Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

A First Catalyst and Solvent-Free Synthesis of 2-Arylimidazo[2,1-*b*][1,3,4]thiadiazoles: A Comparative Assessment of Greenness

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Experimental Section

General. ^{1}HNMR spectra were recorded on a Bruker Advance® 500 (500 MHz) and Jeol Resonance ECX-400II (400 MHz); Chemical shifts (δ in ppm) and coupling constant (*J* in Hz) are calibrated either relative to internal solvent tetramethylsilane TMS (δ_H = 0.00ppm) or $CDCl_3$ (δ_H = 7.26 ppm). In the ^{1}H NMR data, the following abbreviations were used throughout: s = singlet, d = doublet, t = triplet, dd = double doublets, dt = double triplets and brs = broad singlet. ^{13}C NMR spectra were recorded on Bruker Advance® 500 (125 MHz) and Jeol Resonance ECX-400II (100 MHz) at R.T in $CDCl_3$; chemical shifts are calibrated relative to $CDCl_3$ (δc = 77.0 ppm). The acquisition of High-resolution mass spectra (HRMS) was performed on Bruker daltronics microTOF-QII® spectrometer using ESI ionization. IR spectra were recorded on Perkin Elmer FT-IR spectrometer – spectrum two. Melting points were performed with *optimelt* automated melting point system.

The reactions were performed in a G-10 Borosilicate glass vial sealed with Teflon septum in Anton Paar Monowave 300 reactor®, operating at a frequency of 2.455 GHz with continuous irradiation power of 0 to 300 W. Analysis of the reactions were done by thin layer chromatography (TLC). For this, Merck precoated silica gel TLC plates (Merck® $60F_{254}$) were used. Aromatic aldehydes were purchased from locally available commercial sources and few of them from sigma Aldrich. All solvents; ethanol (EtOH), petroleum ether, ethyl acetate were purchased from locally available commercial sources and used as received. A variety of 5-aryl-1,3,4-thiadiazol-2-amines and isocyanides were prepared according to literature procedure.[1-3]

1. R. S. Lamani, N. S. Shetty, R. R. Kamble and I. A. M. Khazi*, Eur. J. Med. Chem*., 2009, **44**, 2828.

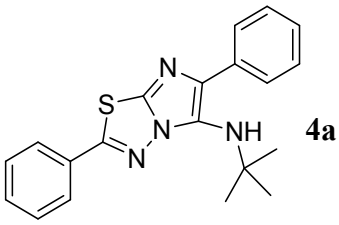
2. G. W. Gokel, R. P. Widera and W. P. Weber, *Organic syntheses*, 1976, **55**, 96.

3. a) I. Ugi and R. Meyr, *Organic Syntheses* 1973**, 5**, 1060; b) R. Obrecht, R. Herrmann and I. Ugi, *Synthesis,* 1985**,** 400.

General procedure for the synthesis of imidazo[2,1-*b*][1,3,4]thiadiazole fused heterocycles *via* microwave assisted Groebke–Blackburn–Bienaymé Reaction.

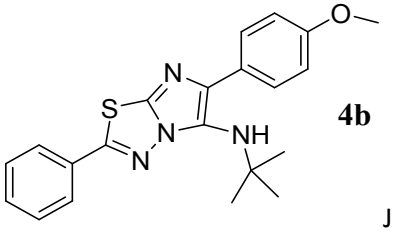
5-Aryl-1,3,4-thiadiazol-2-amines **1a** (0.25 mmol), aromatic aldehyde **2a** (0.27 mmol) and isocyanide **3a** (0.30 mmol) were taken in G-10 glass vial capped with Teflon septum. After a pre-stirring of 1 or 2 minutes at RT, the vial was subjected to microwave irradiation with the initial ramp time of 1 minute at 60 °C. The temperature was then raised to 120 °C with the holding time of 5 minutes. The products were recrystallized using EtOH. Some of the viscous products (**4f, 4i, 4k, 4m**) were purified by silica gel column chromatography (ethyl acetate/hexane). All the 16 compounds were confirmed by FTIR, ^{1}H NMR, ^{13}C NMR and HRMS spectral analyses.

Spectral Data of all Compounds (4a-r)



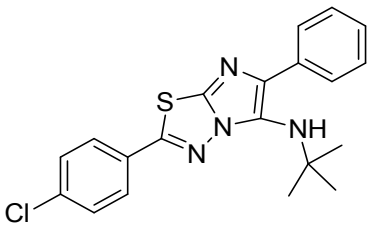
4a

***N–tert*-Butyl-2,6-diphenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4a):** Yellow solid (98%), Mp 174-176 °C, IR (4000-600 cm^{-1}): ν_{max}= 3431 (stretch NH), 1642 (stretch C=N), 1559 (bend NH), 1412, 1339 (stretch C-N). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.10-8.15 (m, 2H), 7.85–7.92 (m, 2H), 7.47-7.55 (m, 3H), 7.40 (t, 2H, *J* = 8 Hz), 7.22-7.28 (m, 1H), 3.16 (brs, NH), 1.20 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 167.1, 160.5, 140.8, 138.4, 135.1, 133.6, 131.5, 130.7, 130.4, 129.3, 128.2, 127.7, 126.9, 56.3, 30.3. HR-MS (ESI) for $C_{20}H_{20}N_4S$ m/z calcd.: 349.1481; found: 349.1516 $[M+H]^+$.



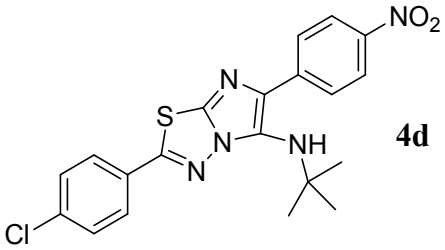
4b

***N–tert*-butyl–6(4-methoxyphenyl)-2-phenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4b):** Yellow solid (90%), Mp 212-213 °C, IR (4000-600 cm^{-1}): ν_{max}= 3411 (stretch NH), 1645 (stretch C=N), 1562 (bend NH), 1509, 1406, 1339 (stretch C-N). ^{1}H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.06 (d, 2H, *J* = 8.5 Hz), 7.83-7.91 (m, 2H), 7.46-7.54 (m, 3H), 6.94 (d, 2H, *J* = 8 Hz), 3.85 (s, 3H), 3.10 (brs, 1H), 2.17 (brs, 1H), 1.19 (s, 9H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ_c (ppm) 160.0, 158.5, 140.6, 138.3, 131.4, 130.7, 129.2, 128.1, 127.8, 126.7, 125.8, 113.6, 56.1, 55.2, 30.3. HR-MS (ESI) for $C_{21}H_{22}N_4OS$ m/z calcd.: 379.1587; found: 379.1580 $[M+H]^+$.



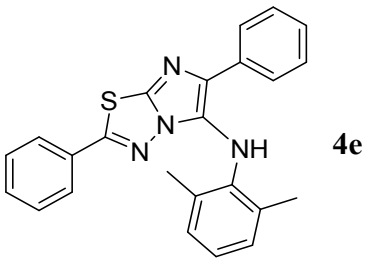
4c

***N–tert*-butyl-2-(4-chlorophenyl)-6-phenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4c):** Yellow solid (91%), Mp 219-221 °C, IR (4000-600 cm^{-1}): ν_{max}= 3437 (stretch NH), 1639 (stretch C=N), 1559 (bend NH), 1409, 1336 (stretch C-N). ^1H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.11 (d, 2H, *J* = 10 Hz), 7.82 (d, 2H, *J* = 10 Hz), 7.48 (d, 2H, *J* = 10 Hz), 7.40 (t, 2H, *J* = 10 Hz), 7.24-7.29 (m, 1H), 3.15 (brs, NH), 2.17 (brs, enaminic proton), 1.19 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 159.2, 138.7, 137.7, 135.0, 129.6, 129.1, 128.3, 128.0, 127.0, 126.9, 126.81, 126.80, 56.4, 30.3. HR-MS (ESI) for $C_{20}H_{19}ClN_4S$ m/z calcd.: 383.1091; found: 383.1125 $[M+H]^+$.



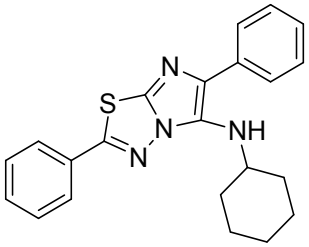
4d

***N–tert*-butyl-2(4-chlorophenyl)-6-(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4d):**Yellow solid (90%), Mp 221-222 °C, IR (4000-600 cm^{-1}): ν_{max}= 3434 (stretch NH), 2952 (sp^2-CH), 2919 (sp^3 –CH), 1592 (stretch C=N), 1509 (asymm. stretch NO_2), 1468 (symm. stretch NO_2), 1327 (stretch C-N). ^1H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.42 (d, 2H, *J* = 12 Hz), 8.24 (d, 2H, *J* = 8 Hz), 7.82 (d, 2H, *J* = 8 Hz), 7.51 (d, 2H, *J* = 12 Hz), 3.15 (brs, NH), 1.10 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 160.4, 160.4, 146.2, 141.6, 141.6, 138.2, 129.8, 128.7, 128.1, 127.0, 123.7, 57.0, 30.4. HR-MS (ESI) for $C_{20}H_{18}ClN_5O_2S$ m/z calcd.: 450.0761; found: 450.0750 $[M+Na]^+$.



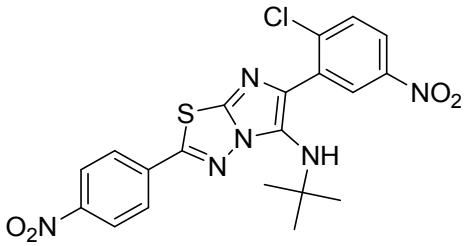
4e

***N*-(2,6-dimethylphenyl)-2,6-diphenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4e):** Yellow solid (87%), Mp 194-195 °C, IR (4000-600 cm^{-1}): ν_{max} = 3417 (stretch NH), 1642 (stretch C=N), 1559 (bend NH), 1409 (stretch C-N). ^1H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.02 (d, 2H, *J* = 8 Hz), 7.69 (d, 2H, *J* = 7 Hz), 7.41-7.51 (m, 3H), 7.36 (t, 2H, *J* = 7.5 Hz), 7.22-7.27 (m, 1H), 6.99 (d, 2H, *J* = 7.5 Hz), 6.853 (t, 1H, *J* = 7 Hz), 5.29 (brs, NH), 2.17 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 161.0, 140.7, 140.5, 136.2, 133.9, 131.5, 130.3, 129.1, 129.1, 128.3, 128.1, 126.9, 126.7, 126.1, 124.7, 122.1, 18.6. HR-MS (ESI) for $C_{24}H_{20}N_4S$ m/z calcd.: 397.1481; found: 397.1473 $[M+H]^+$.



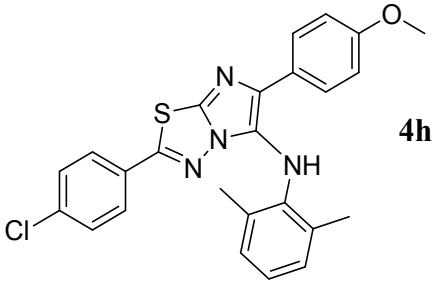
4f

***N*-cyclohexyl-2,6-diphenylimidazo[2,1-*b*][1,3,4] thiazol-5-amine (4f):** Yellow solid (90%), Mp 211 -213 °C, IR (4000-600 cm^{-1}): ν_{max}= 3437 (stretch NH), 1639 (stretch C=N), 1556 (bend NH), 1412, 1339 (stretch C-N). ^{1}H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.04 (d, 2H, *J* = 8 Hz), 7.86-7.92 (m, 2H), 7.48-7.54 (m, 3H), 7.42 (t, 2H, *J* = 8 Hz), 7.24-7.28 (m, 1H) (merge with $CDCl_3$ region (7.260), 3.24-3.40 (m, 2H), 1.92-2.05 (m, 2H), 1.68-1.78 (m, 2H), 1.58-1.62 (m, 1H), 1.15-1.36 (m, 5H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 160.9, 160.8, 134.8, 134.0, 131.6, 130.7, 129.3, 128.7, 128.6, 126.9, 126.6, 125.9, 56.8, 34.2, 25.9, 25.0. HR-MS (ESI) for $C_{22}H_{22}N_4S$ m/z calcd.: 375.1637; found: 375.1648 $[M + H]^+$.



4g

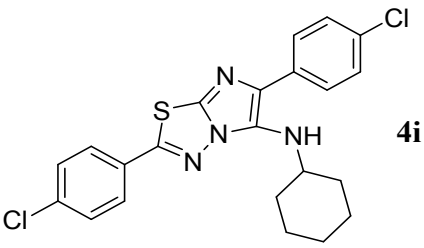
***N*-*tert*-butyl-6-(2-chloro-5-nitrophenyl)-2-(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4g):** Orange solid (85%), Mp 210-211 °C, IR (4000-600 cm^{-1}): ν_{max}= 3428 (stretch NH), 1642 (stretch C=N), 1559 (bend NH), 1412 (asymm. stretch NO_2), 1341 (symm. stretch NO_2). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.55 (d, 1H, *J* = 2.4 Hz), 8.39 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 8.17 (dd, 1H, *J* = 8 Hz, *J* = 4 Hz), 8.11 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 7.65 (d, 1H, *J* = 8.8 Hz), 3.28 (brs, NH), 2.17 (brs, enaminic proton), 1.06 (s, 9H).^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 158.9, 149.6, 139.6, 135.9, 135.5, 135.4, 135.3, 131.0, 129.2, 127.8, 127.6, 124.7, 123.7, 56.0, 30.0. HR-MS (ESI) for $C_{20}H_{17}ClN_6O_4S$ m/z calcd.: 495.0612; found: 473.0590 $[M + Na]^+$.



4h

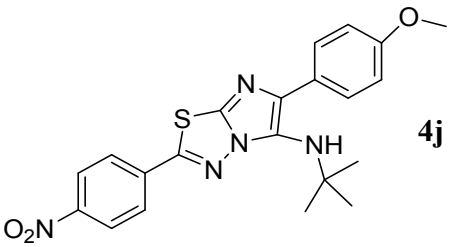
2-(4-chlorophenyl)-*N*–*(*2,6-dimethylphenyl)-6-(4-methoxyphenyl)imidazo[2,1-*b*][1,3,4] thiazol-5-amine (4h): Yellow solid (85%), Mp 197-198 °C, IR (4000-600 cm^{-1}): ν_{max} = 3414 (stretch NH), 1642 (stretch C=N), 1559 (bend NH), 1412, 1339 (stretch C-N). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 7.96 (d, 2H, *J* = 8 Hz), 7.62 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 7.41 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 6.99 (d, 2H, *J* = 8 Hz), 6.90 (d, 2H, *J* = 8 Hz), 6.84 (t, 1H, *J* = 8 Hz), 5.24 (brs, NH), 3.82 (s, 3H), 2.15 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 158.9, 137.7, 129.5, 129.3, 129.0, 127.9, 127.9, 127.9, 127.5,

122.1, 113.9, 55.3, 18.7. HR-MS (ESI) for $C_{25}H_{21}ClN_4OS$ m/z calcd.: 461.1197; found: 461.1210 $[M+H]^+$.



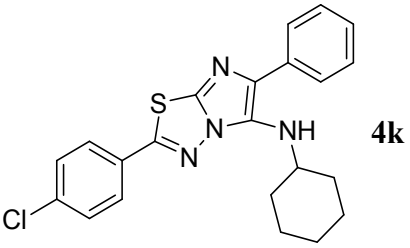
4i

2,6-*bis*(4-chlorophenyl)-*N*–cyclohexylimidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4i): Yellow solid (92%), Mp 223-224 °C, IR (4000-600 cm^{-1}): ν_{max}= 3437 (stretch NH), 1639 (stretch C=N), 1559 (bend NH), 1409, 1336 (stretch C-N). ^1H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.02 (d, 2H, J = 8.5 Hz), 7.82 (d, 2H, J = 8 Hz), 7.49 (d, 2H, J = 8.5 Hz), 7.37 (d, 2H, J = 8.5 Hz), 3.15-3.30 (m, 2H), 1.87-2.00 (m, 2H), 1.68-1.80 (m, 2H), 1.50-1.68 (m, 1H), 1.13-1.40 (m, 5H).^{13}C NMR ($CDCl_3$, 125 MHz): δ_c (ppm) 159.7, 139.7, 137.7, 133.6, 133.1, 132.2, 126.6, 128.9, 128.6, 128.0, 127.1, 56.8, 33.9, 25.8, 24.8. HR-MS (ESI) for $C_{22}H_{20}Cl_2N_4S$ m/z calcd.: 465.0677; found: 465.0653 $[M + Na]^+$.



4j

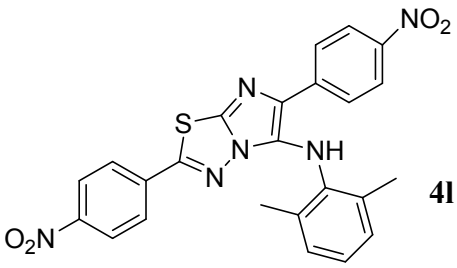
***N*-*tert*-butyl-6-(4-methoxyphenyl)-2-(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4j):** Red solid (92%), Mp 210-211 °C, IR (4000-600 cm^{-1}): ν_{max}= 3431 (stretch NH), 1645 (stretch C=N), 1562 (asymm. stretch NO_2), 1415 (symm. stretch NO_2), 1338 (stretch C-N). ^1H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.34-8.38 (m, 2H), 8.03-8.08 (m, 4H), 6.92-6.97 (m, 2H), 3.85 (s, 3H), 3.11 (brs, NH), 2.17 (brs, 1H), 1.20 (s, 9H). ^{13}C NMR ($CDCl_3$, 125 MHz): δ_c (ppm) 158.9, 157.2, 149.2, 140.6, 139.4, 136.4, 128.2, 127.5, 127.3, 126.1, 124.6, 113.7, 56.3, 55.3, 30.4. HR-MS (ESI) for $C_{21}H_{21}N_5O_3S$ m/z calcd.: 424.1438; found: 424.1463 $[M + H]^+$.



4k

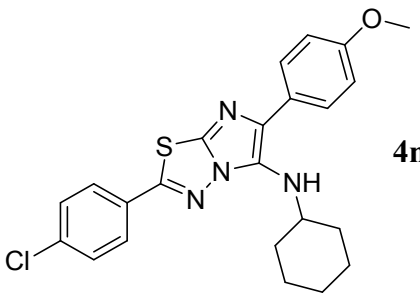
2-(4-chlorophenyl)-*N*-cyclohexyl-6-phenylimidazo[2,1-*b*][1,3,4] thiazol-5-amine (4k): Yellow solid (91%), Mp 201-202 °C, IR (4000-600 cm^{-1}): ν_{max} = 3423 (stretch NH), 1642 (stretch C=N), 1559 (bend NH), 1415, 1336 (stretch C-N). ^1H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.03 (d, 2H, J = 7.5 Hz), 7.83 (d, 2H, J = 8.5 Hz), 7.49 (d, 2H, J = 8.5 Hz), 7.42 (t, 2H, J = 7.5 Hz), 7.24-7.28 (m, 1H), 3.23-3.36 (m, 2H), 2.170 (s, enaminic proton), 1.91-2.02 (m, 2H), 1.69-1.77 (m, 2H), 1.15-1.35 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 169.7, 169.6, 134.7, 129.6, 129.1, 129.1, 128.9, 128.0, 126.7,

125.9, 125.9, 125.9, 56.8, 51.0, 34.2, 25.8, 24.8. HR-MS (ESI) for $C_{22}H_{21}ClN_4S$ m/z calcd.: 409.1248; found = 409.1225 $[M + H]^+$.



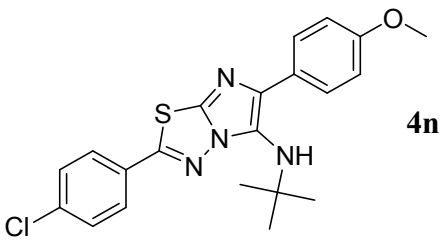
4l

***N*-(2,6-dimethylphenyl)-2,6-bis(4-nitrophenyl)imidazo[2,1-*b*][1,3,4] thiazol-5-amine (4l):** Brown solid (85%), Mp 180-181 °C, IR (4000-600 cm^{-1}): ν_{max}= 3434 (stretch NH), 1639 (stretch C=N), 1553 (asymm. stretch NO_2), 1409 (symm. stretch NO_2), 1341 (stretch C-N). ^1H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 8.32 (d, 2H, *J* = 8.4 Hz), 8.21 (d, 4H, *J* = 8.8 Hz), 8.17 (d, 2H, *J* = 8.6 Hz), 7.85 (d, 2H, *J* = 8.4 Hz), 7.04 (d, 2H, *J* = 7.4 Hz), 6.94 (t, 1H, *J* = 7.3 Hz), 5.41 (brs, NH), 2.17 (s, 6H).^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 149.5, 146.2, 140.7, 140.1, 139.4, 139.4, 135.6, 129.3, 129.3, 127.6, 127.6, 126.3, 124.6, 123.9, 123.7, 18.7. Anal. Calcd for $C_{24}H_{18}N_6O_4S$; C, 59.25; H, 3.73; N, 17.27. Found: C, 59.29; H, 3.81; N, 17.31.



