Comment on "Dithiocarbamate-mediated thioamidation of arylglyoxylic acids by decarboxylative- decarbonylative C–C bond formation reactions" by D. Patra and A. Saha, *Org. Chem. Front.* **2023**, *10*, 1686

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Supporting Information

Experimental procedures. S2-S7

Computational details. S8-S12

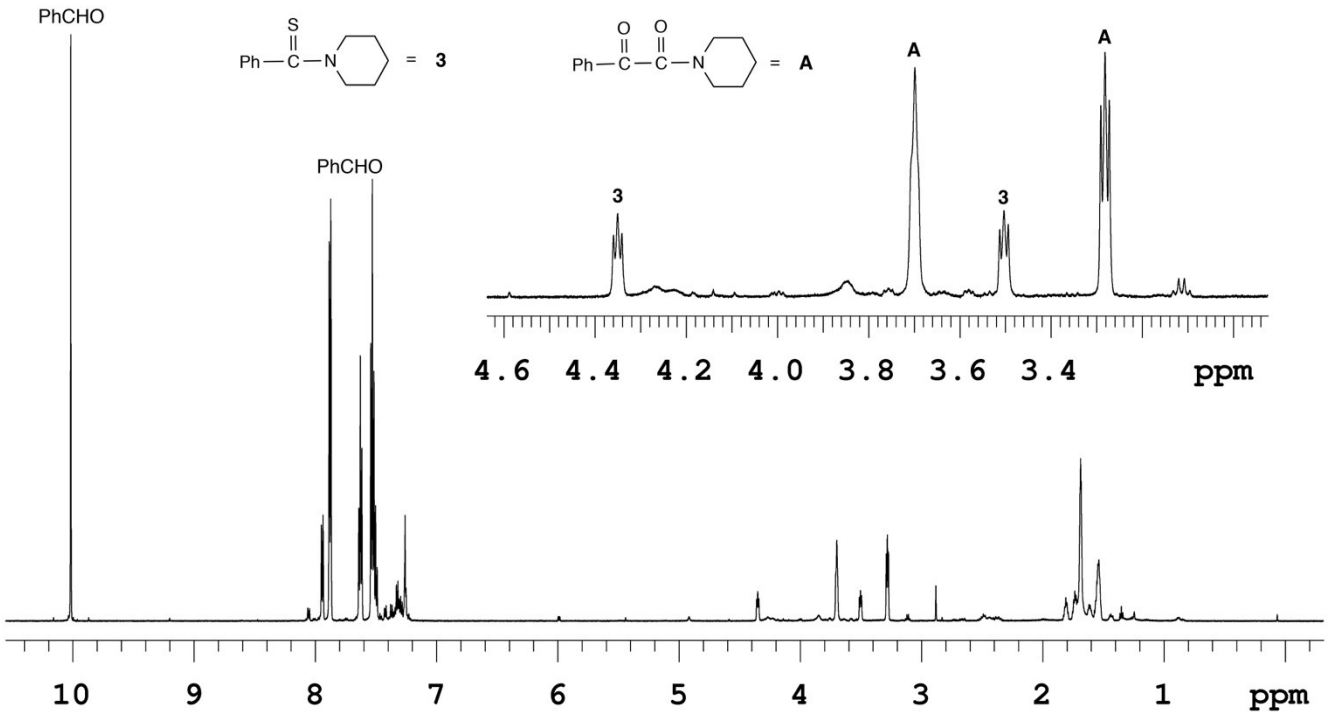
Reaction of Phenylglyoxylic acid, Piperidine Dithiocarbamate Salt, Ammonium Persulfate and (dppf)$PdCl_2$. Piperidine (86 mg; 1.0 mmol) was placed in a 15 mL round bottom flask along with a micro stir bar. Dry *N*-methylpyrrolidone (1.5 mL) was then added followed by 280 μL (205 mg; 2.0 mmol) of Et_3N using a syringe. The stirred mixture was cooled in an ice bath as 100 μL (126 mg; 1.65 mmol) of CS_2 was added using a syringe. The ice bath was removed and the mixture was stirred at room temperature for 10 minutes. $PhCOCO_2H$ (121 mg; 0.8 mmol) in 0.5 mL of *N*-methylpyrrolidone was then added to the stirred mixture followed by 76 mg (0.10 mmol) of [1,1′-bis(diphenylphosphino)-ferrocene]dichloropalladium(II), (dppf)$PdCl_2$. The mixture was then stirred for 10 minutes at room temperature. Solid $(NH_4)_2S_2O_8$ (231 mg; 1.0 mmol) was then added and the stirred mixture was then placed in an oil bath at 70 ± 2 °C for 6 hr. The color of the mixture gradually changed from orange to black. The oil bath was then removed and the contents of the flask were taken up into 10 mL of water, 10 mL of ether, and 5 mL of CH_2Cl_2. The very dark organic extract was washed with two additional portions of water and then saturated NaCl solution. After drying over a mixture of Na_2SO_4 and $MgSO_4$ the solvent was removed using a rotary evaporator. The ^{1}H NMR spectrum of the crude products is shown in Figure 1.

