Electronic supplementary materials *Mendeleev Commun.*, 2024, **34**, 279–281

Unexpected transamination between 2-aminoazoles and *N*-iodoacetyl azoles

Nina O. Yarosh, Ivan A. Dorofeev, Larisa V. Zhilitskaya and Bagrat A. Shainyan

1. General Information

NMR spectra were registered on a Bruker DPX 400 spectrometer at working frequencies 400.13 MHz (^{1}H) and 100.61 MHz (^{13}C) in DMSO-d_6 Chemical shifts are given in parts per million (ppm) relative to the residual signals of the solvent (DMSO: H 2.49, C 39.5). Coupling constants are reported in hertz (Hz). Abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; br.s, broad singlet. Melting points were determined on a Micro-Hot-Stage PolyTherm A. The (C, H, N) microanalyses were performed on a Flash EA 1112 CHNS-O/MAS (CHN Analyzer) instrument. The iodine was determined by mercurimetric titration. The sulfur was determined by combustion followed by iodometric titration of the released sulfur dioxide. The reactions were monitored by ^{1}H and ^{13}C NMR spectroscopy, and by TLC on Silufol UV-254 plates with acetone as eluent, visualized by iodine vapors. The mass spectra were obtained on a Shimadzu GCMS-QP5050A instrument, injector temperature 200–250°C, carrier gas helium, detector temperature 290°C, quadrupole mass analyzer, electron ionization (70 eV).

2. Synthesis of compouds 3

2-Iodo-*N*-(1,3-thiazol-2-yl)acetamide (**3a**) was obtained from 2-aminothiazole **1a** (100 mg, 1 mmol) and 1-(1*H*-1,2,3-benzotriazol-1-yl)-2-iodoethan-1-one **2b** (290 mg, 1 mmol) or 1-(pyrazol-1-yl)-2-iodoethan-1-one **2a** (240 mg, 1 mmol). Yield: 201 mg (76%), light yellow powder, m. p. 172–175°C. ^{1}H NMR, δ: 3.92 (s, 2H, CH_2), 7. 24 (d, 1H, H^5, ^3J = 3.0 Hz), 7.49 (d,1H, H^4, ^3J = 3.0 Hz), 12.41 (br.s, 2H, NH_2). ^{13}C NMR, δ: –1.18 (CH_2), 113.96 (C^5), 137.85 (C^4), 157.80 (C^2), 167.00 (C=O). Mass spectrum, m/z (I_{rel}, %): 268 $[M]^+$ (4), 169 $[CH_2ICO]^+$ (4), 141 $[M – I]^+$ (8), 127 $[M – CH_2I]^+$ (7), 100 $[M – CHI=C=O]^+$ (100), 158 $[C_2H_2S]^+$ (15). Anal. Calcd for $C_5H_5N_2IOS$: C, 22.40; H, 1.87; N, 10.45; I, 47.34; S, 11.96. Found: C, 22.36; H, 1.79; N, 10.42; I, 47.48; S, 11.75.

***N*-(1,3-Benzothiazol-2-yl)-2-iodoacetamide** (**3b**) was obtained from 2-aminobenzothiazole **1b** (150 mg, 1 mmol) and 1-(1*H*-1,2,3-benzotriazol-1-yl)-2-iodoethan-1-one **2b** (290 mg, 1 mmol) or 1-(pyrazol-1-yl)-2-iodoethan-1-one **2a** (240 mg, 1 mmol). Yield: 240 mg (74%), light yellow powder, m. p. 193–195°C.

^{1}H NMR, δ: 3.98 (s, 2H, CH_2), 7.31 (d.d, 1H, H^6, ^3J = 6.9 Hz, ^3J = 7.5 Hz, ^3J 8.0 Hz), 7.44 (d.d, 1H, H^5, ^3J = 6.9 Hz, ^3J = 8.0 Hz), 7.75 (d, 1H, H^7, ^3J = 8.0 Hz), 7.97 (d, 1H, H^4, ^3J = 7.5 Hz), 12.66

(br.s, 2H, NH_2). ^{13}C NMR, δ: –1.19 (CH_2), 120.64.27 (C^4), 121.73 (C^7), 123.70 (C^6), 126.19 (C^5), 131.47 (C^8), 148.46 (C^9), 157.74 (C^2), 167.97 (C=O). Mass spectrum, *m/z* (I_{rel},%): 318 $[M]^+$ (5), 191 $[M – I]^+$ (1), 177 $[M – CH_2I]^+$ (5), 150 $[M – CHI=C=O]^+$ (100), 108 $[C_6H_4S]^+$ (8). Anal. Calcd for $C_9H_7N_2IOS$: C, 33.97; H, 2.22; N, 8.80; I, 39.89; S, 10.07. Found: C, 33.86; H, 2.27; N, 7.42; I, 33.79; S, 10.03.

***N*-(5-Bromo-1,3-benzothiazol-2-yl)-2-iodoacetamide** (**3c**) was obtained from 5-bromo-2-amino-benzothiazole **2c** (230 mg, 1 mmol) and 1-(1*H*-1,2,3-benzotriazol-1-yl)-2-iodoethan-1-one **2b** (290 mg, 1 mmol) or 1-(pyrazol-1-yl)-2-iodoethan-1-one **2a** (240 mg, 1 mmol). Yield: 290 mg (72%), light yellow powder, m. p. 225–227 °C.

^1H NMR, δ: 3.97 (s, 2H, CH_2), 7.57 (d.d 1H, H^6, ^4J = 1.9 Hz, ^3J 8.6 Hz), 7.69 (d, 1H, H^7, ^3J = 8.6 Hz), 8.25 (d, 1H, H^4, ^4J = 1.9 Hz), 12.67 (br.s, 2H, NH_2). ^{13}C NMR, δ: –1.36 (CH_2), 115.68 (C^8), 122.29 (C^7), 124.34 (C^4), 129.26 (C^6), 133.76 (C^5), 147.69 (C^9), 158.0 (C^2), 168.27 (C=O). Mass spectrum, *m/z* (I_{rel}, %): 398 $[M]^+$ (16) (^{81}Br), 396 $[M]^+$ (15), 271 $[M – I]^+$ (1), 257 $[M – CH_2I]^+$ (2), 230 $[M – CHI=C=O]^+$ (100) (^{81}Br). Anal. Calcd for $C_9H_6N_2BrIOS$: C, 27.23; H, 1.52; N, 7.06; I, 31.96; S, 8.07. Found: C, 27.26; H, 1.55; N, 7.02; I, 31.84; S, 8.05.

