

Supplementary Material

First-principle studies of intermolecular and intramolecular catalysis of protonated cocaine

Chang-Guo Zhan,^{*,†,‡} Shi-Xian Deng,[†] Jaime G. Skiba,[§] Beth A. Hayes,[§] Sarah M. Tschampel,[§] George C. Shields,^{*,§} and Donald W. Landry^{*,†}

Division of Clinical Pharmacology and Experimental Therapeutics, College of Physicians & Surgeons, Columbia University, 630 West 168th Street, New York, NY 10032, Department of Pharmaceutical Sciences, College of Pharmacy, University of Kentucky, Rose Street, Lexington, KY 40536, and Department of Chemistry, Hamilton College, 198 College Hill Road, Clinton, NY 13323.

Supporting Information Available. Cartesian coordinates of the geometries optimized at the B3LYP/6-31+G* level and the corresponding energies.

All coordinates in Å and all energies in a.u. (Hartree).

HO⁻

1	8	0.000000	0.000000	0.107908
2	1	0.000000	0.000000	-0.863265
B3LYP/6-31+G*				-75.7966808980

Cocaine protonated (chair conformation)

N	7	-3.394769	0.201048	0.536295
C	6	-3.271754	-1.360659	-1.282852
C	6	-3.379477	-2.144357	0.060041
C	6	-2.976081	-1.130007	1.152357
H	1	-3.517242	-1.259342	2.092679
C	6	-1.461729	-1.056116	1.401499
C	6	-0.689073	-0.853492	0.091684
H	1	-0.691399	-1.772494	-0.500067

* Corresponding authors

† Columbia University

‡ University of Kentucky

§ Hamilton College

C	6	-1.313643	0.261454	-0.805847
H	1	-0.899321	0.158512	-1.811899
C	6	-2.847790	0.069286	-0.883130
H	1	-2.544740	-1.799691	-1.970946
H	1	-4.230350	-1.342795	-1.808486
H	1	-4.396981	-2.510318	0.222421
H	1	-2.723535	-3.018297	0.089584
H	1	-1.234739	-0.244592	2.103124
H	1	-1.134835	-1.987306	1.875882
H	1	-3.302335	0.848093	-1.500377
C	6	-4.857619	0.497138	0.612333
H	1	-5.041226	1.465580	0.142914
H	1	-5.425240	-0.279135	0.099356
H	1	-5.149168	0.537742	1.663624
C	6	-0.960607	1.648853	-0.277085
C	6	1.612162	-0.864996	-0.520879
O	8	1.287969	-1.317681	-1.601174
O	8	0.664008	-0.553156	0.435688
C	6	4.616497	0.115621	1.579825
H	1	4.847049	0.478741	2.577344
C	6	3.290717	-0.114494	1.214673
H	1	2.491033	0.065700	1.924882
C	6	2.993822	-0.590149	-0.074253
C	6	4.032801	-0.832864	-0.989052
H	1	3.788911	-1.204234	-1.979244
C	6	5.355017	-0.599404	-0.617817
H	1	6.156799	-0.788567	-1.325679
C	6	5.647904	-0.125627	0.665828
H	1	6.679950	0.053138	0.955077
O	1	-2.875440	0.994258	0.969294
O	8	-1.542347	2.169379	0.674202
O	8	0.029212	2.213604	-0.940903
C	6	0.484711	3.519164	-0.485134
H	1	-0.334901	4.237312	-0.548093
H	1	0.842391	3.443247	0.543201
H	1	1.292804	3.783826	-1.164306
B3LYP/6-31+G*				-1016.55234388

Cocaine protonated (boat conformation)

1	6	-2.677392	0.352101	0.549318
2	6	-4.004256	-1.036069	-0.973028
3	6	-2.606924	-1.639501	-0.699398
4	7	-2.259317	-1.097800	0.675218
5	8	-0.429152	1.703969	1.653246
6	6	-1.656868	1.101050	-0.350104
7	8	0.562852	0.115509	-1.052624