Reaction of Phenylglyoxylic acid, Piperidine Dithiocarbamate salt, and Ammonium Persulfate with no Pd(II). The procedure was identical to that described above except that no (dppf)$PdCl_2$ was added and the reaction time was 5.0 hr. The oil bath was then removed and the contents of the flask were taken up into 5.5 mL of CH_2Cl_2, 12 mL of ether, and 12 mL of water. The organic extract was washed with two additional portion of water and then saturated NaCl solution. After drying over a mixture of Na_2SO_4 and $MgSO_4$ the solvents were removed from a small portion of the product solution using a rotary evaporator. The ^{1}H NMR spectrum is shown in Figure 3.

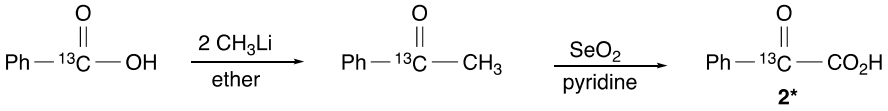
The NMR sample was combined with the crude products above and solvents were removed from the entire sample. The residue was dry packed on about 1 g of silica gel using ether. The powder was

added to a column prepared from 7.5 g of silica gel packed with 2% ether in pentane. The column was eluted with increasing amounts of ether in pentane. Benzaldehyde eluted with 6-8 % ether. The impure thioamide **3** eluted with 15-18% ether in pentane. This impure thioamide **3** was chromatographed again on 1 g of silica gel in a pipette. The yield of thioamide **3** was 7.3 mg (4.5% yield).

