Supporting Information

Understanding ring-closing and racemization to prepare α-amino acid NCA and NTA monomers: A DFT study

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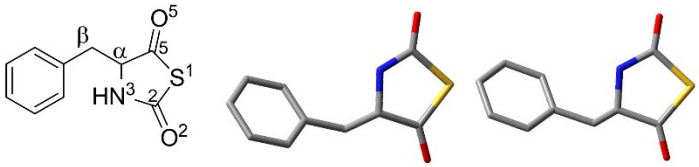

DL-Phe-NTA **X-Ray result** **DFT calculation**

	DFT calculation	X-Ray result
S^1-C^5 (Å)	1.78	1.77
S^1-C^2 (Å)	1.82	1.80
C^2-N^3 (Å)	1.36	1.33
N^3-C^α (Å)	1.44	1.45
C^α-C^β (Å)	1.54	1.53
Angle C^2-S^1-C^5 (°)	91.9	91.7

Figure S1. Comparison of DFT calculated geometry and single crystal structure of DL-phenylalanine-NTA with 3-D tube structure (hydrogen atoms are omitted for clarity), selected bond lengths and angles. The X-Ray result shows that DL-phenylalanine-NTA is cocrystal, and here only L-isomer is demonstrated to estimate reliability of DFT calculations.

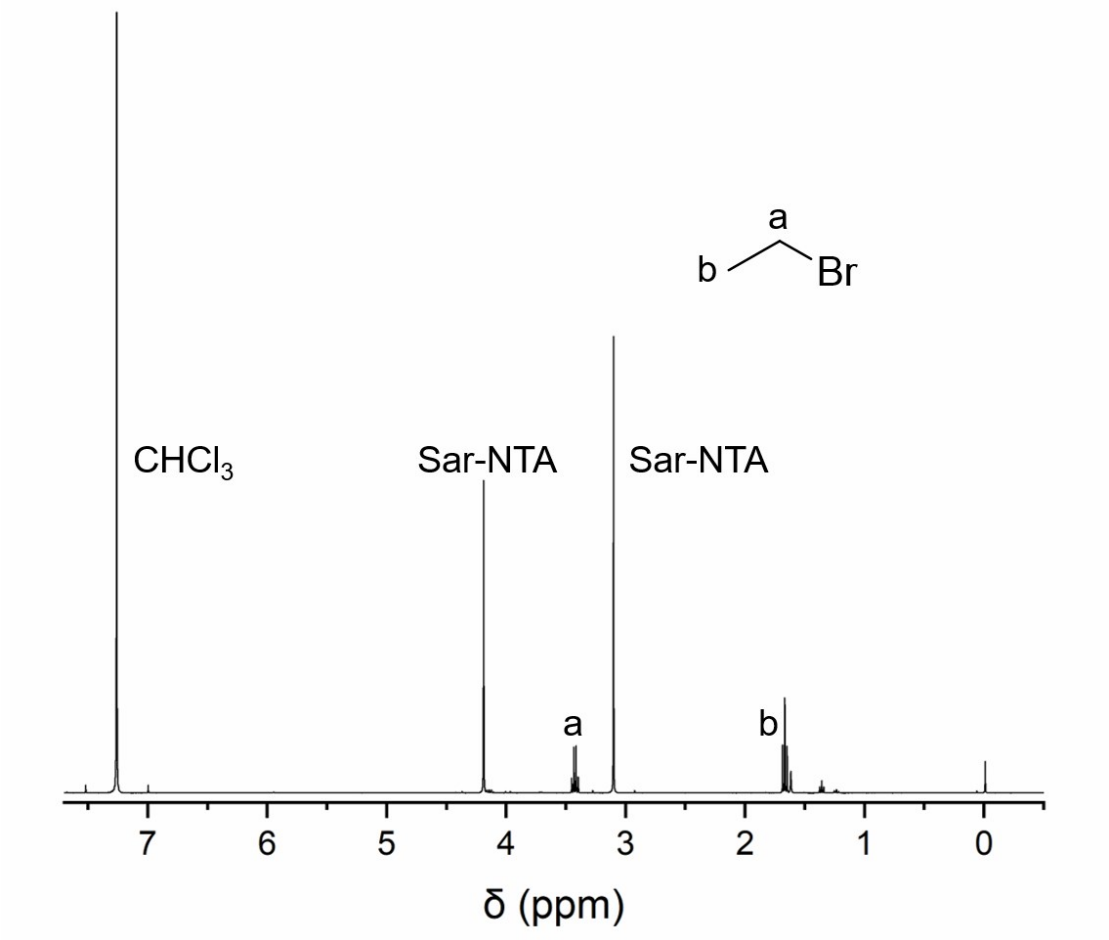

Figure S2. ^{1}H NMR spectrum of EtBr produced in preparation of sarcosine-NTA (Sar-NTA) mediated by PBr_3. The Sar-NTA was prepared according to the report with the assignment of protons.[1]

