

Supporting Information

For

Ruthenium-Catalyzed Synthesis of 6-amino-1,3,5-triazin-2(1H)-ones and 3,4-dihydro[1,3,5]triazino[1,2-a]benzimidazole-2-amines from alcohols and guanides

Ming Zeng^{a,b}, Zhong Pao Xie^{a,b}, Dong-Mei Cui^{*a,b}, and Chen Zhang^{*c}

^a*Institute of Drug Development & Chemical Biology, Zhejiang University of Technology, Hangzhou 310014, China*

^b*College of Pharmaceutical Science, Zhejiang University of Technology, Hangzhou 310014, China*

^c*School of Pharmaceutical Sciences, Zhejiang University, Hangzhou 310058, China*

E-mail Address: cuidongmei@zjut.edu.cn

Experimental Section

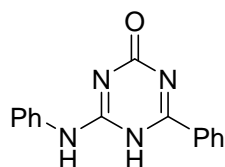
Under otherwise noted, materials were obtained from commercial suppliers and used without further purification. Thin layer chromatography (TLC) was performed using silica gel 60 F254 and visualized using UV light. Column chromatography was performed with silica gel (mesh 300e400). ¹H NMR and ¹³C NMR spectra were recorded on a Bruker Avance 500 MHz spectrometer in CDCl₃ and DMSO-*d*₆ with Me₄Si as an internal standard. Data were reported as follows: chemical shift in parts per million (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, br = broad, and m = multiplet), coupling constant in Hertz (Hz) and integration. IR spectra were recorded on an FT-IR spectrometer and only major peaks are reported in cm⁻¹. HRMS and mass data were recorded by ESI on a TOF mass spectrometer.

General Procedure for Synthesis of 1, 3, 5-triazines:

To a mixture of alcohols (0.5 mmol), guanides (0.75 mmol), and *t*-BuOK (1.5 mmol) in dioxane (3 mmol) was added RuCl₂(COD) (2 mol%). The resulting mixture in a tube reactor

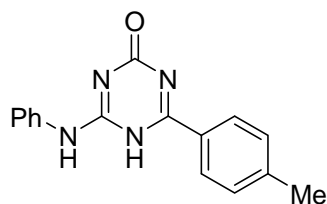
was then sealed and stirred for 20 h at 100 °C. After completion of the reaction, MeOH was added and filtered. The crude residue was obtained after evaporation of the solvent in vacuum, and the residue was purified by flash chromatography with CH₂Cl₂ and CH₃OH as eluents to give the pure product.

4-phenyl-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3a)



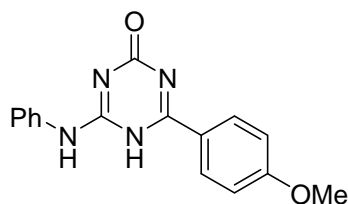
White solid; Mp: >300°C [lit.¹ 331-335°C]; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.25 (br, 1H), 10.12 (br, 1H), 8.19 (d, *J* = 7.6 Hz, 2H), 8.00-7.74 (m, 2H), 7.68 (t, *J* = 7.6 Hz, 1H), 7.59 (t, *J* = 7.6 Hz, 2H), 7.35 (t, *J* = 7.4 Hz, 2H), 7.08 (t, *J* = 7.4 Hz, 1H).

4-(phenylamino)-6-(p-tolyl)-1,3,5-triazin-2(5H)-one (3b)



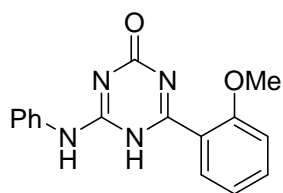
White solid; Mp: >300°C [lit.¹ 350°C]; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.18 (br, 1H), 10.03 (br, 1H), 8.18 (d, *J* = 7.8 Hz, 2H), 7.73-7.69 (m, 2H), 7.67 (t, *J* = 7.4 Hz, 1H), 7.58 (t, *J* = 7.4 Hz, 2H), 7.16 (d, *J* = 7.8 Hz, 2H), 2.29 (s, 3H).