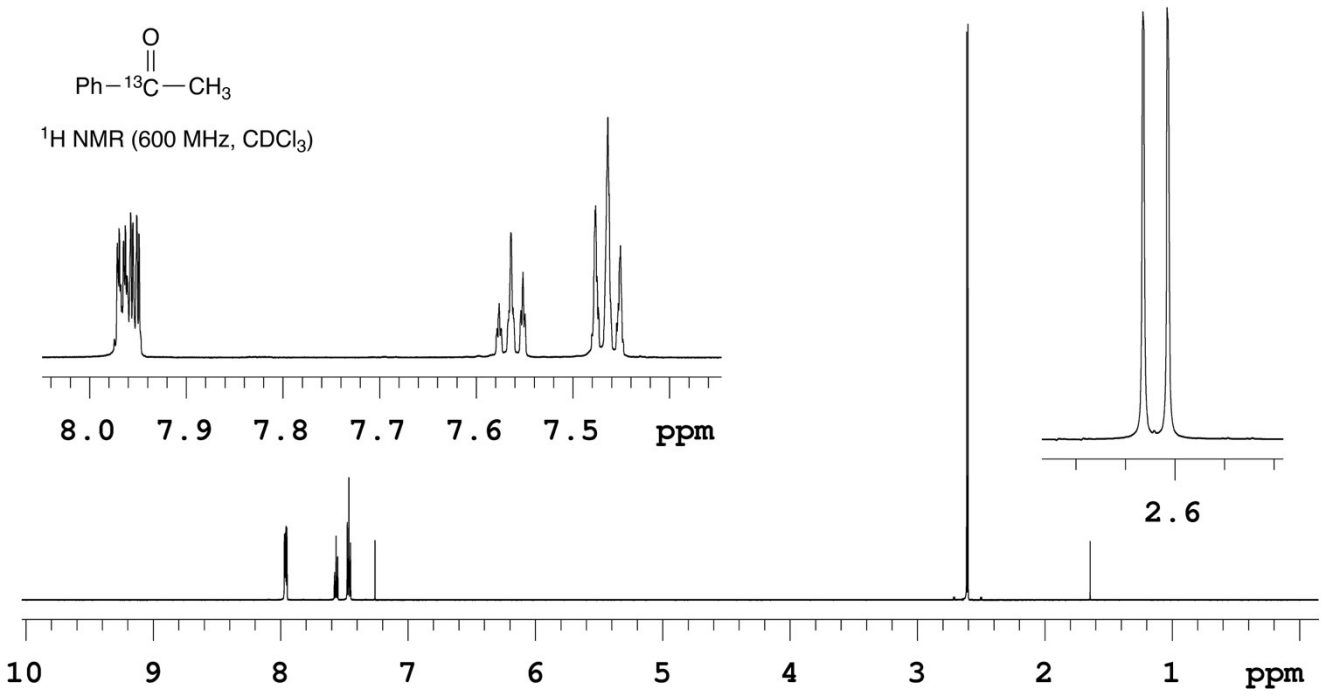
Reaction of Phenylglyoxylic acid, Piperidine Dithiocarbamate Salt. No Pd(II) or $(NH_4)_2S_2O_8$ were added. Piperidine (86 mg; 1.0 mmol) was placed in a 15 mL round bottom flask along with a micro stir bar. Dry 1-methylpyrrolidone (1.5 mL) was then added followed by 280 μL (205 mg; 2.0 mmol) of Et_3N using a syringe. The stirred mixture was cooled in an ice bath as 100 μL (126 mg; 1.65 mmol) of CS_2 was added using a syringe. The mixture was stirred at room temperature for 5 min. $PhCOCO_2H$ (120 mg; 0.8 mmol) in 0.5 mL of NMP was then added. The mixture was then placed in an oil bath at 70 ± 2 °C for 6 hr and 40 min. The reaction mixture was then dissolved in ether and water. The aqueous phase was separated and the organic extract was washed with two additional portions of water, saturated NaCl solution, and dried over a mixture of Na_2SO_4 and $MgSO_4$. The solvent was removed using a rotary evaporator. The ^1H NMR spectrum of the crude products is shown below.