4m

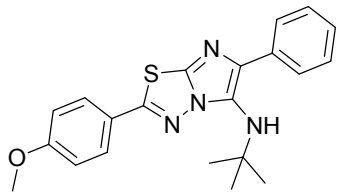
2-(4-chlorophenyl)-*N*-cyclohexyl-6-(4-methoxyphenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4m): Yellow solid (86%), Mp 208-209 °C, IR (4000-600 cm^{-1}): ν_{max}= 3428 (stretch NH), 1636 (stretch C=N), 1565 (bend NH), 1409 (stretch C-N). ^1H NMR ($CDCl_3$, 500 MHz): δ_H (ppm) 7.98 (d, 2H, *J* = 9 Hz), 7.82 (d, 2H, *J* = 8.5 Hz), 7.48 (d, 2H, *J* = 8.5 Hz), 6.97 (d, 2H, *J* = 9 Hz), 3.85 (s, 3H), 3.18-3.27 (bm, 2H), 1.92-1.98 (m, 2H), 1.71-1.78 (m, 2H), 1.175-1.325 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 177.8, 177.8, 177.5, 161.6, 157.3, 142.0, 129.5, 127.9, 127.2, 113.9, 113.9, 113.9, 55.3, 55.3, 34.0, 25.8, 24.8. HR-MS (ESI) for $C_{23}H_{23}ClN_4OS$ m/z calcd.: 461.1173; found: 461.1136 $[M + Na]^+$.



4n

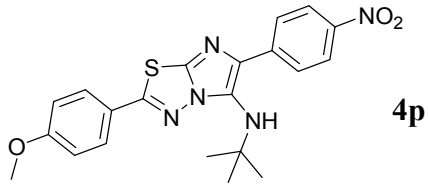
***N*-*tert*-butyl-2-(4-chlorophenyl)-6-(4-methoxyphenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4n):** Off white solid (85%), Mp 209-210 °C, IR (4000-600 cm^{-1}): ν_{max}= 3428 (stretch NH), 1642 (stretch

C=N), 1562 (bend NH), 1415, 1336 (stretch C-N). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.05 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 7.81 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 7.48 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 6.94 (dt, 2H, *J* = 8 Hz, *J* = 4 Hz), 3.85 (s, 3H), 3.09 (brs, NH), 2.18 (brs, enaminic proton), 1.19 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ_c (ppm) 158.7, 137.5, 137.5, 129.6, 129.2, 128.1, 127.9, 127.7, 127.7, 113.7, 56.2, 55.3, 30.4. Anal. Calcd for $C_{21}H_{21}ClN_4OS$; C, 61.08; H, 5.13; N, 13.57. Found: C, 61.13; H, 5.18; N, 13.63.



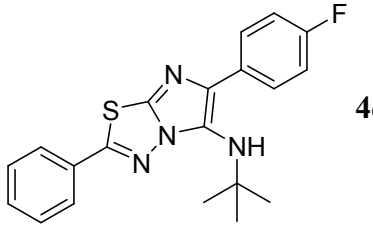
4o

***N-tert*-butyl-2(4-methoxyphenyl)-6-phenylimidazo[2,1-b][1,3,4]thiadiazol-5-amine (4o):** Off white solid (85%), Mp 204-204.5 °C, IR (4000-600 cm^{-1}): ν_{max}= 3443 (stretch NH), 1640 (stretch C=N), 1563 (bend NH), 1467 (stretch C-N), 1414 (stretch C-N). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.10 (d, 2H, *J* = 8 Hz), 7.80 (d, 2H, *J* = 8.8 Hz), 7.38 (t, 2H, *J* = 8 Hz), 7.22-7.26 (m, 1H), 6.99 (d, 2H, *J* = 8.8 Hz), 3.87 (s, 3H), 3.13 (brs, NH), 1.18 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δc (ppm) 162.3, 160.4, 135.2, 135.2, 128.4, 128.2, 128.2, 126.8, 126.8, 126.8, 123.3, 114.7, 56.3, 55.6, 30.3. Anal. Calcd. for $C_{21}H_{22}N_4OS$; C, 66.64; H, 5.86; N, 14.80. Found: C, 66.70; H, 5.80; N, 14.86.



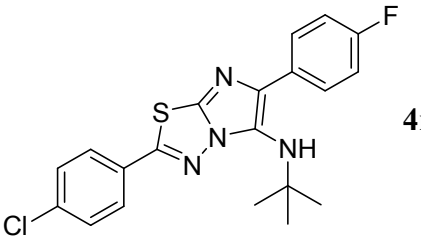
4p

***N-tert*-butyl-2(4-methoxyphenyl)-6-(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4p):** yellow solid (87%), Mp 227-227.5 °C, IR (4000-600 cm^{-1}): ν_{max}= 3447 (stretch NH), 1643 (stretch C=N), 1567 (bend NH), 1412 (stretch C-N), 1340 (stretch C-N). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.40 (d, 2H, *J* = 8 Hz), 8.22 (d, 2H, *J* = 8 Hz), 7.80 (d, 2H, *J* = 8 Hz), 7.00 (d, 2H, *J* = 8 Hz), 3.88 (s, 3H), 3.14 (brs, NH), 2.16 (s, enaminic proton), 1.20 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δc (ppm) 162.6, 146.0, 141.9, 136.0, 128.6, 128.5, 126.8, 123.7, 122.8, 122.8, 114.8, 57.0, 55.7, 30.4. Anal. Calcd. for $C_{21}H_{21}N_5O_3S$; C, 59.56; H, 5.00; N, 16.54. Found: C, 59.65; H, 5.08; N, 16.61.



4q

***N-tert*-butyl-6-(4-fluorophenyl)-2-phenylimidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4q):** yellow solid (89 %), Mp 233.7-233.9 °C, IR (4000-600 cm^{-1}): ν_{max} = 3446 (stretch NH), 1639 (stretch C=N) , 1559 (bend NH), .^{1}H NMR ($CDCl_3$, 400 MHz): δH (ppm) 8.09-8.16 (m, 2H), 7.83-7.90 (m, 2H), 7.46-7.53 (m, 3H), 7.06 (t, 2H, *J* = 8 Hz), 3.07 (brs, NH), 2.16 (s, enaminic proton), 1.17 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δc (ppm) 163.1, 160.7, 160.6, 131.6, 131.2, 131.2, 130.6, 130.2, 129.3, 129.1, 128.6, 128.5, 127.1, 126.8, 115.2, 115.0, 56.3, 30.3. Anal. Calcd. for C20H19FN4S; C, 65.55; H, 5.23; N, 15.29. Found: C, 65.62; H, 5.32; N, 15.35.



4r

***N*-*tert*-butyl-2-(4-chlorophenyl)-6-(4-fluorophenyl)imidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4r):** yellow solid (86 %), Mp 229.0-229.2 °C, IR (4000-600 cm^{-1}): ν_{max} = 3431(stretch NH), 1648 (stretch C=N), 1564 (bend NH),1349 (stretch C-N). ^{1}H NMR ($CDCl_3$, 400 MHz): δ_H (ppm) 8.09-8.15 (m, 2H), 7.80 (d, 2H, *J* = 8.8 Hz), 7.47 (d, 2H, *J* = 8.4 Hz), 7.07 (t, 2H, *J* = 8.8 Hz), 3.07 (brs, NH), 2.17 (s, enaminic proton), 1.18 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz): δc (ppm) 163.2, 160.7, 159.3, 140.7, 137.7, 131.1, 131.1, 129.6, 129.1, 128.6, 128.5, 128.0, 115.2, 115.0, 56.4, 30.3. Anal. Calcd. for C20H18ClFN4S; C, 59.92; H, 4.53; N, 13.98. Found: C, 59.99; H, 4.62; N, 14.06.

Green Metrics Calculations

$$\%\ Atom\ Efficiency\ = \frac{(Mol\ \ Wt.\ \ of\ desired\ product)}{(Mol\ Wt.\ \ of\ all\ reagents)} \times 100$$

$$\%\ Carbon\ Efficiency\ = \frac{Mass\ of\ \ carbon\ in\ product}{Total\ mass\ of\ \ carbon\ in\ key\ reactants}\ \times 100$$

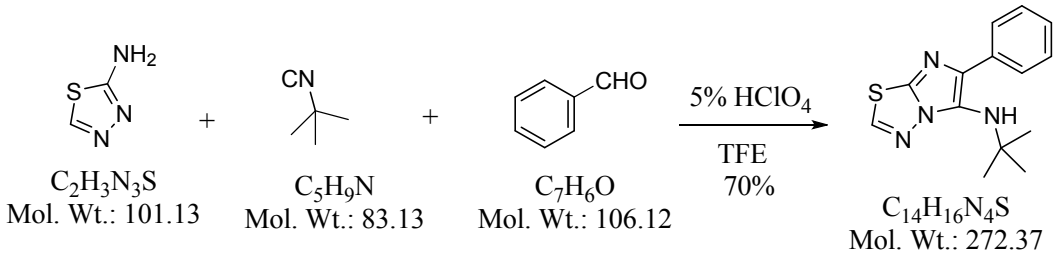
$$Reaction\ Mass\ Efficiency\ = \frac{(Mass\ \ of\ Isolated\ Product)}{(Total\ mass\ \ of\ \ reactants\ used\ in\ the\ reaction)}\ \times 100$$

$$E - Factor\ = \frac{Mass\ of\ Total\ Waste}{Mass\ of\ \ crude\ Product}$$

$$Process\ Mass\ Intensity\ (PMI)\ = \frac{Total\ mass\ used\ in\ process}{Mass\ of\ product}$$

Comparison of present protocol for the synthesis of *N-tert*-butyl-2,6-diphenylimidazo[2,1-*b*][1,3,4]thiadiazol-5-amine 4a with reported methods

A) Calculation for the synthesis of *N-tert*-butyl-6-phenylimidazo[2,1- *b*][1,3,4]thiadiazol-5-amine



$C_2H_3N_3S$
Mol. Wt.: 101.13

C_5H_9N
Mol. Wt.: 83.13

C_7H_6O
Mol. Wt.: 106.12

$C_{14}H_{16}N_4S$
Mol. Wt.: 272.37

Raw Materials Used		**Crude Product and Waste**	
1,3,4-Thiadiazole-5-amine (1.0 eq.)	101.13 mg	Product	207.0 mg
tert-butylisocyanide (1.2 eq.)	99.75 mg	Waste	2766 mg
Benzaldehyde (1.2 eq.)	127.3 mg		
$HClO_4$ (5%)	5.02 mg		
Trifluoroethanol (TFE)	2640 mg		
Total	2973 mg	**Total**	2973 mg

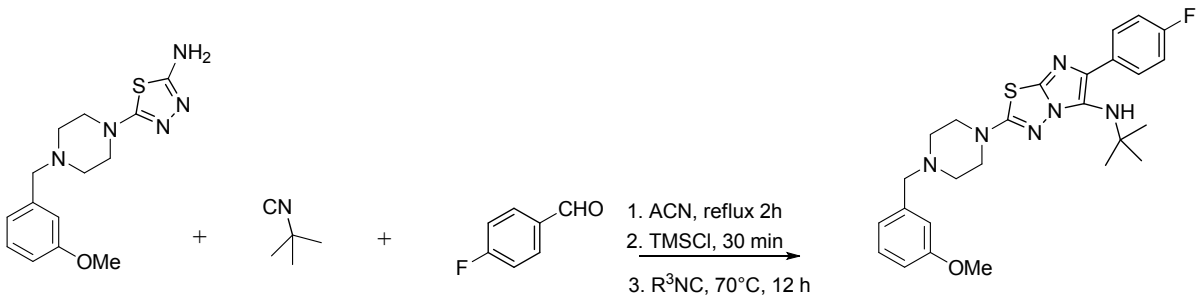
E-Factor (E) = (2766 mg of waste produced / 207.0 mg of crude product) = 13.36.

Mass Intensity = (2973 mg of raw material used / 207.0 mg of crude product) = 14.36.

Considerations:

1. Calculation did not consider organic solvents used for work-up and column chromatography.

B) Calculation for the synthesis of 2-(4-(3-methoxybenzyl)piperazin-1-yl)-*N*-*tert*-butyl-6-(4-fluorophenyl)imidazo[2,1- *b*][1,3,4]thiadiazol-5-amine.



$C_{14}H_{19}N_5OS$ Mol. Wt.: 305.4 + C_5H_9N Mol. Wt.: 83.13 + C_7H_6O Mol. Wt.: 106.12 → 84% → $C_{26}H_{31}FN_6OS$ Mol. Wt.: 494.63

Raw Materials Used		**Crude Product and Waste**	
5-(4-(3-methoxybenzyl)piperazin-1-yl)-1,3,4-thiadiazole-5-amine (1.0 eq.)	305.4 mg	Product	415.5 mg
tert-butylisocyanide (1.0 eq.)	83.13 mg	Waste	1759.8mg
4-Fluoro benzaldehyde (1.0 eq.)	106.12 mg		
TMSCl	108.64 mg		
Acetonitrile	1572 mg		
Total	2175mg	**Total**	2175 mg

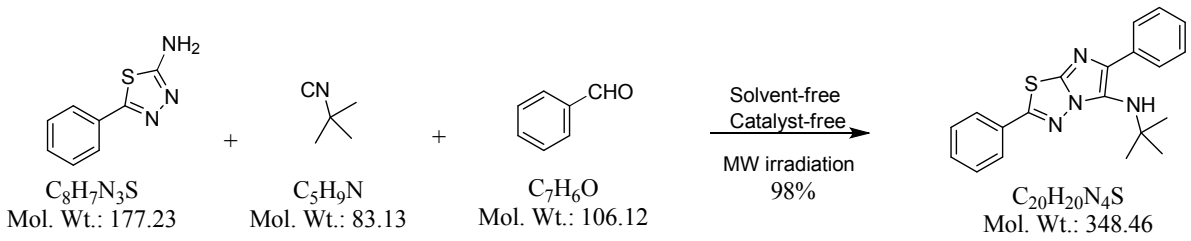
E-Factor (E) = (1759 mgof waste produced / 415.5 mg of crude product) = 4.23.

Mass Intensity = (2175 mg of raw material used / 415.5 mg of crude product) = 5.23.

Considerations:

1. Calculation did not consider organic solvents used for work-up and column chromatography.

C) Calculation for the synthesis of *N*-*tert*-butyl-2,6-diphenylimidazo[2,1- *b*][1,3,4]thiadiazol-5-amine **4a**



$C_8H_7N_3S$
Mol. Wt.: 177.23

C_5H_9N
Mol. Wt.: 83.13

C_7H_6O
Mol. Wt.: 106.12

$C_{20}H_{20}N_4S$
Mol. Wt.: 348.46

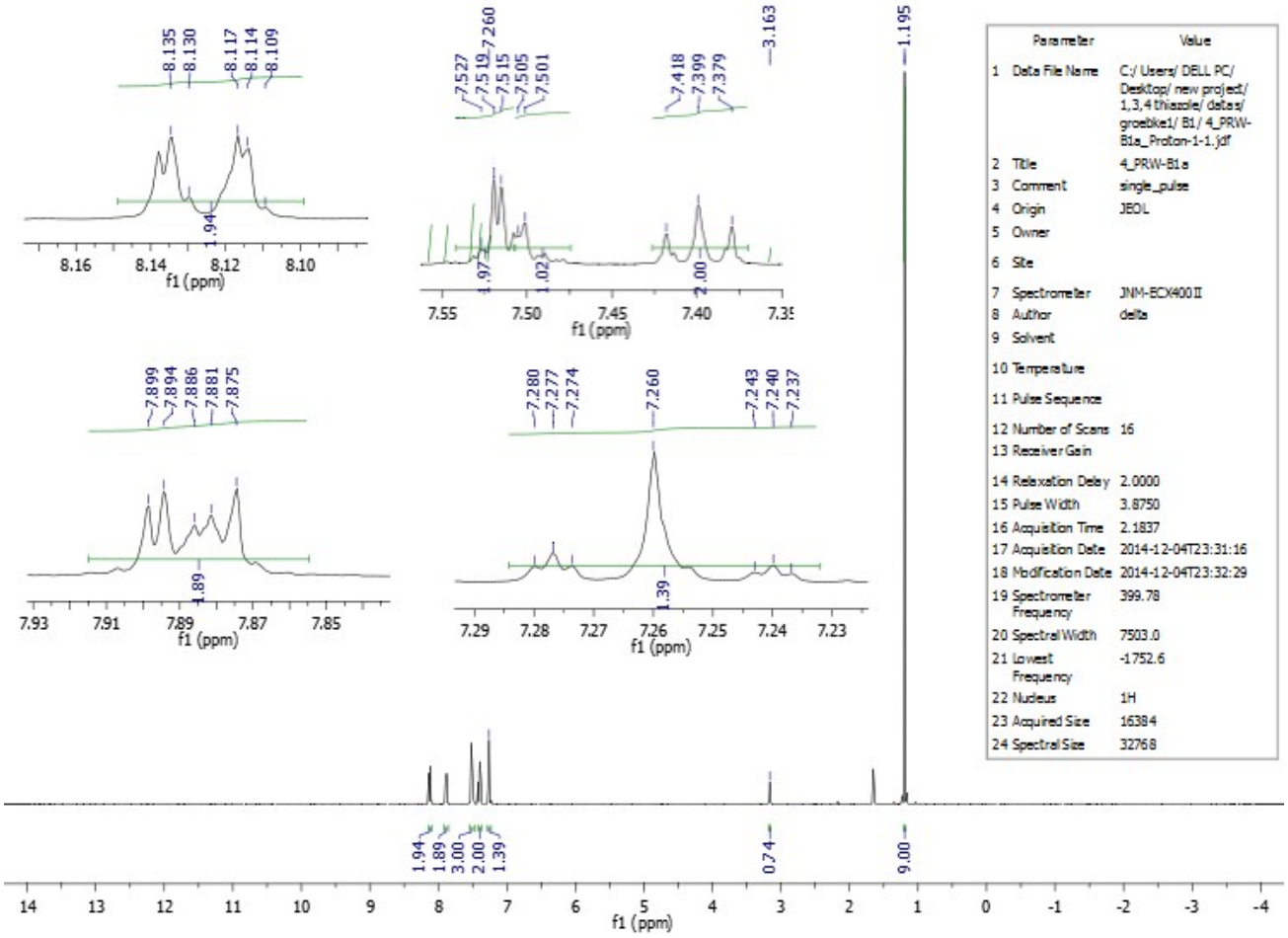
Raw Materials Used		**Crude Product and Waste**	
5-Phenyl-1,3,4-thiadiazole-5-amine (1.0 eq.)	177.23 mg	Product	341.5 mg
tert-butylisocyanide (1.2 eq.)	99.75 mg	Waste	52.2mg
Benzaldehyde (1.1 eq.)	116.7 mg		
Total	393.7mg	**Total**	393.7 mg

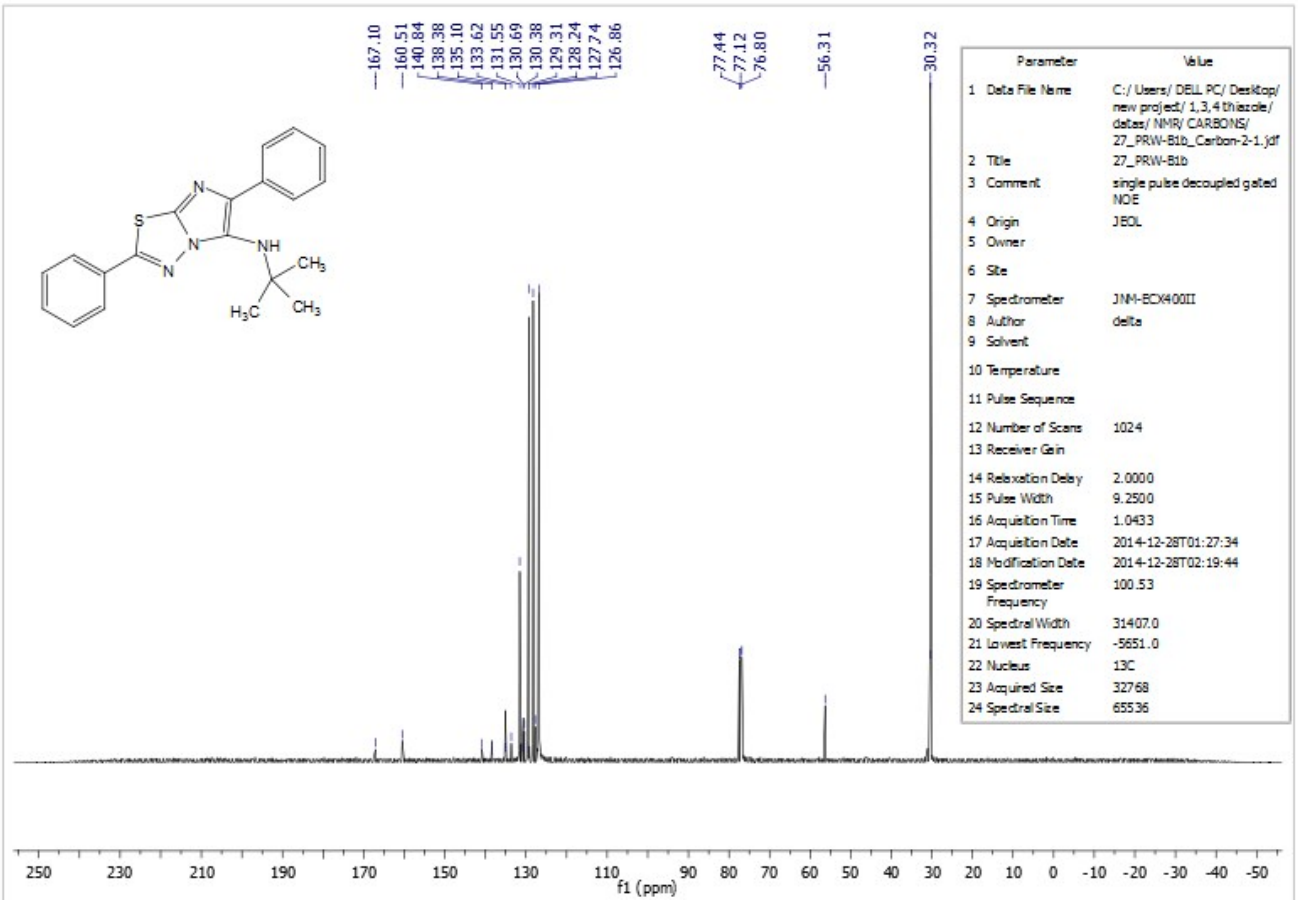
E-Factor (E) = (52.2 mg of waste produced / 341.5mg of crude product) = 0.153.