4-(4-methoxyphenyl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3c)



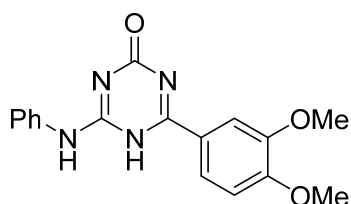
White solid; Mp: >300°C; IR(KBr, cm⁻¹): 3444, 1666, 1605, 1538, 1445, 1360, 1262, 1179, 799; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.09 (br, 1H), 10.02 (br, 1H), 8.21 (d, *J* = 8.9 Hz, 2H), 7.85-7.67 (m, 2H), 7.34 (t, *J* = 7.3 Hz, 2H), 7.13 (d, *J* = 8.9 Hz, 2H), 7.07 (t, *J* = 7.3 Hz, 1H), 3.87 (s, 3H); ¹³C NMR (150 MHz, DMSO-*d*₆) δ 164.1, 163.7, 163.2, 156.7, 139.4, 130.5, 129.0, 123.7, 123.1, 121.0, 114.7, 56.1. HRMS (ESI) *m/z* [M+H]⁺ calcd for C₁₆H₁₅N₄O₂ 295.1195, found 295.1192.

4-(2-methoxyphenyl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3d)



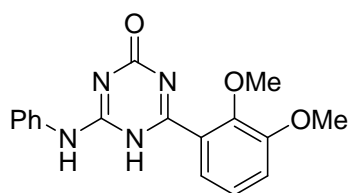
White solid; Mp: 238-240 °C; IR(KBr, cm^{-1}): 3444, 1697, 1644, 1589, 1489, 1232, 746; ^1H NMR (500 MHz, $\text{DMSO}-d_6$) δ 11.69 (br, 1H), 10.12 (br, 1H), 7.84 (d, $J = 7.8$ Hz, 2H), 7.75 (d, $J = 7.4$ Hz, 1H), 7.60 (t, $J = 7.8$, 1H), 7.34 (t, $J = 7.8$ Hz, 2H), 7.22 (d, $J = 7.4$ Hz, 1H), 7.12 (t, $J = 7.4$ Hz, 1H), 7.07 (t, $J = 7.4$ Hz, 1H), 3.89 (s, 3H); ^{13}C NMR (150 MHz, $\text{DMSO}-d_6$) δ 164.1, 163.9, 158.0, 155.8, 139.3, 134.0, 130.7, 129.0, 123.7, 121.0, 120.9, 120.5, 112.6, 56.4. HRMS (ESI) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{16}\text{H}_{15}\text{N}_4\text{O}_2$ 295.1195, found 295.1190.

4-(3,4-dimethoxyphenyl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3e)



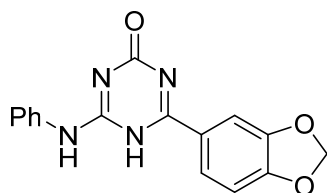
White solid; Mp: >300 °C; IR(KBr, cm^{-1}): 3418, 2935, 1693, 1601, 1568, 1497, 1441, 1274, 1128, 1021, 792; ^1H NMR (500 MHz, $\text{DMSO}-d_6$) δ 12.11 (br, 1H), 10.02 (br, 1H), 8.26-7.69 (m, 4H), 7.41-7.25 (m, 2H), 7.16 (d, $J = 8.3$ Hz, 1H), 7.10-7.05 (m, 1H), 3.87 (s, 6H); ^{13}C NMR (125 MHz, DMSO) δ 163.7, 163.6, 161.4, 153.0, 148.6, 139.0, 128.5, 123.2, 122.0, 120.6, 120.5, 111.4, 110.8, 55.8, 55.7. HRMS (ESI) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{17}\text{H}_{17}\text{N}_4\text{O}_3$ 325.1301, found 325.1313.