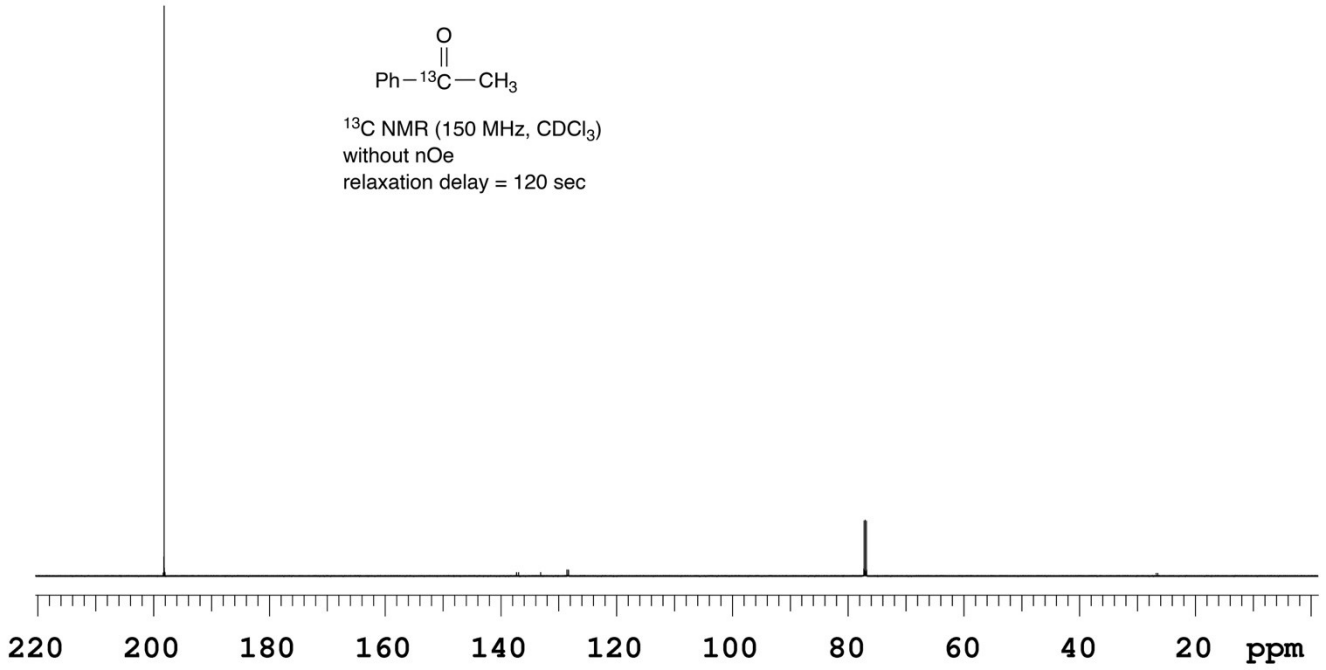


The crude products were chromatographed on 5 g of silica gel and eluted with increasing amounts of ether in pentane. Benzaldehyde eluted with 6 to 8% ether in pentane. Thioamide **3** eluted with 16% ether in pentane. Amide **A** eluted with 50 to 75% ether in pentane. Structures were assigned by spectral comparisons with authentic samples.



Preparation of Ph^{13}COCH$_3$. ^{13}C Labelled benzoic acid, Ph^{13}CO$_2$H (0.99 g; Cambridge Isotope Laboratories) was placed in a 100 mL 3-neck flask and 27 mL of anhydrous ether was added. The mixture was cooled in an ice bath and 14.0 mL of 1.6 M methyllithium in ether (Thermo Scientific) was slowly added dropwise to the stirred mixture. On completion of the addition, the ice bath was removed and the mixture was heated to reflux for 70 minutes. The mixture was re-cooled to 0 °C and a solution of 0.5 g of ethyl acetate in 5 mL of ether was added dropwise. Water was then added with stirring and the mixture was transferred to a separatory funnel. The ether phase was then washed with water, saturated NaCl solution, and dried over a mixture of Na_2SO_4 and $MgSO_4$. After filtration, solvent was removed using a rotary evaporator. The crude product contained 8 mol% of cumyl alcohol. The crude product was chromatographed on a column prepared from 19 g of silica gel using 2% ether in pentane. The column was eluted with increasing amounts of ether in pentane. The Ph^{13}COCH$_3$ eluted with 8% ether in pentane. After solvent removal, distillation using a short path distillation head gave 834 mg (86% yield) of pure Ph^{13}COCH$_3$, bp 89-90 °C (15 mm). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.96 (m, 2 H), 7.56 (t, J = 7.4 Hz, 1 H), 7.46 (t, J = 7.6 Hz, 2 H), 2.61 (d, J = 6.0 Hz, 3 H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 198.2, 137.1 (d, J = 52.9 Hz), 133.1, 128.6 (d, J = 4.0 Hz), 128.3 (d, J = 3.0 Hz).