Table S1. DFT calculated ΔGs on ring-closing pathway of Ala-NTA with PBr_3 and PCl_3 using M06-2X/6-311++G(d,p), B3PW91/6-311++G(d,p) and BHandH/6-311++G(d,p)

	$\Delta G_{TS1\_Cl} - \Delta G_{TS1}$	$\Delta G_{2\_Cl} - \Delta G_2$
M06-2X/6-311++G(d,p)	+1.5	+0.5
B3PW91/6-311++G(d,p)	+0.6	+0.6
BHandH/6-311++G(d,p)	+1.7	+1.6

According to RRKM theory,[2] a ΔG difference of 1.5 kcal/mol means a reactivity difference $k_{fast} / k_{slow} = \exp(\Delta\Delta G/RT) = 13$ at room temperature which is not negligible in experiments.

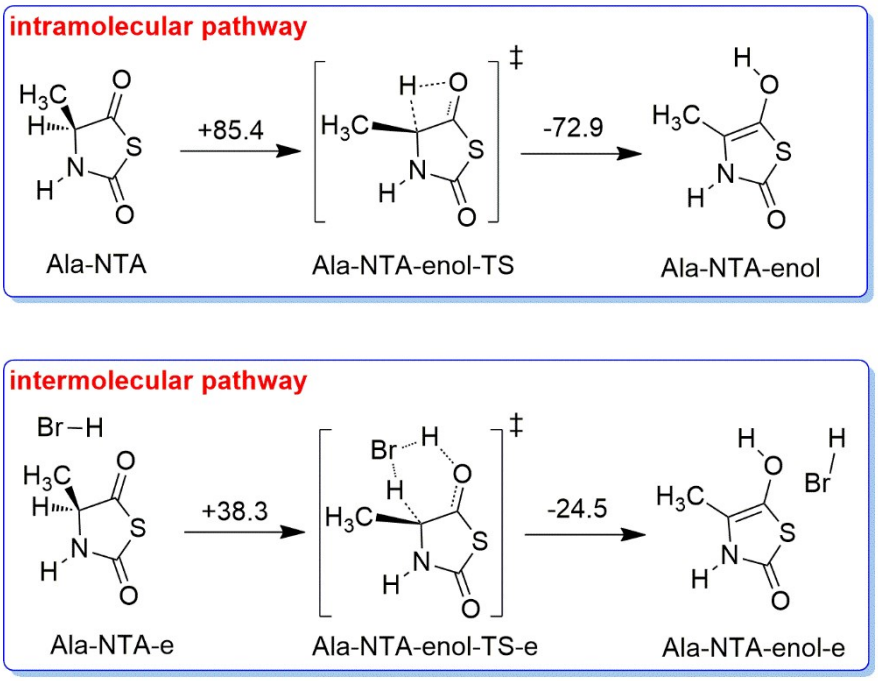

Figure S3. DFT calculated enol transformation of Ala-NTA with ΔG (kcal/mol) under M06-2X/6-311++G(d,p) in DCM via intra- and intermolecular pathways.

Optimized geometries by M06-2X/6-311++G(d,p) in DCM

1

N	-0.566511	0.536035	-0.843670
C	0.767498	1.032351	-1.110016
H	1.036278	0.638842	-2.096718
C	0.883600	2.551564	-1.134930
C	1.823069	0.417075	-0.187918
H	0.162516	2.943399	-1.853760
H	0.685707	2.978365	-0.153094
O	2.781154	0.941513	0.238883
C	-1.171844	0.572376	0.353984
S	-0.461883	1.172874	1.743233
O	-2.399366	0.079310	0.429671
H	1.886453	2.838177	-1.452807
Br	1.614352	-1.558221	0.034018
C	-3.059746	-0.498652	-0.719271
H	-3.147350	0.263830	-1.498704
H	-2.461298	-1.338254	-1.085357
C	-4.417754	-0.963885	-0.254515
H	-5.004786	-0.123726	0.119614
H	-4.949215	-1.415906	-1.094070
H	-4.316539	-1.709302	0.535920
H	-1.041640	0.112528	-1.630122

