

Supporting Information

for

Transition States and Energetics of Nucleophilic Additions of Thiols to Substituted α,β -Unsaturated Ketones: Substituent Effects Involve Enone Stabilization, Product Branching, and Solvation

Elizabeth H. Krenske,* Russell C. Petter, Zhendong Zhu, and K. N. Houk*

School of Chemistry, University of Melbourne, VIC 3010, Australia; ARC Centre of Excellence for Free Radical Chemistry and Biotechnology; Department of Chemistry and Biochemistry, University of California, Los Angeles, CA 90095; and Avila Therapeutics, 100 Beaver Street, Waltham, MA 02453

Contents

CBS-QB3 Geometries and Energies	p. S2
Solution-Optimized Geometries	p. S17
Geometries Optimized at Other Levels of Theory	p. S18
Complete Citations for Refs 4, 6, 33, and 34	p. S36

CBS-QB3 Geometries and Energies

Below are given the geometries of species optimized at the B3LYP/CBSB7 level, together with the associated CBS-QB3 enthalpy at 0 K (in Hartree). Where applicable, the CBS-QB3 free energy at 298.15 K and 1 atm (in Hartree) is also listed, along with the free energy of solvation (in kcal/mol at 1 mol L⁻¹) obtained from CPCM single-point calculations at the B3LYP/6-31+G(d) level.

MeSH

H	1.285650	-0.836180	0.000000
S	-0.047829	-0.669745	0.000000
C	-0.047829	1.162320	0.000000
H	-1.095534	1.463127	0.000000
H	0.431060	1.557529	0.894936
H	0.431060	1.557529	-0.894936

0 imaginary frequencies

H_{0K} = -438.152814

G_{298.15K} = -438.177050

G_{solv, 298.15K} = -1.43

MeS⁻

C	0.000000	0.000000	-1.132450
S	0.000000	0.000000	0.713525
H	0.000000	1.020217	-1.540566
H	0.883533	-0.510108	-1.540566
H	-0.883533	-0.510108	-1.540566

0 imaginary frequencies

H_{0K} = -437.586003

G_{298.15K} = -437.608588

G_{solv, 298.15K} = -68.63

Enone 1

C	-0.609743	-1.920260	0.000000
C	0.340325	-0.986774	0.000000
C	0.000000	0.472012	0.000000
O	-1.149145	0.861927	0.000000
C	1.172563	1.432504	0.000000
H	1.392221	-1.258514	0.000000
H	-0.376750	-2.978565	0.000000
H	-1.653976	-1.626226	0.000000
H	0.809497	2.458921	0.000000
H	1.801648	1.262036	0.880017
H	1.801648	1.262036	-0.880017

0 imaginary frequencies

H_{0K} = -230.834417

G_{298.15K} = -230.863407

G_{solv, 298.15K} = -2.97

TS-1

C	-3.359253	-0.615169	-0.182755
C	-2.059526	0.187486	0.005601
C	-0.987579	-0.471147	0.691897
C	0.247860	0.123220	0.883890
O	-2.033857	1.343848	-0.438483
S	2.065551	-0.448330	-0.675871
C	3.366751	0.389954	0.301853
H	-1.144660	-1.495358	1.018092
H	-4.210183	0.008281	0.108584
H	-3.479204	-0.848291	-1.246754
H	-3.381245	-1.551317	0.382572
H	0.334128	1.175905	0.646218
H	0.922659	-0.259816	1.638096
H	3.632762	1.366043	-0.117954
H	3.021478	0.557465	1.332444
H	4.276787	-0.216477	0.357586

1 imaginary frequency

$$H_{0K} = -668.432849$$

$$G_{298.15K} = -668.469648$$

$$G_{\text{solv},298.15K} = -53.76$$

Enolate: 1 + MeS⁻

C	2.866671	0.254014	-0.712500
H	2.820419	-0.159191	-1.725827
H	2.996088	1.340772	-0.775502
H	3.755272	-0.140600	-0.205592
C	1.621044	-0.055996	0.143518
O	1.625411	0.395462	1.317564
C	0.616255	-0.829375	-0.456720
H	0.718148	-1.134740	-1.494008
C	-0.570280	-1.217856	0.284266
S	-2.241467	-0.186712	-0.090941
H	-0.954513	-2.218882	0.072407
H	-0.424849	-1.075680	1.354049
C	-1.523629	1.480952	-0.195143
H	-0.550756	1.384316	-0.688464
H	-2.182222	2.113358	-0.794909
H	-1.377770	1.923916	0.791860

0 imaginary frequencies

$$H_{0K} = -668.450223$$

$$G_{298.15K} = -668.485053$$

$$G_{\text{solv},298.15K} = -52.44$$

Enol: 1 + MeSH

C	2.843749	0.017906	-0.833022
C	1.624217	-0.087363	0.027943
C	0.577244	-0.885786	-0.230091
C	-0.656497	-1.012868	0.600949
S	-2.181602	-0.299774	-0.168984
C	-1.678069	1.438626	-0.357737
O	1.732625	0.738228	1.116135

H	2.767221	-0.631022	-1.704932
H	2.982035	1.050353	-1.168189
H	3.734716	-0.257683	-0.260673
H	0.611391	-1.476666	-1.137315
H	-0.921918	-2.062785	0.749426
H	-0.549524	-0.581705	1.602715
H	-0.773970	1.514400	-0.962688
H	-2.495235	1.944946	-0.872796
H	-1.523047	1.918002	0.611439
H	0.949095	0.649633	1.669425

0 imaginary frequencies

$H_{0K} = -669.002920$

$G_{298.15K} = -669.037809$

$G_{solv,298.15K} = -5.56$

Product: 1 + MeSH

H	-2.304098	3.548088	0.000000
C	-1.343861	3.031116	0.000000
S	-1.707211	1.246627	0.000000
C	0.000000	0.585738	0.000000
C	-0.037518	-0.938332	0.000000
C	1.352260	-1.568446	0.000000
O	2.357860	-0.895838	0.000000
C	1.401069	-3.084703	0.000000
H	2.438007	-3.417552	0.000000
H	-0.787405	3.318137	0.893894
H	-0.787405	3.318137	-0.893894
H	0.529702	0.948800	0.882639
H	0.529702	0.948800	-0.882639
H	-0.585041	-1.314943	0.872758
H	-0.585041	-1.314943	-0.872758
H	0.886191	-3.483040	0.879791
H	0.886191	-3.483040	-0.879791

0 imaginary frequencies

$H_{0K} = -669.018710$

$G_{298.15K} = -669.057026$

$G_{solv,298.15K} = -5.88$

Enone 2

C	-2.283677	1.605517	0.000000
C	-1.333493	0.453680	0.000000
C	0.000000	0.539737	0.000000
C	0.858476	-0.679053	0.000000
C	2.357047	-0.441105	0.000000
O	0.392774	-1.801839	0.000000
H	0.494388	1.508194	0.000000
H	-1.759681	-0.547776	0.000000
H	2.881203	-1.395436	0.000000
H	2.649160	0.141349	0.880111
H	2.649160	0.141349	-0.880111
H	-1.766460	2.567104	0.000000
H	-2.940037	1.563636	-0.876550
H	-2.940037	1.563636	0.876550

0 imaginary frequencies

$$H_{0K} = -270.066326$$

$$G_{298.15K} = -270.097671$$

$$G_{\text{solv},298.15K} = -4.18$$

TS-2

C	3.424459	-0.263526	-0.597092
C	2.104368	-0.228251	0.193503
C	1.106337	0.692620	-0.259364
C	-0.151499	0.779310	0.318767
C	-0.964350	2.043082	0.187133
O	2.001446	-0.987900	1.166693
S	-1.808285	-0.741325	-0.754232
C	-3.132066	-0.682896	0.512632
H	4.263438	-0.241936	0.105156
H	3.482567	-1.212228	-1.142260
H	3.526158	0.555744	-1.314740
H	1.335549	1.315002	-1.121117
H	-0.282431	0.205375	1.230365
H	-0.970114	2.396317	-0.847355
H	-0.516798	2.834369	0.809478
H	-2.000142	1.908765	0.501689
H	-3.838962	0.139143	0.346361
H	-3.701161	-1.618298	0.518751
H	-2.700612	-0.559894	1.514365

1 imaginary frequency

$$H_{0K} = -707.662553$$

$$G_{298.15K} = -707.701471$$

$$G_{\text{solv},298.15K} = -53.75$$

Enolate: 2 + MeS⁻

C	1.758792	0.035270	0.147771
O	1.845058	-0.368047	1.334929
C	3.030944	-0.097498	-0.714556
H	2.908457	0.264640	-1.740833
H	3.846053	0.456760	-0.234670
H	3.336854	-1.149708	-0.740604
C	0.634949	0.612391	-0.465218
H	0.679343	0.898469	-1.513204
C	-0.593485	0.844190	0.269644
S	-2.062482	-0.506979	-0.072554
C	-1.306185	2.165776	-0.001916
H	-0.414300	0.693861	1.333966
C	-1.051187	-2.012196	-0.188991
H	-0.829239	-2.432605	0.793838
H	-1.581215	-2.748873	-0.797413
H	-0.111090	-1.734524	-0.677939
H	-2.275399	2.224919	0.508053
H	-1.480970	2.298029	-1.074465
H	-0.682215	2.997472	0.344301