Mass Intensity = (393.7 mg of raw material used / 341.5 mg of crude product) =1.153.

Copies of ^{1}H, ^{13}C NMR of all compounds.

***N–tert*-butyl-2,6-diphenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4a)**





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8	Author	delta
9	Solvent	
10	Temperature	
11	Pulse Sequence	
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14	Relaxation Delay	2.0000
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16	Acquisition Time	1.0433
17	Acquisition Date	2014-12-28T01:27:34
18	Modification Date	2014-12-28T02:19:44
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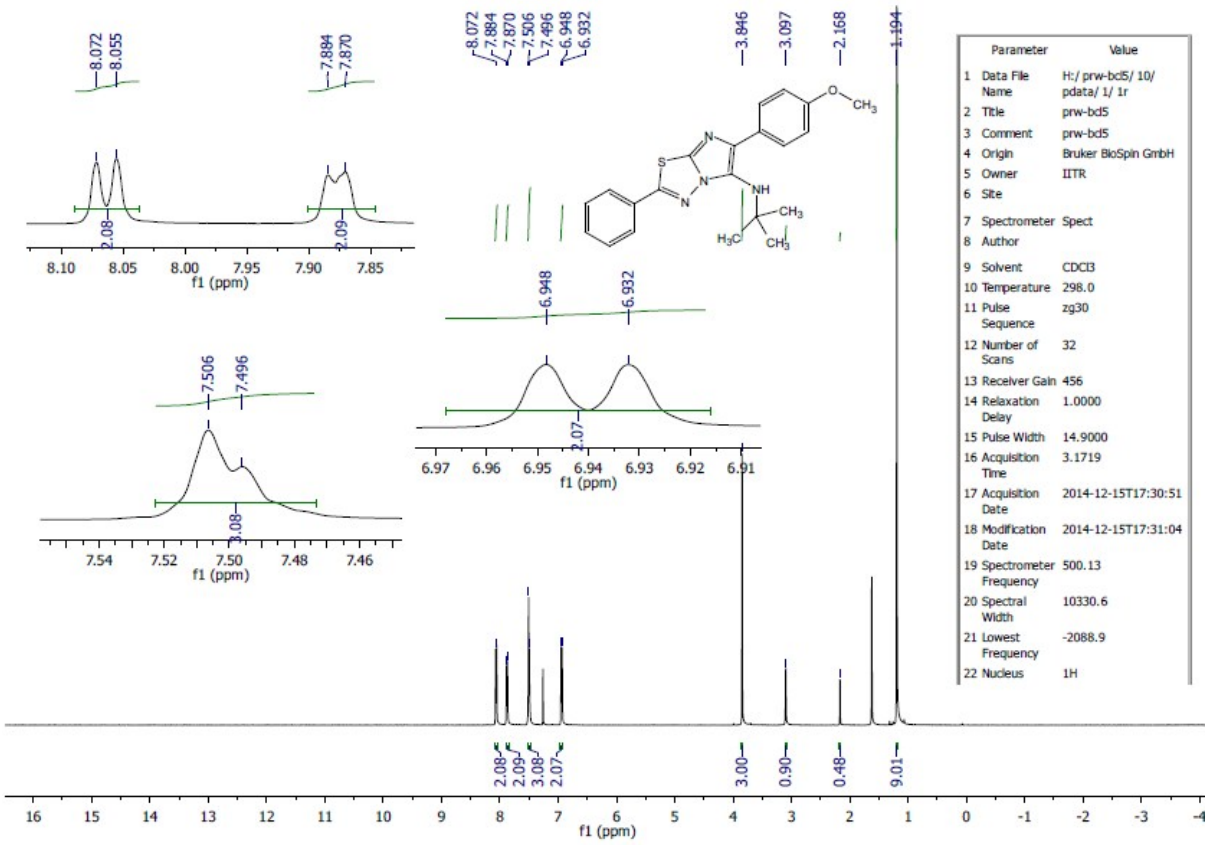
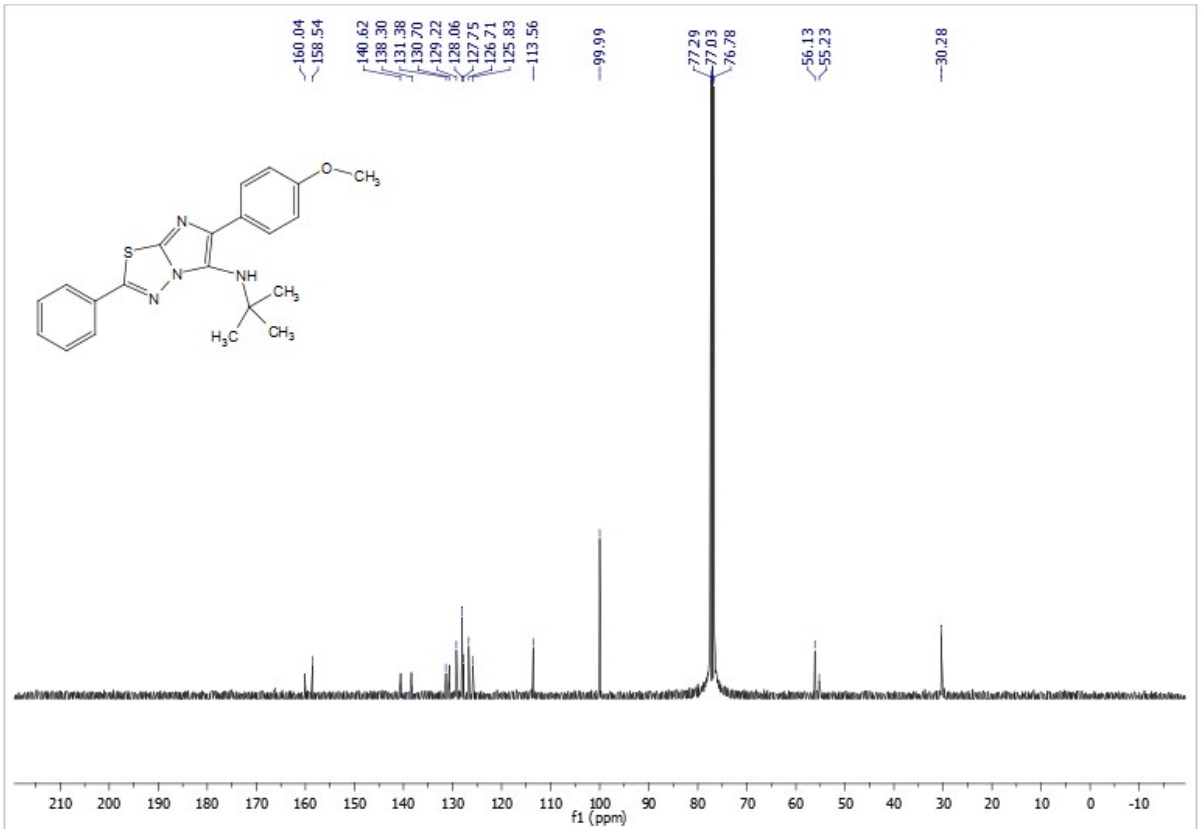
21	Lowest Frequency	-5651.0
22	Nucleus	13C
23	Acquired Size	32768
24	Spectral Size	65536

_N_–_tert_-butyl–6(4-methoxyphenyl)-2-phenylimidazo[2,1-_b_][1,3,4]thiazol-5-amine (4b)

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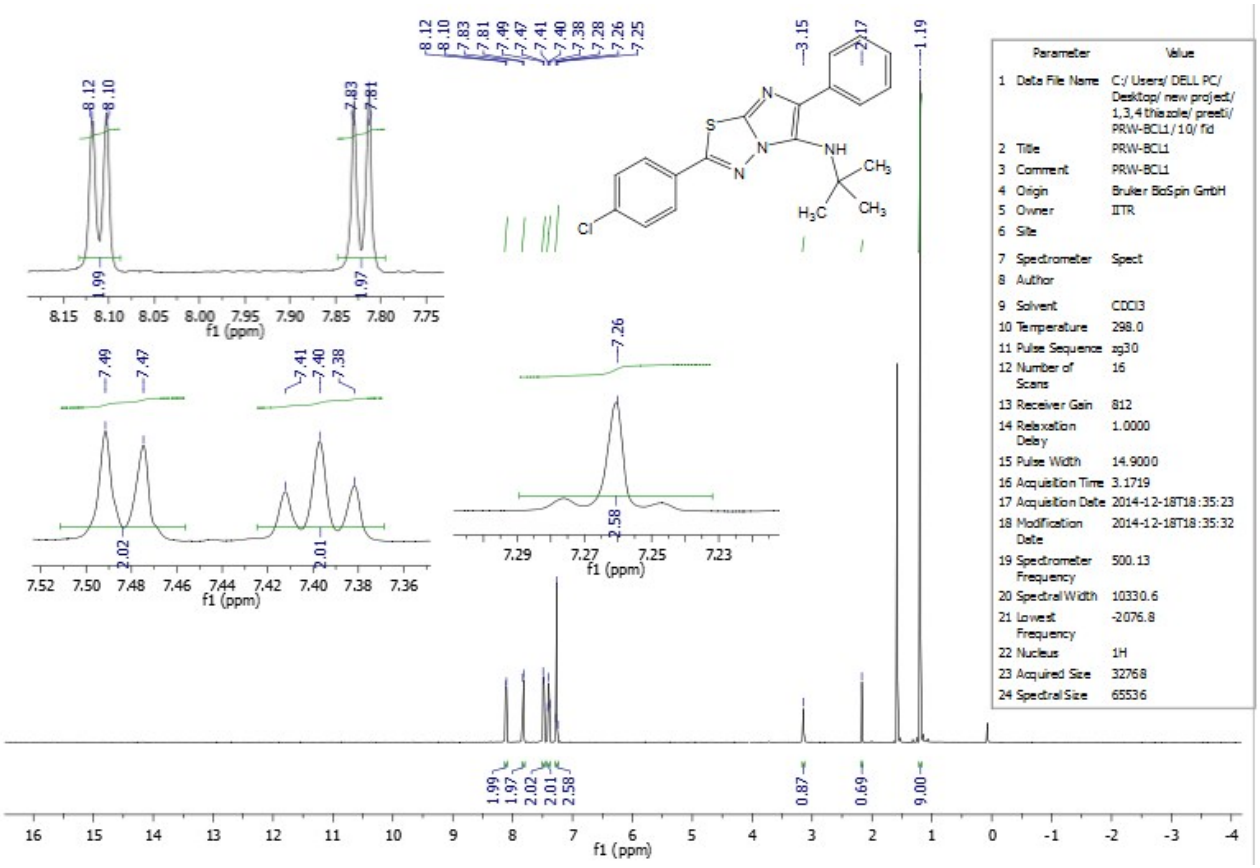
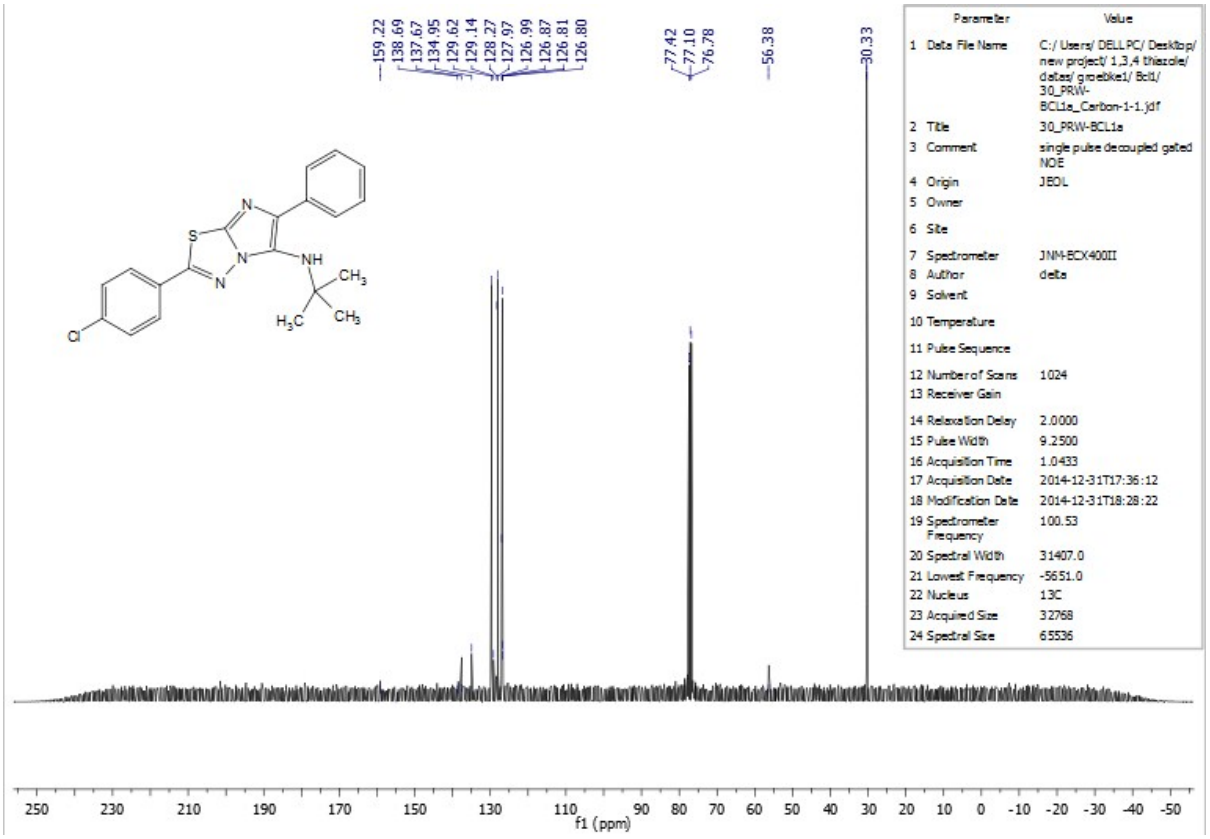
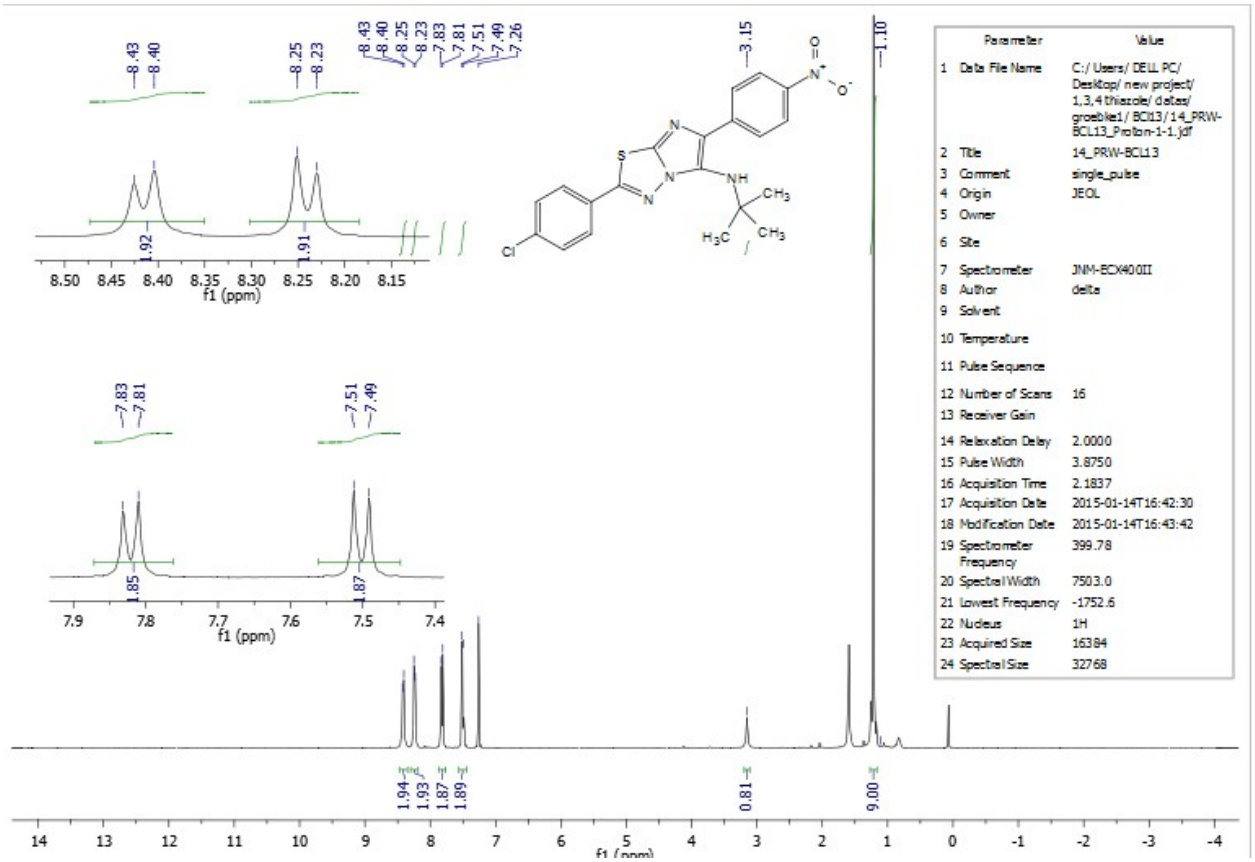
30.28
O
CH3
N
S
N
NH
CH3
H3C
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