2

N	-0.580368	0.517029	-0.941195
C	0.769550	0.974633	-1.172427
H	1.084742	0.535872	-2.127050
C	0.894493	2.491608	-1.294879
C	1.812551	0.408645	-0.201954
H	0.224709	2.823123	-2.089416
H	0.618077	3.012939	-0.377084
O	2.706641	0.978244	0.306262
C	-1.168394	0.578347	0.174156
S	-0.641190	1.190510	1.774329
O	-2.402826	0.108299	0.351640
H	1.916239	2.766564	-1.558647
Br	1.647039	-1.555549	0.064355
H	0.454280	1.841260	1.356533
C	-3.023277	-0.563065	-0.766907
H	-3.122253	0.150976	-1.586805

H	-2.366679	-1.373966	-1.089095
C	-4.362339	-1.068992	-0.289552
H	-4.994914	-0.242974	0.040880
H	-4.865653	-1.582527	-1.111351
H	-4.239348	-1.773811	0.534872

3

N	0.502278	-0.978307	-0.946717
C	-0.847821	-1.494167	-0.971794
H	-1.475785	-0.844146	-1.590363
C	-0.896295	-2.924195	-1.509667
C	-1.448859	-1.471748	0.437661
H	-0.498741	-2.940088	-2.524850
H	-0.290620	-3.582096	-0.881661
O	-2.563524	-1.761040	0.743075
C	0.912682	-0.706726	0.215744
S	-0.170706	-0.962402	1.618575
O	2.093078	-0.218753	0.546995
H	-1.925261	-3.285880	-1.523436
Br	-1.189386	2.314133	-0.241690
H	-0.798307	1.713024	0.991733
C	3.012523	0.028152	-0.546404
H	3.180978	-0.915389	-1.069392
H	2.541345	0.732749	-1.234967
C	4.279481	0.578864	0.057729
H	4.715440	-0.134807	0.759315
H	5.003051	0.768390	-0.737628
H	4.085084	1.517421	0.580050

4

N	-0.348370	-0.154943	-0.102881
C	-1.210474	-1.326101	-0.185368
H	-1.020048	-1.841215	-1.132139
C	-1.007157	-2.264129	1.000361
C	-2.643613	-0.818955	-0.223299
H	0.026022	-2.613511	1.003908
H	-1.216765	-1.743403	1.936826
O	-3.625992	-1.475986	-0.310419
C	-0.925159	1.002542	-0.033731
S	-2.675814	1.000703	-0.073241
O	-0.347994	2.148582	0.056313
H	-1.677414	-3.118300	0.900786
Br	2.609576	-1.157474	-0.135736
C	1.121925	2.191871	0.095251

H	1.441389	1.597025	0.952854
H	1.484607	1.730556	-0.825161
C	1.512562	3.638968	0.214575
H	2.602012	3.700341	0.245708
H	1.157057	4.210056	-0.644292
H	1.113749	4.074400	1.131907
H	0.709205	-0.336946	-0.101497

5

N	0.755824	-0.318695	-0.144107
C	1.827352	-1.104527	0.430147
H	1.609871	-1.332791	1.478548
C	2.101670	-2.385861	-0.351181
C	3.065476	-0.216277	0.427787
H	1.210181	-3.015320	-0.345873
H	2.365379	-2.149809	-1.384521
O	4.133932	-0.539558	0.852889
C	0.982869	0.926542	-0.595596
S	2.723536	1.372026	-0.324289
O	0.191164	1.682568	-1.101347
H	2.921047	-2.933190	0.116272
Br	-2.818296	-0.761434	-0.137234
C	-2.765957	1.200383	0.133053
H	-3.810068	1.503592	0.132028
H	-2.254812	1.584056	-0.745187
C	-2.054334	1.553301	1.416178
H	-1.019984	1.205279	1.409102
H	-2.045225	2.643204	1.513749
H	-2.563191	1.133856	2.285402
H	-0.183409	-0.695665	-0.233636

d_TS1

N	0.312465	-0.865925	-1.158202
C	-1.013581	-1.345479	-0.830329
H	-1.706575	-1.029909	-1.609793
C	-1.447103	-0.660900	0.474511
O	-2.330622	-0.966620	1.192309
C	1.114154	-0.472803	-0.187957
S	0.483762	-0.445641	1.390955
O	2.311903	-0.107702	-0.546521
Br	-1.670283	1.575982	-0.248342
C	3.235758	0.411616	0.453448
H	2.785429	1.302049	0.894711
H	3.367659	-0.354590	1.219691