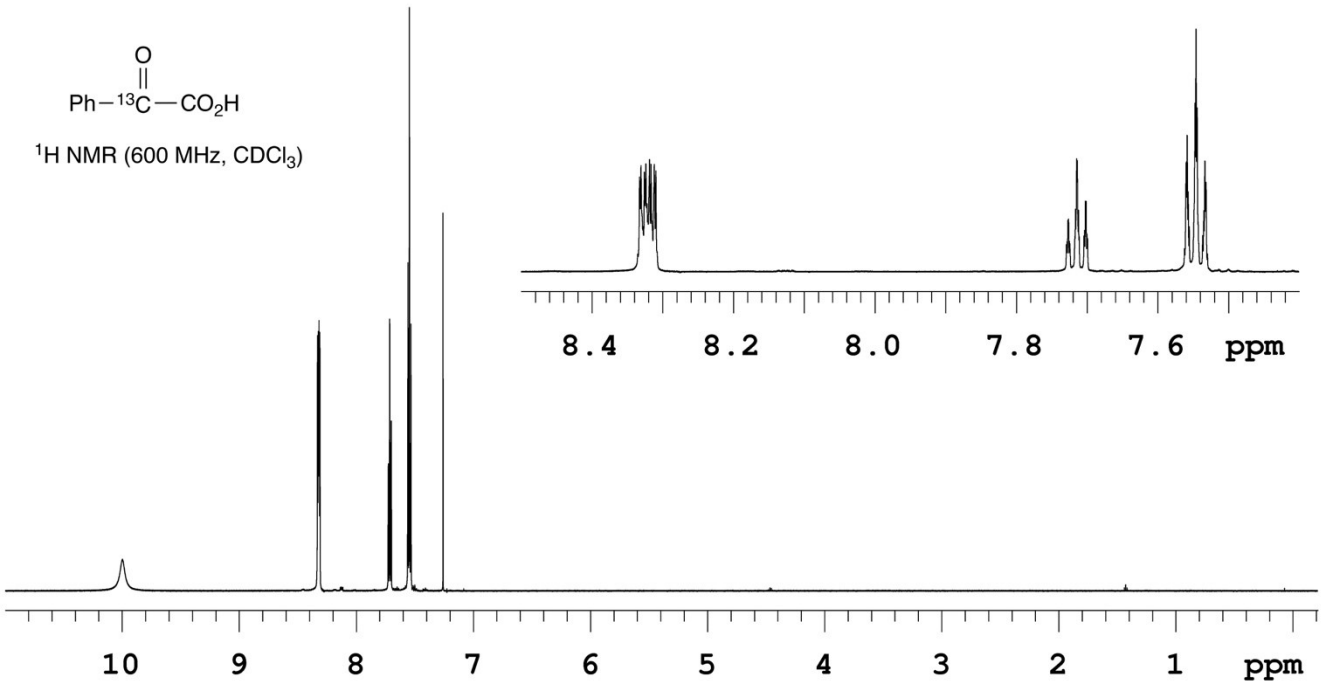


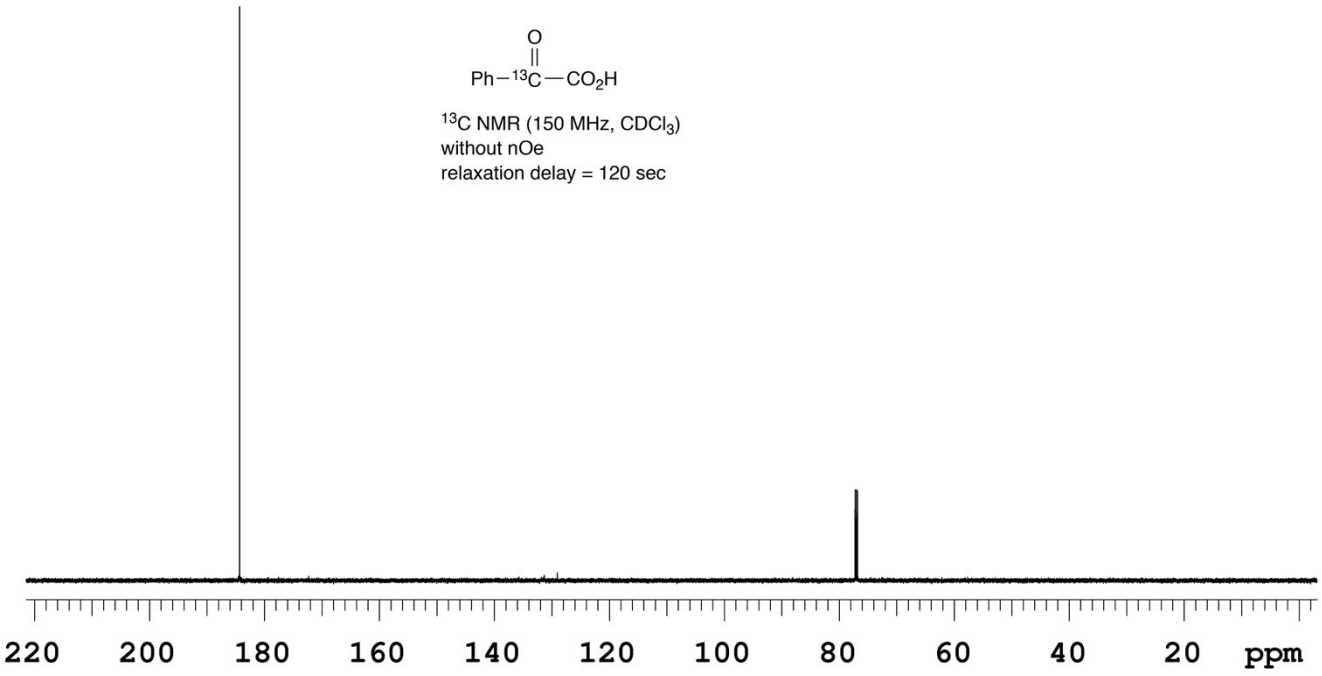


Preparation of $Ph^{13}COCO_2H$. Selenium dioxide (1.128 g) was placed in a 50 mL flask and 821 mg of $Ph^{13}COCH_3$ dissolved in 14 ml of pyridine was added. The mixture was refluxed for 3 hr, and then cooled to room temperature. The orange pyridine solution was carefully decanted from the precipitated selenium using a pipet. The selenium was washed with a small amount of ether and the ether wash was combined with the pyridine solution. The pyridine and ether solvents were removed