***N*–*tert*-butyl-2-(4-chlorophenyl)-6-phenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4c)**





***N*–*tert*-butyl-2(4-chlorophenyl)-6-(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4d):**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1.91
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f1 (ppm)
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7.81
7.51
7.49
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1.87
7.9 7.8 7.7 7.6 7.5 7.4
f1 (ppm)
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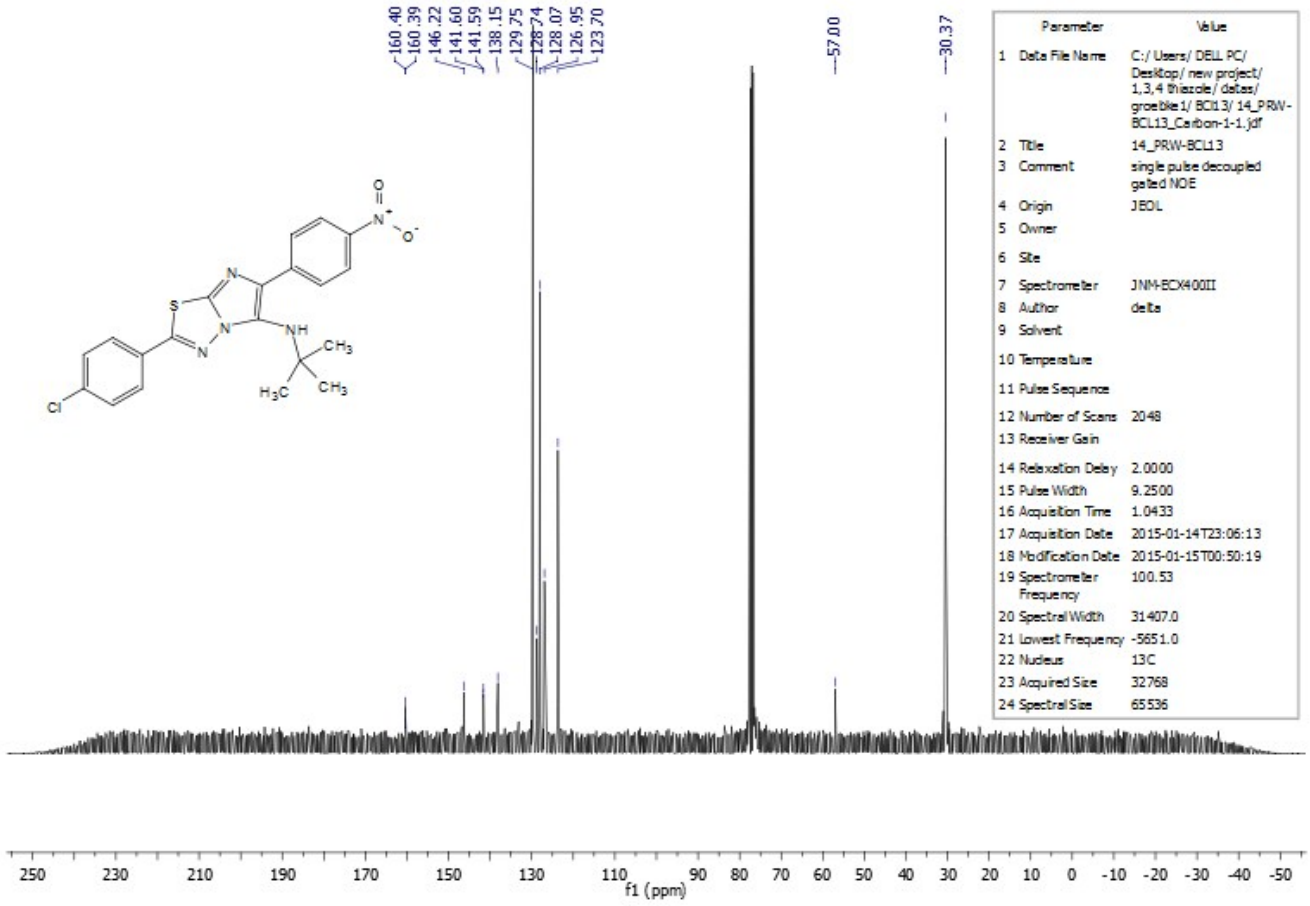
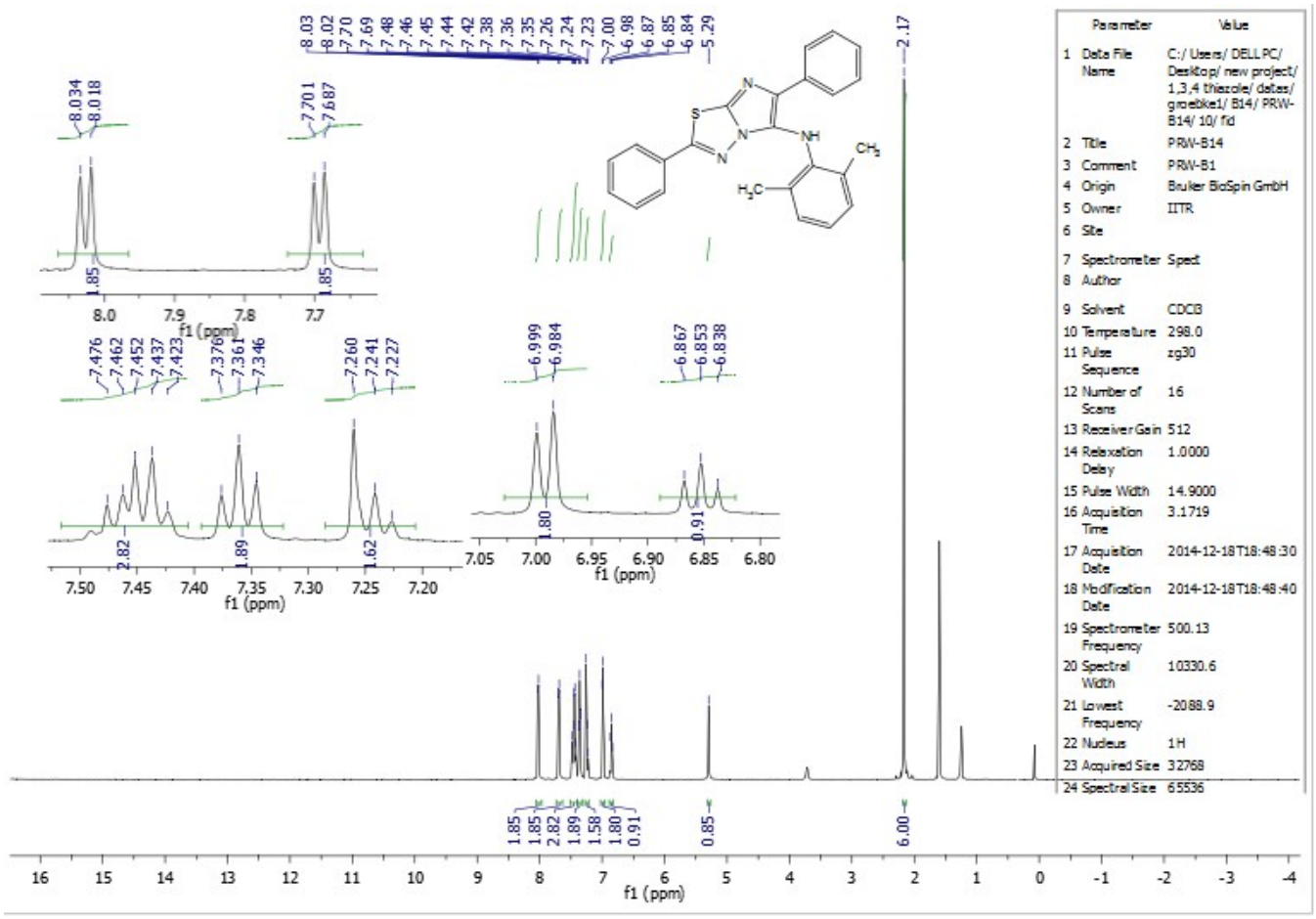


***N*-(2,6-dimethylphenyl)-2,6-diphenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4e)**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7.24
7.23
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6.98
6.87
6.85
6.84
5.29
2.17
8.034
8.018
7.701
7.687
1.85
1.85
8.0
7.9
7.8
7.7
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7.423
7.376
7.361
7.346
7.260
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7.30
7.25
7.20
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S
N
NH
CH3
H3C
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8 Author
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6.00
16
15
14
13
12
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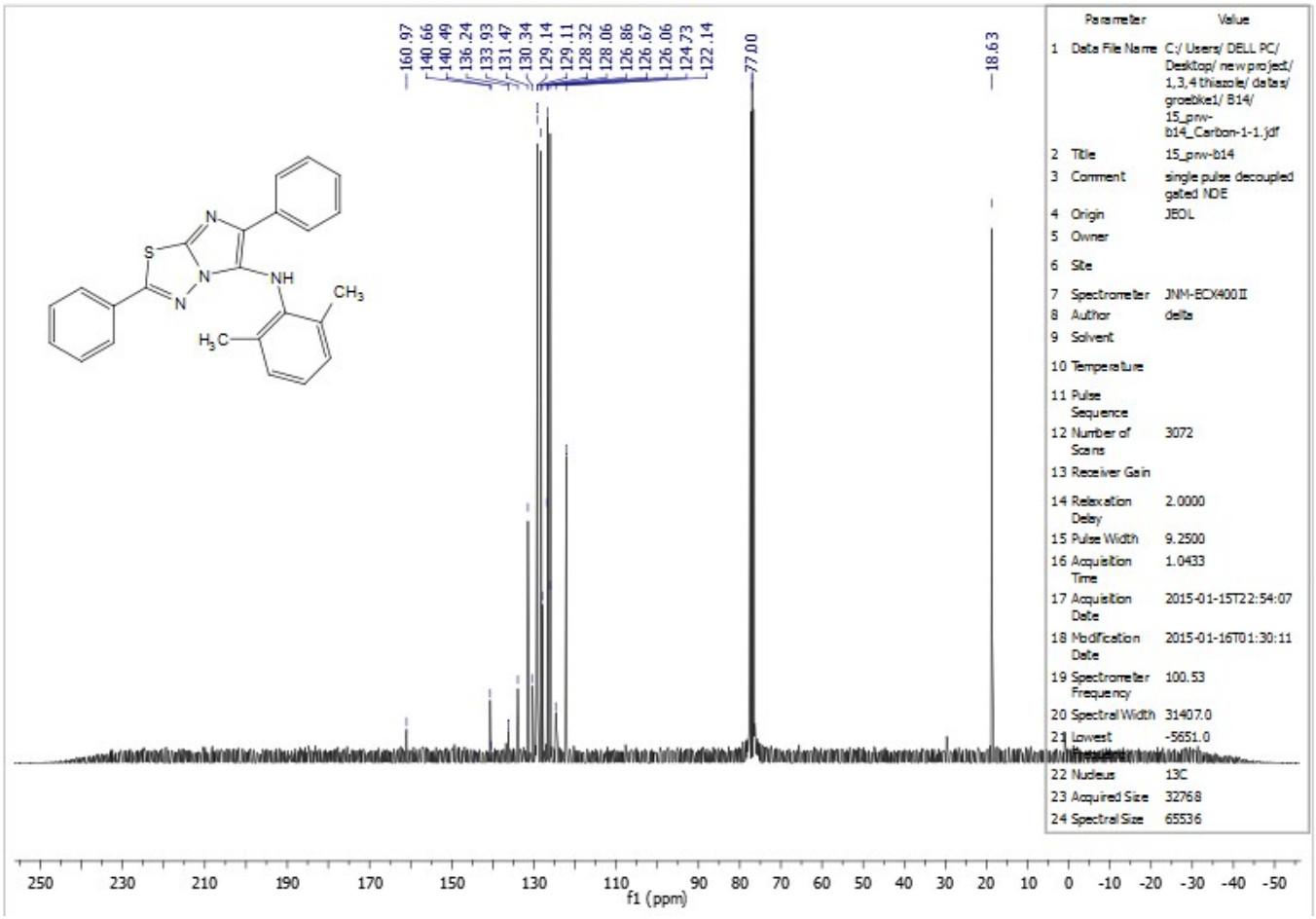
f1 (ppm)



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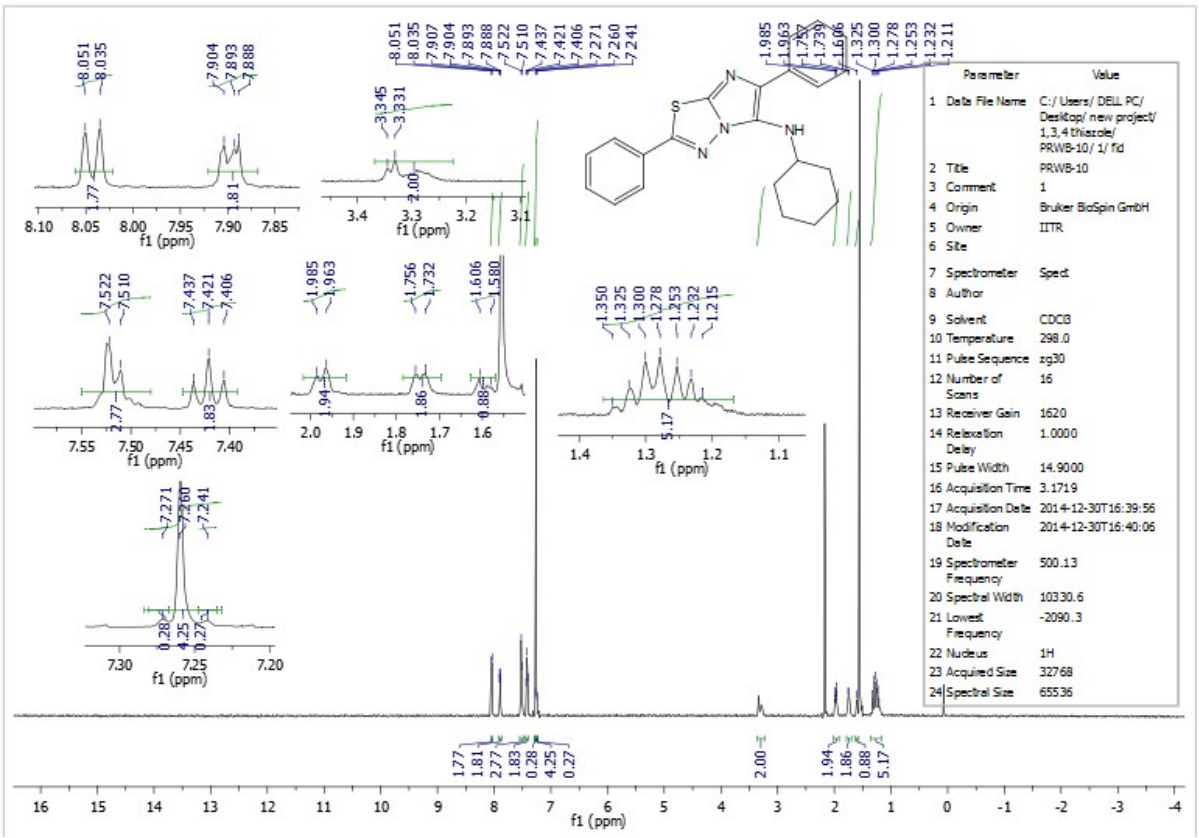
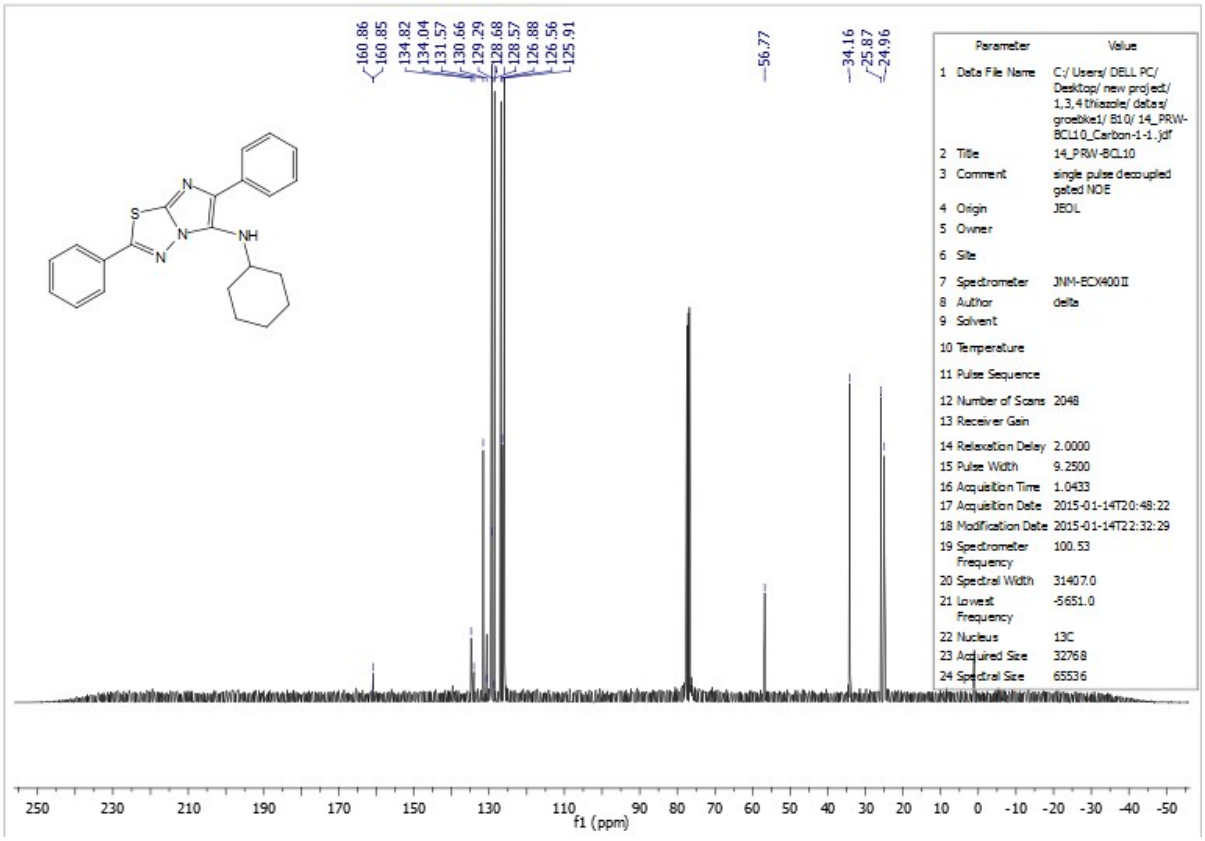
_N_-cyclohexyl-2,6-diphenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4f)

