987)[344]	1.10E+06	2.1	5.206	448-841
Sutherland (1990)[345]	9.39E+06	1.94	6.461	448-1790
Espinosa (2000)[346]	2.92E+03	2.93	4.839	500-2000
Klippenstein (2009)[347]	2.79E+02	3.29	4.471	300-2500

Table S4. Modified Arrhenius expression kinetic parameters for eq 31 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Dove (1974)[318]	8.00E+09	0.68	1.100	1620-1923
Zellner (1974)[349]	1.39E+12	0	1.600	230-490
Perry (1976)[350]	1.76E+12	0	1.710	297-424
Silver (1980)[351]	3.26E+12	0	2.120	294-1075
Fujii (1981)[254]	3.16E+12	0	2.000	1360-1830
Salimian (1984)[341]	2.04E+06	2.04	0.566	1750-2060
Stephens (1984)[352]	2.74E+12	0	1.934	297-364
Zabielski (1985)[353]	2.14E+06	2	0.336	2080-2360
Jeffries (1986)[354]	9.58E+06	1.80	0.500	840-1425
Monge (2013)[355]	2.40E+05	2.24	-0.090	200-2000
Nguyen (2017)[356]	4.30E+03	2.83	-0.430	250-2000
Samu (2018)[357]	4.50E+10	0.56	1.451	500-2000
Vahedpour (2018)[358]	3.16E+04	2.75	0.074	300-3000

Table S5. Modified Arrhenius expression kinetic parameters for eq 32 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)

Bahn (1966)[360]	5.00E+11	0.5	3.974	-
Roose (1979)[303]	3.00E+13	0	8.545	2800
Dove (1979)[299]	5.67E+13	0	4.692	2601-2788
Yumura (1981)[305]	3.02E+13	0.00	8.560	2450-3020
Dean (1984)[258]	1.00E+12	0.5	2.000	1841-2019
Davidson (1990)[308]	4.00E+13	0	3.650	2200-2800
Ischtwan (1994)[364]	1.60E+13	0.1684	13.310	400-2500
Röhrig (1994)[363]	6.49E+05	2.252	1.118	1280-1685
Xu (1995)[365]	2.16E+07	1.888	5.387	2000-3000
Linder (1995)[366]	7.20E+05	2.32	1.588	500-3000
Mackie (2005)[367]	1.90E+14	0	10.181	1100-1800
Fontijn (2006)[368]	5.49E+06	1.993	1.223	833-1432
Samu (2018)[357]	2.13E+21	-2.25	8.247	800-2250
Present Work	1.29E+06	2.18	1.144	500-2800

Table S6. Modified Arrhenius expression kinetic parameters for eq 33 and 34 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Gehring (1973)[369]	$k_{33}+k_{34}$	2.10E+12	0	0	298
Salimian (1984)[341]	k_{33}	6.61E+14	-0.5	0	-
	k_{34}	1.17E+14	-0.5	0	-
Dransfeld (1985)[370]	k_{33}	4.60E+13	0	0	296
	k_{34}	7.00E+12	0	0	296
Adamson (1994)[371]	k_{33}	3.58E+13	0	0	298
	k_{34}	3.31E+12	0	0	298
Sumathi (1998)[372]	$k_{33}+k_{34}$	2.01E+15	-0.49	0.423	300-2000
Inomata (1999)[373]	$k_{33}+k_{34}$	5.92E+13	0	-0.136	242-473
	k_{33}	6.62E+13	0	0	242-473
	k_{34}	7.23E+12	0	0	242-473

Table S7. Modified Arrhenius expression kinetic parameters for eq 35 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Bahn (1967)[360]	3.00E+10	0.679	1.300	-
Niemitz (1981)[374]	5.00E+12	0	0.000	1080-1695
$Miller_1$ (1981)[375]	7.00E+12	0	2.200	
$Miller_2$ (1981)[375]	1.00E+13	0	2.200	
Branch (1982)[376]	4.50E+12	0	2.200	1000-1500
Dean (1982)[255]	3.02E+10	0.68	1.192	1279-1323

Salimian (1984)[377]	5.01E+11	0.50	1.987	1600-2100
Kimball-Linne (1986)[378]	6.00E+12	0	0.000	1050-1450
Miller (1989)[257]	4.00E+06	2.00	1.000	1150-1350
Cohen (1991)[379]	8.60E+07	1.50	-0.457	250-3000
Xu (2000)[380]	1.23E+05	2.385	-0.704	400-3000
Mackie (2005)[367]	1.64E+04	2.644	0.000	1000-2000
Klippenstein (2009)[347]	1.10E+10	1.094	2.210	1355-1889
Mousavipour (2009)[382]	9.60E+06	1.97	0.669	250-2000
Klippenstein (2011)[381]	3.30E+06	1.949	-0.217	300-2500
Vahedpour (2018)[358]	2.36E+05	2.4471	-1.292	300-2500