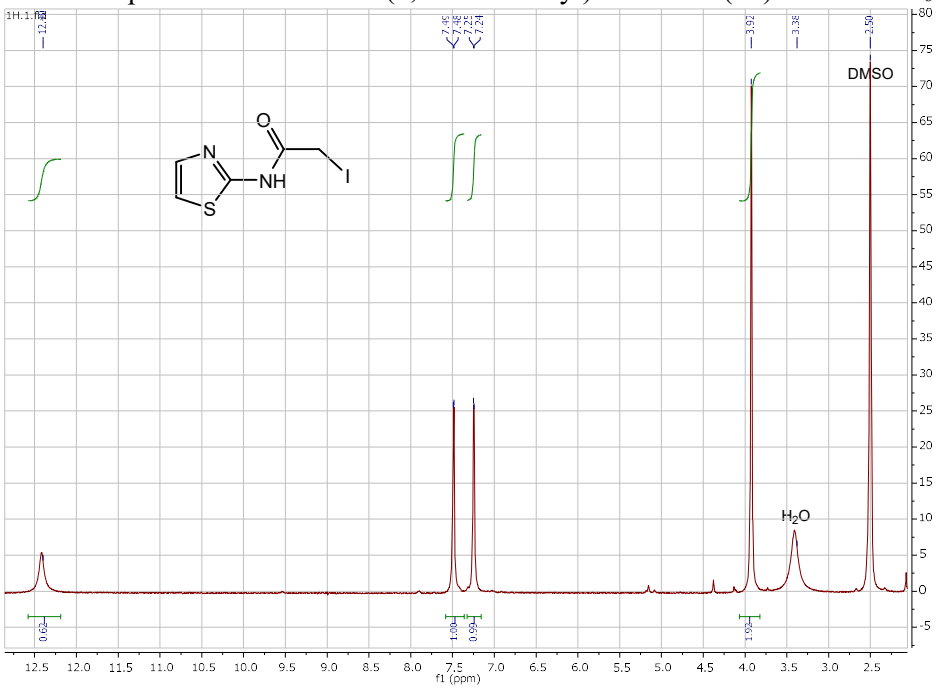
***N*-(1*H*-Benzimidazol-2-yl)-2-iodoacetamide** (**3d)** was obtained from 2-aminobenzimidazole **1d** (130 mg, 1 mmol) and 1-(1*H*-1,2,3-benzotriazol-1-yl)-2-iodoethan-1-one **2b** (290 mg, 1 mmol) or 1-(pyrazol-1-yl)-2-iodoethan-1-one **2a** (240 mg, 1 mmol). Yield: 203 mg (75%), light yellow powder, m. p. 179–182°C.

^1H NMR, δ: 3.93 (s, 2H, CH_2), 7.03–7.15 (m, 2H, $H^{5,6}$), 7.37–7.53 (m, 2H, $H^{4,7}$), 11.98 (br.s, 2H, NH_2). ^{13}C NMR, δ: 0.34 (CH_2), 113.79 ($C^{4,7}$), 121.44 ($C^{5,6}$), 135.95 ($C^{8,9}$), 146.60 (C^2), 168.86 (C=O). Mass spectrum, *m/z* (I_{rel}, %): 301 $[M]^+$ (5), 175 $[M+H – I]^+$ (3), 160 $[M – CH_2I]^+$ (13), 133 $[M – CHI=C=O]^+$ (100), 108 $[C_7H_5N_2]^+$ (19). Anal. Calcd for $C_9H_8N_3IO$: C, 35.90; H, 2.68; N, 13.96. I, 42.15; Found: C, 35.96; H, 2.62; N, 13.92. I, 42.24.

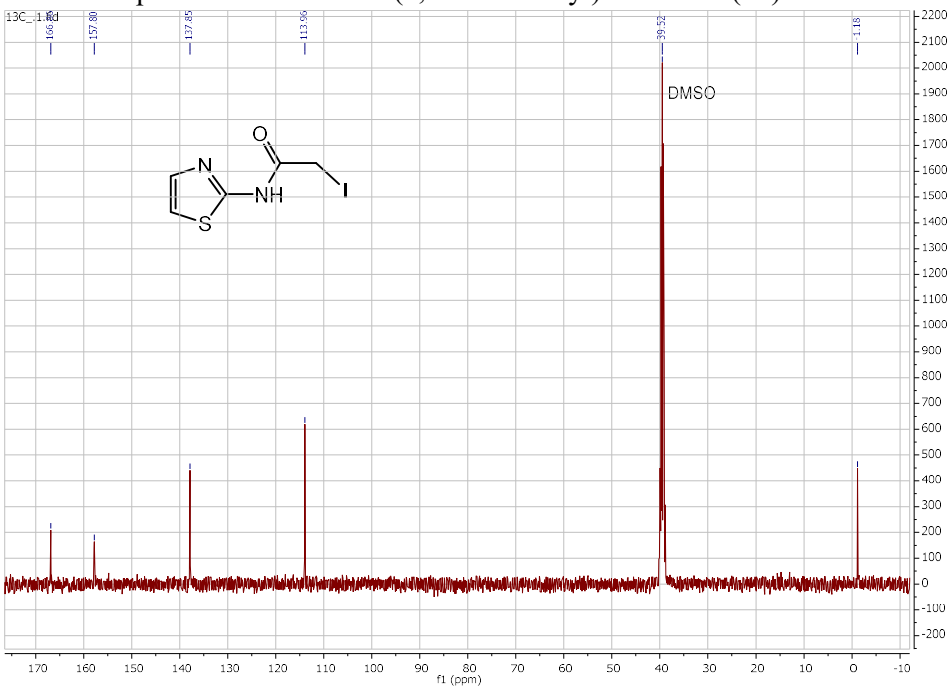
2-Oxo-2,3-dihydroimidazo[1,2-*a*][3,1]benzimidazol-9-ium iodide (**4**) was obtained from *N*-(1*H*-benzimidazol-2-yl)-2-iodoacetamide **3d** (301 mg, 1 mmol). Yield: 110 mg (35%), yellow powder, m. p. 170–175 °C. ^1H NMR, δ: 4.25 (s, 2H, CH_2), 7.35–7.44 (m, 2H, $H^{5,6}$), 7.64–7.83 (m, 2H, $H^{4,7}$), 8.39 (br.s, H, NH). ^{13}C NMR, δ: 62.12 (CH_2), 114.19 ($C^{4,7}$), 125.02 ($C^{5,6}$), 130.01 ($C^{8,9}$), 143.69 (C^2), 173.30 (C=O). Anal. Calcd for $C_9H_8N_3IO$: C, 35.90; H, 2.68; N, 13.96; I, 42.15. Found: C, 36.06; H, 2.57; N, 14.02; I, 42.09.