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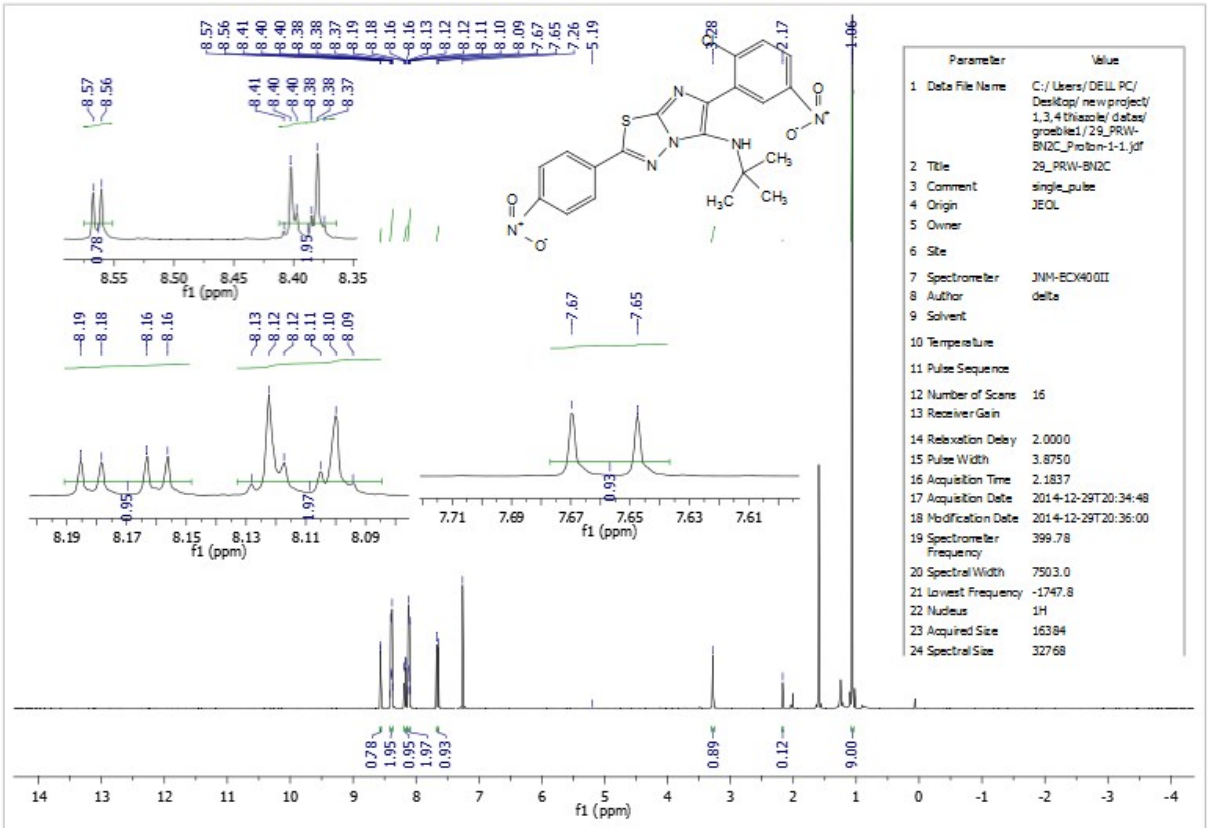
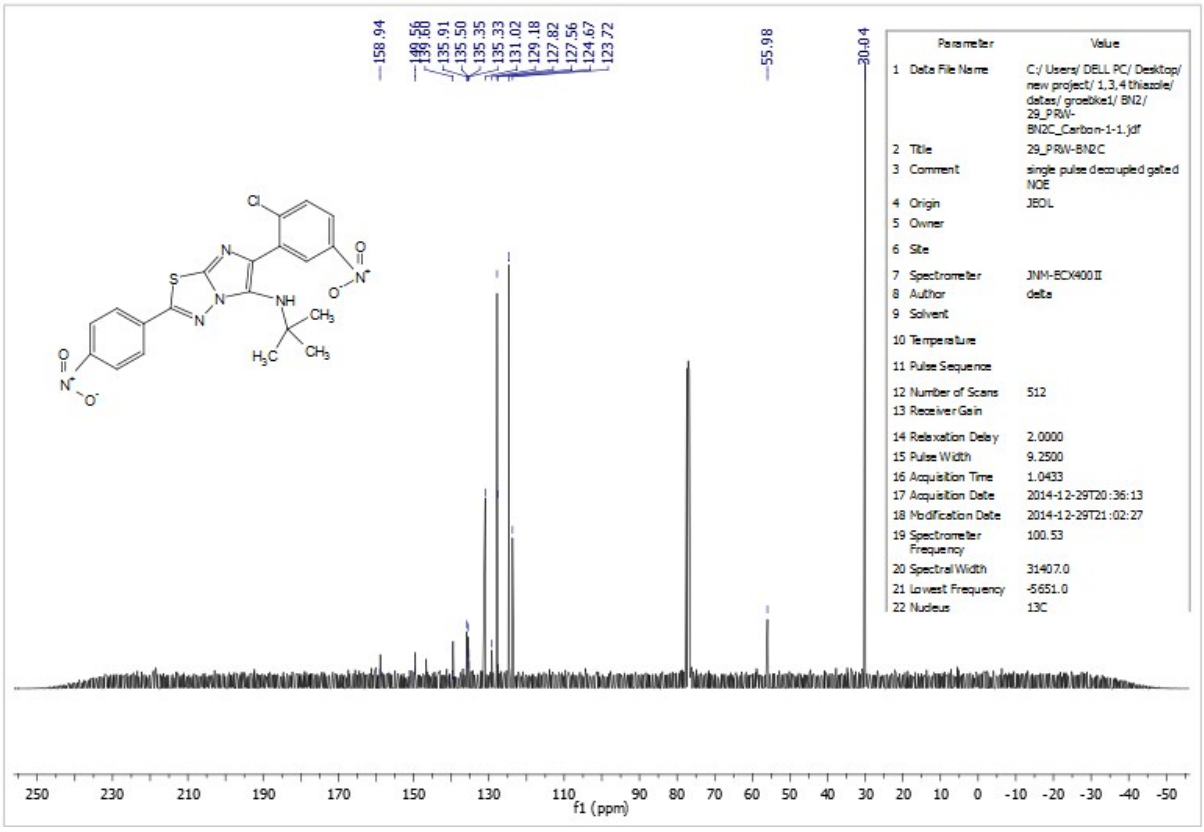
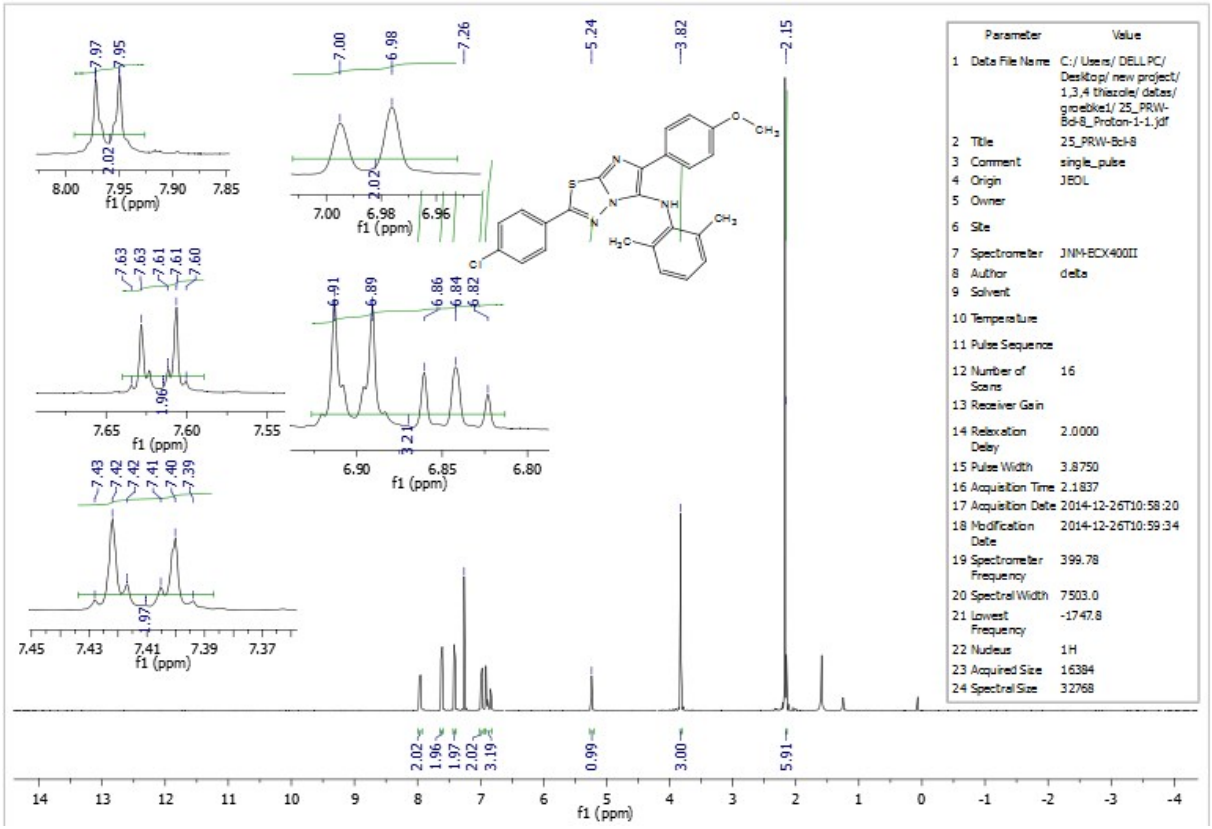
34.16
25.87
24.96
N
S
N
N
NH
Parameter Value
1 Data File Name C:/ Users/ DELL PC/ Desktop/ new project/ 1,3,4 thiazole/ dates/ groebke1/ B10/ 14_PRW-BCL10_Carbon-1-1.jdf
2 Title 14_PRW-BCL10
3 Comment single pulse decoupled gated NOE
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 2048
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 9.2500
16 Acquisition Time 1.0433
17 Acquisition Date 2015-01-14T20:48:22
18 Modification Date 2015-01-14T22:32:29
19 Spectrometer Frequency 100.53
20 Spectral Width 31407.0
21 Lowest Frequency -5651.0
22 Nucleus 13C
23 Acquired Size 32768
24 Spectral Size 65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

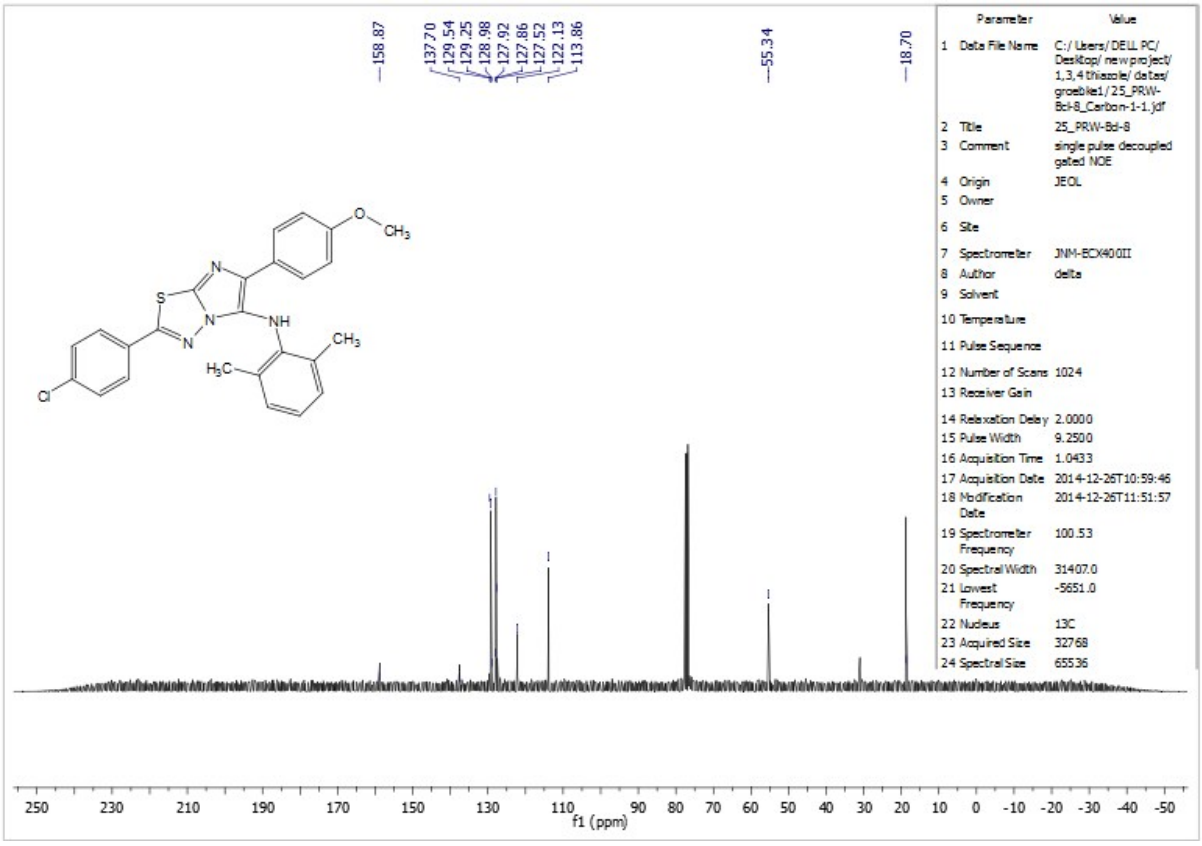
***N-tert*-butyl-6-(2-chloro-5-nitrophenyl)-2-(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4g)**



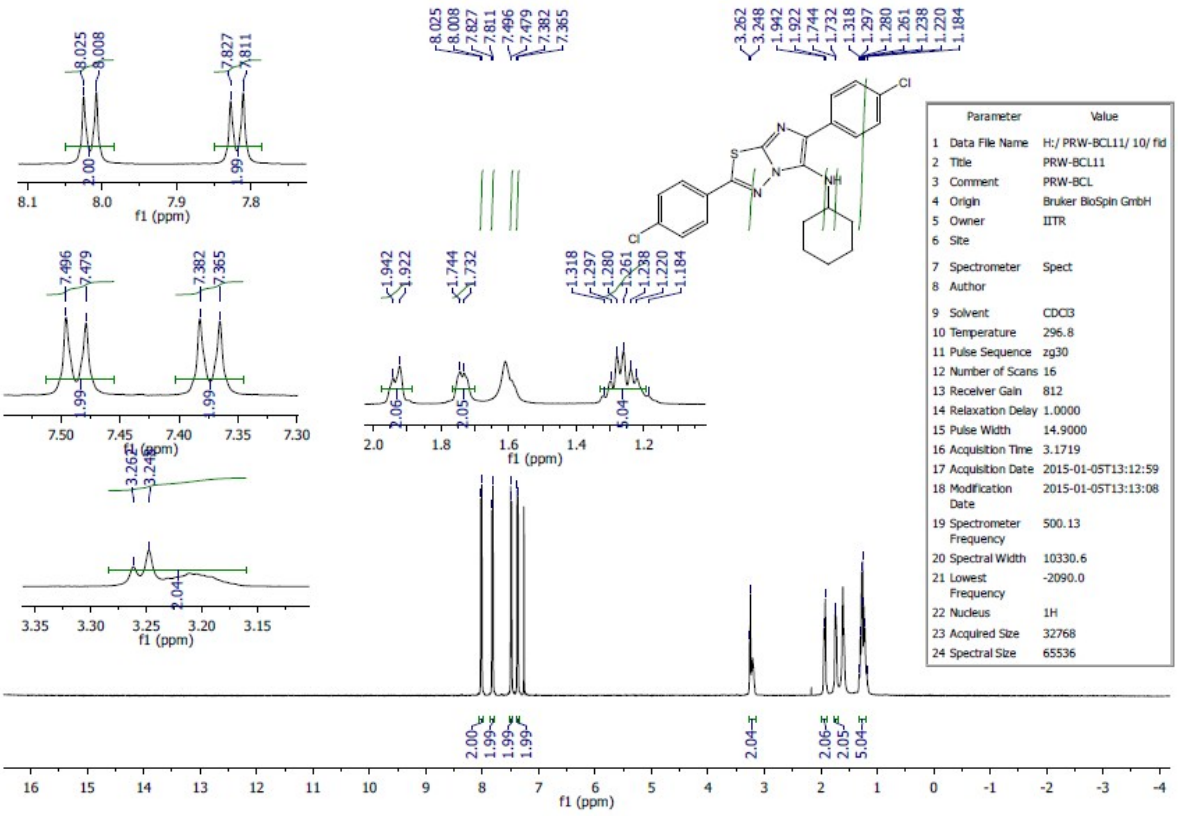


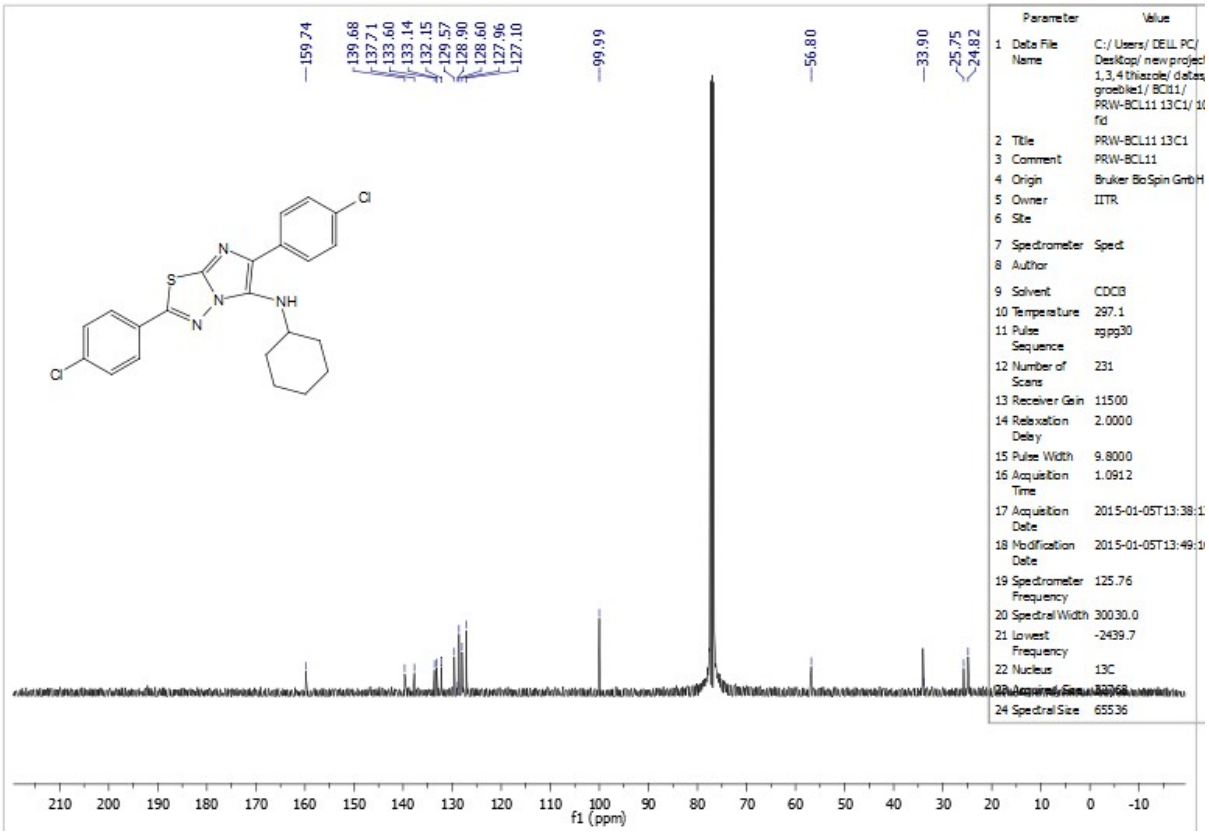
2-(4-chlorophenyl)-*N*–*(*2,6-dimethylphenyl)-6-(4-methoxyphenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4h)


7.97
7.95
2.02
8.00
7.95
7.90
7.85
f1 (ppm)
7.00
6.98
7.26
2.02
7.00
6.98
6.96
f1 (ppm)
5.24
3.82
2.15
7.63
7.63
7.61
7.61
7.60
1.96
7.65
7.60
7.55
f1 (ppm)
6.91
6.89
6.86
6.84
6.82
3.21
6.90
6.85
6.80
f1 (ppm)
7.43
7.42
7.42
7.41
7.40
7.39
1.97
7.45
7.43
7.41
7.39
7.37
f1 (ppm)
2.02
1.96
1.97
2.02
3.19
0.99
3.00
5.91
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
f1 (ppm)
Parameter
Value
1 Data File Name C:/ Users/ DELL PC/ Desktop/ new project/ 1,3,4 thiazole/ dates/ greebke1/ 25_PRW-Bdi-8_Proton-1-1.jdf
2 Title 25_PRW-Bdi-8
3 Comment single_pulse
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 16
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 3.8750
16 Acquisition Time 2.1837
17 Acquisition Date 2014-12-26T10:58:20
18 Modification Date 2014-12-26T10:59:34
19 Spectrometer Frequency 399.78
20 Spectral Width 7503.0
21 Lowest Frequency -1747.8
22 Nucleus 1H
23 Acquired Size 16384
24 Spectral Size 32768

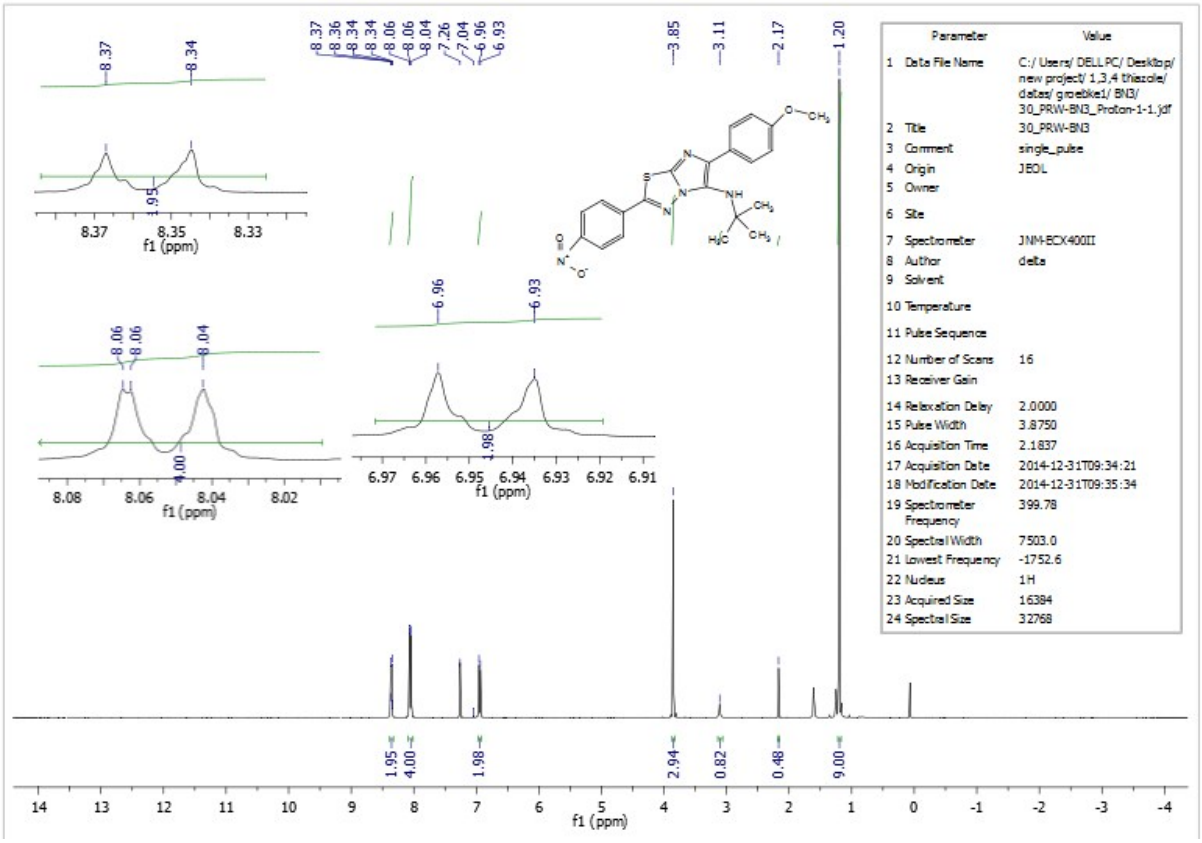

158.87
137.70
129.54
129.25
128.98
127.92
127.86
127.52
122.13
113.86
55.34
18.70
O
CH3
N
S
N
N
NH
CH3
H3C
Cl
Parameter
Value
1 Data File Name C:/Users/DELL PC/Desktop/newproject/1,3,4 thiazole/datas/groebke1/25_PRW-Bcl-8_Carbon-1-1.jdf
2 Title 25_PRW-Bcl-8
3 Comment single pulse decoupled gated NOE
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 1024
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 9.2500
16 Acquisition Time 1.0433
17 Acquisition Date 2014-12-26T10:59:46
18 Modification Date 2014-12-26T11:51:57
19 Spectrometer Frequency 100.53
20 Spectral Width 31407.0
21 Lowest Frequency -5651.0
22 Nucleus 13C
23 Acquired Size 32768
24 Spectral Size 65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