Table S8. Modified Arrhenius expression kinetic parameters for 36, 37, 41 and 42 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Song (2001)[386]	k_{36}	4.29E+10	0.29	-0.870	200-2500
	k_{37}	2.61E+19	-2.37	0.866	
Mosevitzky (2018)[19]	k_{36}	3.70E+10	0.29	-1.008	300-650
	k_{37}	7.08E+17	-1.89	0.312	
Mosevitzky (2019)[288]	k_{36}	4.10E+10	0.31	-0.731	500-1400
	k_{37}	7.16E+17	-1.89	0.320	
Glarborg (1995)[267,390]	k_{41}	2.20E+11	0.11	-1.186	850-1350
	k_{42}	8.60E+11	0.11	-1.186	

Table S9. Modified Arrhenius expression kinetic parameters for eq 45 at high pressures ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm^3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)	P (mbar)
Hanes (1963)[396]	2.33E+12	0	0.000	-	-
Diesen (1963)[273]	2.50E+13	0	0.000	1900-2400	63-283
Salzman (1964)[397]	2.96E+12	0	0.000	-	7-13
Gordon (1971)[404]	5.00E+13	0	0.000	298	333-2026
Back (1973)[406]	4.70E+13	0	0.000	573	300
Khe (1977)[399]	1.50E+13	0	0.000	300-500	1-1000
Pagsberg (1979)[400]	1.60E+13	0	0.000	300	1007
Lozovskii (1979)[401]	3.61E+13	0	0.000	298	10-760
Patrick (1984)[402]	7.77E+12	0	0.000	272-348	225-293
Fagerström (1995)[403]	3.70E+13	0	0.000	200-400	200-1000

Stothard (1995)[393]	7.83E+11	0	0.000	300	1
Klippenstein (2009)[347]	5.62E+14	-0.41	0.066	300-2500	-

Table S10. Modified Arrhenius expression kinetic parameters for eq 46 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Salzman (1964)[397]	4.60E+11	0	0.000	-
Michel (1965)[274]	6.31E+12	0	9.936	1100-1600
Carbaugh (1967)[405]	6.33E+05	0	0.000	298
Bahn (1967)$_1$[360]	1.00E+12	0.5	3.000	-
Bahn (1967)$_2$[360]	1.70E+11	0.632	3.600	-
Dransfeld (1985)[370]	2.00E+09	0	0.000	298
Cohen (1987)[344]	1.00E+05	1.5	0.000	-
Davidson (1990)[308]	5.00E+13	0	10	2200-2800
Röhrig (1994)[409]	7.68E+13	-0.09	12.600	1290-1711
Xu (1998)[365]	5.56E+01	3.186	0.3567	300-3000
Klippenstein (2009)[347]	5.64E+00	3.53	0.552	300-2500

Table S11. Modified Arrhenius expression kinetic parameters for eq 49 and 50 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Salimian (1984)[377]	k_{49}	1.00E+13	0	1.987	1610-2040
Cohen (1987)[344]	k_{49}	1.00E+12	0	0.000	-
Klippenstein (2009)[347]	k_{49}	9.57E+03	2.46	0.107	200-2500
Pagsberg (1979)[400]	k_{50}	7.00E+13	0	0.000	349
Salimian (1984)[377]	k_{50}	3.02E+13	0	0.994	1610-2040
Dean (1984)[258]	k_{50}	5.00E+13	0	0.000	-
Dransfeld (1985)[370]	k_{50}	8.00E+13	0	0.000	296
Cohen (1987)[344]	k_{50}	3.16E+13	0	0.000	-
Davidson (1995)[308]	k_{50}	1.50E+15	-0.5	0.000	2200-2800
Bhang (2009)[416]	k_{50}	5.78E+13	0	0.000	293
Klippenstein (2009)[347]	k_{50}	4.26E+14	-0.272	-0.078	200-2500

Table S12. Modified Arrhenius expression kinetic parameters for eq 38 ($k=A\cdot T^{\beta}\cdot \exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Bahn (1967)[360]	k_{38}	6.10E+11	0.5	0.000	-
Miller (1981)[375]	k_{38}	5.00E+13	0	1.000	-