0 imaginary frequencies

$$H_{0K} = -707.680877$$

$$G_{298.15K} = -707.717685$$

$$G_{\text{solv}, 298.15K} = -51.10$$

Product: 2 + MeSH

C	-3.217004	0.224810	-0.544241
S	-1.904807	-0.857554	0.107529
C	-0.431210	0.249526	-0.023179
C	0.802900	-0.630541	0.195479
C	2.115798	0.016579	-0.237562
C	3.382088	-0.704984	0.183132
O	2.149451	1.035934	-0.888914
H	-4.120144	-0.384520	-0.596440
H	4.237546	-0.285239	-0.344471
H	-3.407025	1.075113	0.111510
H	-2.968590	0.573348	-1.548291
C	-0.485577	1.428881	0.948330
H	-0.403261	0.621409	-1.050212
H	0.882762	-0.943500	1.243575
H	0.711919	-1.559781	-0.382348
H	3.529184	-0.579973	1.261332
H	3.309791	-1.779290	-0.008242
H	0.385560	2.072604	0.803084
H	-1.375589	2.040093	0.785874
H	-0.502814	1.077506	1.983725

0 imaginary frequencies

$$H_{0K} = -708.248063$$

$$G_{298.15K} = -708.285294$$

$$G_{\text{solv}, 298.15K} = -4.77$$

Enone 3

H	2.029872	-1.720861	-0.000061
C	1.454278	-0.795813	-0.000027
C	2.270412	0.457133	0.000137
C	0.118296	-0.925247	-0.000142
C	-0.888421	0.171328	-0.000093
C	-2.338749	-0.284340	0.000138
O	-0.607489	1.355920	-0.000143
H	-0.292902	-1.931066	-0.000238
H	-2.544131	-0.901457	0.881012
H	-2.994590	0.584744	-0.000716
H	-2.544071	-0.903297	-0.879436
H	2.929467	0.468316	0.876384
H	1.651886	1.349375	0.000219
H	2.929487	0.468524	-0.876095

0 imaginary frequencies

$$H_{0K} = -270.063027$$

$$G_{298.15K} = -270.094810$$

$$G_{\text{solv}, 298.15K} = -3.46$$

TS-3

C	-2.886846	-1.011424	0.362283
C	-1.758087	-0.048612	-0.061221
C	-0.709214	0.146939	0.884904
C	0.417087	0.976118	0.740157
C	0.454612	2.114852	-0.253755
O	-1.877950	0.486099	-1.178721
S	2.332480	-0.262921	0.033542
C	1.468822	-1.782670	-0.460931
H	0.944279	1.182955	1.665577
H	-3.839895	-0.472081	0.333950
H	-2.955508	-1.818568	-0.374442
H	-2.751309	-1.447094	1.356128
H	-0.764928	-0.442929	1.795618
H	1.446133	-1.901887	-1.547867
H	1.933917	-2.667521	-0.015772
H	0.430421	-1.714455	-0.101730
H	0.134290	1.780979	-1.237609
H	-0.247384	2.899833	0.066970
H	1.455660	2.547496	-0.316349

1 imaginary frequency

$$H_{0K} = -707.668735$$

$$G_{298.15K} = -707.705468$$

$$G_{solv,298.15K} = -50.28$$

Enolate: 3 + MeS⁻

C	1.758792	0.035270	0.147771
O	1.845058	-0.368047	1.334929
C	3.030944	-0.097498	-0.714556
H	2.908457	0.264640	-1.740833
H	3.846053	0.456760	-0.234670
H	3.336854	-1.149708	-0.740604
C	0.634949	0.612391	-0.465218
H	0.679343	0.898469	-1.513204
C	-0.593485	0.844190	0.269644
S	-2.062482	-0.506979	-0.072554
C	-1.306185	2.165776	-0.001916
H	-0.414300	0.693861	1.333966
C	-1.051187	-2.012196	-0.188991
H	-0.829239	-2.432605	0.793838
H	-1.581215	-2.748873	-0.797413
H	-0.111090	-1.734524	-0.677939
H	-2.275399	2.224919	0.508053
H	-1.480970	2.298029	-1.074465
H	-0.682215	2.997472	0.344301

0 imaginary frequencies

$$H_{0K} = -707.680877$$

$$G_{298.15K} = -707.717685$$

$$G_{solv,298.15K} = -51.10$$

Product: 3 + MeSH

C	-3.217004	0.224810	-0.544241
---	-----------	----------	-----------

S	-1.904807	-0.857554	0.107529
C	-0.431210	0.249526	-0.023179
C	0.802900	-0.630541	0.195479
C	2.115798	0.016579	-0.237562
C	3.382088	-0.704984	0.183132
O	2.149451	1.035934	-0.888914
H	-4.120144	-0.384520	-0.596440
H	4.237546	-0.285239	-0.344471
H	-3.407025	1.075113	0.111510
H	-2.968590	0.573348	-1.548291
C	-0.485577	1.428881	0.948330
H	-0.403261	0.621409	-1.050212
H	0.882762	-0.943500	1.243575
H	0.711919	-1.559781	-0.382348
H	3.529184	-0.579973	1.261332
H	3.309791	-1.779290	-0.008242
H	0.385560	2.072604	0.803084
H	-1.375589	2.040093	0.785874
H	-0.502814	1.077506	1.983725

0 imaginary frequencies

$H_{0K} = -708.248063$

$G_{298.15K} = -708.285294$

$G_{\text{solv},298.15K} = -4.77$

Enone 4

H	-1.191227	2.491833	0.000000
C	-1.162060	1.407467	0.000000
H	-2.119374	0.901305	0.000000
C	0.000000	0.745206	0.000000
C	1.336973	1.435282	0.000000
H	1.219825	2.520067	0.000000
C	0.050444	-0.756446	0.000000
O	1.127406	-1.320508	0.000000
C	-1.241561	-1.557019	0.000000
H	-0.986744	-2.615515	0.000000
H	1.923656	1.140106	0.873820
H	1.923656	1.140106	-0.873820
H	-1.845904	-1.330389	0.882469
H	-1.845904	-1.330389	-0.882469

0 imaginary frequencies

$H_{0K} = -270.067537$

$G_{298.15K} = -270.098517$

$G_{\text{solv},298.15K} = -2.43$

TS-4

C	-2.748801	-0.355982	0.713177
C	-1.560313	-0.472911	-0.260730
C	-0.677004	0.664875	-0.365726
C	-0.886792	1.897418	0.489614
O	-1.457044	-1.519817	-0.916967
C	0.403983	0.603642	-1.235363
S	2.511397	0.005374	-0.126411
C	1.715516	-0.931613	1.215382

H	-3.437387	0.441526	0.408565
H	-3.282416	-1.307161	0.710055
H	-2.422470	-0.123792	1.732699
H	0.452890	-0.236378	-1.913463
H	0.887739	1.515887	-1.559556
H	0.645244	-0.679305	1.230686
H	1.803443	-2.012078	1.068207
H	2.144183	-0.670408	2.188233
H	-0.184571	2.680656	0.191345
H	-1.899960	2.314262	0.403274
H	-0.712239	1.716762	1.560145

1 imaginary frequency

$H_{0K} = -707.667486$

$G_{298.15K} = -707.704792$

$G_{solV,298.15K} = -51.26$

Enolate: 4 + MeS⁻

C	-2.844067	-0.271558	0.534287
C	-1.502258	-0.417250	-0.215712
O	-1.337935	-1.540359	-0.770261
H	-2.861444	-0.983154	1.368397
H	-3.077964	0.723424	0.921288
H	-3.638926	-0.577638	-0.154094
C	-0.590619	0.653239	-0.259365
C	-0.722713	1.978513	0.449747
H	0.129278	2.166924	1.122476
H	-1.626211	2.053111	1.058699
H	-0.739423	2.834111	-0.251263
C	0.614488	0.467683	-1.067586
H	0.928793	1.356977	-1.626769
H	0.513011	-0.392182	-1.725573
S	2.287444	0.122468	-0.082327
C	1.681848	-1.171329	1.046969
H	1.613201	-2.140290	0.549999
H	0.683927	-0.879029	1.385023
H	2.360059	-1.234664	1.901096

0 imaginary frequencies

$H_{0K} = -707.676555$

$G_{298.15K} = -707.714578$

$G_{solV,298.15K} = -50.80$

Product: 4 + MeSH

C	-2.227775	-1.507370	-0.617379
H	-2.935693	-0.963141	-1.250327
H	-1.523341	-2.011998	-1.287326
H	-2.752840	-2.248025	-0.015587
C	-1.460763	-0.558293	0.275904
O	-1.364963	-0.729130	1.469728
C	-0.828722	0.676750	-0.391865
C	-1.715979	1.899439	-0.082128
C	0.598371	0.891799	0.123310
H	-0.809861	0.527669	-1.477035
H	-1.323250	2.793065	-0.573251