3. NMR and Mass Spectra of the synthesized compounds

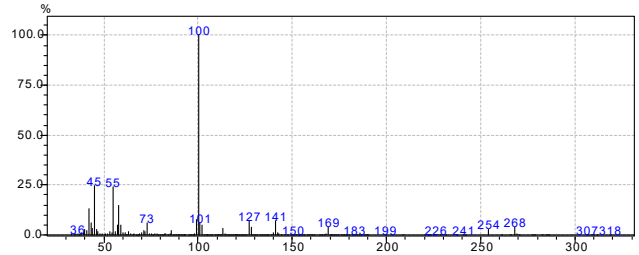
^{1}H NMR spectrum of 2-iodo-*N*-(1,3-thiazol-2-yl)acetamide (**3a**) in DMSO-d$_6$



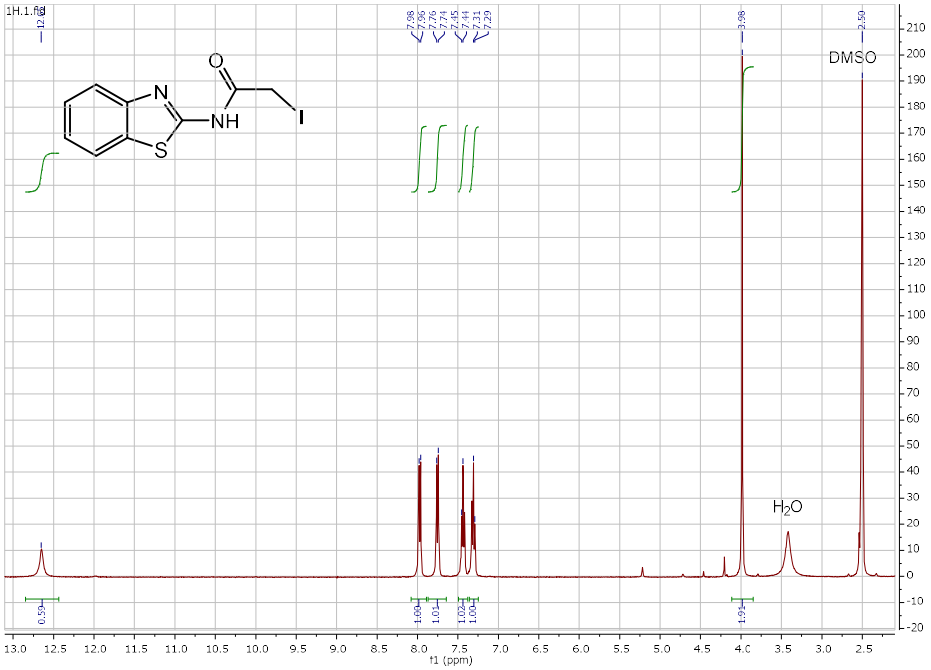
^{13}C NMR spectrum of 2-iodo-*N*-(1,3-thiazol-2-yl)acetamide (**3a**) in DMSO-d6



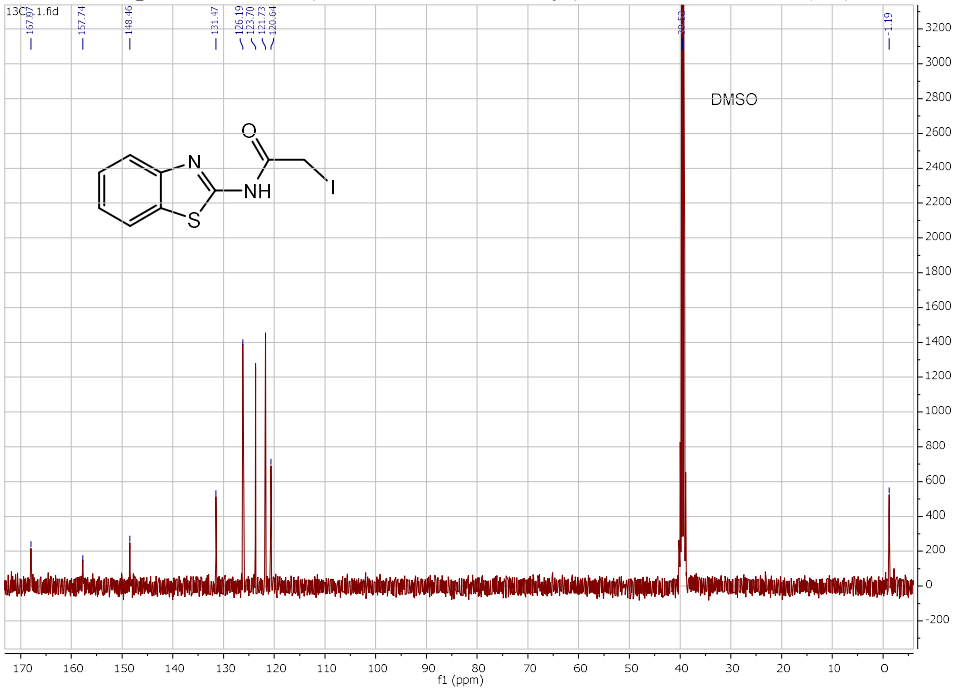
Mass spectrum of 2-iodo-*N*-(1,3-thiazol-2-yl)acetamide (**3a**)