using a rotary evaporator using water bath kept below 30 °C. The residue was transferred to a separatory funnel using 6 mL of water and 25 mL of ether. About 20 mL of 10% hydrochloric acid was then added and the mixture was shaken. The aqueous phase was discarded and the ether phase was then washed with 2 mL of water. The ether phase was then extracted with 12 ml of 10% sodium hydroxide solution. The basic aqueous phase was separated and acidified by adding 10% dilute hydrochloric acid. The crude $Ph^{13}COCO_2H$ separated as an orange oil. The mixture was then extracted with ether, washed with saturated NaCl solution, and dried over a mixture of Na_2SO_4 and $MgSO_4$. After filtration, the ether was removed using a rotary evaporator to give the crude product as an oil. The oil was distilled to give 911 mg of product, bp 88-90 °C (0.3 mm). This product contained $Ph^{13}COCO_2H$ along with 4.4 mol% $Ph^{13}CO_2H$.

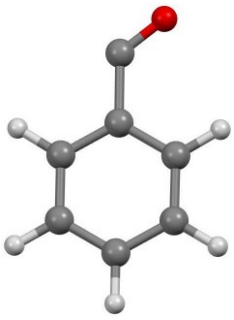
The distilled product from above (793 mg) was dissolved in 22 mL of ether in a separatory funnel. A solution of 290 mg of 86.9% KOH in 22 mL of water was added to the separatory funnel. The separatory funnel was shaken vigorously and the aqueous phase was separated. The aqueous extract was then acidified with 10% HCl in water and $Ph^{13}COCO_2H$ separated. The mixture was then extracted with ether and the ether extract was washed with saturated NaCl solution, dried over $MgSO_4$, and filtered. The ether solvent was then removed using a rotary evaporator to give 644 mg of pure $Ph^{13}COCO_2H$. ^1H NMR (600 MHz, $CDCl_3$) δ 10.00 (bs, 1 H), 8.33 (m, 2 H), 7.71 (t, J = 7.4 Hz, 1 H), 7.55 (t, J = 7.6 Hz, 2 H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 184.3, 135.7, 131.x (d, J = 59.3 Hz), 131.4 (d, J = 2.9 Hz), 129.0 (d, J = 4.3 Hz).


Ph−13C−CO2H
1H NMR (600 MHz, CDCl3)
8.4
8.2
8.0
7.8
7.6
ppm
10
9
8
7
6
5
4
3
2
1
ppm

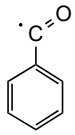

Ph−13C−CO2H
13C NMR (150 MHz, CDCl3)
without nOe
relaxation delay = 120 sec
220
200
180
160
140
120
100
80
60
40
20
ppm

Molecular orbital calculations were performed using the Gaussian 16 series of programs.[1] Structures were characterized as energy minima *via* frequency calculations that showed no negative frequencies. Transition states showed one imaginary frequency.

M062X/6-311+G** Optimized Structure and Energy of Benzoyl Radical **4**



4



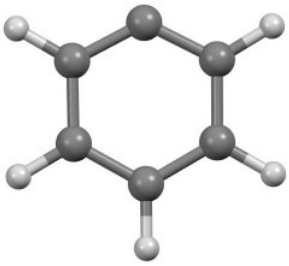
4

No imaginary frequencies

E(RM062X) = -344.864004450
Zero-point correction= 0.098138 (Hartree/Particle)
Thermal correction to Energy= 0.104487
Thermal correction to Enthalpy= 0.105431
Thermal correction to Gibbs Free Energy= 0.066820
Sum of electronic and zero-point Energies= -344.765866
Sum of electronic and thermal Energies= -344.759517
Sum of electronic and thermal Enthalpies= -344.758573
Sum of electronic and thermal Free Energies= -344.797185