H	-2.741148	1.748239	-0.431494
H	-1.749485	2.078652	0.995102
H	0.947982	1.897425	-0.122055
H	0.601504	0.762675	1.207607
S	1.735607	-0.340610	-0.620923
C	3.151030	-0.194898	0.515061
H	3.909437	-0.895781	0.164297
H	2.861191	-0.463872	1.532017
H	3.568520	0.813324	0.497576

0 imaginary frequencies

$H_{0K} = -708.246397$

$G_{298.15K} = -708.284074$

$G_{solv,298.15K} = -3.99$

Enone 5

C	2.402553	-1.036497	0.000046
C	1.206020	-0.121858	-0.000015
C	1.530098	1.345699	-0.000117
C	-0.038704	-0.639396	0.000071
C	-1.331940	0.089847	0.000028
C	-2.566010	-0.800681	-0.000157
O	-1.448222	1.303097	0.000186
H	-0.130732	-1.722668	0.000131
H	-2.568168	-1.450720	0.880882
H	-3.461274	-0.180988	-0.001177
H	-2.567077	-1.452284	-0.880019
H	3.029805	-0.844630	0.877974
H	2.120445	-2.090343	-0.000474
H	3.030489	-0.843914	-0.877228
H	2.140845	1.588274	-0.877857
H	0.636832	1.961745	0.000646
H	2.142509	1.588069	0.876502

0 imaginary frequencies

$H_{0K} = -309.296184$

$G_{298.15K} = -309.330248$

$G_{solv,298.15K} = -3.36$

TS-5

C	-3.047991	0.532644	-0.787385
C	-1.876092	0.006588	0.067365
O	-2.056371	-0.008048	1.298693
C	-0.723970	-0.428416	-0.652794
C	0.471760	-0.959909	-0.132124
C	0.509759	-1.475013	1.293649
C	1.303442	-1.791120	-1.093941
S	2.102768	0.820074	0.075893
C	0.949368	2.220645	0.004168
H	-3.935937	-0.073972	-0.578879
H	-3.279715	1.555595	-0.473600
H	-2.853710	0.524936	-1.863415
H	-0.760960	-0.299852	-1.731547
H	1.338108	-1.335219	-2.085113
H	0.856349	-2.793301	-1.189296

H	2.330509	-1.910323	-0.739330
H	1.313024	2.993835	-0.679461
H	-0.013096	1.846193	-0.375442
H	0.779075	2.667050	0.988148
H	0.033389	-0.777658	1.976242
H	-0.055806	-2.419015	1.345222
H	1.537808	-1.667567	1.609016

1 imaginary frequency

$H_{0K} = -746.900963$

$G_{298.15K} = -746.939188$

$G_{solv,298.15K} = -48.86$

Enolate: 5 + MeS⁻

C	-3.075551	0.213547	-0.831150
H	-2.908722	0.040110	-1.898705
H	-3.415546	1.244562	-0.683830
H	-3.885872	-0.439088	-0.486501
C	-1.831096	-0.031217	0.051723
O	-1.984844	0.185992	1.277601
C	-0.679092	-0.487288	-0.621994
H	-0.736863	-0.542305	-1.706219
C	0.600825	-0.830477	-0.045700
S	1.977462	0.812765	-0.128141
C	1.392105	-1.835030	-0.883986
C	0.607190	-1.218602	1.431542
H	1.404564	-1.543790	-1.936780
H	0.923939	-2.825099	-0.803850
H	2.429328	-1.919034	-0.540534
H	1.630338	-1.356426	1.793058
H	0.058526	-2.163687	1.552197
H	0.089370	-0.473023	2.029232
C	0.811381	2.199552	-0.012274
H	-0.130346	1.876068	-0.471387
H	0.616603	2.493996	1.021384
H	1.209471	3.052628	-0.567582

0 imaginary frequencies

$H_{0K} = -746.906739$

$G_{298.15K} = -746.945961$

$G_{solv,298.15K} = -47.84$

Product: 5 + MeSH

C	2.213263	-0.027029	-0.025686
O	2.393253	1.170224	-0.023052
C	3.382255	-0.996419	0.028801
H	3.408785	-1.481256	1.010467
H	4.312967	-0.451845	-0.124464
H	3.280974	-1.788246	-0.718346
C	0.834475	-0.681568	-0.073558
H	0.797169	-1.421060	0.736646
H	0.796864	-1.272202	-0.998466
C	-0.403374	0.236216	0.002070
S	-1.810181	-1.003741	-0.044650
C	-0.429516	1.024027	1.318663

C	-0.476423	1.172946	-1.211489
H	-1.390082	1.771520	-1.193008
H	-0.462763	0.605120	-2.144935
H	0.373075	1.857826	-1.201361
H	-0.385372	0.351530	2.178707
H	-1.340557	1.620834	1.403069
H	0.420607	1.707693	1.357815
C	-3.305537	0.032212	0.035022
H	-3.385882	0.697789	-0.824755
H	-4.143680	-0.665951	0.012426
H	-3.356101	0.603995	0.962082

0 imaginary frequencies

$H_{0K} = -747.476367$

$G_{298.15K} = -747.514878$

$G_{solv,298.15K} = -3.84$

Enone 6

C	0.724692	-0.544869	0.000000
C	0.000000	0.724031	0.000000
C	-1.328394	0.925378	0.000000
C	-1.887340	2.303404	0.000000
O	-1.179895	3.293578	0.000000
C	-3.401164	2.410747	0.000000
H	-2.034347	0.100816	0.000000
H	0.612551	1.623298	0.000000
H	-3.695851	3.458949	0.000000
H	-3.817577	1.910344	0.880499
H	-3.817577	1.910344	-0.880499
C	2.129161	-0.516912	0.000000
C	2.871905	-1.692912	0.000000
C	2.223294	-2.925065	0.000000
C	0.827573	-2.971946	0.000000
C	0.086928	-1.798468	0.000000
H	2.635683	0.442371	0.000000
H	3.954978	-1.647413	0.000000
H	2.798026	-3.844228	0.000000
H	0.318608	-3.929265	0.000000
H	-0.995260	-1.854167	0.000000

0 imaginary frequencies

$H_{0K} = -461.459870$

$G_{298.15K} = -461.496913$

$G_{solv,298.15K} = -4.49$

TS-6

C	3.938074	-0.591528	-0.190966
C	3.095574	-0.467485	-1.298142
C	1.731931	-0.259973	-1.127491
C	1.163662	-0.179769	0.153760
C	2.024241	-0.294556	1.253412
C	3.393521	-0.499788	1.086926
C	-0.299909	0.004094	0.370008
C	-1.229511	-0.757330	-0.393001
C	-2.460082	-1.182426	0.169132

O	-2.867206	-0.930258	1.321264
C	-3.363588	-2.060020	-0.715941
S	-0.438877	2.189385	0.040051
C	-2.198568	2.250315	-0.400399
H	-3.517652	-3.025047	-0.220758
H	-4.346590	-1.585125	-0.801900
H	-2.961108	-2.233186	-1.718581
H	-0.991755	-1.046066	-1.411213
H	-0.570842	0.026899	1.421148
H	-2.834273	2.464327	0.461778
H	-2.361697	3.003658	-1.175545
H	-2.470387	1.264118	-0.802023
H	1.605241	-0.224914	2.252022
H	4.034471	-0.587801	1.959312
H	5.003407	-0.750636	-0.325880
H	3.508582	-0.524762	-2.301075
H	1.090212	-0.138759	-1.992003

1 imaginary frequency

$H_{0K} = -899.073578$

$G_{298.15K} = -899.115047$

$G_{solv,298.15K} = -48.30$

Enolate: 6 + MeS⁻

C	-3.244423	-2.125770	-0.835269
H	-2.837311	-2.235200	-1.845339
H	-3.336169	-3.117024	-0.377314
H	-4.256228	-1.710778	-0.900174
C	-2.392045	-1.228595	0.081268
O	-2.810048	-1.056450	1.249598
C	-1.206867	-0.698152	-0.468714
H	-0.948937	-0.920514	-1.498761
C	-0.311899	0.094274	0.338319
S	-0.493735	2.164864	0.084727
C	1.160286	-0.114134	0.145549
H	-0.593570	0.016556	1.386038
C	1.772702	0.010762	-1.110950
C	3.133144	-0.227241	-1.274722
C	3.925516	-0.586927	-0.182788
C	3.335934	-0.701103	1.073596
C	1.970919	-0.464353	1.232437
H	1.166801	0.313405	-1.956847
H	3.581960	-0.124566	-2.258494
H	4.988032	-0.769181	-0.310930
H	3.938970	-0.973855	1.934816
H	1.516375	-0.557257	2.213442
C	-2.291188	2.237149	-0.169566
H	-2.837450	2.321643	0.771868
H	-2.527480	3.087068	-0.814369
H	-2.587339	1.308025	-0.671305