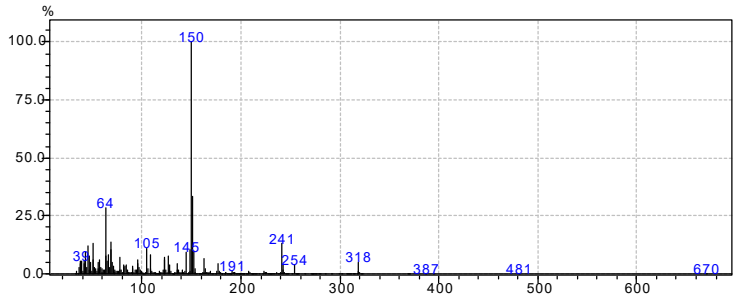
^{1}H NMR spectrum of *N*-(1,3-benzothiazol-2-yl)-2-iodoacetamide (**3b**) in DMSO-d_6



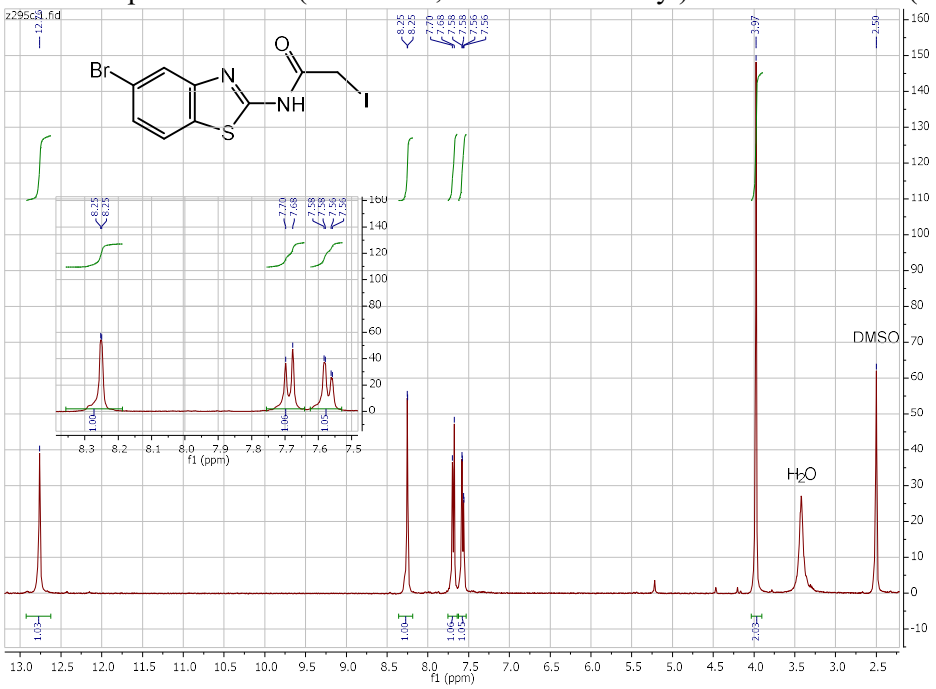
^{13}C NMR spectrum of *N*-(1,3-benzothiazol-2-yl)-2-iodoacetamide (**3b**) in DMSO-d_6



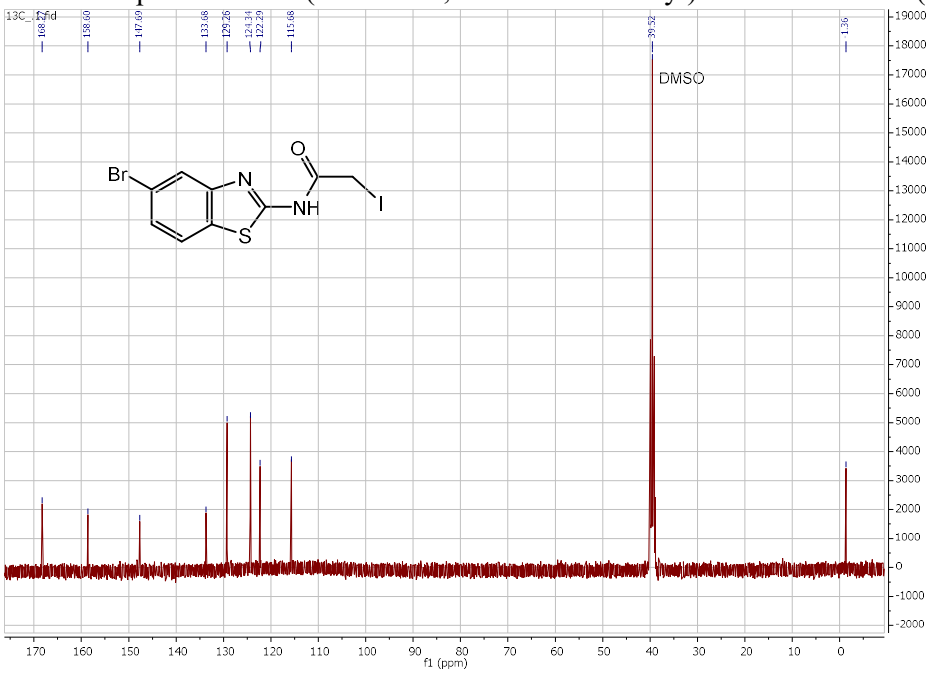
Mass spectrum of *N*-(1,3-benzothiazol-2-yl)-2-iodoacetamide (**3b**)