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	0.551988	0.254459	-0.000000
2	6	0	-2.159700	-0.303318	0.000000
3	6	0	-0.366821	1.300557	0.000000
4	6	0	0.121082	-1.075809	-0.000000
5	6	0	-1.238259	-1.350430	0.000000
6	6	0	-1.728096	1.019497	0.000000
7	1	0	-0.003014	2.321642	-0.000000
8	1	0	0.857455	-1.871078	-0.000000
9	1	0	-1.584328	-2.377017	0.000000
10	1	0	-2.449937	1.826818	0.000000
11	1	0	-3.220983	-0.522694	0.000000
12	6	0	2.004683	0.567317	-0.000000
13	8	0	2.911661	-0.183103	-0.000000

M062X/6-311+G** Optimized Structure and Energy of Phenyl Radical **5**



5

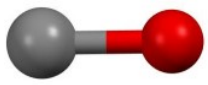
5

No imaginary frequencies

E(RM062X) = -231.512692844
Zero-point correction= 0.087985 (Hartree/Particle)
Thermal correction to Energy= 0.092343
Thermal correction to Enthalpy= 0.093288
Thermal correction to Gibbs Free Energy= 0.059953
Sum of electronic and zero-point Energies= -231.424708
Sum of electronic and thermal Energies= -231.420349
Sum of electronic and thermal Enthalpies= -231.419405
Sum of electronic and thermal Free Energies= -231.452740

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	0.005731	-1.393936	0.000000
2	6	0	-0.005332	1.323343	0.000000
3	6	0	-1.217707	-0.769937	0.000000
4	6	0	1.224048	-0.759999	0.000000
5	6	0	1.206994	0.638099	0.000000
6	6	0	-1.212040	0.628253	0.000000
7	1	0	-2.147985	-1.325581	0.000000
8	1	0	2.158825	-1.308040	0.000000
9	1	0	2.141966	1.186842	0.000000
10	1	0	-2.151453	1.169358	0.000000
11	1	0	-0.009740	2.406601	0.000000

M062X/6-311+G** Optimized Structure and Energy of CO, **6**



6

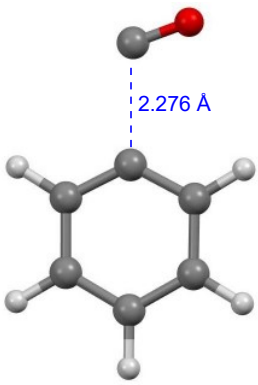
6

No imaginary frequencies

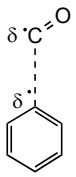
E(RM062X) = -113.309910123
Zero-point correction= 0.005211 (Hartree/Particle)
Thermal correction to Energy= 0.007571
Thermal correction to Enthalpy= 0.008515
Thermal correction to Gibbs Free Energy= -0.013901
Sum of electronic and zero-point Energies= -113.304700
Sum of electronic and thermal Energies= -113.302339
Sum of electronic and thermal Enthalpies= -113.301395
Sum of electronic and thermal Free Energies= -113.323812

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	0.000000	0.000000	-0.640649
2	8	0	0.000000	0.000000	0.481506

M062X/6-311+G** Optimized Structure and Energy of Transition State **7**



7



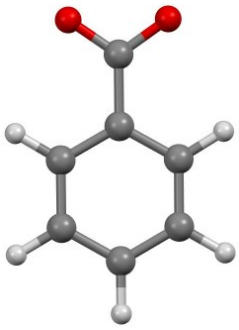
7

One imaginary frequency at -240.9 cm^{-1}

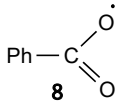
E(RM062X) = -344.822084927
Zero-point correction= 0.094052 (Hartree/Particle)
Thermal correction to Energy= 0.101270
Thermal correction to Enthalpy= 0.102215
Thermal correction to Gibbs Free Energy= 0.060415
Sum of electronic and zero-point Energies= -344.728033
Sum of electronic and thermal Energies= -344.720815
Sum of electronic and thermal Enthalpies= -344.719870
Sum of electronic and thermal Free Energies= -344.761670