0 imaginary frequencies

$H_{0K} = -899.076022$

$G_{298.15K} = -899.119239$

$G_{solv,298.15K} = -48.42$

Product: 6 + MeSH

C	-2.497621	-0.745277	0.159929
O	-2.329381	-1.014211	1.327298
C	-3.492225	-1.496979	-0.701100
H	-4.096200	-0.811204	-1.302082
H	-2.945121	-2.140402	-1.398800
H	-4.133338	-2.114609	-0.073485
C	-1.739436	0.389933	-0.527220
H	-1.522035	0.117943	-1.564311
H	-2.439489	1.235544	-0.574849
C	-0.464466	0.806996	0.220983
S	-0.029844	2.509543	-0.353333
C	0.661558	-0.198840	0.058181
H	-0.717334	0.881241	1.279672
C	1.319970	-0.371082	-1.165714
C	2.327698	-1.320650	-1.303106
C	2.699632	-2.112196	-0.216556
C	2.054632	-1.946604	1.005637
C	1.043116	-0.996557	1.140951
H	1.054375	0.259538	-2.007218
H	2.828733	-1.439163	-2.257664
H	3.487873	-2.849044	-0.323102
H	2.335909	-2.556754	1.856817
H	0.529013	-0.884708	2.088757
C	1.378562	2.880252	0.739072
H	1.703722	3.891409	0.491272
H	2.201721	2.186301	0.566406
H	1.076205	2.850919	1.787182

0 imaginary frequencies

 $H_{0K} = -899.641975$ $G_{298.15K} = -899.684528$ $G_{solv,298.15K} = -3.36$ **H₂**

H	0.000000	0.000000	-0.372091
H	0.000000	0.000000	0.372091

0 imaginary frequencies

 $H_{0K} = -1.166083$ **Ethylene**

C	0.000000	0.000000	0.663610
C	0.000000	0.000000	-0.663610
H	0.000000	0.922662	1.234557
H	0.000000	-0.922662	1.234557
H	0.000000	0.922662	-1.234557
H	0.000000	-0.922662	-1.234557

0 imaginary frequencies

 $H_{0K} = -78.416649$ **Ethane**

C	0.000000	0.000000	0.765136
C	0.000000	0.000000	-0.765136

H	0.881988	0.509216	-1.163447
H	-0.881988	0.509216	-1.163447
H	0.000000	-1.018432	-1.163447
H	0.000000	1.018432	1.163447
H	0.881988	-0.509216	1.163447
H	-0.881988	-0.509216	1.163447

0 imaginary frequencies

$H_{0K} = -79.630570$

Propene

C	0.000000	0.472863	0.000000
H	-0.278803	1.525420	0.000000
C	1.290423	0.153268	0.000000
H	1.620597	-0.881519	0.000000
H	2.064395	0.912445	0.000000
C	-1.136473	-0.506670	0.000000
H	-0.777201	-1.538422	0.000000
H	-1.776345	-0.367342	0.878474
H	-1.776345	-0.367342	-0.878474

0 imaginary frequencies

$H_{0K} = -117.646212$

Propane

H	0.000000	2.173428	0.366805
C	0.000000	1.277172	-0.259820
H	-0.882972	1.322712	-0.905203
H	0.882972	1.322712	-0.905203
C	0.000000	0.000000	0.585987
H	-0.875832	0.000000	1.244560
H	0.875832	0.000000	1.244560
C	0.000000	-1.277172	-0.259820
H	-0.882972	-1.322712	-0.905203
H	0.000000	-2.173428	0.366805
H	0.882972	-1.322712	-0.905203

0 imaginary frequencies

$H_{0K} = -118.855868$

1-H₂

H	2.671779	0.242698	-0.109014
C	1.889413	-0.503152	0.025211
C	0.528097	0.169723	-0.014201
O	0.415357	1.374359	-0.016903
C	-0.684448	-0.753714	-0.043673
C	-2.020076	-0.020381	0.035796
H	-2.852938	-0.725919	-0.012788
H	1.971459	-1.275853	-0.744655
H	2.027560	-0.998168	0.992357
H	-0.617584	-1.349064	-0.963990
H	-0.578660	-1.480416	0.771851
H	-2.121233	0.692670	-0.784105
H	-2.101146	0.544324	0.966768

0 imaginary frequencies

$$H_{0K} = -232.045784$$

2-H₂

C	1.138375	0.146263	-0.010591
O	1.254026	1.350843	-0.016360
C	2.350596	-0.769114	0.016801
H	2.301562	-1.508183	-0.788421
H	2.377080	-1.324527	0.960127
H	3.259699	-0.176664	-0.077843
C	-0.224830	-0.534894	-0.026378
H	-0.274587	-1.152509	-0.934117
H	-0.257321	-1.252391	0.804714
C	-1.409722	0.427872	0.036087
H	-1.332351	1.029035	0.946868
H	-1.334190	1.137380	-0.792528
C	-2.760416	-0.291262	-0.005608
H	-2.872354	-0.982746	0.835702
H	-2.876303	-0.871254	-0.926844
H	-3.587462	0.421923	0.041355

0 imaginary frequencies

$$H_{0K} = -271.271211$$

4-H₂

C	-1.922531	0.611826	0.248176
C	-0.744314	-0.321633	0.013227
C	0.649963	0.194922	0.386362
C	1.716266	-0.885150	0.201272
H	2.691695	-0.520055	0.533776
O	-0.911482	-1.424445	-0.456951
H	-2.840996	0.026515	0.278507
H	-1.996066	1.323345	-0.580759
H	-1.811787	1.191775	1.167867
C	0.989047	1.477462	-0.400434
H	0.595007	0.467985	1.449937
H	1.470385	-1.784871	0.767727
H	1.795609	-1.175453	-0.848950
H	1.977365	1.843902	-0.112281
H	1.008501	1.277859	-1.476119
H	0.271553	2.279995	-0.215714

0 imaginary frequencies

$$H_{0K} = -271.272520$$

Solution-Optimized Geometries

The geometries of **TS-1a** and **TS-2a** were optimized in water [CPCM, B3LYP/6-31+G(d)]. Their coordinates are given below, along with CBS-QB3 enthalpies and free energies obtained from single-point calculations on the solution-optimized geometries, and free energies of solvation obtained from CPCM single-point calculations at the B3LYP/6-31+G(d) level. Units are the same as above.

TS-1a

C	-2.821373	0.735821	-0.442734
C	-1.685049	-0.103764	0.133769
O	-1.679349	-0.306238	1.380762
C	-0.713702	-0.627581	-0.773604
C	0.353611	-1.431624	-0.370973
S	2.344327	-0.146430	0.139127
C	1.618812	1.522534	-0.044673
H	-0.801644	-0.347117	-1.822177
H	-3.784198	0.264387	-0.204540
H	-2.823232	1.726643	0.030455
H	-2.750555	0.863579	-1.528134
H	0.324779	-1.869728	0.621753
H	0.893788	-2.005332	-1.116775
H	1.643152	2.076696	0.899558
H	2.142763	2.104260	-0.810269
H	0.566917	1.407083	-0.352705

1 imaginary frequency

$$H_{0K} = -668.439315$$

$$G_{298.15K} = -668.473525$$

$$G_{\text{solv}, 298.15K} = -53.58$$

TS-2a

C	2.997217	-0.280685	-0.702424
C	1.791168	0.046900	0.175338
C	0.693209	0.717919	-0.429681
C	-0.465930	1.096224	0.267194
C	-1.320026	2.237459	-0.234993
O	1.855863	-0.280979	1.398534
S	-2.115252	-0.630969	0.145892
C	-1.063646	-2.021020	-0.406419
H	3.893216	0.205913	-0.294184
H	3.183511	-1.362756	-0.683273
H	2.868129	0.035527	-1.743217
H	0.752682	0.926002	-1.498118
H	-0.407465	1.015093	1.352727
H	-1.459253	2.187324	-1.321121
H	-0.822590	3.192375	-0.003357
H	-2.307386	2.254247	0.239285
H	-0.907658	-2.757178	0.389407
H	-1.502545	-2.524388	-1.274248
H	-0.085473	-1.609606	-0.700532

1 imaginary frequency

$$H_{0K} = -707.670766$$

$$G_{298.15K} = -707.706360$$

$$G_{\text{soln}, 298.15K} = -52.55$$

Geometries Optimized at Other Levels of Theory

The species in Eqs 1 and 5 were optimized with a variety of DFT and ab initio methods, using the 6-31+G(d) basis set. Below are given the optimized coordinates, potential energy, and zero-point energy for each species. Also listed is the potential energy obtained from a single-point calculation at the same geometry with the 6-311G(2d,p) basis set (E_{LBS}). All energies are in Hartree. For the MP2 geometries, single-point SCS-MP2 calculations were also performed. The SCS-MP2 potential energies are listed as $E_{\text{SCS-MP2}}$ [6-31+G(d) basis set] and $E_{\text{SCS-MP2,LBS}}$ [6-311G(2d,p) basis set].