Dean (1982)[255]	k_{38}	1.82E+14	0	0.994	1279-1323
Miller (1983)[256]	k_{38}	2.00E+13	0	1.000	-
Hanson (1984)[307]	k_{38}	5.01E+11	0.5	0.994	-
Mebel (1996)[417]	k_{38}	3.63E+06	1.63	-1.252	300-5000
Xu (2009)[419]	k_{38}	6.38E+10	0.41	-0.701	300-550
	k_{38}	5.87E+02	2.95	-3.470	550-3000
P=1 torr	k_{45}	2.38E+03	2.70	-0.256	300-3000
P=10 torr	k_{51}	7.29E+03	2.56	-0.018	300-3000
P=100 torr	k_{51}	4.07E+04	2.36	0.354	300-3000
P=760 torr	k_{51}	2.43E+05	2.15	0.759	300-3000
P=7600 torr	k_{51}	1.21E+06	1.97	1.166	300-3000
P=76000 torr	k_{51}	1.95E+06	1.92	1.312	300-3000
P=1 torr	k_{52}	2.18E+32	-8.34	3.237	300-3000
P=10 torr	k_{52}	1.86E+33	-8.33	3.239	300-3000
P=100 torr	k_{52}	2.04E+34	-8.34	3.309	300-3000
P=760 torr	k_{52}	1.91E+35	-8.36	3.474	300-3000
P=7600 torr	k_{52}	2.85E+36	-8.40	3.821	300-3000
P=76000 torr	k_{52}	5.22E+37	-8.46	4.416	300-3000

Table S13. Modified Arrhenius expression kinetic parameters for eq 39, 53 and NH_2+HO_2 ($k=A\cdot T^{\beta}\cdot exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Lozovskii (1979)[401]	k_{39}+k_{53}	3.67E+13	0	0.000	298
Pagsberg (1979)[400]	k_{39}+k_{53}	1.60E+13	0	0.000	349
Cheskis (1979)[420]	k_{39}+k_{53}	1.51E+13	0	0.000	298
Lescalux (1984)[421]	k_{39}+k_{53}	3.00E+13	0	0.000	-
Hanson (1984)[307]	k_{53}	1.00E+13	0	1.987	-
Bozzelli (1989)[424]	k_{39}	2.95E+13	-0.023	0.022	200-1900
Baev (1989)[422]	k_{53}	1.81E+13	0	0.000	-
Glarborg (1994)[425]	k_{39}	2.50E+13	0	0.000	-
	k_{53}	1.00E+13	0	0.000	-
Sumathi (1996)[427]	k_{39}+k_{53}	2.45E+17	-1.28	1.166	200-3000
	k_{39}	2.91E+17	-1.32	1.248	200-3000
	k_{53}	1.65E+04	1.55	2.027	200-3000
Dean (2000)[309]	k_{53}	9.20E+05	1.94	-1.153	-
Song (2016)[265]	k_{39}	5.00E+13	0	0.000	450-925
Nakamura (2017)[429]	k_{39}	1.00E+13	0	0.000	-
Zhang (2018)[430]	k_{53}	1.95E+08	0.506	-5.030	275-320

Table S14. Modified Arrhenius expression kinetic parameters for eq 40 ($k=A\cdot T^{\beta}\cdot exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Whyte (1983)[431,433]	7.29E+13	0	0.000	298
Dransfeld (1987)[432]	6.90E+13	0	0.000	298
Average	7.10E+13	0	0.000	298

Table S15. Modified Arrhenius expression kinetic parameters for 55 ($k=A\cdot T^{\beta}\cdot exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Bahn (1967)[360]	1.00E+12	0.680	1.900	-
Morley (1981)[434]	3.01E+13	0	0.000	1790-2200
Davidson (1990)[435]	6.15E+13	-0.070	0.317	1950-2850
Xu (1997)[436]	2.95E+07	1.739	-0.719	300-3000
Zhang (2000)[437]	5.55E+08	1.44	0.780	400-2500
Pascual (2002)[438]	9.39E+07	1.640	0.700	1000-2500
Adam (2005)$_1$[439]	1.90E+12	0.000	0.000	298
Adam (2005)$_2$[439]	1.88E+08	1.55	0.205	300-2000
Han (2010)[440]	1.61E+11	0.680	0.799	200-2500
Zhai (2011)[441]	4.01E+11	0.576	0.967	200-3000
Yao (2014)[442]	1.65E+11	0.71	0.931	200-660
Yang (2016)[443]	2.86E+11	0.640	0.965	200-3000

Table S16. Modified Arrhenius expression kinetic parameters for eq 56, 63 and NH+O ($k=A\cdot T^{\beta}\cdot exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Mayer (1966)[361]	k_{56}+k_{63}	1.00E+12	0	0.100	-
Bahn (1967)[360]	k_{56}+ k_{63}	3.12E+12	0.705	0.096	-
	k_{56}	5.00E+11	0.500	5.000	-
	k_{63}	8.40E+12	0.700	0.100	-
Westly (1980)[445]	k_{56}+ k_{63}	1.10E+11	0.740	-0.233	-
	k_{56}	6.30E+11	0.500	0.000	-
	k_{63}	6.30E+11	0.500	7.949	-
Dransfeld (1985)[370]	k_{56}+ k_{63}	5.00E+13	0	0.000	296
Walch (1990)[448]	k_{63}	4.17E+05	2.232	1.364	300-3000
Mertens (1991)[449]	k_{56}+ k_{63}	9.20E+13	0	0.000	2730-3380
Cohen (1991)[379]	k_{56}+ k_{63}	7.70E+13	0	0.000	200-2000
	k_{56}	7.00E+13	0	0.000	200-2000
	k_{63}	7.00E+12	0	0.000	200-2000