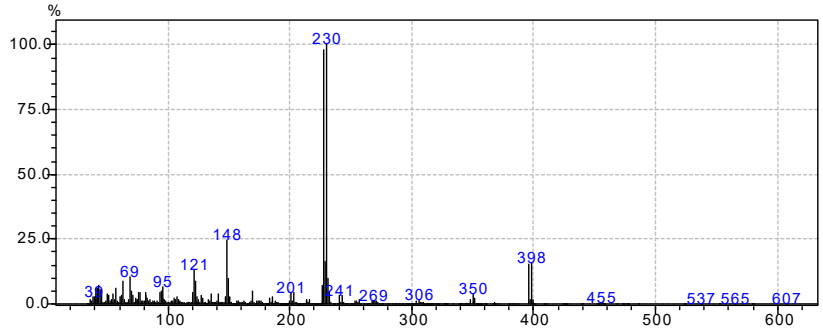
^{1}H NMR spectrum of *N*-(5-bromo-1,3-benzothiazol-2-yl)-2-iodoacetamide (**3c**) in DMSO-*d*$_6$



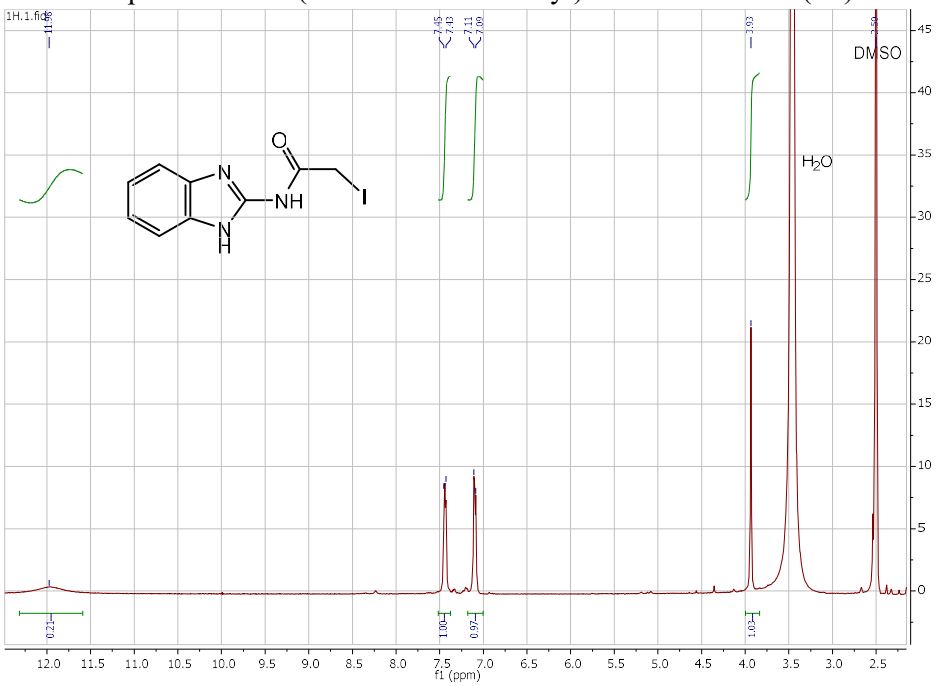
^{13}C NMR spectrum of *N*-(5-bromo-1,3-benzothiazol-2-yl)-2-iodoacetamide (**3c**) in DMSO-*d*$_6$



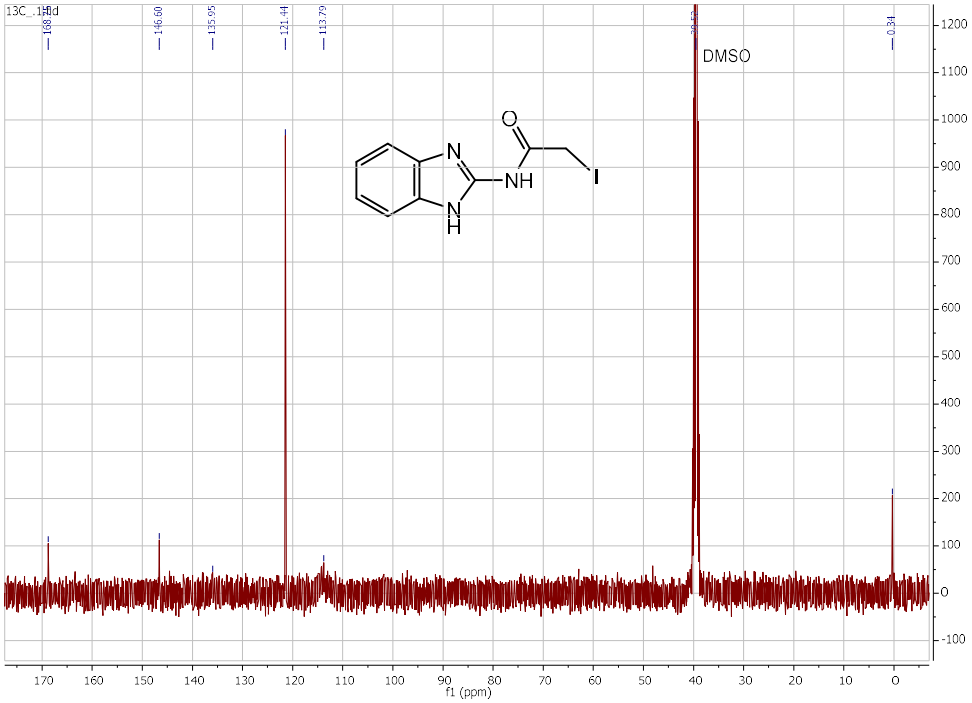
Mass spectrum of *N*-(5-bromo-1,3-benzothiazol-2-yl)-2-iodoacetamide (**3c**)