C	4.524350	0.721236	-0.262731
H	4.365947	1.470647	-1.039929
H	5.240537	1.117371	0.459635
H	4.945979	-0.179736	-0.711172
H	0.617405	-0.796329	-2.124076
C	-1.043012	-2.857629	-0.635193
H	-2.056773	-3.176263	-0.390378
H	-0.731084	-3.343055	-1.561126
H	-0.369698	-3.159492	0.169732

r_TS1

N	0.313463	1.252907	0.179089
C	-0.609430	0.785836	1.192550
H	-0.239108	-0.077419	1.747593
C	-0.968806	1.913334	2.147714
C	-1.870963	0.285684	0.479374
H	-0.068462	2.218599	2.682486
H	-1.360381	2.769070	1.595415
O	-2.976325	0.654365	0.605746
C	1.346185	0.684322	-0.384819
S	1.772785	1.652625	-1.774040
O	2.039380	-0.383072	-0.093526
H	-1.715261	1.580228	2.869547
Br	-1.472351	-1.197344	-0.799126
H	0.504729	2.123990	-0.916331
C	1.943212	-1.042000	1.196433
H	1.915119	-0.275214	1.973696
H	1.027233	-1.635826	1.214217
C	3.162745	-1.919523	1.325551
H	4.073881	-1.319686	1.302801
H	3.118433	-2.454426	2.276196
H	3.195204	-2.650891	0.516239

r_TS2

N	-0.727552	0.910101	-0.810777
C	0.588840	1.442441	-0.915902
H	1.085246	1.031242	-1.799381
C	0.584277	2.972886	-0.940306
C	1.513192	1.030761	0.240929
H	-0.052912	3.289495	-1.766808
H	0.177658	3.371122	-0.007671
O	2.552323	1.306782	0.640179
C	-1.116932	0.416728	0.277530
S	-0.040390	0.383389	1.735659

O	-2.292454	-0.122291	0.510725
H	1.592590	3.356851	-1.095682
Br	1.636013	-1.647117	-0.370146
H	0.471345	-0.853711	1.389467
C	-3.205305	-0.190954	-0.619220
H	-3.410553	0.829641	-0.948318
H	-2.701088	-0.727913	-1.424780
C	-4.444774	-0.902779	-0.142167
H	-4.920673	-0.355440	0.673401
H	-5.153034	-0.975688	-0.969819
H	-4.204680	-1.911874	0.197198

TS3

N	-1.193637	-0.525817	-0.345919
C	-2.441095	-1.270120	-0.394387
H	-2.583485	-1.683892	-1.396908
C	-2.507963	-2.364291	0.665223
C	-3.553075	-0.255864	-0.169101
H	-1.708856	-3.087403	0.496725
H	-2.399028	-1.932909	1.662442
O	-4.718005	-0.497551	-0.160739
C	-1.216824	0.775321	-0.089144
S	-2.874817	1.390310	0.127472
O	-0.255014	1.544534	0.003646
H	-3.467275	-2.877753	0.594573
Br	3.724765	-0.689372	-0.033743
C	1.556098	0.864508	-0.023241
H	1.333582	0.180274	0.779755
H	1.471623	0.504723	-1.038345
C	2.212974	2.178260	0.238283
H	2.243107	2.399084	1.304374
H	3.228338	2.159146	-0.152797
H	1.665555	2.965150	-0.283523
H	-0.314335	-1.005397	-0.512476

Optimized geometries by M06-2X/6-311++G(d,p) for Phe-NTA

S	-3.272361	0.122163	0.140506
O	-2.308757	-2.352762	0.144535
O	-2.280226	2.550145	-0.357279
N	-0.847005	0.775481	-0.567986
H	-0.048169	1.365195	-0.763459
C	2.498312	-1.175430	-0.448028
H	2.164094	-2.124966	-0.855398

C	3.746163	-0.673496	-0.796086
H	4.381411	-1.230552	-1.474508
C	4.181605	0.539687	-0.269599
C	3.365019	1.242860	0.608485
H	3.700433	2.184614	1.026770
C	2.115381	0.737056	0.956592
H	1.483702	1.284746	1.649124
C	1.669200	-0.476491	0.431709
C	0.291641	-0.999015	0.749678
H	-0.077921	-0.569968	1.685273
H	0.298626	-2.086273	0.854947
C	-0.698047	-0.645493	-0.375235
H	-0.384871	-1.132777	-1.304952
C	-2.080209	-1.194442	-0.025283
C	-2.034661	1.380866	-0.307014
H	5.154944	0.931338	-0.539351

References

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2. Marcus, R. A.; Rice, O. K. *J. Phys. Chem.* **1951**, 55, 894−908.