4-(2,3-dimethoxyphenyl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3f)



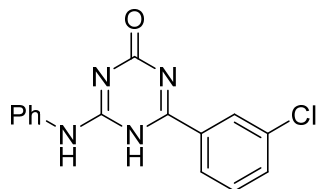
White solid; Mp: 214-216 °C; IR(KBr, cm^{-1}): 3470, 3414, 1692, 1615, 1384, 1268, 1071, 934; ^1H NMR (500 MHz, $\text{DMSO}-d_6$) δ 11.86 (br, 1H), 10.12 (br, 1H), 7.84 (d, $J = 7.2$ Hz, 2H), 7.34 (t, $J = 7.2$ Hz, 2H), 7.29 (dd, $J = 7.0, 2.8$ Hz, 1H), 7.24-7.21 (m, 2H), 7.07 (t, $J = 7.0$ Hz, 1H), 3.88 (s, 3H), 3.82 (s, 3H); ^{13}C NMR (125 MHz, $\text{DMSO}-d_6$) δ 164.2, 163.9, 155.7, 152.9, 147.4, 139.3, 128.9, 126.9, 124.6, 123.8, 121.4, 121.1, 116.6, 61.7, 56.6. HRMS (ESI) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{17}\text{H}_{17}\text{N}_4\text{O}_3$ 325.1301, found 325.1311.

4-(benzo[d][1,3]dioxol-5-yl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3g)



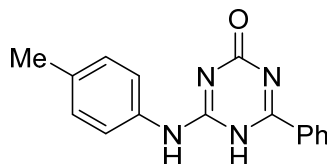
White solid; Mp: >300°C; IR(KBr, cm⁻¹): 3365, 3034, 1698, 1573, 1477, 1444, 1383, 1263, 1037, 798; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.07 (br, 1H), 10.01 (br, 1H), 8.06-7.58 (m, 4H), 7.48-7.24 (m, 2H), 7.21-7.00 (m, 2H), 6.18 (s, 2H); ¹³C NMR (150 MHz, DMSO-*d*₆) δ 164.0, 163.9, 156.7, 152.0, 148.3, 139.4, 129.0, 124.7, 124.2, 123.7, 121.0, 108.9, 108.0, 102.7. HRMS (ESI) m/z [M+H]⁺ calcd for C₁₆H₁₃N₄O₃ 309.0988, found 309.0985.

4-(3-chlorophenyl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3h)



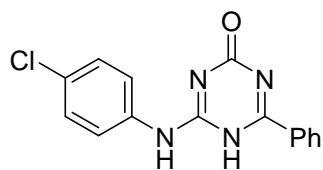
White solid; Mp: >300°C; IR(KBr, cm⁻¹): 3478, 1705, 1615, 1571, 1481, 1384, 1074, 787; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.33(br, 1H), 10.16(br, 1H), 8.34-8.21(m, 1H), 8.15 (d, *J* = 7.1 Hz, 1H), 7.85-7.45(m, 3H), 7.63(t, *J* = 7.5 Hz, 1H), 7.46-7.24 (m, 2H), 7.17-7.01 (m, 1H); ¹³C NMR (125 MHz, DMSO-*d*₆/CDCl₃) δ 164.1, 163.5, 157.1, 155.4, 138.9, 134.2, 132.8, 130.7, 128.8, 128.4, 126.9, 123.9, 121.4. HRMS (ESI) m/z [M+H]⁺ calcd for C₁₅H₁₂ClN₄O 299.0700, found 299.0696.

4-phenyl-6-(*p*-tolylamino)-1,3,5-triazin-2(5H)-one (3i)²



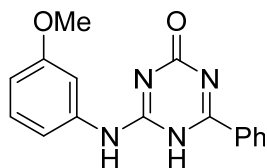
White solid; Mp: >300°C; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.18 (br, 1H), 10.03 (br, 1H), 8.18 (d, *J* = 7.8 Hz, 2H), 7.73-7.69 (m, 2H), 7.67 (t, *J* = 7.4 Hz, 1H), 7.58 (t, *J* = 7.4 Hz, 2H), 7.16 (d, *J* = 7.8 Hz, 2H), 2.29 (s, 3H).

4-(4-chlorophenyl)-6-(phenylamino)-1,3,5-triazin-2(5H)-one (3j)



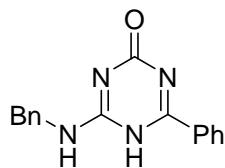
White solid; Mp: >300°C [lit.³ 352 - 354°C]; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.31 (br, 1H), 10.25 (br, 1H), 8.31-8.08 (m, 2H), 8.04-7.84 (m, 2H), 7.69-7.60 (m, 3H), 7.51-7.34 (m, 2H).