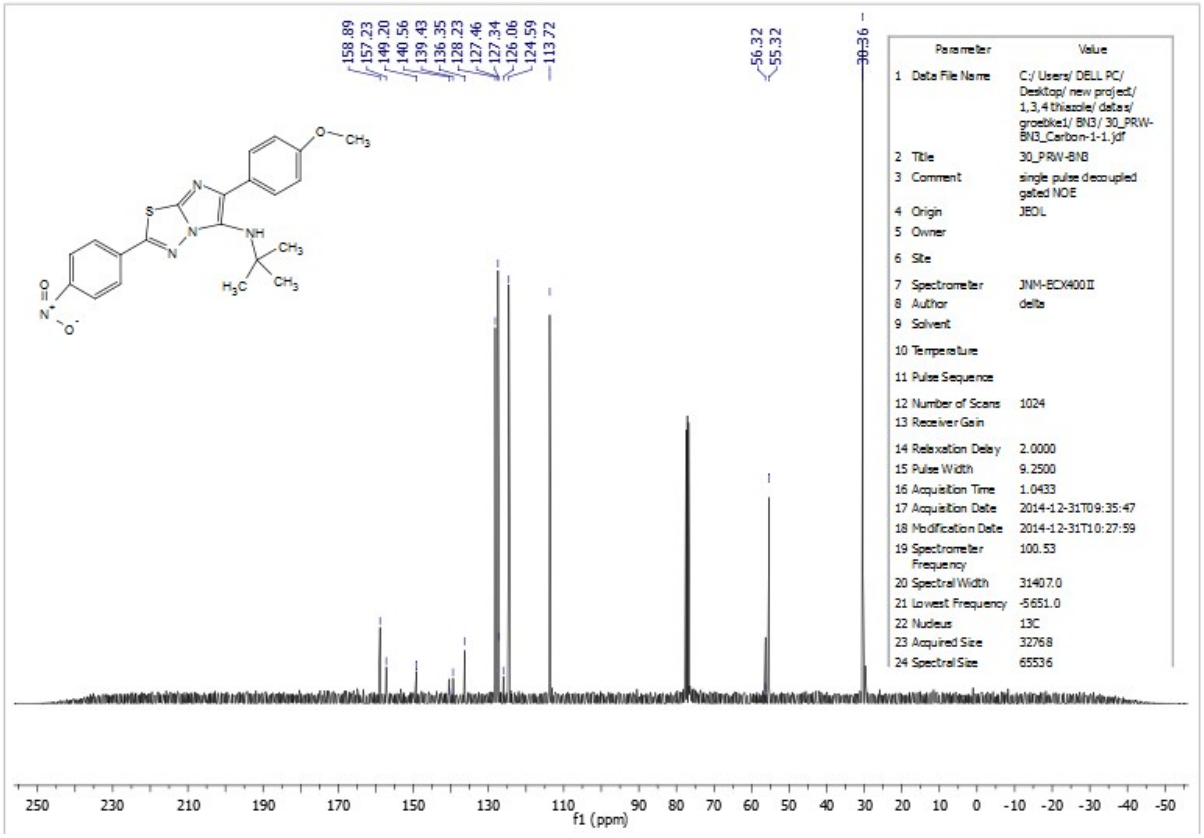
2,6-bis(4-chlorophenyl)-*N*–cyclohexylimidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4i)



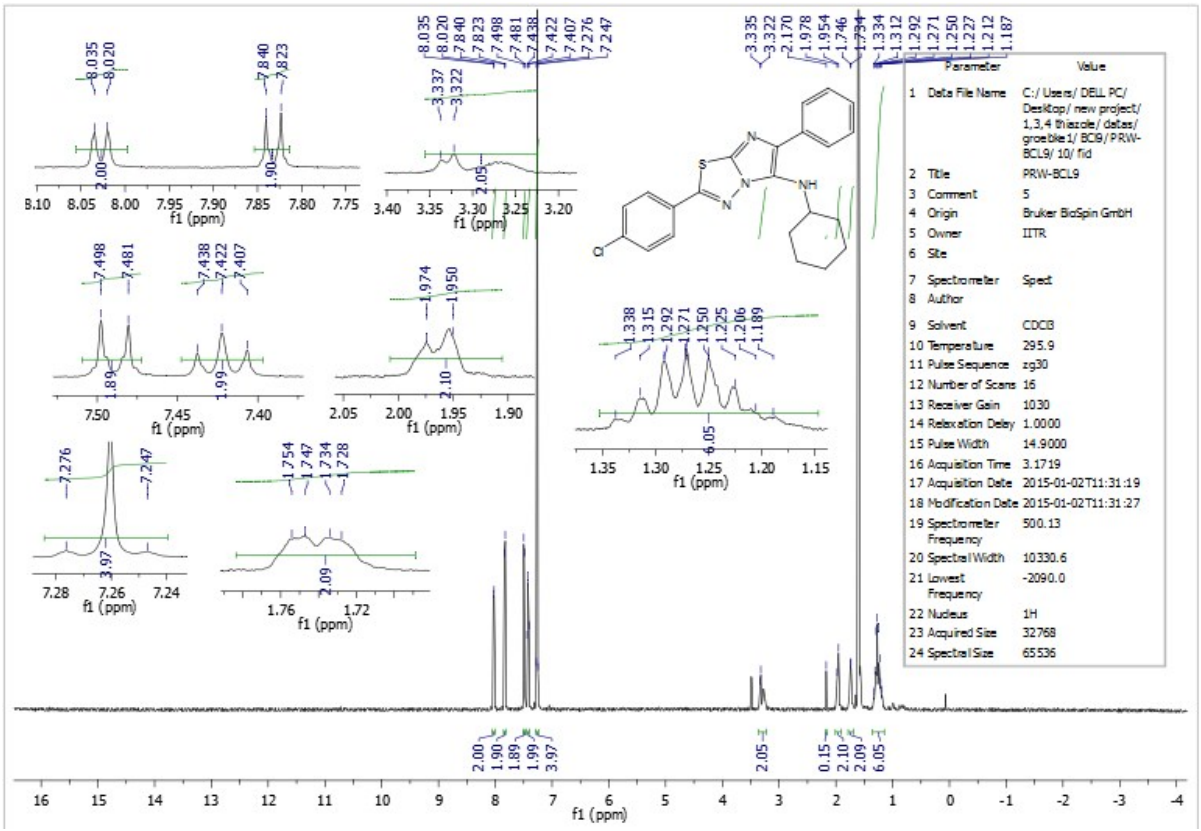

159.74
139.68
137.71
133.60
133.14
132.15
129.57
128.90
128.60
127.96
127.10
99.99
56.80
33.90
25.75
24.82
Cl
Cl
N
S
N
N
NH
Parameter
Value
1 Data File Name
C:/ Users/ DELL PC/ Desktop/ new project 1,3,4 thiazole/ dattes groebke1/ BCl11/ PRW-BCL11 13C1/ 1
fid
2 Title
PRW-BCL11 13C1
3 Comment
PRW-BCL11
4 Origin
Bruker BioSpin GmbH
5 Owner
IITR
6 Site
7 Spectrometer
Spect
8 Author
9 Solvent
CDCl3
10 Temperature
297.1
11 Pulse Sequence
zgpg30
12 Number of Scans
231
13 Receiver Gain
11500
14 Relaxation Delay
2.0000
15 Pulse Width
9.8000
16 Acquisition Time
1.0912
17 Acquisition Date
2015-01-05T13:38:1
18 Modification Date
2015-01-05T13:49:1
19 Spectrometer Frequency
125.76
20 Spectral Width
30030.0
21 Lowest Frequency
-2439.7
22 Nucleus
13C
24 Spectral Size
65536
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

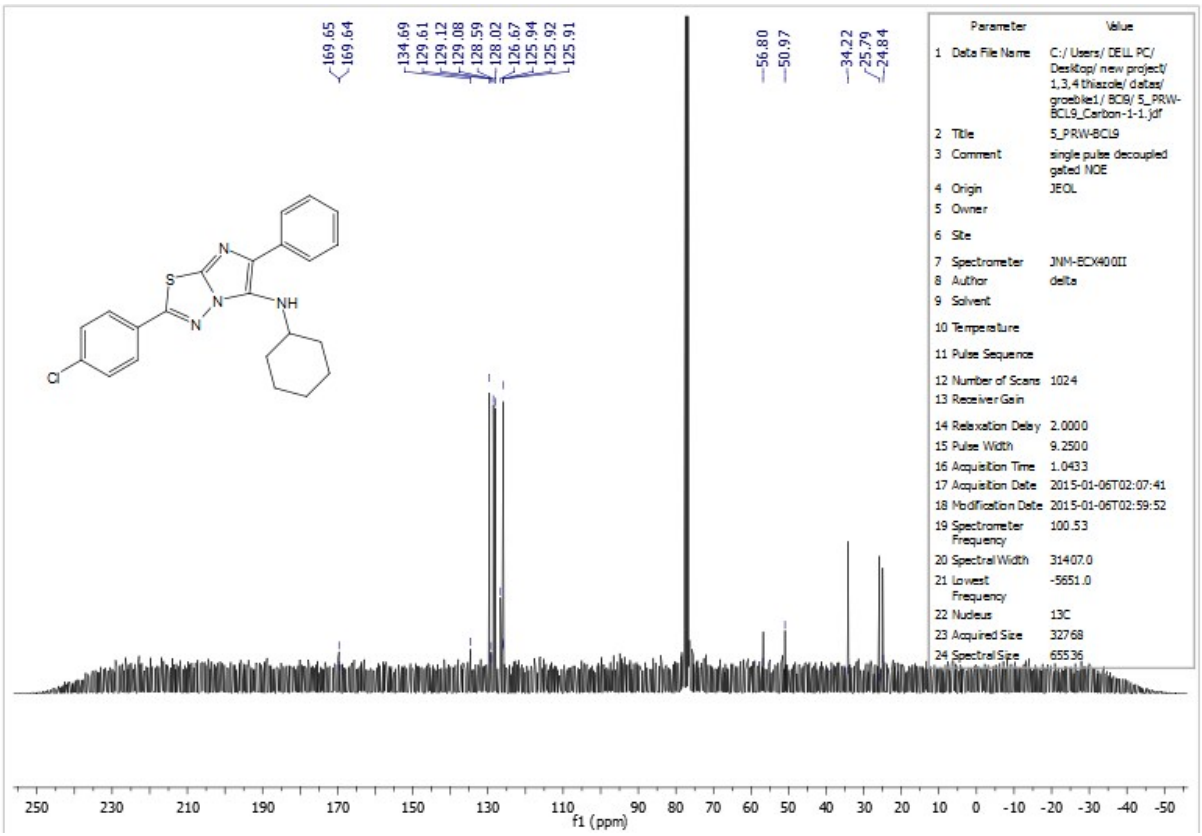
N-tert-butyl-6-(4-methoxyphenyl)-2-(4-nitrophenyl)imidazo[2,1-_b_][1,3,4]thiadiazol-5-amine (4j)



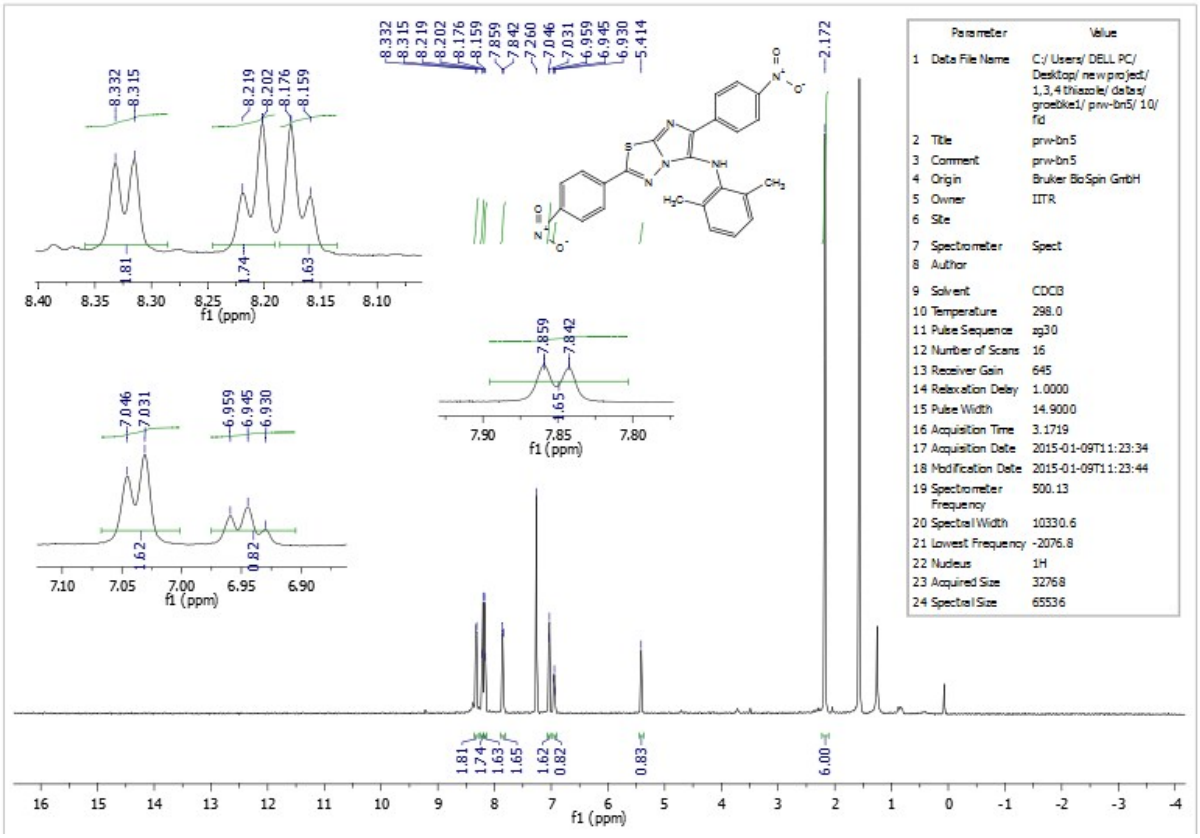

158.89
157.23
149.20
140.56
139.43
136.35
128.23
127.46
127.34
126.06
124.59
113.72
56.32
55.32
30.36
Parameter Value
1 Data File Name C:/ Users/ DELL PC/ Desktop/ new project/ 1,3,4 thiazole/ dates/ groebke1/ BN3/ 30_PRW-BN3_Carbon-1-1.jdf
2 Title 30_PRW-BN3
3 Comment single pulse decoupled gated NOE
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 1024
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 9.2500
16 Acquisition Time 1.0433
17 Acquisition Date 2014-12-31T09:35:47
18 Modification Date 2014-12-31T10:27:59
19 Spectrometer Frequency 100.53
20 Spectral Width 31407.0
21 Lowest Frequency -5651.0
22 Nucleus 13C
23 Acquired Size 32768
24 Spectral Size 65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

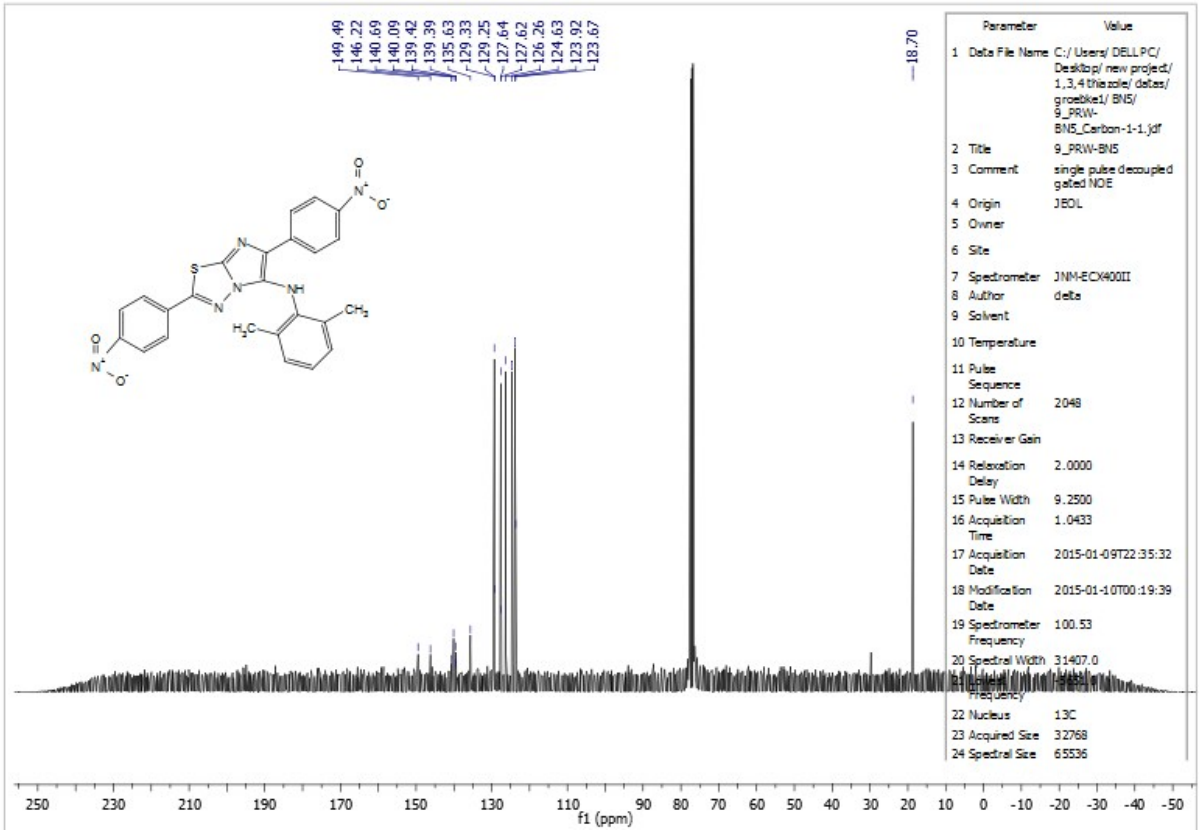
2-(4-chlorophenyl)-*N*-cyclohexyl-6-phenylimidazo[2,1-*b*][1,3,4]thiazol-5-amine (4k)



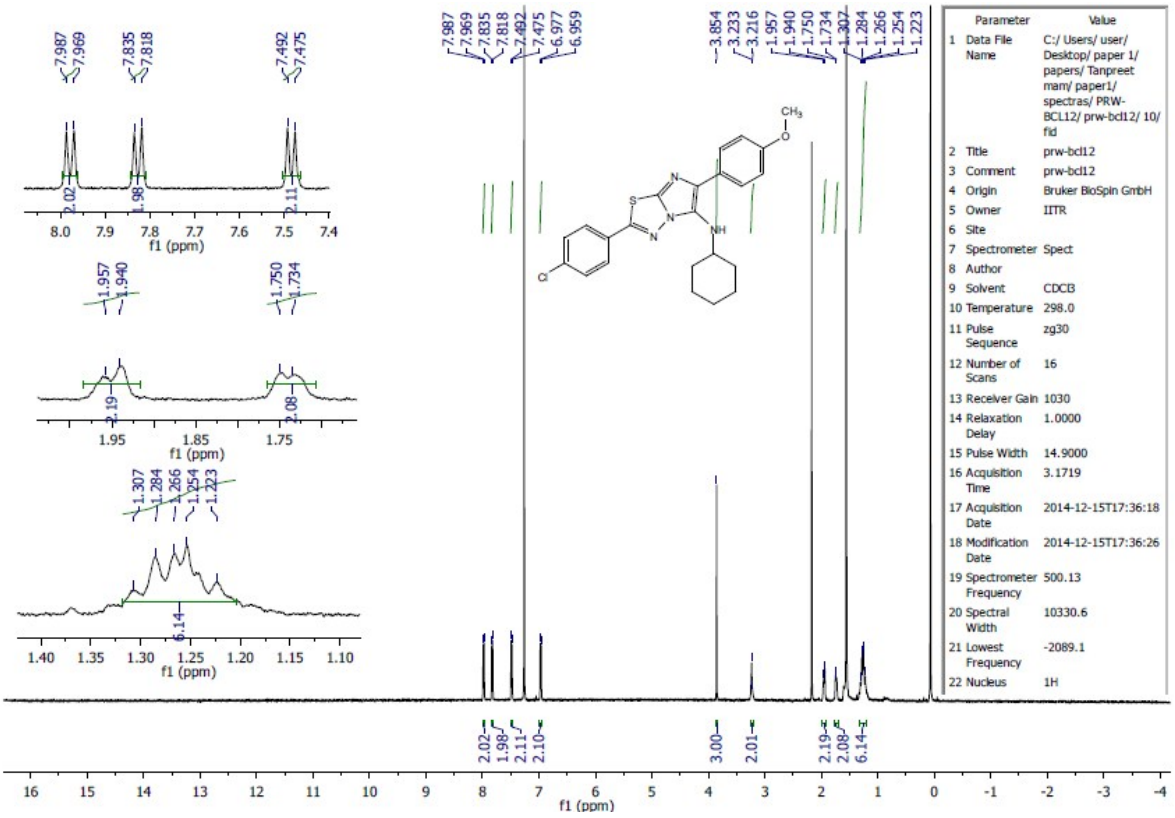

169.65
169.64
134.69
129.61
129.12
129.08
128.59
128.02
126.67
125.94
125.92
125.91
56.80
50.97
34.22
25.79
24.84
Parameter
Value
1 Data File Name
C:/ Users/ DELL PC/ Desktop/ new project/ 1,3,4 thiazole/ dates/ groebke1/ BCl9/ 5_PRW-BCL9_Carbon-1-1.jdf
2 Title
5_PRW-BCL9
3 Comment
single pulse decoupled gated NOE
4 Origin
JEOL
5 Owner
6 Site
7 Spectrometer
JNM-ECX400II
8 Author
delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans
1024
13 Receiver Gain
14 Relaxation Delay
2.0000
15 Pulse Width
9.2500
16 Acquisition Time
1.0433
17 Acquisition Date
2015-01-06T02:07:41
18 Modification Date
2015-01-06T02:59:52
19 Spectrometer Frequency
100.53
20 Spectral Width
31407.0
21 Lowest Frequency
-5651.0
22 Nucleus
13C
23 Acquired Size
32768
24 Spectral Size
65536
N
S
N
N
NH
Cl
250
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
f1 (ppm)