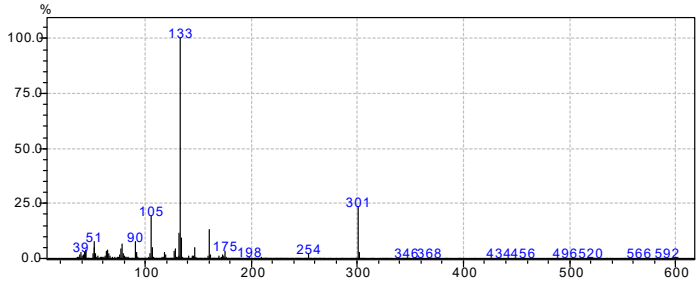
^{1}H NMR spectrum of *N*-(1*H*-benzimidazol-2-yl)-2-iodoacetamide (**3d**) in DMSO-d_6



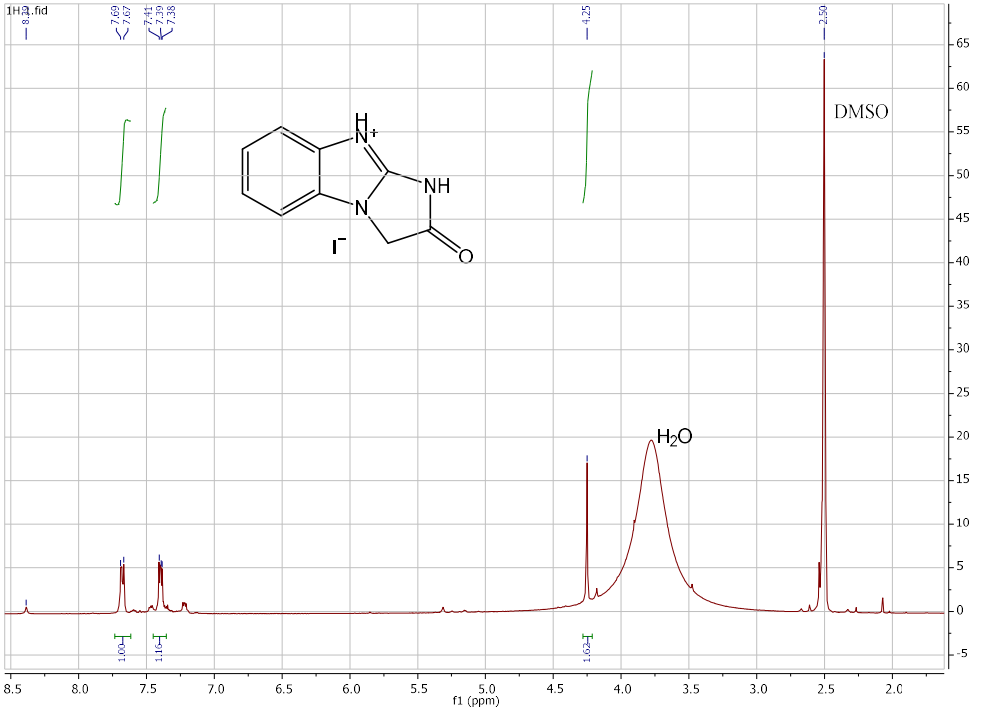
^{13}C NMR spectrum of *N*-(1*H*-benzimidazol-2-yl)-2-iodoacetamide (**3d**) in DMSO-d_6



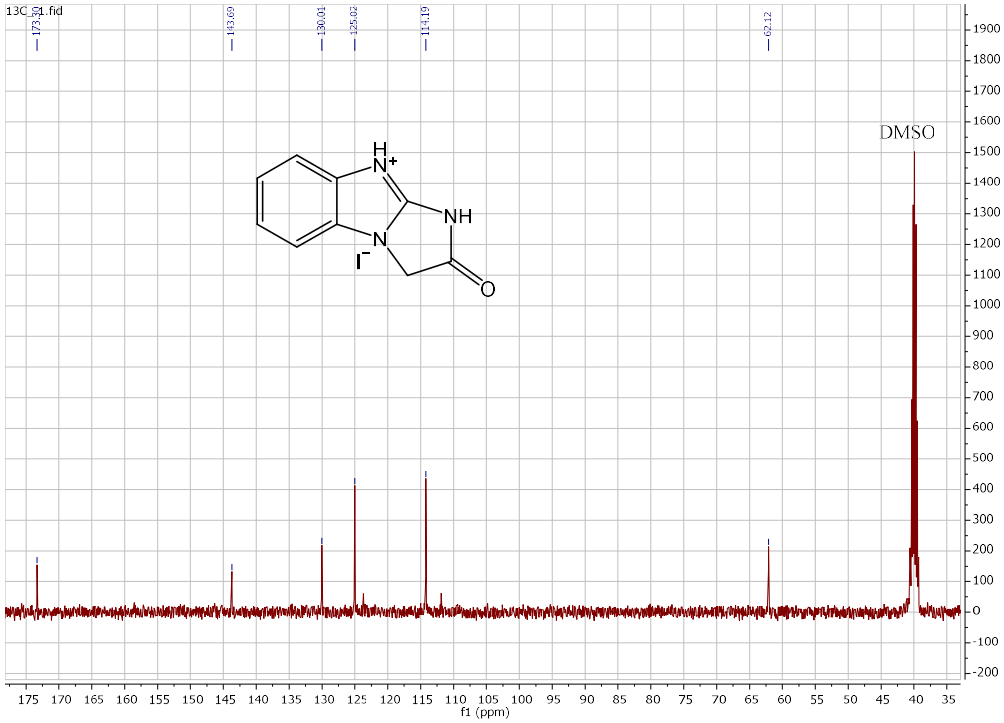
Mass spectrum of *N*-(1*H*-benzimidazol-2-yl)-2-iodoacetamide (**3d**)



^{1}H NMR spectrum of 2-oxo-2,3-dihydroimidazo[1,2-*a*][3,1]benzimidazol-9-ium iodide (**4**) in DMSO-d_6

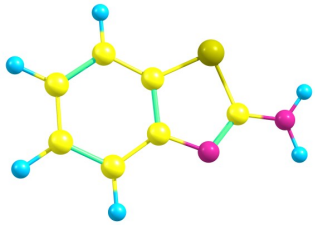


^{13}C NMR spectrum of 2-oxo-2,3-dihydroimidazo[1,2-*a*][3,1]benzimidazol-9-ium iodide (**4**) in DMSO-d_6