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	0.139397	-1.315015	0.450460
2	6	0	-0.061745	1.270360	-0.336954
3	6	0	-1.014796	-0.947423	-0.194850
4	6	0	1.201735	-0.492143	0.733537
5	6	0	1.086773	0.838779	0.322780
6	6	0	-1.107983	0.387590	-0.596366
7	1	0	-1.812238	-1.656712	-0.382823
8	1	0	2.085036	-0.853108	1.248720
9	1	0	1.894670	1.534414	0.519351
10	1	0	-1.996907	0.734894	-1.110524
11	1	0	-0.142078	2.303783	-0.651672
12	6	0	0.331525	-3.480884	1.121908
13	8	0	1.321797	-3.659262	1.640274

M062X/6-311+G** Optimized Structure and Energy of Benzoyloxy Radical **8**



8



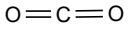
8

No imaginary frequencies

E(RM062X) = -420.082860227
Zero-point correction= 0.101666 (Hartree/Particle)
Thermal correction to Energy= 0.108782
Thermal correction to Enthalpy= 0.109726
Thermal correction to Gibbs Free Energy= 0.069421
Sum of electronic and zero-point Energies= -419.981194
Sum of electronic and thermal Energies= -419.974079
Sum of electronic and thermal Enthalpies= -419.973134
Sum of electronic and thermal Free Energies= -420.013439

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	-0.000000	0.000000	0.237998
2	6	0	0.000000	-0.000000	-2.525563
3	6	0	1.213172	0.000000	-0.447120
4	6	0	-1.213172	-0.000000	-0.447120
5	6	0	-1.209857	-0.000000	-1.835250
6	6	0	1.209857	0.000000	-1.835250
7	1	0	2.142624	0.000000	0.111117
8	1	0	-2.142624	-0.000000	0.111117
9	1	0	-2.146106	-0.000000	-2.379324
10	1	0	2.146106	0.000000	-2.379324
11	1	0	0.000000	-0.000000	-3.609166
12	6	0	-0.000000	0.000000	1.710386
13	8	0	1.027851	0.000000	2.426635
14	8	0	-1.027851	0.000000	2.426635

M062X/6-311+G** Optimized Structure and Energy of CO_2, **9**



9

9

No imaginary frequencies

E(RM062X) = -188.574879675
Zero-point correction= 0.011992 (Hartree/Particle)
Thermal correction to Energy= 0.014595
Thermal correction to Enthalpy= 0.015539
Thermal correction to Gibbs Free Energy= -0.009339
Sum of electronic and zero-point Energies= -188.562888
Sum of electronic and thermal Energies= -188.560285
Sum of electronic and thermal Enthalpies= -188.559341
Sum of electronic and thermal Free Energies= -188.584219

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	-0.000000	0.000000	-0.000000
2	8	0	-0.000000	0.000000	-1.154787
3	8	0	-0.000000	0.000000	1.154787

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1. Frisch, M, J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Scalmani, G.; Barone, V.; Petersson, G. A.; Nakatsuji, H.; Li, X.; Caricato, M.; Marenich, A. V.; Bloino, J.; Janesko, B. G.; Gomperts, R.; Mennucci, B.; Hratchian, H. P.; Ortiz, J. V.; A. Izmaylov, F.; Sonnenberg, J. L.; Williams-Young, D.; Ding, F.; Lipparini, F.; Egidi, F.; Goings, J.; Peng, B.; Petrone, A.; Henderson, T.; Ranasinghe, D.; Zakrzewski, V. G.; Gao, J.; Rega, N.; Zheng, G.; Liang, W.; Hada, M.; Ehara, M.; Toyota, K.; Fukuda, R.; Hasegawa, J.; Ishida, M.; Nakajima, T.; Honda, Y.; Kitao, O.; Nakai, H.; T. Vreven, T.; Throssell, K.; Montgomery Jr., J. A.; Peralta, J. E.; Ogliaro, F.; M. J. Bearpark, M. J.; Heyd, J. J.; Brothers, E. N.; Kudin, K. N.; Staroverov,V. N.; Keith, T. A.; Kobayashi, R.; Normand, J.; Raghavachari, K.; Rendell, A. P.; Burant, J. C.; Iyengar, S. S.; Tomasi, J.; Cossi, M.; Millam, J. M.; Klene, M.; Adamo, C.; Cammi, R.; Ochterski, J. W.; Martin, R. L.; Morokuma, K.; Farkas, O.; J. B. Foresman, J. B.; Fox, D. J. Gaussian 16, Revision B.01, Gaussian, Inc., Wallingford CT, 2016.