Geometries of MeSH

B3LYP

H	1.292674	-0.835050	0.000000
S	-0.048213	-0.672143	0.000000
C	-0.048213	1.164769	0.000000
H	-1.097465	1.470763	0.000000
H	0.432733	1.564980	0.896025
H	0.432733	1.564980	-0.896025

0 imaginary frequencies

$$E = -438.701187$$

$$\text{ZPE} = 0.046301$$

$$E_{\text{LBS}} = -438.7462792$$

MPW1PW91

H	1.287230	-0.829110	0.000000
S	-0.047896	-0.666136	0.000000
C	-0.047896	1.152474	0.000000
H	-1.094804	1.461007	0.000000
H	0.430648	1.555720	0.894212
H	0.430648	1.555720	-0.894212

0 imaginary frequencies

$$E = -438.690684$$

$$\text{ZPE} = 0.046849$$

$$E_{\text{LBS}} = -438.7342907$$

B1B95

H	1.285969	-0.825349	0.000000
S	-0.047800	-0.664851	0.000000
C	-0.047800	1.149752	0.000000
H	-1.093745	1.457668	0.000000
H	0.429687	1.553393	0.893173

H 0.429687 1.553393 -0.893173

0 imaginary frequencies

E = -438.6957816

ZPE = 0.046877

E_{LBS} = -438.7394231

PBE1PBE

H 1.288481 -0.828741 0.000000

S -0.047885 -0.665686 0.000000

C -0.047885 1.151256 0.000000

H -1.096145 1.460157 0.000000

H 0.430561 1.556016 0.895261

H 0.430561 1.556016 -0.895261

0 imaginary frequencies

E = -438.4876552

ZPE = 0.046778

E_{LBS} = -438.5307313

M06-2X

H 1.285882 -0.821494 0.000000

S -0.048049 -0.667472 0.000000

C -0.048049 1.155272 0.000000

H -1.094587 1.464049 0.000000

H 0.432888 1.552681 0.894757

H 0.432888 1.552681 -0.894757

0 imaginary frequencies

E = -438.6292614

ZPE = 0.046685

E_{LBS} = -438.6782839

B2PLYP

H 1.286521 -0.831613 0.000000

S -0.048082 -0.669133 0.000000

C -0.048082 1.158929 0.000000

H -1.094367 1.467445 0.000000

H 0.432822 1.558361 0.893638

H 0.432822 1.558361 -0.893638

0 imaginary frequencies

E = -438.4746273

ZPE = 0.046943

E_{LBS} = -438.5374801

B2PLYP-D

H 1.286929 -0.831726 0.000000

S -0.048147 -0.669789 0.000000

C -0.048147 1.160080 0.000000

H -1.095289 1.469004 0.000000

H	0.433796	1.559436	0.894394
H	0.433796	1.559436	-0.894394

0 imaginary frequencies

E = -438.4756417

ZPE = 0.046797

E_{LBS} = -438.5384800

MP2

H	1.283334	-0.824742	0.000000
S	-0.047952	-0.665687	0.000000
C	-0.047952	1.150857	0.000000
H	-1.093547	1.463092	0.000000
H	0.432580	1.553753	0.892856
H	0.432580	1.553753	-0.892856

0 imaginary frequencies

E = -437.955753

ZPE = 0.047514

E_{SCS-MP2} = -437.957215

E_{LBS} = -438.0588795

E_{SCS-MP2,LBS} = -438.0608742

Geometries of Enone 1

B3LYP

C	-0.601126	-1.934237	0.000000
C	0.342028	-0.983725	0.000000
C	0.000000	0.472925	0.000000
O	-1.158170	0.865748	0.000000
C	1.169092	1.439283	0.000000
H	1.398408	-1.248747	0.000000
H	-0.347774	-2.990828	0.000000
H	-1.654324	-1.664300	0.000000
H	0.804971	2.468669	0.000000
H	1.802054	1.271873	0.881770
H	1.802054	1.271873	-0.881770

0 imaginary frequencies

E = -231.247283

ZPE = 0.089546

E_{LBS} = -231.3073263

MPW1PW91

C	-0.597653	-1.924000	0.000000
C	0.346084	-0.979510	0.000000
C	0.000000	0.471296	0.000000
O	-1.155081	0.856867	0.000000
C	1.160978	1.435131	0.000000
H	1.401277	-1.244102	0.000000
H	-0.349738	-2.980377	0.000000

H	-1.647664	-1.646402	0.000000
H	0.796071	2.462341	0.000000
H	1.792123	1.268050	0.880448
H	1.792123	1.268050	-0.880448

0 imaginary frequencies

E = -231.1821269

ZPE = 0.090342

E_{LBS} = -231.2397058

B1B95

C	-0.592861	-1.920835	0.000000
C	0.349600	-0.977986	0.000000
C	0.000000	0.470173	0.000000
O	-1.155690	0.850081	0.000000
C	1.155088	1.437276	0.000000
H	1.404323	-1.240354	0.000000
H	-0.346513	-2.976717	0.000000
H	-1.641703	-1.641621	0.000000
H	0.786458	2.461870	0.000000
H	1.785996	1.272206	0.879471
H	1.785996	1.272206	-0.879471

0 imaginary frequencies

E = -231.1320097

ZPE = 0.090249

E_{LBS} = -231.1892303

PBE1PBE

C	-0.597704	-1.923125	0.000000
C	0.347584	-0.979440	0.000000
C	0.000000	0.471480	0.000000
O	-1.155806	0.855607	0.000000
C	1.160359	1.435038	0.000000
H	1.404137	-1.244359	0.000000
H	-0.351858	-2.981333	0.000000
H	-1.648239	-1.641424	0.000000
H	0.795582	2.463737	0.000000
H	1.792698	1.267404	0.881223
H	1.792698	1.267404	-0.881223

0 imaginary frequencies

E = -230.968492

ZPE = 0.090189

E_{LBS} = -231.0248543

M06-2X

C	-0.600551	-1.919356	0.000000
C	0.350092	-0.984285	0.000000
C	0.000000	0.472107	0.000000
O	-1.153818	0.850426	0.000000
C	1.160980	1.439489	0.000000
H	1.405893	-1.248666	0.000000

H	-0.361815	-2.978333	0.000000
H	-1.648020	-1.628262	0.000000
H	0.792506	2.465711	0.000000
H	1.789427	1.269203	0.881895
H	1.789427	1.269203	-0.881895

0 imaginary frequencies

E = -231.1309923

ZPE = 0.090477

E_{LBS} = -231.1955485

B2PLYP

C	-0.589166	-1.933772	0.000000
C	0.353412	-0.980488	0.000000
C	0.000000	0.471700	0.000000
O	-1.166184	0.854595	0.000000
C	1.158040	1.445686	0.000000
H	1.409496	-1.240049	0.000000
H	-0.334537	-2.988065	0.000000
H	-1.640231	-1.662771	0.000000
H	0.783745	2.469624	0.000000
H	1.788641	1.282873	0.881486
H	1.788641	1.282873	-0.881486

0 imaginary frequencies

E = -230.9903786

ZPE = 0.090200

E_{LBS} = -231.0831853

B2PLYP-D

C	-0.596795	-1.930529	0.000000
C	0.349453	-0.980729	0.000000
C	0.000000	0.472309	0.000000
O	-1.163955	0.861416	0.000000
C	1.165669	1.437522	0.000000
H	1.405213	-1.242178	0.000000
H	-0.345816	-2.986073	0.000000
H	-1.646337	-1.651664	0.000000
H	0.800229	2.465381	0.000000
H	1.794196	1.265886	0.882085
H	1.794196	1.265886	-0.882085

0 imaginary frequencies

E = -230.9940993

ZPE = 0.090044

E_{LBS} = -231.0869098

MP2

C	-0.573499	-1.935872	0.000000
C	0.367227	-0.976421	0.000000
C	0.000000	0.470823	0.000000
O	-1.177484	0.841545	0.000000
C	1.144365	1.455427	0.000000

H	1.425791	-1.231792	0.000000
H	-0.312976	-2.989595	0.000000
H	-1.626081	-1.667267	0.000000
H	0.754494	2.474410	0.000000
H	1.775041	1.299070	0.882790
H	1.775041	1.299070	-0.882790

0 imaginary frequencies

E = -230.5020724

ZPE = 0.090469

E_{SCS-MP2} = -230.4881999

E_{LBS} = -230.6688237

E_{SCS-MP2, LBS} = -230.6570209

Geometries of Product: 1 + MeSH

B3LYP

C	-3.332344	-0.628569	0.030474
C	-2.064327	0.205294	-0.010175
O	-2.099273	1.423665	-0.026689
C	-0.746539	-0.563594	-0.022733
C	0.482286	0.341212	0.017828
S	2.003329	-0.686916	-0.015814
C	3.261390	0.637221	0.023986
H	-4.206763	0.016564	-0.080863
H	-3.397459	-1.162506	0.987807
H	-3.327722	-1.389390	-0.759843
H	-0.745809	-1.263745	0.825484
H	-0.732384	-1.196263	-0.922790
H	0.478618	1.020345	-0.840522
H	0.472215	0.952284	0.926321
H	4.240605	0.150578	0.007703
H	3.177237	1.289775	-0.851006
H	3.179577	1.234311	0.937969

0 imaginary frequencies

E = -669.9805207

ZPE = 0.142300

E_{LBS} = -670.0815108

MPW1PW91

C	-3.310081	-0.623423	0.040574
C	-2.047646	0.203918	-0.013392
O	-2.078094	1.417509	-0.034364
C	-0.739203	-0.564363	-0.030368
C	0.481385	0.338128	0.020707
S	1.986760	-0.680889	-0.020449
C	3.233290	0.630010	0.032558
H	-4.181515	0.015775	-0.105636
H	-3.386743	-1.115110	1.017284
H	-3.296317	-1.415461	-0.715145
H	-0.739741	-1.273034	0.808587
H	-0.723675	-1.186101	-0.936136