2-aminothiazole, 1b

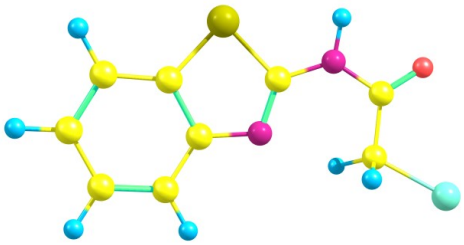
E = -778.068093 a.e. (B3LYP/DGDZVP)



Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	0.334477	0.768820	-0.000003
2	6	0	0.400310	-0.647588	0.000001
3	7	0	-0.943664	1.314748	-0.000002
4	16	0	-1.237823	-1.304096	-0.000006
5	6	0	-1.842396	0.377071	-0.000003
6	7	0	-3.186809	0.610161	-0.000048
7	6	0	1.529954	1.503865	-0.000002
8	6	0	1.616633	-1.331807	0.000005
9	6	0	2.749733	0.824418	0.000003
10	6	0	2.797009	-0.580170	0.000006
11	1	0	-3.863320	-0.136918	0.000231
12	1	0	-3.506029	1.568987	0.000159
13	1	0	1.486398	2.589490	-0.000004
14	1	0	1.653174	-2.418036	0.000007
15	1	0	3.677636	1.391008	0.000003
16	1	0	3.756305	-1.091016	0.000010

***N*-(1,3-benzothiazol-2-yl)-2-iodoacetamide, 3b**

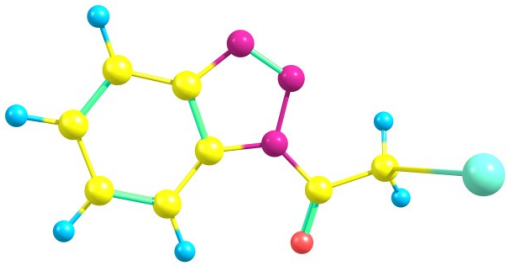
E = -7849.996814 a.e. (B3LYP/DGDZVP)



Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	3.638671	0.360368	-0.000483
2	6	0	2.679911	-0.681987	0.000581
3	16	0	2.810165	1.913457	-0.001000
4	7	0	1.350556	-0.272099	0.001090
5	8	0	-2.106531	2.230646	0.001710
6	6	0	1.268057	1.019771	0.000387
7	6	0	-1.519534	-0.134640	0.000451
8	53	0	-3.636991	-0.616453	-0.000460

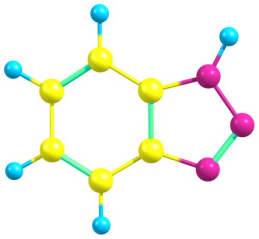
9	6	0	5.011071	0.098688	-0.000994
10	6	0	3.113898	-2.016108	0.001112
11	6	0	5.423911	-1.236494	-0.000453
12	6	0	4.482883	-2.282072	0.000586
13	7	0	0.095681	1.759813	0.000571
14	6	0	-1.254140	1.361169	0.000943
15	1	0	-1.079669	-0.607193	-0.876184
16	1	0	-1.080410	-0.607527	0.877285
17	1	0	5.740568	0.903830	-0.001799
18	1	0	2.380402	-2.817415	0.001931
19	1	0	6.486114	-1.465749	-0.000844
20	1	0	4.828295	-3.312508	0.000992
21	1	0	0.182799	2.771936	0.000942

1-(1*H*-1,2,3-benzotriazol-1-yl)-2-iodoethan-1-one, 2a
E = -7467.834007 a.e. (B3LYP/DGDZVP)



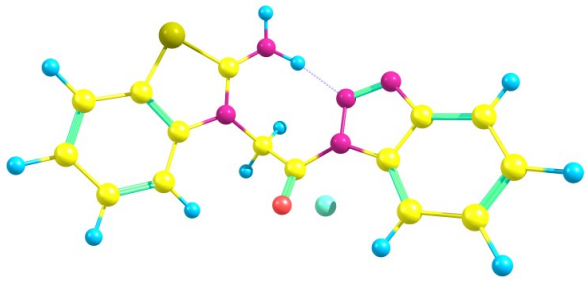
Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	-2.675749	-1.013321	0.131762
2	6	0	-2.087416	0.264564	0.134003
3	7	0	-1.747260	-1.935335	0.607941
4	7	0	-0.810008	0.031554	0.615587
5	6	0	1.546692	0.375654	1.297354
6	8	0	0.041131	2.144596	0.671150
7	7	0	-0.656933	-1.327986	0.890183
8	53	0	2.774386	-0.161678	-0.439352
9	6	0	-3.995413	-1.208480	-0.301833
10	6	0	-2.780601	1.405253	-0.292855
11	6	0	-4.692062	-0.082276	-0.728187
12	6	0	-4.091131	1.199763	-0.722072
13	6	0	0.231273	0.953782	0.839155
14	1	0	2.102671	1.145767	1.825595
15	1	0	1.442617	-0.538899	1.874105
16	1	0	-4.441582	-2.198543	-0.301240
17	1	0	-2.320767	2.386094	-0.285579
18	1	0	-5.717344	-0.182981	-1.073540
19	1	0	-4.671248	2.053443	-1.062813

benzotriazole
E = -395.904688 a.e. (B3LYP/DGDZVP)



Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	0.274870	-0.716573	0.000243
2	6	0	0.275332	0.695062	0.000247
3	7	0	1.586045	-1.160800	0.000452
4	7	0	1.608515	1.002608	-0.000624
5	7	0	2.371104	-0.130898	-0.000437
6	6	0	-0.935256	-1.434662	0.000007
7	6	0	-0.913063	1.446028	-0.000114
8	6	0	-2.113349	-0.699060	-0.000032
9	6	0	-2.099616	0.720681	0.000042
10	1	0	2.072497	1.902128	0.003163
11	1	0	-0.935787	-2.520892	-0.000966
12	1	0	-0.914026	2.532615	-0.000158
13	1	0	-3.069908	-1.214703	-0.000205
14	1	0	-3.045930	1.255629	0.000078