4-((3-methoxyphenyl)amino)-6-phenyl-1,3,5-triazin-2(5H)-one (3k)³²



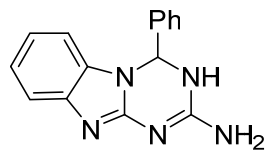
White solid; Mp: >300°C; ¹H NMR (500 MHz, DMSO-*d*₆) δ 12.27 (br, 1H), 10.08 (br, 1H), 8.19 (d, *J* = 7.5 Hz, 2H), 7.68 (t, *J* = 7.5 Hz, 1H), 7.60-7.57 (m, 3H), 7.50-7.35 (m, 1H), 7.25 (t, *J* = 8.4 Hz, 1H), 6.67 (dd, *J* = 8.4, 2.2 Hz, 1H), 3.76 (s, 3H).

4-(benzylamino)-6-phenyl-1,3,5-triazin-2(5H)-one (3l)



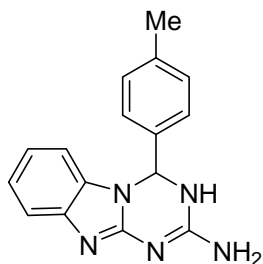
White solid; Mp: >300°C [lit.¹ 316-319°C]; ¹H NMR (500 MHz, DMSO-*d*₆) δ 11.94 (br, 1H), 8.54 (br, 1H), 8.12 (m, 2H), 7.65-7.26 (m, 8H), 4.65-4.51 (m, 2H).

4-phenyl-10,10a-dihydrobenzo[4,5]imidazo[1,2-a][1,3,5]triazin-2-amine(5a)



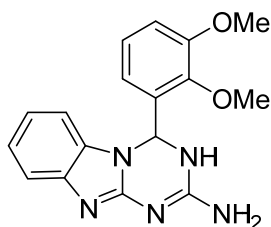
Light brown solid; Mp: 291-292°C [lit.⁴ 294-295°C]; ¹H NMR (500 MHz, DMSO-*d*₆) δ 8.51 (br, 1H), 7.45-7.33 (m, 5H), 7.22 (d, *J* = 7.8 Hz, 1H), 6.94 (t, *J* = 7.5 Hz, 1H), 6.87-6.71 (m, 5H).

4-(p-tolyl)-10,10a-dihydrobenzo[4,5]imidazo[1,2-a][1,3,5]triazin-2-amine(5b)



Light brown solid; Mp: 276-278°C [lit.⁵ 278-279°C]; ¹H NMR (500 MHz, DMSO-*d*₆) δ 8.26 (br, 1H), 7.24 (d, *J* = 8.1 Hz, 2H), 7.21-7.17 (m, 3H), 6.91 (td, *J* = 7.5 Hz, 0.9 Hz, 1H), 6.77 (t, *J* = 7.5 Hz, 1H), 6.72-6.69 (m, 2H), 6.44 (br, 2H), 2.27 (s, 3H).

4-(2,3-dimethoxyphenyl)-10,10a-dihydrobenzo[4,5]imidazo[1,2-a][1,3,5]triazin-2-amine (5c) (CAS: 326021-87-8)