H	0.474288	1.025504	-0.829720
H	0.465802	0.940402	0.933811
H	4.212552	0.146916	0.013233
H	3.152735	1.290675	-0.834840
H	3.152731	1.218974	0.950181

0 imaginary frequencies

E = -669.9144134

ZPE = 0.143677

E_{LBS} = -670.011234

B1B95

C	-3.308629	-0.610664	0.029790
C	-2.039347	0.201906	-0.010368
O	-2.055324	1.414919	-0.027086
C	-0.737701	-0.573222	-0.021221
C	0.478970	0.330464	0.017676
S	1.982745	-0.682108	-0.016101
C	3.216336	0.635673	0.024063
H	-4.172813	0.042327	-0.086122
H	-3.381268	-1.137573	0.986761
H	-3.310002	-1.373227	-0.754359
H	-0.738011	-1.269911	0.826103
H	-0.723934	-1.205393	-0.918127
H	0.465439	1.009230	-0.838447
H	0.461489	0.942354	0.923105
H	4.199087	0.162269	0.009087
H	3.129971	1.287120	-0.848400
H	3.130934	1.232230	0.935065

0 imaginary frequencies

E = -669.8655762

ZPE = 0.143421

E_{LBS} = -669.9625876

PBE1PBE

C	-3.308235	-0.621899	0.039658
C	-2.045463	0.203830	-0.013439
O	-2.073954	1.417887	-0.033787
C	-0.738371	-0.565555	-0.030166
C	0.481851	0.336205	0.021223
S	1.985567	-0.681344	-0.019828
C	3.227710	0.631232	0.031374
H	-4.180141	0.019122	-0.105645
H	-3.385076	-1.115586	1.016824
H	-3.295187	-1.414221	-0.717700
H	-0.739461	-1.275450	0.809627
H	-0.722835	-1.188391	-0.936899
H	0.474183	1.025130	-0.829966
H	0.465484	0.939815	0.935299
H	4.209968	0.151159	0.012549
H	3.145106	1.291770	-0.837752
H	3.145555	1.222180	0.949311

0 imaginary frequencies

E = -669.5001994

ZPE = 0.143410

E_{LBS} = -669.5953236

M06-2X

C	1.687998	0.246032	0.122032
C	2.689149	-0.161510	-0.929861
H	3.306327	-0.994109	-0.574035
H	2.142951	-0.516903	-1.812325
H	3.317183	0.686970	-1.204223
O	1.541070	1.398324	0.464727
C	0.862590	-0.867762	0.762807
H	1.338363	-1.099003	1.726042
H	0.909778	-1.781148	0.158216
C	-0.579285	-0.431893	0.995420
H	-0.581090	0.573926	1.426684
H	-1.091372	-1.116630	1.677789
S	-1.447231	-0.392492	-0.606850
C	-2.844868	0.665577	-0.148595
H	-3.486255	0.761782	-1.027174
H	-3.425641	0.217494	0.662054
H	-2.496620	1.658238	0.147938

0 imaginary frequencies

E = -669.802787

ZPE = 0.144145

E_{LBS} = -669.9124056

B2PLYP

C	-3.320457	-0.624156	0.052779
C	-2.053210	0.202305	-0.017658
O	-2.082899	1.425367	-0.044704
C	-0.741930	-0.569124	-0.042651
C	0.482843	0.333755	0.032728
S	1.996380	-0.686517	-0.024679
C	3.236932	0.641278	0.038203
H	-4.188977	0.014281	-0.113074
H	-3.399865	-1.088743	1.042360
H	-3.303383	-1.434106	-0.683457
H	-0.748089	-1.293189	0.782640
H	-0.723473	-1.169914	-0.962193
H	0.479808	1.037147	-0.803686
H	0.464743	0.915299	0.958582
H	4.220712	0.168372	0.011948
H	3.144550	1.308297	-0.822445
H	3.150025	1.219538	0.961415

0 imaginary frequencies

E = -669.5016999

ZPE = 0.143859

E_{LBS} = -669.6530925

B2PLYP-D

C	-3.316057	-0.622808	0.052148
C	-2.049872	0.205054	-0.017931
O	-2.076906	1.427969	-0.044876
C	-0.742812	-0.572255	-0.042446
C	0.483809	0.328003	0.033029
S	1.997526	-0.691146	-0.024104
C	3.224709	0.650619	0.037740
H	-4.187020	0.013915	-0.111931
H	-3.390161	-1.089692	1.041711
H	-3.293796	-1.431663	-0.686111
H	-0.753153	-1.295110	0.784192
H	-0.727383	-1.172605	-0.962566
H	0.480183	1.031477	-0.803900
H	0.464733	0.910050	0.959055
H	4.215945	0.191921	0.011770
H	3.119959	1.316009	-0.823785
H	3.126860	1.228602	0.960996

0 imaginary frequencies

E = -669.5093451

ZPE = 0.143449

E_{LBS} = -669.6607361

MP2

C	-3.306125	-0.619771	0.075228
C	-2.040263	0.198600	-0.027128
O	-2.064336	1.429535	-0.063899
C	-0.735899	-0.574977	-0.069932
C	0.484131	0.322542	0.061595
S	1.989055	-0.686858	-0.030712
C	3.205968	0.648080	0.044847
H	-4.171465	0.012348	-0.131693
H	-3.392405	-1.026699	1.089672
H	-3.281871	-1.468335	-0.616190
H	-0.753732	-1.337343	0.721081
H	-0.708094	-1.129373	-1.019254
H	0.483267	1.064111	-0.742802
H	0.452041	0.859819	1.015068
H	4.198604	0.192854	0.007926
H	3.100627	1.326722	-0.805742
H	3.115963	1.212486	0.976860

0 imaginary frequencies

E = -668.5017496

ZPE = 0.145131

E_{SCS-MP2} = -668.4854972

E_{LBS} = -668.7675357

E_{SCS-MP2,LBS} = -668.7535866

Geometries of Enone 5

B3LYP

C	-2.419049	-1.019727	-0.006760
C	-1.202254	-0.131421	0.002374
C	-1.475588	1.352515	0.022188
C	0.037938	-0.676575	-0.010591
C	1.314656	0.067953	-0.007209
C	2.578400	-0.779745	0.019330
O	1.382409	1.295145	-0.025972
H	0.123276	-1.762667	-0.021446
H	2.614522	-1.443346	-0.854802
H	3.458059	-0.132541	0.021629
H	2.593226	-1.422010	0.909789
H	-3.053351	-0.789002	-0.874275
H	-2.163054	-2.083293	-0.036182
H	-3.035038	-0.833119	0.884165
H	-2.548414	1.550374	0.120375
H	-0.940156	1.847090	0.838649
H	-1.112958	1.829348	-0.896115

0 imaginary frequencies

E = -309.8876357

ZPE = 0.145827

E_{LBS} = -309.9681457

MPW1PW91

C	-2.411443	-1.010250	-0.003063
C	-1.196658	-0.131874	0.000888
C	-1.460422	1.346121	0.010836
C	0.038274	-0.680121	-0.005614
C	1.307977	0.066578	-0.003637
C	2.566795	-0.774318	0.009650
O	1.369487	1.288793	-0.012692
H	0.122054	-1.765276	-0.010946
H	2.598174	-1.430329	-0.867783
H	3.444352	-0.127180	0.012111
H	2.586240	-1.421662	0.893794
H	-3.038568	-0.786761	-0.875125
H	-2.161439	-2.073766	-0.017435
H	-3.029012	-0.808254	0.880953
H	-2.533888	1.550490	0.055428
H	-0.966306	1.830958	0.857169
H	-1.044639	1.824623	-0.880999

0 imaginary frequencies

E = -309.8052386

ZPE = 0.147042

E_{LBS} = -309.8820968

B1B95

C	2.409925	-1.004492	-0.000010
C	1.193404	-0.132606	0.000045
C	1.448333	1.344493	-0.000012

C	-0.037190	-0.684832	0.000024
C	-1.303287	0.063143	-0.000020
C	-2.564468	-0.769429	-0.000031
O	-1.357285	1.284648	0.000010
H	-0.118924	-1.769188	0.000023
H	-2.593250	-1.419562	0.880358
H	-3.437354	-0.117937	-0.000835
H	-2.592532	-1.420940	-0.879407
H	3.030807	-0.789510	0.877144
H	2.162994	-2.067679	0.000079
H	3.030620	-0.789635	-0.877335
H	2.520310	1.555037	-0.000031
H	0.987642	1.822262	-0.868228
H	0.987661	1.822315	0.868184