8	6	-1.501300	-1.174824	-1.677129
9	6	-0.858286	0.208428	-1.369083
10	8	0.396711	-1.374372	0.651126
11	6	2.561432	-0.679124	-0.081768
12	6	3.317236	0.036530	-1.028490
13	6	4.708690	0.006713	-0.966898
14	6	5.350927	-0.730848	0.034157
15	6	4.601681	-1.443022	0.977543
16	6	3.210650	-1.420701	0.921671
17	8	-0.223469	2.976714	-0.208888
18	6	0.725287	3.844857	0.465937
19	6	-2.886516	-1.827043	1.817999
20	1	-2.227926	1.803751	-0.964611
21	6	-4.075266	0.241455	-0.089426
22	1	-2.679231	0.793314	1.546823
23	1	-4.793800	-1.744263	-0.706260
24	1	-4.126397	-0.818188	-2.037168
25	1	-2.620159	-2.730443	-0.648376
26	1	-0.704883	-1.922166	-1.715881
27	1	-1.935079	-1.143117	-2.681263
28	1	-0.796508	0.775980	-2.295850
29	1	2.817179	0.604008	-1.805536
30	1	5.293515	0.555216	-1.699449
31	1	6.436341	-0.751284	0.078197
32	1	5.102775	-2.013824	1.753694
33	1	2.617213	-1.967050	1.647186
34	1	-2.502545	-2.849021	1.823979
35	1	-3.971837	-1.838868	1.715337
36	1	-2.602321	-1.323554	2.744004
37	1	0.965163	4.619119	-0.261029
38	1	0.265487	4.273723	1.358503
39	1	1.615593	3.275848	0.741728
40	1	-4.843976	0.144765	0.682714
41	1	-4.319991	1.140449	-0.660305
42	6	-0.699569	1.949753	0.495633
43	1	-1.215749	-1.165521	0.791817
44	6	1.088277	-0.691226	-0.106544
B3LYP/6-31+G*			-1016.54210876	

TS1_{ben}-Re

1	6	2.660840	0.071103	1.019318
2	6	3.042165	-2.227787	0.218474
3	6	3.024966	-1.211958	-0.948454
4	1	3.185750	0.912899	-0.796591
5	6	1.178535	1.844219	0.013827
6	6	1.224828	0.462650	0.626492

7	8	-0.627751	-0.253473	-0.758714
8	6	1.616902	-0.937280	-1.504052
9	6	0.667886	-0.625703	-0.341843
10	8	-1.396604	-2.397716	-0.631482
11	6	-1.592501	-1.217072	-0.394955
12	6	-2.939072	-0.612027	-0.180216
13	6	-3.112641	0.727781	0.194933
14	6	-4.396811	1.247601	0.356799
15	6	-5.519679	0.436890	0.149833
16	6	-5.349555	-0.900647	-0.218573
17	6	-4.064388	-1.422240	-0.384043
18	8	0.129559	2.561223	0.389290
19	6	-0.041653	3.853480	-0.233338
20	6	4.965851	0.155042	-0.047967
21	1	0.555697	0.385774	1.499585
22	6	2.766412	-1.389496	1.504447
23	1	3.105201	0.797679	1.705632
24	1	4.010437	-2.736345	0.275802
25	1	2.282227	-2.997386	0.060571
26	1	3.733648	-1.451211	-1.746744
27	1	1.649758	-0.122570	-2.240041
28	1	1.255581	-1.832180	-2.021648
29	1	0.548731	-1.511427	0.282020
30	1	-2.236943	1.335457	0.387585
31	1	-4.525708	2.284985	0.658194
32	1	-6.519410	0.845295	0.279861
33	1	-6.216723	-1.537166	-0.379050
34	1	-3.914270	-2.458774	-0.670313
35	1	5.471890	0.113904	-1.015266
36	1	5.298100	-0.673882	0.577842
37	1	5.192194	1.103592	0.444018
38	1	0.819809	4.492343	-0.024161
39	1	-0.161117	3.732913	-1.312514
40	1	-0.947107	4.263199	0.212706
41	1	3.578534	-1.499620	2.230233
42	1	1.830294	-1.671911	1.998477
43	8	2.029737	2.276259	-0.774406
44	7	3.498140	0.070189	-0.268084
45	8	-0.853422	-0.983595	1.793667
46	1	-1.528225	-1.415790	2.339471
B3LYP/6-31+G*				-1092.49274060