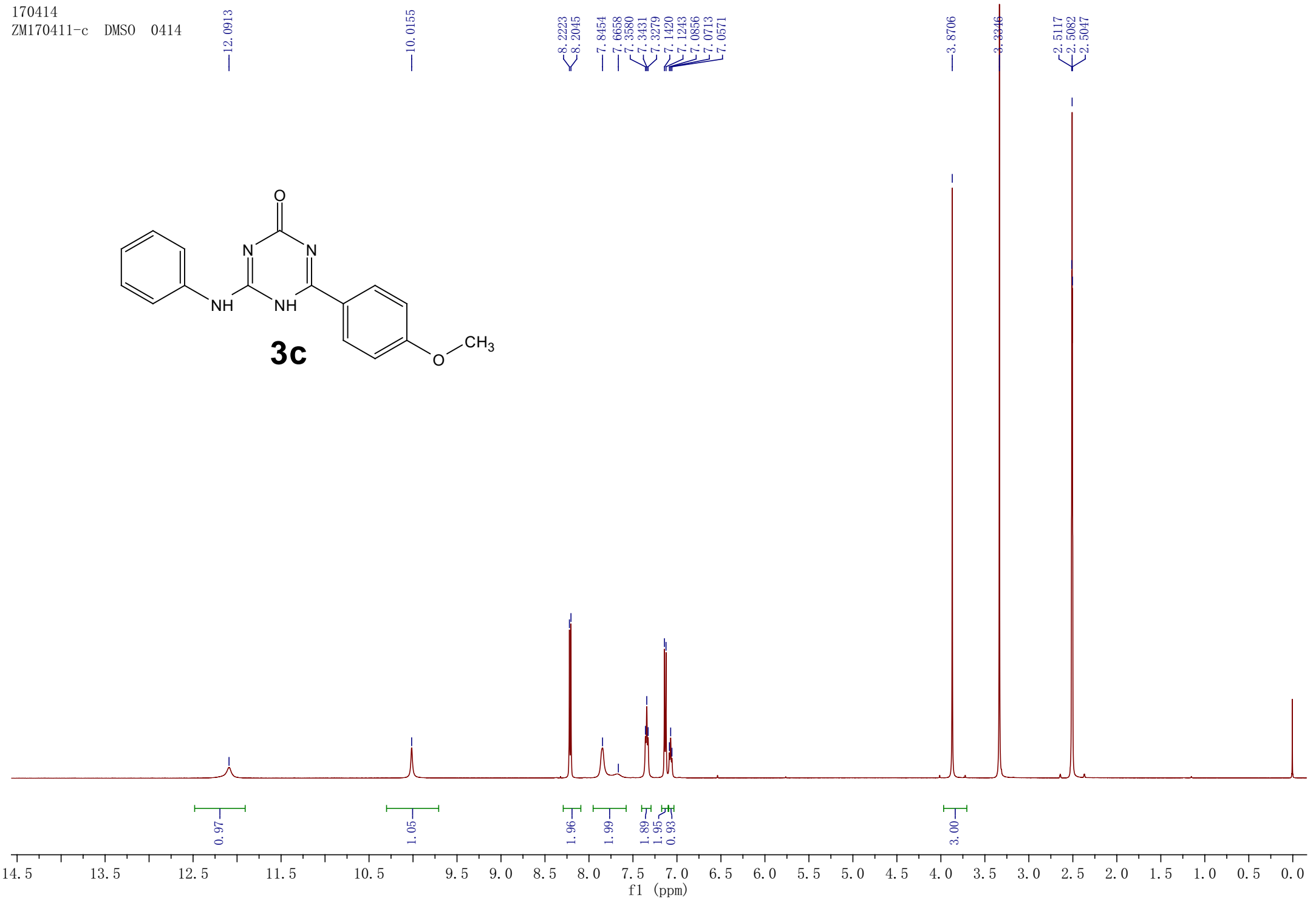
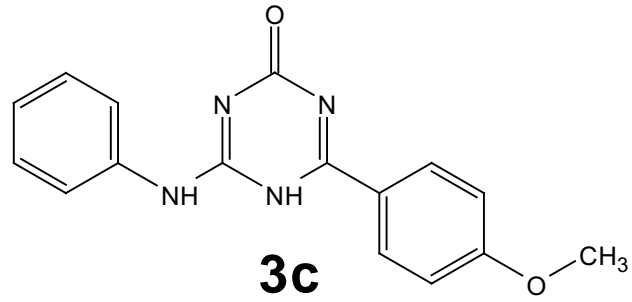


Light brown solid; Mp: 272-274°C; ¹H NMR (500 MHz, DMSO-*d*₆) δ 7.88 (br, 1H), 7.24 (d, *J* = 7.9 Hz, 1H), 7.06 (t, *J* = 7.9 Hz, 1H), 7.01 (t, *J* = 7.9 Hz, 1H), 6.97-6.92 (m, 2H), 6.82 (t, *J* = 7.5 Hz, 1H), 6.75 (d, *J* = 7.9 Hz, 1H), 6.55 (d, *J* = 7.5 Hz, 1H), 6.37 (br, 2H), 3.81 (s, 3H), 3.79 (s, 3H).