Huang (1992)[450]	k_{56}	8.43E+13	0.000	0.000	298
Adamson (1994)[371]	k_{56}+ k_{63}	4.16E+13	0.000	0.000	295
Hack (1994)[452]	k_{63}<	1.00E+11	0.000	0.000	298
Guadagnini (1995)[453]	k_{56}+ k_{63}	4.12E+13	0.049	0.071	300-3000
	k_{56}	4.82E+13	0.023	0.095	300-3000
	k_{63}	2.07E+10	0.622	-0.358	300-3000
Dean (2000)[309]	k_{63}	1.70E+08	1.500	3.368	-
Wang (2005)[454]	k_{56}+ k_{63}	3.05E+13	0.000	0.171	300-900
Baulch (2005)[310]	k_{56}	1.08E+14	0.000	0.596	295-3000
Li (2013)[455]	k_{56}+ k_{63}	4.86E+13	0.000	0.000	298
	k_{56}	4.64E+13	0.000	0.000	298
	k_{63}	2.20E+12	0.000	0.000	298

Table S17. Modified Arrhenius expression kinetic parameters for eq 57 and 58 ($k=A\cdot T^{\beta}\cdot exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Bahn (1967)[360]	k_{57}	1.60E+12	0.560	1.500	-
	k_{58}	5.00E+11	0.500	2.000	-
Westly (1980)[445]	k_{58}	5.01E+11	0.500	1.987	-
Hanson (1984)[307]	k_{57}	1.00E+12	0.500	1.987	-
Hack (1985)[457]	k_{57}	5.00E+13	0.000	0.000	295
Cohen (1991)[379]	k_{57}	2.00E+13	0.000	0.000	298
	k_{58}	2.00E+09	1.200	0.000	-
Sumathi (1998)[372]	k_{57}	2.67E+13	-0.303	0.689	200-2000
	k_{58}	1.14E+14	-0.604	0.549	200-2000
Dean (2000)[309]	k_{58}	1.20E+06	2.000	-0.487	-
Klippenstein (2009)[347]	k_{57}	3.25E+14	-0.376	-0.046	200-2500
	k_{58}	1.59E+07	1.737	-0.576	200-2500

Table S18. Modified Arrhenius expression kinetic parameters for eq 59, 60 and $NH+O_2$ ($k=A\cdot T^{\beta}\cdot exp[-E_a\cdot R^{-1}\cdot T^{-1}]$).

Source	ID	A (cm3, mole, s)	β	E_a (kcal·mol^{-1})	T range (K)
Zetzsch (1978)[458]	k_{59}+k_{60}	5.00E+09	0	0.000	296
Pagsberg (1979)[400]	k_{59}+ k_{60}<	2.00E+10	0	0.000	349
Dean (1982)[255]	k_{60}	3.02E+13	0	3.378	-
Miller (1983)[256]	k_{59}	1.40E+11	0	2.000	-
	k_{60}	1.00E+13	0	12.000	-
Dean (1984)[258]	k_{60}	6.00E+12	0	3.400	-

Hack (1984)[459]	k_{59}+ k_{60}	7.60E+10	0	1.530	268-543
Bian (1988)[461]	k_{59}	4.50E+13	0	9.936	1523-2254
Bian (1991)[462]	k_{59}	5.00E+12	0	0.000	800-1000
Mertens (1991)[449]	k_{60}	3.90E+13	0	17.885	2198-3273
Miller (1992)[464]	k_{59}	1.28E+06	1.500	0.100	300-3300
	k_{60}	4.61E+05	2.000	6.500	300-3300
Fueno (1992)[463]	k_{59}	4.07E+03	2.782	1.142	250-2500
Hennig (1993)[465]	k_{59}	9.00E+10	0	1.530	985-1729
	k_{60}	1.90E+13	0	13.671	985-1729
Lillich (1994)[466]	k_{59}+ k_{60}	1.31E+01	3.340	-0.550	293-793
Römming (1996)[467]	k_{59}	4.50E+08	0.790	1.195	1218-2551
	k_{60}	2.10E+13	0	15.822	1218-2551
Talipov (2009)[469]	k_{59}	2.01E+16	-1.380	5.672	214-3953
	k_{60}	1.93E+10	0.667	9.878	300-3000
Present Work	k_{60}	3.32E+09	1.034	11.420	1218-3273