TS1_{ben-Si}

1	6	2.926532	-0.194760	0.836503
2	6	2.445198	-2.529371	0.182368
3	6	2.411366	-1.573817	-1.031126

4	1	3.149919	0.429016	-1.121284
5	6	1.726765	1.907114	0.076515
6	6	1.584573	0.576037	0.782762
7	8	-0.706133	0.285993	-0.144820
8	6	1.037806	-0.936898	-1.239250
9	6	0.536870	-0.344028	0.080038
10	6	-1.682330	-0.152875	0.767358
11	8	-1.151513	-2.341403	0.069119
12	6	-3.053009	-0.137244	0.182406
13	6	-4.144149	-0.103075	1.061909
14	6	-5.449334	-0.071328	0.566860
15	6	-5.675027	-0.066774	-0.812930
16	6	-4.587402	-0.098205	-1.693977
17	6	-3.283282	-0.135058	-1.200740
18	8	1.011042	2.872320	0.636604
19	6	0.962374	4.142266	-0.052092
20	6	4.808767	-0.760366	-0.763786
21	1	1.231728	0.752068	1.802687
22	6	2.787528	-1.624525	1.405235
23	1	3.705536	0.397756	1.325345
24	1	3.196117	-3.315470	0.051256
25	1	1.462740	-3.004909	0.286470
26	1	2.805287	-2.012511	-1.952354
27	1	1.073965	-0.189684	-2.044000
28	1	0.306958	-1.713714	-1.494437
29	1	0.332761	-1.186979	0.745280
30	1	-3.950865	-0.106534	2.130291
31	1	-6.289365	-0.048457	1.257339
32	1	-6.691061	-0.042946	-1.200464
33	1	-4.758436	-0.105681	-2.768092
34	1	-2.437301	-0.190870	-1.875311
35	1	5.014226	-0.931058	-1.822883
36	1	5.062836	-1.654229	-0.193211
37	1	5.396590	0.088804	-0.407801
38	1	1.964451	4.572180	-0.123374
39	1	0.544180	4.004789	-1.051665
40	1	0.311334	4.767671	0.557270
41	1	3.722412	-1.934037	1.883981
42	1	2.006391	-1.656606	2.169038
43	8	2.413435	2.076838	-0.935384
44	7	3.363527	-0.448704	-0.604942
45	8	-1.440081	-0.177579	1.963595
46	1	-1.838560	-2.889581	0.479266
B3LYP/6-31+G*				-1092.49069486