0 imaginary frequencies

E = -309.7232543

ZPE = 0.147222

E_{LBS} = -309.7996880

PBE1PBE

C	-2.411981	-1.008491	-0.001761
C	-1.196496	-0.132255	0.000337
C	-1.457577	1.345606	0.006850
C	0.038433	-0.681951	-0.003886
C	1.307351	0.065887	-0.002356
C	2.566501	-0.773517	0.006267
O	1.367091	1.288649	-0.007995
H	0.121582	-1.768528	-0.007245
H	2.596865	-1.427852	-0.874094
H	3.444558	-0.124822	0.009304
H	2.587780	-1.424603	0.889247
H	-3.038006	-0.787728	-0.876969
H	-2.163189	-2.073702	-0.010410
H	-3.031927	-0.800606	0.880886
H	-2.532459	1.552545	0.033455
H	-0.976369	1.828622	0.863635
H	-1.022956	1.825806	-0.876555

0 imaginary frequencies

E = -309.5117436

ZPE = 0.146749

E_{LBS} = -309.5870189

M06-2X

H	-0.988544	1.824262	-0.872562
H	-2.516573	1.559397	0.009536
H	-0.976258	1.824594	0.870583
C	-1.443059	1.349876	0.002430
C	-1.192896	-0.135216	0.000276
C	0.034178	-0.692227	-0.001060
H	0.119495	-1.777881	-0.002226
C	-2.420650	-1.002492	-0.000775
H	-3.037547	-0.778358	-0.879767
H	-2.177955	-2.067955	-0.003173

H	-3.036639	-0.782073	0.879781
C	1.306216	0.064560	-0.000776
O	1.356204	1.283552	-0.002971
C	2.571353	-0.770135	0.002126
H	2.595937	-1.420532	-0.879577
H	3.444544	-0.116864	0.002970
H	2.593051	-1.419195	0.884871

0 imaginary frequencies

E = -309.7289211

ZPE = 0.147470

E_{LBS} = -309.8150639

B2PLYP

C	-2.419075	-1.014501	-0.008381
C	-1.200488	-0.131686	0.002690
C	-1.465687	1.352121	0.028081
C	0.037850	-0.681805	-0.014298
C	1.312389	0.063919	-0.009668
C	2.574558	-0.778619	0.025237
O	1.375597	1.295463	-0.033617
H	0.121288	-1.766836	-0.027965
H	2.613448	-1.443351	-0.845088
H	3.449800	-0.128261	0.027660
H	2.585675	-1.413827	0.918038
H	-3.049624	-0.779431	-0.874490
H	-2.163099	-2.076302	-0.041397
H	-3.030781	-0.829294	0.882890
H	-2.536530	1.549993	0.128672
H	-0.929176	1.838199	0.846330
H	-1.103058	1.828831	-0.887677

0 imaginary frequencies

E = -309.5253869

ZPE = 0.147095

E_{LBS} = -309.6541031

B2PLYP-D

C	-2.418931	-1.012666	-0.002804
C	-1.199274	-0.132407	0.000830
C	-1.461011	1.351785	0.009520
C	0.038141	-0.683011	-0.004937
C	1.310556	0.065175	-0.003399
C	2.571264	-0.780603	0.008568
O	1.373360	1.296730	-0.011364
H	0.121756	-1.768260	-0.009515
H	2.594849	-1.437900	-0.868741
H	3.449320	-0.132872	0.007503
H	2.587084	-1.424534	0.895909
H	-3.041756	-0.789987	-0.878437
H	-2.163199	-2.075722	-0.013458
H	-3.035751	-0.806097	0.880962
H	-2.536144	1.552748	0.040875
H	-0.976746	1.830396	0.865485
H	-1.030766	1.828744	-0.876346

0 imaginary frequencies

E = -309.533694

ZPE = 0.146786

E_{LBS} = -309.6624352

MP2

C	-2.421174	-0.997602	-0.052145
C	-1.197127	-0.126682	0.011400
C	-1.459167	1.344024	0.183600
C	0.035721	-0.677592	-0.106069
C	1.316986	0.058371	-0.068051
C	2.553480	-0.780429	0.175031
O	1.398553	1.284819	-0.224489
H	0.111898	-1.761202	-0.201759
H	2.658143	-1.537674	-0.610653
H	3.434242	-0.136017	0.183500
H	2.472147	-1.310776	1.130700
H	-3.088648	-0.651302	-0.851098
H	-2.170921	-2.046249	-0.236559
H	-2.987816	-0.931370	0.884789
H	-2.425142	1.497911	0.675809
H	-0.669796	1.837404	0.752632
H	-1.494848	1.840183	-0.794043

0 imaginary frequencies

E = -308.8472077

ZPE = 0.148116

E_{SCS-MP2} = -308.8292009

E_{LBS} = -309.0840505

E_{SCS-MP2,LBS} = -309.0694094

Geometries of Product: 5 + MeSH

B3LYP

C	2.219851	-0.029901	-0.033326
O	2.409996	1.174198	-0.031331
C	3.383462	-1.006601	0.036780
H	3.440437	-1.430169	1.048801
H	4.318678	-0.484568	-0.178502
H	3.251381	-1.845810	-0.656102
C	0.835981	-0.674680	-0.092500
H	0.799198	-1.433523	0.703765
H	0.797378	-1.247481	-1.032121
C	-0.403938	0.241801	0.003373
S	-1.809512	-1.006116	-0.058245
C	-0.428116	1.009055	1.334248
C	-0.487920	1.200593	-1.194610
H	-1.408850	1.793146	-1.162377
H	-0.472789	0.649601	-2.141776
H	0.357258	1.895466	-1.176880
H	-0.375600	0.322524	2.186789
H	-1.344579	1.601047	1.433151
H	0.419445	1.700323	1.382395

C	-3.315829	0.022278	0.043712
H	-3.408640	0.702416	-0.807599
H	-4.154482	-0.679834	0.017336
H	-3.367556	0.585849	0.979626

0 imaginary frequencies

E = -748.6061789

ZPE = 0.198483

E_{LBS} = -748.7286877

MPW1PW91

C	2.200458	-0.027996	-0.036583
O	2.385423	1.172181	-0.032005
C	3.359692	-0.997404	0.034244
H	3.428829	-1.399829	1.051952
H	4.290646	-0.479703	-0.200256
H	3.220238	-1.848576	-0.639080
C	0.827083	-0.673970	-0.098201
H	0.792110	-1.438374	0.691382
H	0.787670	-1.239857	-1.040663
C	-0.405988	0.236233	0.005016
S	-1.792263	-0.998525	-0.055221
C	-0.421649	0.994704	1.331627
C	-0.490117	1.194971	-1.182326
H	-1.402674	1.796985	-1.138429
H	-0.490256	0.647466	-2.129856
H	0.361733	1.879620	-1.168931
H	-0.369248	0.305162	2.179732
H	-1.334086	1.589390	1.435275
H	0.427634	1.681774	1.378315
C	-3.283033	0.022380	0.038079
H	-3.378930	0.693896	-0.818026
H	-4.123200	-0.675976	0.019215
H	-3.336312	0.593475	0.967812

0 imaginary frequencies

E = -748.523588

ZPE = 0.200246

E_{LBS} = -748.6406648

B1B95

C	2.190329	-0.025519	-0.052022
O	2.360340	1.175930	-0.039142
C	3.358900	-0.980301	-0.000783
H	3.436791	-1.396888	1.009273
H	4.281710	-0.449300	-0.232213
H	3.224332	-1.821600	-0.685552
C	0.823786	-0.679632	-0.108585
H	0.800198	-1.455748	0.668604
H	0.773241	-1.228737	-1.058950
C	-0.404759	0.226074	0.024418
S	-1.788247	-1.003500	-0.010704
C	-0.395490	0.975086	1.352931
C	-0.514488	1.192122	-1.150050
H	-1.419714	1.800219	-1.072012

H	-0.547498	0.652368	-2.100557
H	0.343022	1.868402	-1.153301
H	-0.298776	0.282205	2.192836
H	-1.319883	1.542758	1.488998
H	0.436385	1.682976	1.375665
C	-3.261535	0.039626	-0.038140
H	-3.370232	0.575835	-0.982236
H	-4.112167	-0.635095	0.073431
H	-3.278624	0.746420	0.793803

0 imaginary frequencies

E = -748.4442998

ZPE = 0.199908

E_{LBS} = -748.5612393

PBE1PBE

C	2.198034	-0.027035	-0.040370
O	2.381570	1.173811	-0.034659
C	3.357262	-0.995143	0.034314
H	3.433772	-1.382336	1.058858
H	4.287786	-0.480313	-0.214057
H	3.212629	-1.857614	-0.625450
C	0.826182	-0.674223	-0.107111
H	0.792417	-1.448485	0.674895
H	0.786421	-1.230624	-1.056910
C	-0.406472	0.233737	0.006636
S	-1.791172	-0.998751	-0.055877
C	-0.416489	0.983195	1.337727
C	-0.494779	1.200229	-1.173252
H	-1.407009	1.804493	-1.120420
H	-0.500911	0.658156	-2.125439
H	0.359920	1.883485	-1.159083
H	-0.357390	0.287152	2.181779
H	-1.331115	1.575326	1.450712
H	0.432380	1.673030	1.383705
C	-3.277293	0.025889	0.035583
H	-3.373875	0.693641	-0.825219
H	-4.121330	-0.670026	0.023674
H	-3.326165	0.603751	0.963107