2-amino-3-[2-(1*H*-benzotriazol-1-yl)-2-oxoethyl]-1,3-benzothiazol-3-ium iodide, 3'b
E = -8245.893435 a.e. (B3LYP/DGDZVP)

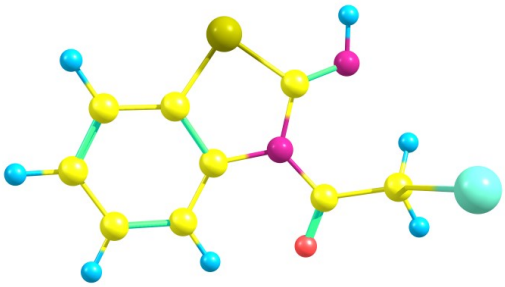


Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	-4.220755	0.603519	0.096198
2	6	0	-3.053743	-0.117886	0.388996
3	16	0	-3.942306	1.713423	-1.252044
4	7	0	-1.990940	0.192382	-0.488969
5	6	0	-2.292558	1.144548	-1.384595
6	6	0	-0.732889	-0.626674	-0.554526
7	6	0	0.294628	-0.180883	0.488067
8	6	0	-5.394511	0.421199	0.827162
9	6	0	-3.025592	-1.031253	1.446556
10	6	0	-5.372620	-0.506206	1.872476

11	6	0	-4.201252	-1.217436	2.176971
12	7	0	1.246970	0.797910	0.051697
13	8	0	0.134549	-0.368487	1.685079
14	7	0	-1.435146	1.593258	-2.304633
15	7	0	2.121892	2.262789	-1.311295
16	7	0	1.145101	1.429405	-1.161159
17	6	0	2.365432	1.253803	0.706468
18	6	0	4.704535	2.579853	1.341352
19	6	0	2.964503	0.942662	1.936649
20	6	0	2.922205	2.190679	-0.188261
21	6	0	4.111889	2.875323	0.122674
22	6	0	4.138387	1.625913	2.229516
23	1	0	-0.346684	-0.600798	-1.570212
24	1	0	-1.004686	-1.653473	-0.323891
25	1	0	-6.296236	0.980741	0.595650
26	1	0	-2.108730	-1.546334	1.712591
27	1	0	-6.272050	-0.668525	2.459419
28	1	0	-4.200169	-1.920943	3.004422
29	1	0	-1.732624	2.339545	-2.921612
30	1	0	-0.414018	1.520803	-2.097566
31	1	0	5.626619	3.079610	1.625824
32	1	0	2.534712	0.207401	2.606099
33	1	0	4.540812	3.592551	-0.570782
34	1	0	4.646321	1.419340	3.167954
35	53	0	1.889928	-2.545094	-0.635274

Intermediate A

E = -7849.979081 a.e. (B3LYP/DGDZVP)

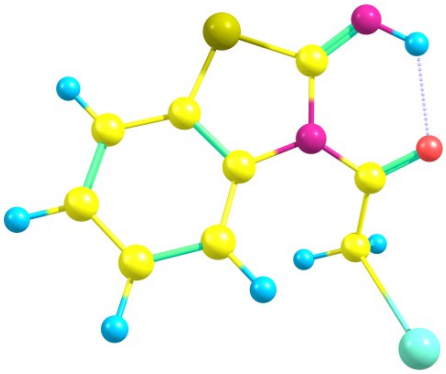


Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	-1.874538	0.415409	0.251318
2	6	0	-2.669980	-0.611041	-0.287601
3	7	0	-0.625741	-0.065532	0.758210
4	16	0	-1.905744	-2.191225	-0.133597
5	6	0	-0.505297	-1.482805	0.724944
6	7	0	0.452227	-2.131096	1.261069
7	6	0	-2.346293	1.734214	0.212840
8	6	0	-3.910371	-0.355454	-0.868130
9	6	0	-3.591701	1.991335	-0.373308
10	6	0	-4.372503	0.963672	-0.910400

11	6	0	0.382020	0.814623	1.236889
12	8	0	0.105387	1.966356	1.531796
13	6	0	1.816442	0.348883	1.340937
14	53	0	2.720545	0.167053	-0.652538
15	1	0	0.358847	-3.136980	1.126079
16	1	0	-1.764644	2.538429	0.637418
17	1	0	-4.504910	-1.166912	-1.279025
18	1	0	-3.953247	3.015712	-0.399744
19	1	0	-5.338622	1.183031	-1.356598
20	1	0	2.373673	1.133550	1.845335
21	1	0	1.936755	-0.628535	1.794373

Intermediate B

E = -7849.971752 a.e. (B3LYP/DGDZVP)



Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms) X	Y	Z
1	6	0	-1.438260	0.496936	-0.031444
2	6	0	-2.838920	0.576694	0.070416
3	7	0	-0.964626	-0.847513	-0.052593
4	16	0	-3.604780	-1.008193	0.062629
5	6	0	-2.029687	-1.820683	-0.198479
6	7	0	-1.983918	-3.065245	-0.414191
7	6	0	-0.689807	1.666576	-0.197689
8	6	0	-3.488764	1.810747	0.098195
9	6	0	-1.341904	2.905155	-0.160821
10	6	0	-2.728977	2.981263	0.002386
11	6	0	0.327367	-1.306371	0.262928
12	8	0	0.677232	-2.448707	-0.000087
13	6	0	1.248665	-0.408716	1.068698
14	53	0	2.971828	0.271631	-0.104943
15	1	0	-1.025088	-3.395270	-0.534635
16	1	0	0.377091	1.634883	-0.388005
17	1	0	-4.571394	1.859230	0.178404
18	1	0	-0.756587	3.812407	-0.281151
19	1	0	-3.224326	3.947989	0.026595
20	1	0	1.688170	-1.031138	1.845899
21	1	0	0.785403	0.475912	1.495880