Ref.

- (1) Kohra, S.; Ueda, K.; Tominaga, Y. *Heterocycles* **1996**, *27*, 839.
- (2) Basyouni, M. N.; El-Khamry, A. A.; El-Adly, M. M. *Egypt. J. Chem.* **1981**, *23*, 243.
- (3) Degener, E.; Schmelzer, H. G.; Holtschmidt, H. *Angew. Chem., Int. Ed. Engl.* **1966**, *5*, 960.
- (4) Dolzhenko, A. V.; Chui, W. K. *J. Heterocyclic Chem.* **2006**, *43*, 95.
- (5) Dolzhenko, A. V.; Chui, W.-K.; Dolzhenko, A. V. *J. Heterocyclic Chem.* **2006**, *43*, 1513.

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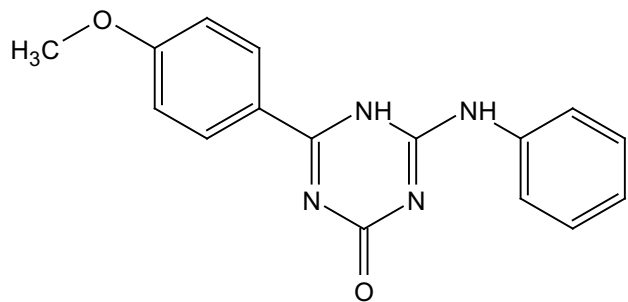