0 imaginary frequencies

E = -748.0302829

ZPE = 0.199927

E_{LBS} = -748.1452362

M06-2X

C	2.192502	-0.020434	-0.055725
O	2.351230	1.181176	-0.034539
C	3.372918	-0.969200	-0.014437
H	3.432162	-1.424664	0.981179
H	4.294577	-0.419337	-0.210143
H	3.254698	-1.782041	-0.737831
C	0.827181	-0.689910	-0.116829
H	0.813432	-1.472277	0.657183
H	0.779338	-1.228546	-1.075286

C	-0.405795	0.213501	0.029265
S	-1.799275	-1.007695	0.007514
C	-0.381139	0.964072	1.362600
C	-0.522518	1.185769	-1.145860
H	-1.417195	1.809536	-1.048325
H	-0.584125	0.644461	-2.096332
H	0.347224	1.848057	-1.165399
H	-0.254436	0.267764	2.198091
H	-1.315405	1.513131	1.519227
H	0.439244	1.687623	1.370009
C	-3.261263	0.060553	-0.062843
H	-3.353913	0.562075	-1.028551
H	-4.123520	-0.596771	0.071852
H	-3.264838	0.798587	0.743377

0 imaginary frequencies

E = -748.3943499

ZPE = 0.200275

E_{LBS} = -748.5265914

B2PLYP

C	2.207458	-0.028661	-0.038941
O	2.389595	1.181431	-0.031136
C	3.374254	-0.996127	0.024827
H	3.426740	-1.433707	1.028679
H	4.304367	-0.463881	-0.178310
H	3.249324	-1.821919	-0.682317
C	0.830938	-0.679996	-0.100041
H	0.799765	-1.443793	0.690047
H	0.790285	-1.242338	-1.044284
C	-0.405522	0.231645	0.009091
S	-1.802387	-1.004334	-0.040996
C	-0.414622	0.993730	1.339320
C	-0.496255	1.191890	-1.182514
H	-1.407997	1.794397	-1.134014
H	-0.502956	0.640968	-2.128155
H	0.356591	1.874606	-1.174963
H	-0.343284	0.303534	2.185555
H	-1.334060	1.575200	1.454031
H	0.426277	1.690993	1.375590
C	-3.293652	0.035195	0.018340
H	-3.383564	0.676018	-0.860692
H	-4.138119	-0.657769	0.026790
H	-3.337537	0.639522	0.926578

0 imaginary frequencies

E = -748.0263282

ZPE = 0.200633

E_{LBS} = -748.2145916

B2PLYP-D

C	2.202713	-0.020617	-0.044322
O	2.375995	1.190456	-0.032399
C	3.373464	-0.983377	0.009922
H	3.422202	-1.433564	1.008978
H	4.303069	-0.446071	-0.185602
H	3.247793	-1.800443	-0.708221
C	0.833311	-0.685739	-0.102543
H	0.815291	-1.451807	0.686247
H	0.794666	-1.242516	-1.050332
C	-0.406243	0.216281	0.016583
S	-1.806561	-1.011976	-0.022256
C	-0.405681	0.978747	1.345476
C	-0.506504	1.178935	-1.170692
H	-1.417576	1.781611	-1.108123
H	-0.523146	0.627792	-2.116770
H	0.349429	1.858110	-1.165627
H	-0.311973	0.287502	2.189252
H	-1.332893	1.546273	1.470641
H	0.427634	1.686117	1.365057
C	-3.274221	0.062880	-0.012336
H	-3.350865	0.656081	-0.926139
H	-4.138280	-0.604126	0.043215
H	-3.289369	0.720365	0.860191

0 imaginary frequencies

E = -748.042283

ZPE = 0.200450

E_{LBS} = -748.2306163

MP2

C	2.192286	-0.026265	-0.059940
O	2.368485	1.192461	-0.038192
C	3.360474	-0.986587	-0.006030
H	3.411991	-1.437394	0.992283
H	4.287613	-0.444793	-0.201834
H	3.237375	-1.801428	-0.726798
C	0.822839	-0.680746	-0.133482
H	0.802807	-1.477895	0.626080
H	0.771703	-1.202821	-1.102116
C	-0.408273	0.220449	0.028857
S	-1.792907	-1.003679	-0.000454
C	-0.376638	0.954045	1.370794
C	-0.530938	1.200667	-1.137762
H	-1.419735	1.830747	-1.031732
H	-0.602477	0.663194	-2.089978
H	0.343158	1.856997	-1.160772
H	-0.243630	0.245422	2.195349
H	-1.309940	1.500353	1.542037
H	0.442908	1.678452	1.383155
C	-3.262997	0.049941	-0.052362
H	-3.355976	0.581957	-1.001104
H	-4.118830	-0.622709	0.050127
H	-3.288856	0.760071	0.777657

0 imaginary frequencies

$$E = -746.8431993$$

$$ZPE = 0.202375$$

$$E_{\text{SCS-MP2}} = -746.821636$$

$$E_{\text{LBS}} = -747.1800389$$

$$E_{\text{SCS-MP2,LBS}} = -747.1619838$$

Complete Citation for Ref 4

Wong, K.-K.; Fracasso, P. M.; Bukowski, R. M.; Lynch, T. J.; Munster, P. N.; Shapiro, G. I.; Jänne, P. A.; Eder, J. P.; Naughton, M. J.; Ellis, M. J.; Jones, S. F.; Mekhail, T.; Zacharchuk, C.; Vermette, J.; Abbas, R.; Quinn, S.; Powell C.; Burris, H. A. *Clin. Cancer Res.* **2009**, *15*, 2552–2558 and references cited therein.

Complete Citation for Ref 6

Pan, Z.; Scheerens, H.; Li, S.-J.; Schultz, B. E.; Sprengeler, P. A.; Burrill, L. C.; Mendonca, R. V.; Sweeney, M. D.; Scott, K. C. K.; Grothaus, P. G.; Jeffery, D. A.; Spoerke, J. M.; Honigberg, L. A.; Young, P. R.; Dalrymple, S. A.; Palmer, J. T. *ChemMedChem* **2007**, *2*, 58–61.

Complete Citation for Ref 33

Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Montgomery, Jr., J. A.; Vreven, T.; Kudin, K. N.; Burant, J. C.; Millam, J. M.; Iyengar, S. S.; Tomasi, J.; Barone, V.; Mennucci, B.; Cossi, M.; Scalmani, G.; Rega, N.; Petersson, G. A.; Nakatsuji, H.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; Klene, M.; Li, X.; Knox, J. E.; Hratchian, H. P.; Cross, J. B.; Bakken, V.; Adamo, C.; Jaramillo, J.; Gomperts, R.; Stratmann, R. E.; Yazyev, O.; Austin, A. J.; Cammi, R.; Pomelli, C.; Ochterski, J. W.; Ayala, P. Y.; Morokuma, K.; Voth, G. A.; Salvador, P.; Dannenberg, J. J.; Zakrzewski, V. G.; Dapprich, S.; Daniels, A. D.; Strain, M. C.; Farkas, O.; Malick, D. K.; Rabuck, A. D.; Raghavachari, K.; Foresman, J. B.; Ortiz, J. V.; Cui, Q.; Baboul, A. G.; Clifford, S.; Cioslowski, J.; Stefanov, B. B.; Liu, G.; Liashenko, A.; Piskorz, P.; Komaromi, I.; Martin, R. L.; Fox, D. J.; Keith, T.; Al-Laham, M. A.; Peng, C. Y.; Nanayakkara, A.; Challacombe, M.; Gill, P. M. W.; Johnson, B.; Chen, W.; Wong, M. W.; Gonzalez, C.; and Pople, J. A. Gaussian 03, Revision C.02, Gaussian, Inc., Wallingford CT, 2004.

Complete Citation for Ref 34

Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Scalmani, G.; Barone, V.; Mennucci, B.; Petersson, G. A.; Nakatsuji, H.; Caricato, M.; Li, X.; Hratchian, H. P.; Izmaylov, A. F.; Bloino, J.; Zheng, G.; Sonnenberg, J. L.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; Vreven, T.; Montgomery, Jr., J. A.; Peralta, J. E.; Ogliaro, F.; Bearpark, M.; Heyd, J. J.; Brothers, E.; Kudin, K. N.; Staroverov, V. N.; Kobayashi, R.; Normand, J.; Raghavachari, K.; Rendell, A.; Burant, J. C.; Iyengar, S. S.; Tomasi, J.; Cossi, M.; Rega, N.; Millam, N. J.; Klene, M.; Knox, J. E.; Cross, J. B.; Bakken, V.; Adamo, C.; Jaramillo, J.; Gomperts, R.; Stratmann, R. E.; Yazyev, O.; Austin, A. J.; Cammi, R.; Pomelli, C.; Ochterski, J. W.; Martin, R. L.; Morokuma, K.; Zakrzewski, V. G.; Voth, G. A.; Salvador, P.; Dannenberg, J. J.; Dapprich, S.; Daniels, A. D.; Farkas, Ö.; Foresman, J. B.; Ortiz, J. V.; Cioslowski, J.; Fox, D. J. Gaussian 09, Revision A.02, Gaussian, Inc., Wallingford CT, 2009.