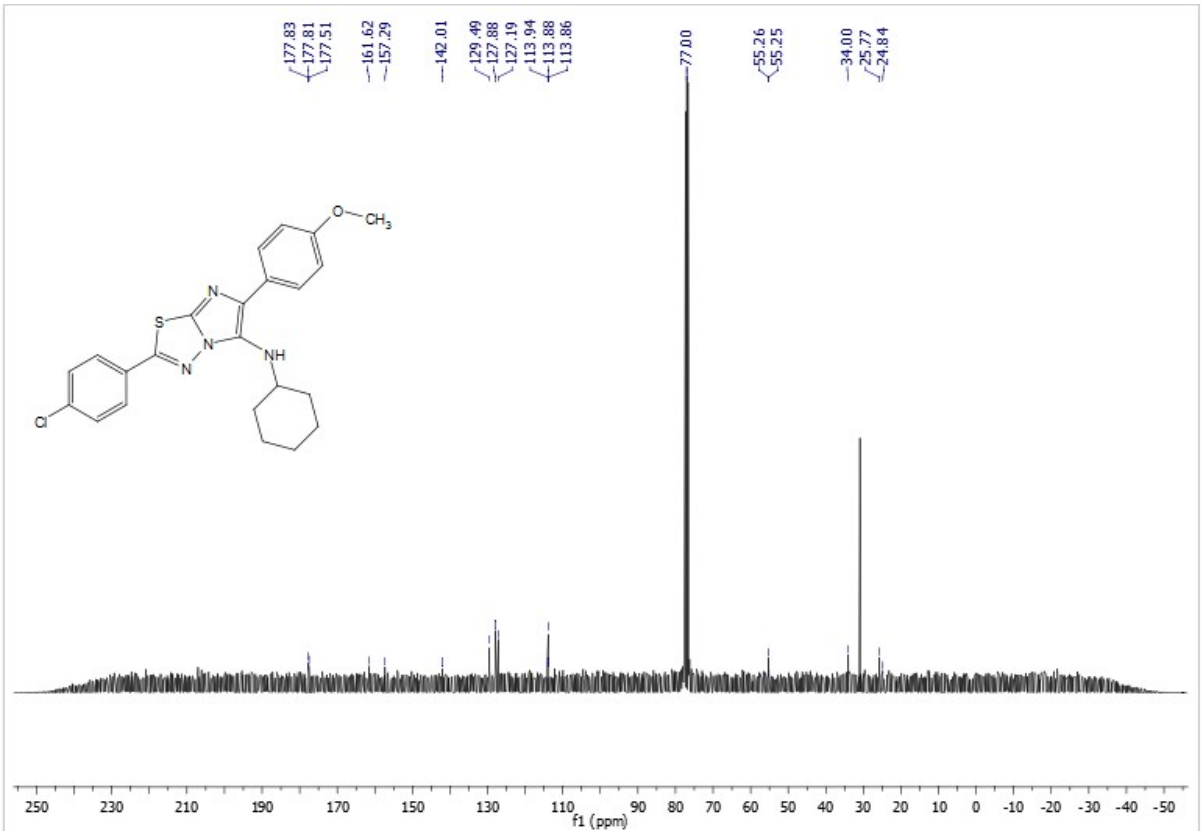
***N*-(2,6-dimethylphenyl)-2,6-bis(4-nitrophenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4l)**



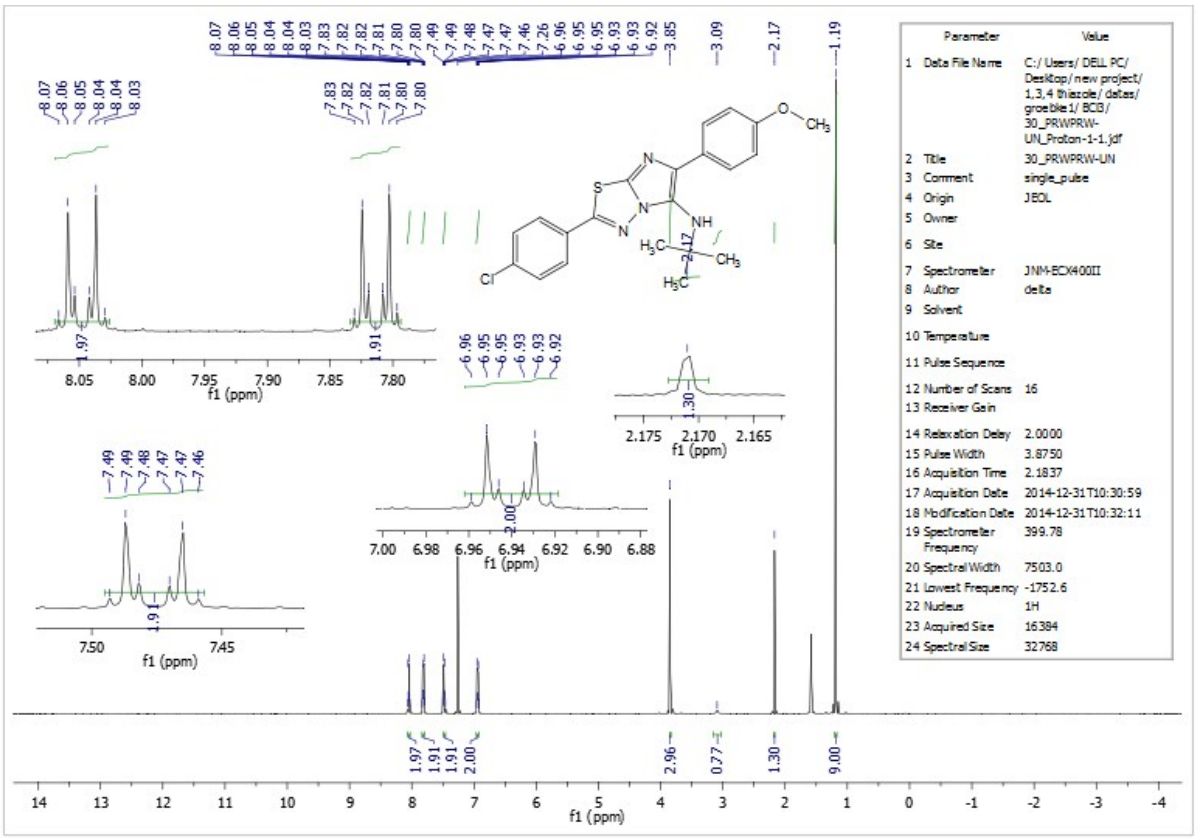

149.49
146.22
140.69
140.09
139.42
139.39
135.63
129.33
129.25
127.64
127.62
126.26
124.63
123.92
123.67
18.70
Parameter Value
1 Data File Name C:/ Users/ DELL PC/ Desktop/ new project/ 1,3,4 thiazole/ datas/ groebke1/ BN5/ 9_PRW-BN5_Carbon-1-1.jdf
2 Title 9_PRW-BN5
3 Comment single pulse decoupled gated NOE
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 2048
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 9.2500
16 Acquisition Time 1.0433
17 Acquisition Date 2015-01-09T22:35:32
18 Modification Date 2015-01-10T00:19:39
19 Spectrometer Frequency 100.53
20 Spectral Width 31407.0
22 Nucleus 13C
23 Acquired Size 32768
24 Spectral Size 65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

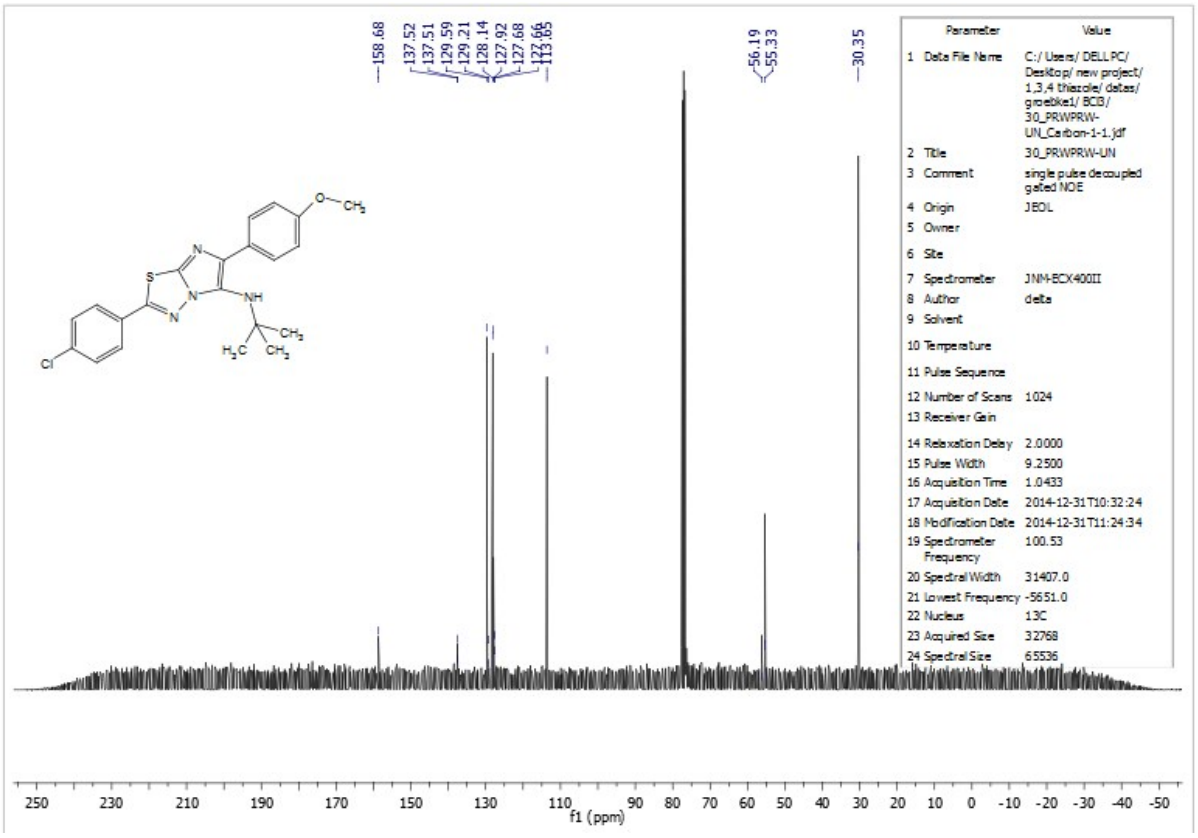
2-(4-chlorophenyl)-*N*-cyclohexyl-6-(4-methoxyphenyl)imidazo[2,1-*b*][1,3,4]thiazol-5-amine (4m)



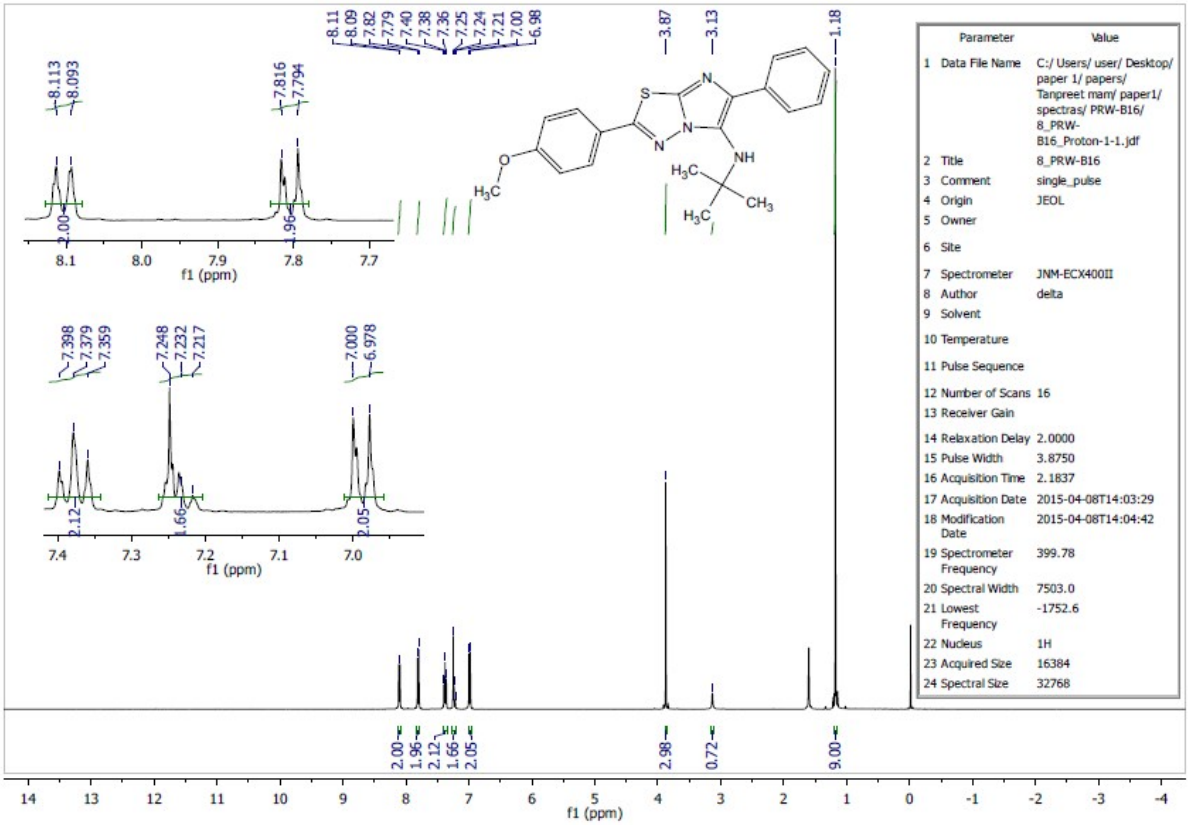

177.83
177.81
177.51
161.62
157.29
142.01
129.49
127.88
127.19
113.94
113.88
113.86
77.00
55.26
55.25
34.00
25.77
24.84
O
CH3
N
S
N
N
NH
Cl
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

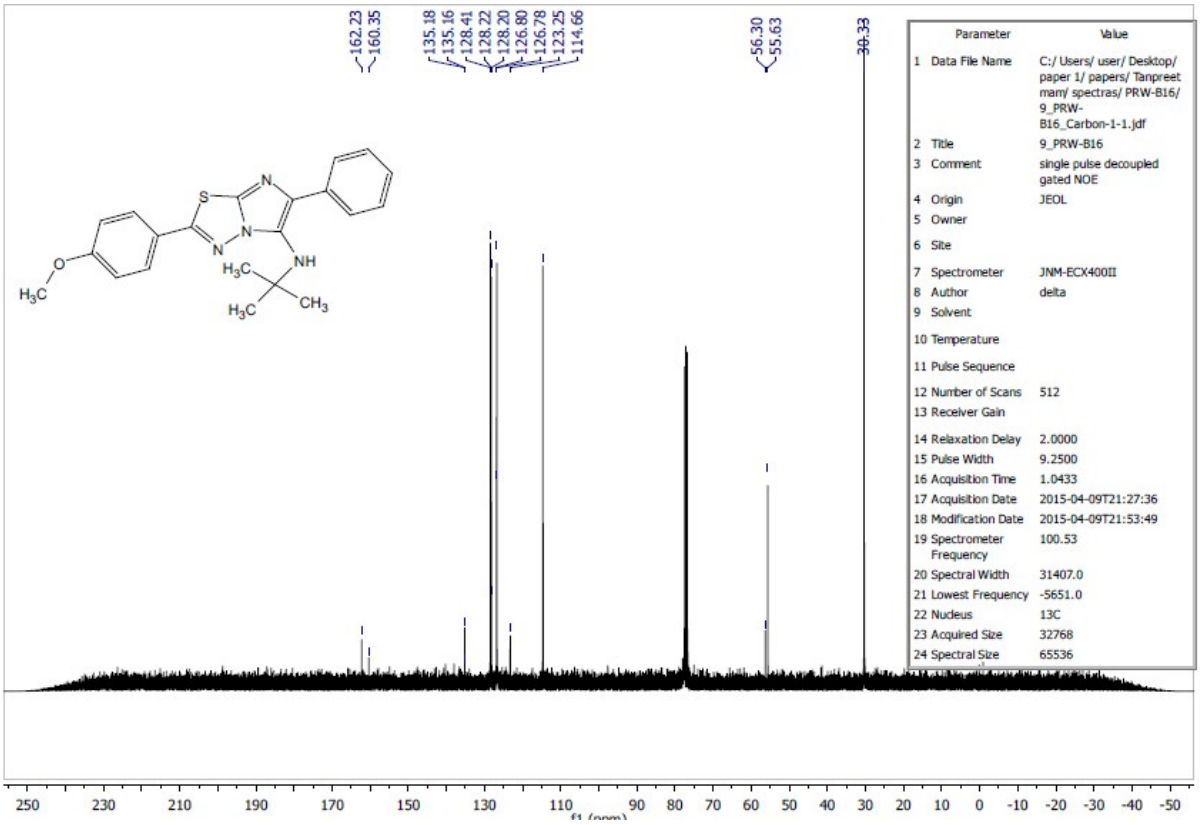
N-tert-butyl-2-(4-chlorophenyl)-6-(4-methoxyphenyl)imidazo[2,1-_b_][1,3,4]thiazol-5-amine (4n)



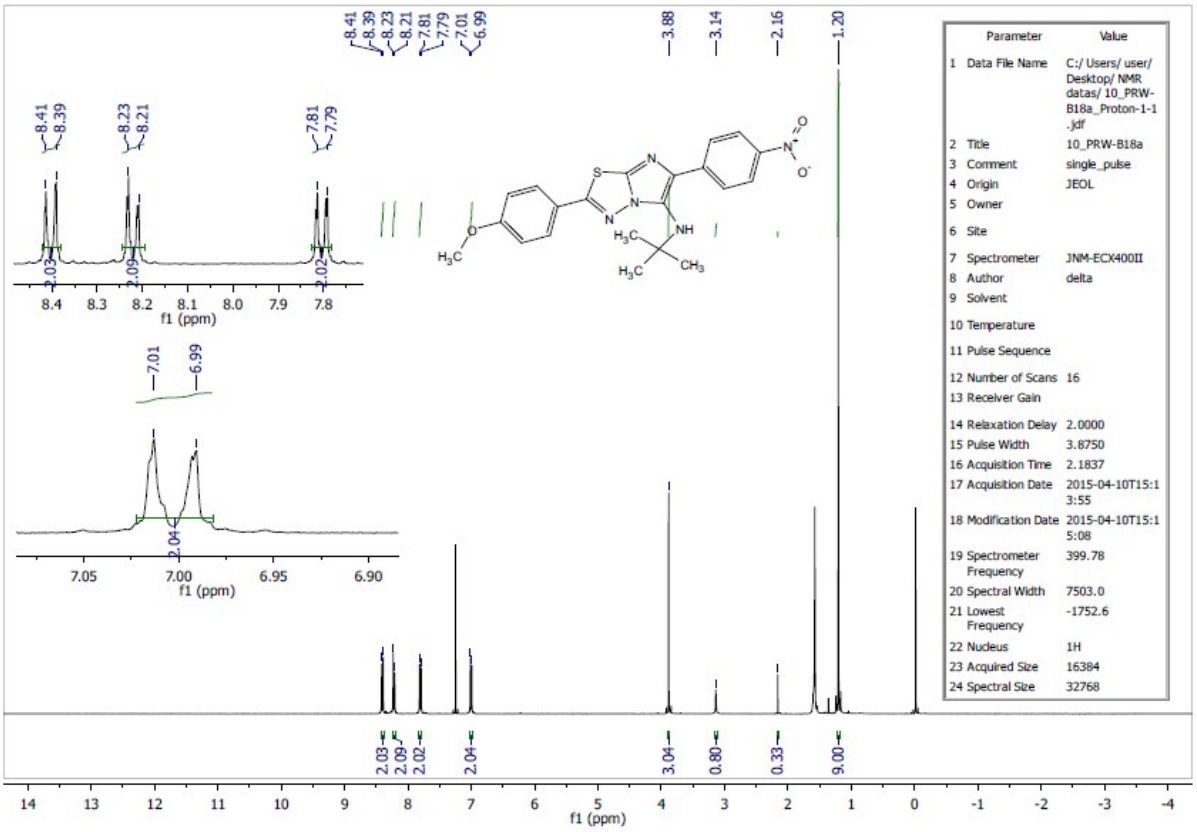

158.68
137.52
137.51
129.59
129.21
128.14
127.92
127.68
115.65
56.19
55.33
30.35
Parameter Value
1 Data File Name C:/Users/DELLPC/Desktop/new project/1,3,4 thiazole/dates/greebke1/BCB/30_PRWPRW-UN_Carbon-1-1.jdf
2 Title 30_PRWPRW-UN
3 Comment single pulse decoupled gated NOE
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 1024
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 9.2500
16 Acquisition Time 1.0433
17 Acquisition Date 2014-12-31T10:32:24
18 Modification Date 2014-12-31T11:24:34
19 Spectrometer Frequency 100.53
20 Spectral Width 31407.0
21 Lowest Frequency -5651.0
22 Nucleus 13C
23 Acquired Size 32768
24 Spectral Size 65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