TS1_{met}

1	6	-2.747811	-0.258630	-0.872243
2	6	-1.295589	0.262854	-0.863559
3	6	-2.944913	-1.702377	-1.382045
4	1	-3.381782	0.499996	-1.328088
5	7	-3.140603	-0.360885	0.597421
6	6	-2.820357	-2.614232	-0.125571
7	6	-2.447978	-1.643837	1.016204
8	6	-1.161912	1.575017	-0.053872
9	6	-0.398814	-0.844142	-0.260926
10	6	-4.612430	-0.298070	0.825461
11	1	-0.995247	0.460501	-1.896686
12	1	-3.932341	-1.803452	-1.843072
13	1	-2.212903	-1.952139	-2.155601
14	8	0.940126	-0.328430	-0.105795
15	6	-0.934526	-1.371896	1.085963
16	1	-3.764764	-3.125954	0.085947
17	1	-2.054897	-3.388021	-0.235004
18	1	-2.830516	-1.950808	1.993760
19	1	-0.335787	-1.671376	-0.971988
20	1	-4.804301	-0.424567	1.894173
21	1	-5.115705	-1.084611	0.260679
22	1	-4.908988	0.700121	0.489497
23	6	1.960524	-1.215981	-0.183566
24	1	-0.721107	-0.635947	1.864724
25	1	-0.424200	-2.307300	1.338715
26	8	1.793708	-2.412282	-0.354062
27	6	3.291975	-0.563665	-0.040128
28	6	3.428116	0.822122	0.137064
29	6	4.433698	-1.377877	-0.089123
30	6	4.699366	1.383649	0.263317
31	6	5.701359	-0.811760	0.037676
32	1	2.542736	1.447327	0.173287
33	1	4.309135	-2.447323	-0.227283
34	6	5.835591	0.569792	0.214211
35	1	4.803515	2.456782	0.399790
36	1	6.583554	-1.445303	-0.000865
37	1	6.824150	1.011286	0.313124
38	1	-2.735297	0.482587	1.058278
39	8	-1.143459	1.569955	1.181232
40	8	-0.585276	2.545415	-0.798723
41	8	-3.336490	2.153931	-0.292015
42	1	-3.369439	3.116093	-0.182728
43	6	-0.327938	3.774248	-0.109364
44	1	-1.265173	4.195377	0.266729
45	1	0.355814	3.614613	0.729773
46	1	0.118727	4.438318	-0.851201

B3LYP/6-31+G*

-1092.52107808

TS1_{ben}-boat

1	6	2.706540	0.194826	-0.683316
2	6	3.822439	-1.519211	0.702815
3	6	2.307851	-1.768322	0.572850
4	7	2.011008	-1.155588	-0.794508
5	8	1.155059	2.328801	-1.733764
6	6	1.860753	1.101681	0.250645
7	8	-0.326140	0.140105	0.166125
8	6	1.442114	-0.999512	1.604404
9	6	0.821640	0.294792	1.066305
10	8	-0.577531	-2.087553	-0.072041
11	6	-2.547745	-0.729263	-0.063784
12	6	-3.197674	0.326643	0.590456
13	6	-4.551136	0.555013	0.342377
14	6	-5.254790	-0.255502	-0.558614
15	6	-4.606334	-1.312206	-1.204302
16	6	-3.254463	-1.554299	-0.951253
17	8	0.625203	3.102925	0.325492
18	6	-0.180380	4.150009	-0.252225
19	6	2.427865	-1.973032	-1.966699
20	1	2.526795	1.570692	0.984534
21	6	4.078966	-0.201822	-0.090340
22	1	2.763253	0.634385	-1.680523
23	1	4.402083	-2.347473	0.280912
24	1	4.104078	-1.439484	1.755520
25	1	2.031433	-2.822771	0.530467
26	1	0.624137	-1.588977	2.024617
27	1	2.068988	-0.702970	2.454037
28	1	0.418186	0.839342	1.919488
29	1	-2.630554	0.876453	1.336720
30	1	-5.067095	1.357846	0.863446
31	1	-6.309158	-0.068754	-0.750259
32	1	-5.150492	-1.945933	-1.900601
33	1	-2.737822	-2.375827	-1.439111
34	1	1.872265	-2.912269	-1.939252
35	1	3.499685	-2.168696	-1.931313
36	1	2.181261	-1.423094	-2.877721
37	1	-0.581953	4.700077	0.598608
38	1	0.434378	4.798685	-0.881539
39	1	-0.987168	3.712483	-0.844787
40	1	4.815389	-0.359200	-0.885040
41	1	4.467093	0.600331	0.542473
42	6	1.182038	2.230507	-0.521818
43	6	-1.101119	-0.992421	0.128273

44	8	-1.108800	-0.312861	2.689148
45	1	-1.688531	-0.448225	3.454816
46	1	0.984976	-1.056119	-0.848263
B3LYP/6-31+G*			-1092.47550320	