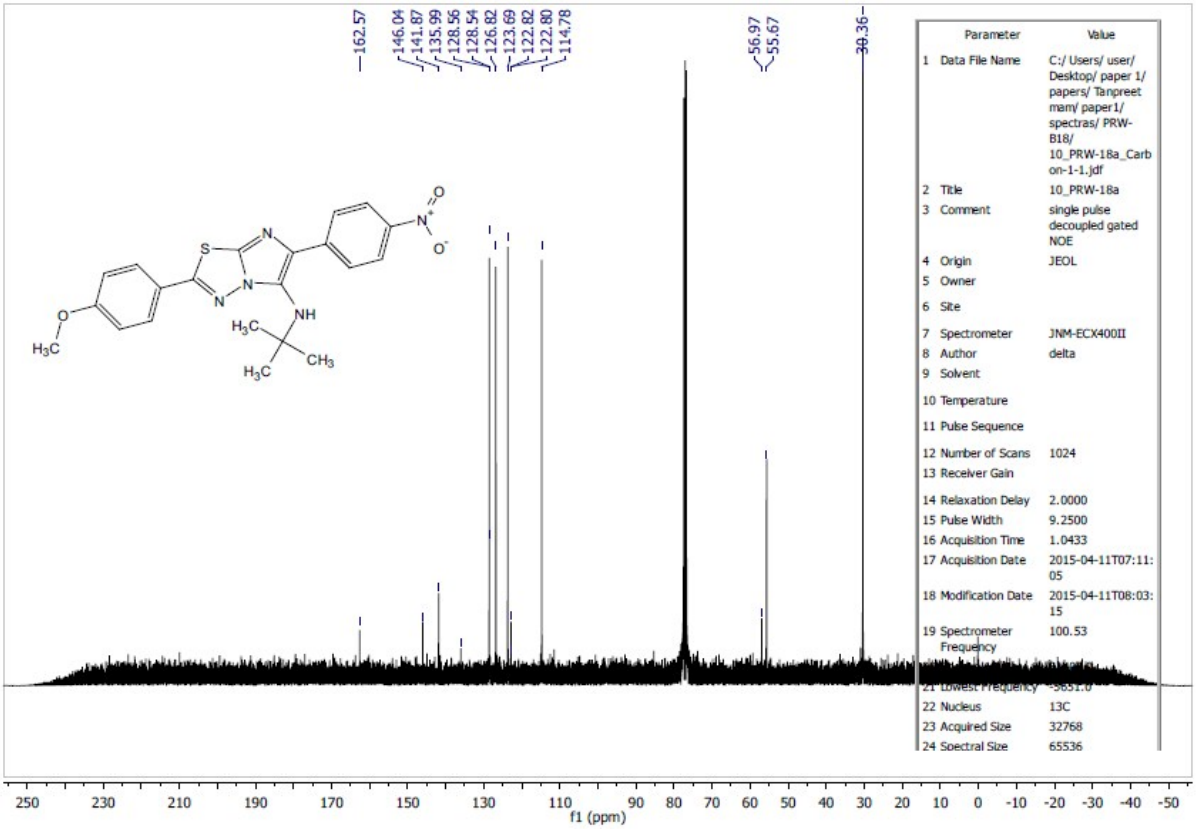
***N-tert*-butyl-2(4-methoxyphenyl)-6-phenylimidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4o):**



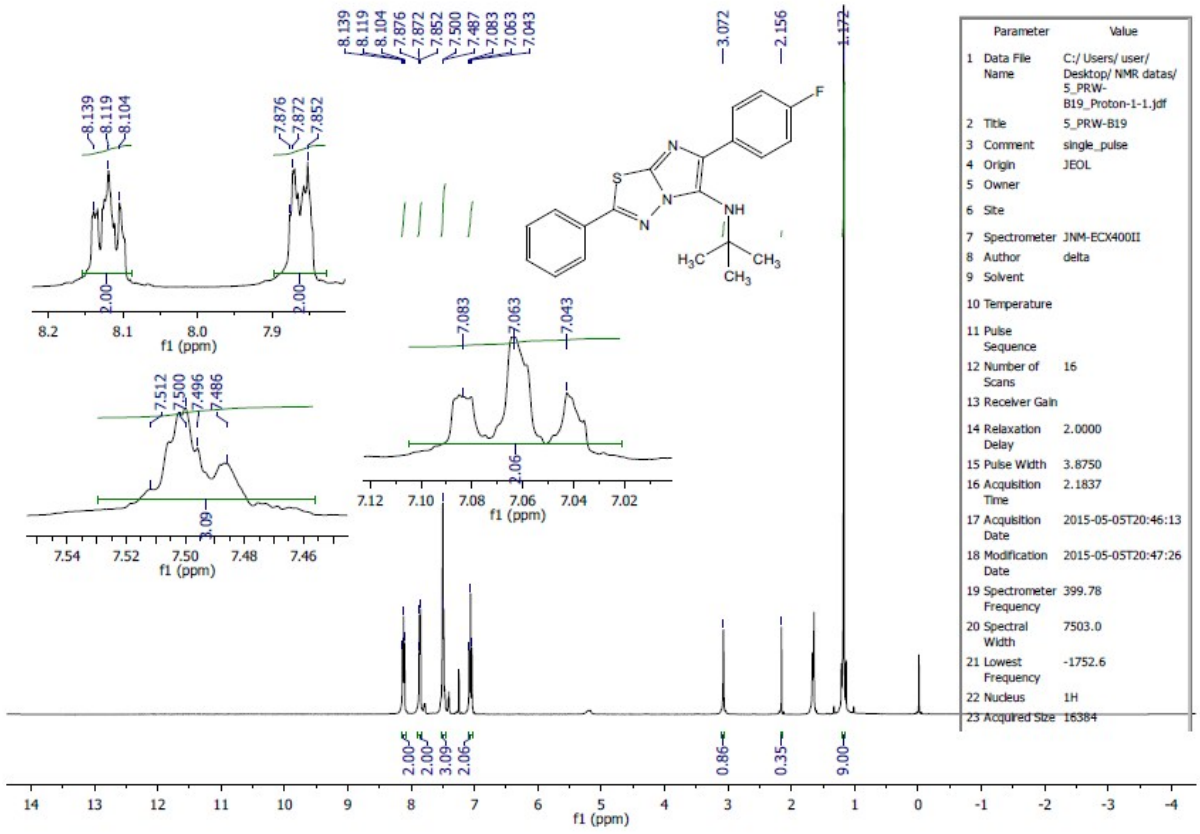

162.23
160.35
135.18
135.16
128.41
128.22
128.20
126.80
126.78
123.25
114.66
56.30
55.63
30.33
Parameter
Value
1 Data File Name
C:/ Users/ user/ Desktop/ paper 1/ papers/ Tanpreet mam/ spectras/ PRW-B16/ 9_PRW-B16_Carbon-1-1.jdf
2 Title
9_PRW-B16
3 Comment
single pulse decoupled gated NOE
4 Origin
JEOL
5 Owner
6 Site
7 Spectrometer
JNM-ECX400II
8 Author
delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans
512
13 Receiver Gain
14 Relaxation Delay
2.0000
15 Pulse Width
9.2500
16 Acquisition Time
1.0433
17 Acquisition Date
2015-04-09T21:27:36
18 Modification Date
2015-04-09T21:53:49
19 Spectrometer Frequency
100.53
20 Spectral Width
31407.0
21 Lowest Frequency
-5651.0
22 Nucleus
13C
23 Acquired Size
32768
24 Spectral Size
65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50

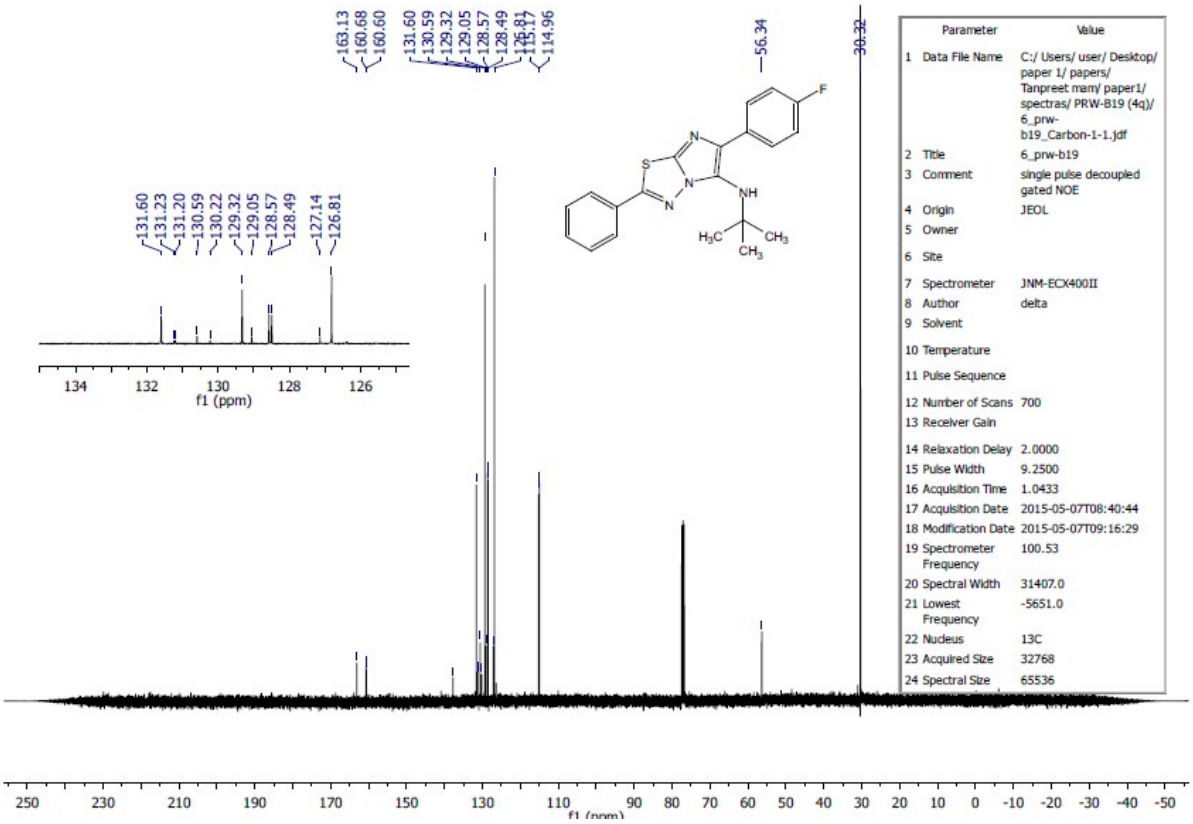
N-tert-butyl-2(4-methoxyphenyl)-6-(4-nitrophenyl)imidazo[2,1-_b_][1,3,4]thiadiazol-5-amine (4p):



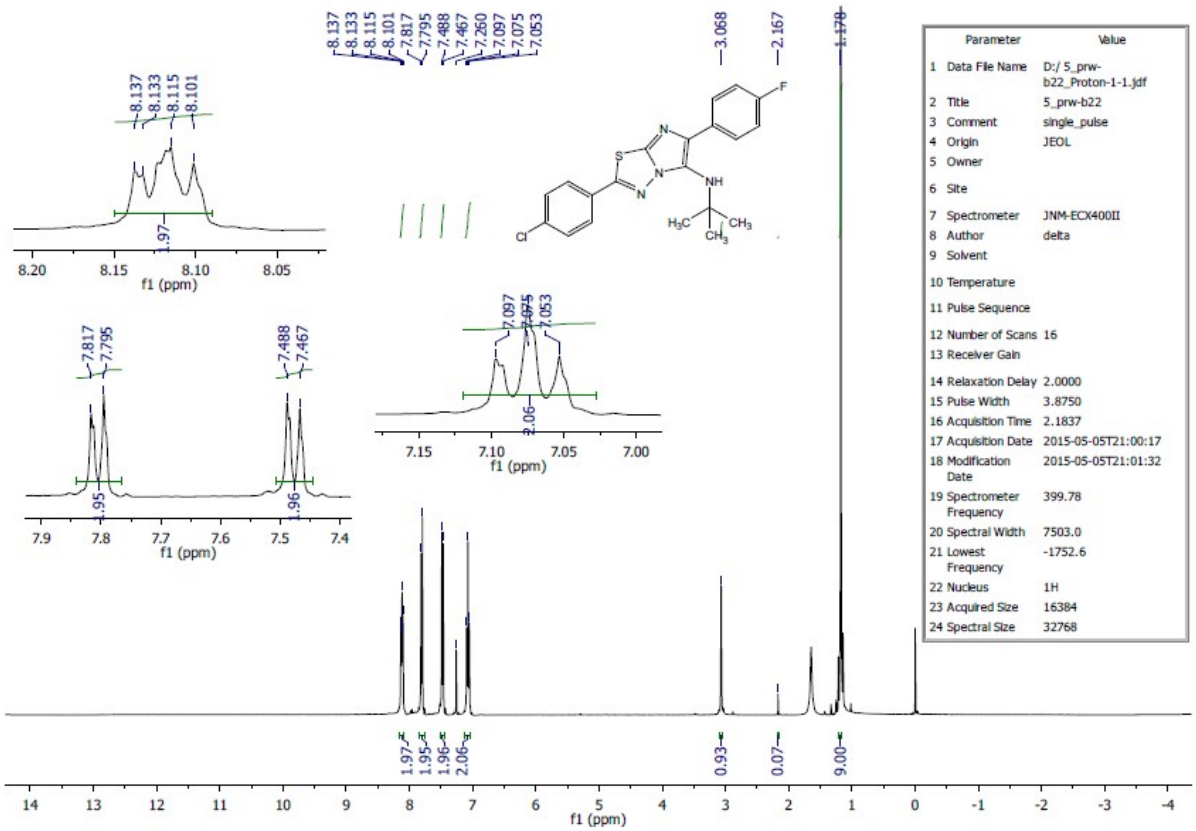

162.57
146.04
141.87
135.99
128.56
128.54
126.82
123.69
122.82
122.80
114.78
56.97
55.67
30.36
Parameter
Value
1 Data File Name
C:/ Users/ user/ Desktop/ paper 1/ papers/ Tanpreet mam/ paper1/ spectras/ PRW-B18/ 10_PRW-18a_Carbon-1-1.jdf
2 Title
10_PRW-18a
3 Comment
single pulse decoupled gated NOE
4 Origin
JEOL
5 Owner
6 Site
7 Spectrometer
JNM-ECX400II
8 Author
delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans
1024
13 Receiver Gain
14 Relaxation Delay
2.0000
15 Pulse Width
9.2500
16 Acquisition Time
1.0433
17 Acquisition Date
2015-04-11T07:11:05
18 Modification Date
2015-04-11T08:03:15
19 Spectrometer Frequency
100.53
22 Nucleus
13C
23 Acquired Size
32768
24 Spectral Size
65536
250 230 210 190 170 150 130 110 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50
f1 (ppm)

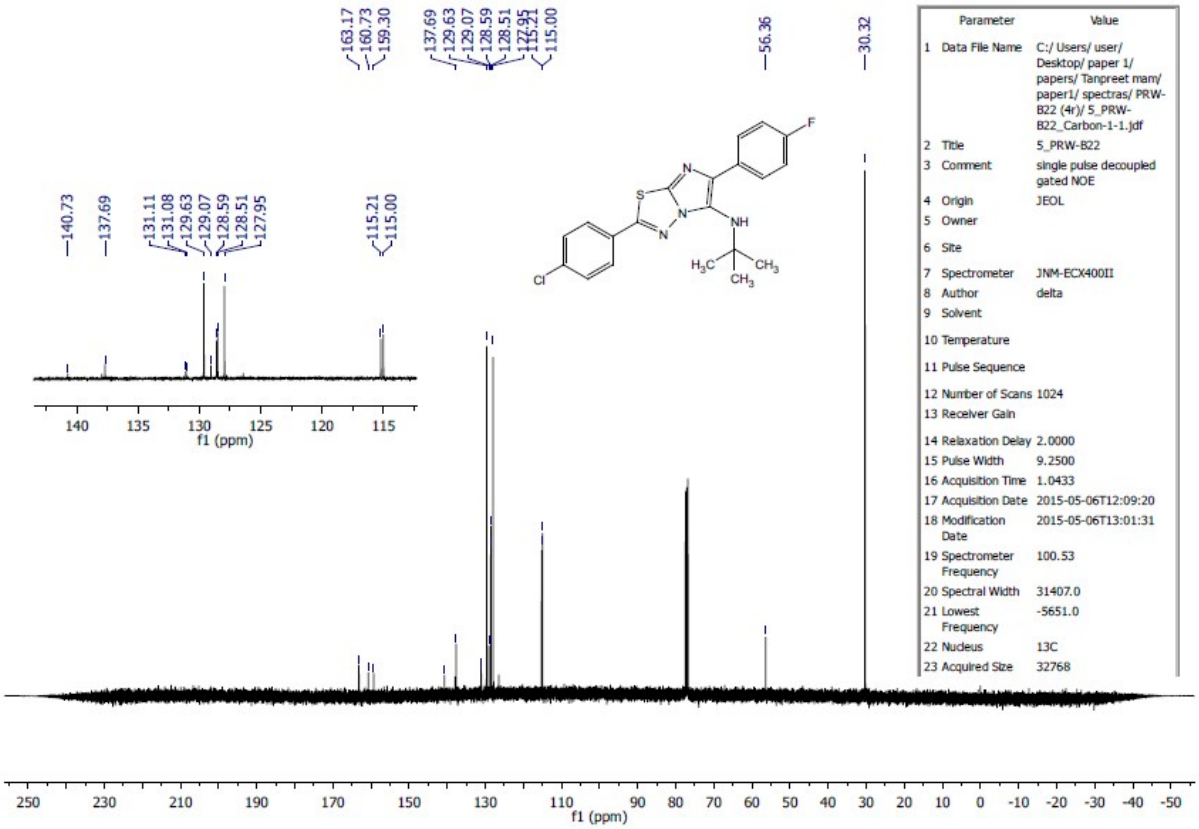
***N-tert*-butyl-6-(4-fluorophenyl)-2-phenylimidazo[2,1-*b*][1,3,4]thiadiazol-5-amine (4q):**





N-tert-butyl-2-(4-chlorophenyl)-6-(4-fluorophenyl)imidazo[2,1-_b_][1,3,4]thiadiazol-5-amine (4r):


8.137
8.133
8.115
8.101
7.817
7.795
7.488
7.467
7.260
7.097
7.075
7.053
3.068
2.167
1.178
F
N
S
N
N
NH
H3C
CH3
CH3
Cl
1.97
8.20
8.15
8.10
8.05
f1 (ppm)
7.817
7.795
7.488
7.467
1.95
1.96
7.9
7.8
7.7
7.6
7.5
7.4
f1 (ppm)
7.097
7.075
7.053
2.06
7.15
7.10
7.05
7.00
f1 (ppm)
1.97
1.95
1.96
2.06
0.93
0.07
9.00
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
f1 (ppm)
Parameter
Value
1 Data File Name D:/ 5_prw-b22_Proton-1-1.jdf
2 Title 5_prw-b22
3 Comment single_pulse
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 16
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 3.8750
16 Acquisition Time 2.1837
17 Acquisition Date 2015-05-05T21:00:17
18 Modification Date 2015-05-05T21:01:32
19 Spectrometer Frequency 399.78
20 Spectral Width 7503.0
21 Lowest Frequency -1752.6
22 Nucleus 1H
23 Acquired Size 16384
24 Spectral Size 32768


163.17
160.73
159.30
137.69
129.63
129.07
128.59
128.51
115.21
115.00
56.36
30.32
140.73
137.69
131.11
131.08
129.63
129.07
128.59
128.51
127.95
115.21
115.00
f1 (ppm)
F
Cl
N
S
N
N
NH
H3C
CH3
CH3
Parameter
Value
1 Data File Name C:/ Users/ user/ Desktop/ paper 1/ papers/ Tanpreet mam/ paper1/ spectras/ PRW-B22 (4r)/ 5_PRW-B22_Carbon-1-1.jdf
2 Title 5_PRW-B22
3 Comment single pulse decoupled gated NOE
4 Origin JEOL
5 Owner
6 Site
7 Spectrometer JNM-ECX400II
8 Author delta
9 Solvent
10 Temperature
11 Pulse Sequence
12 Number of Scans 1024
13 Receiver Gain
14 Relaxation Delay 2.0000
15 Pulse Width 9.2500
16 Acquisition Time 1.0433
17 Acquisition Date 2015-05-06T12:09:20
18 Modification Date 2015-05-06T13:01:31
19 Spectrometer Frequency 100.53
20 Spectral Width 31407.0
21 Lowest Frequency -5651.0
22 Nucleus 13C
23 Acquired Size 32768
f1 (ppm)