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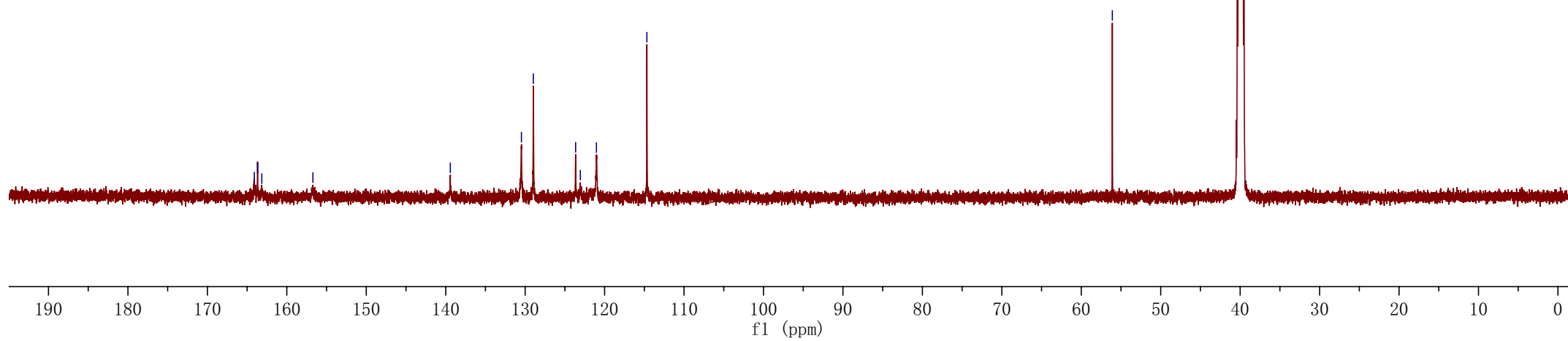
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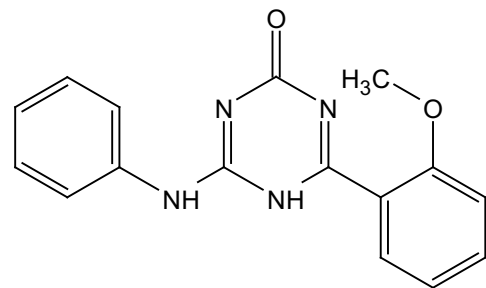
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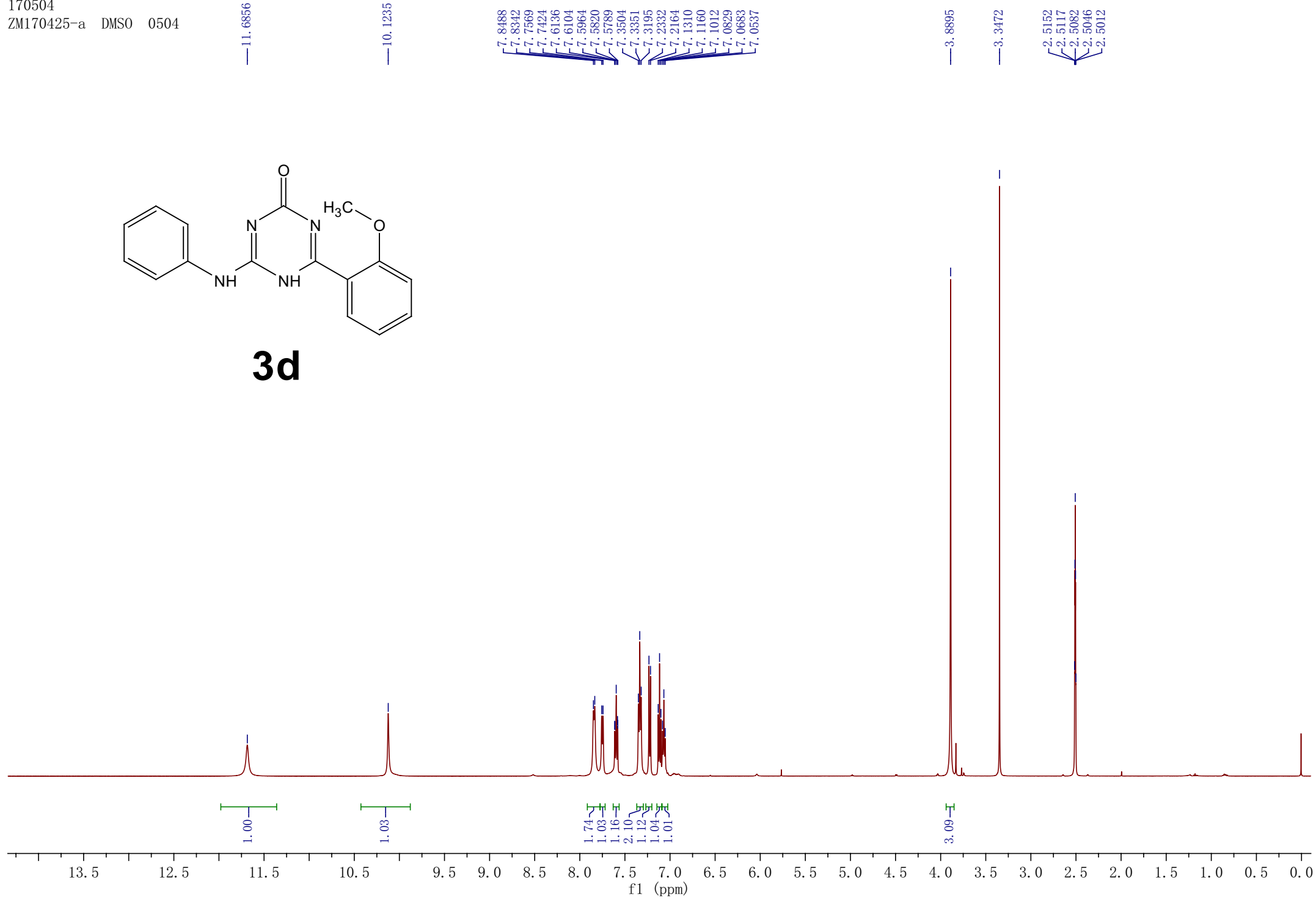
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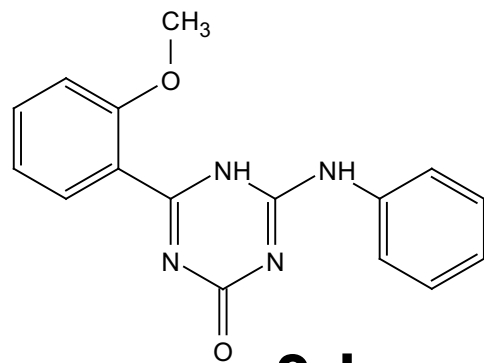


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3d

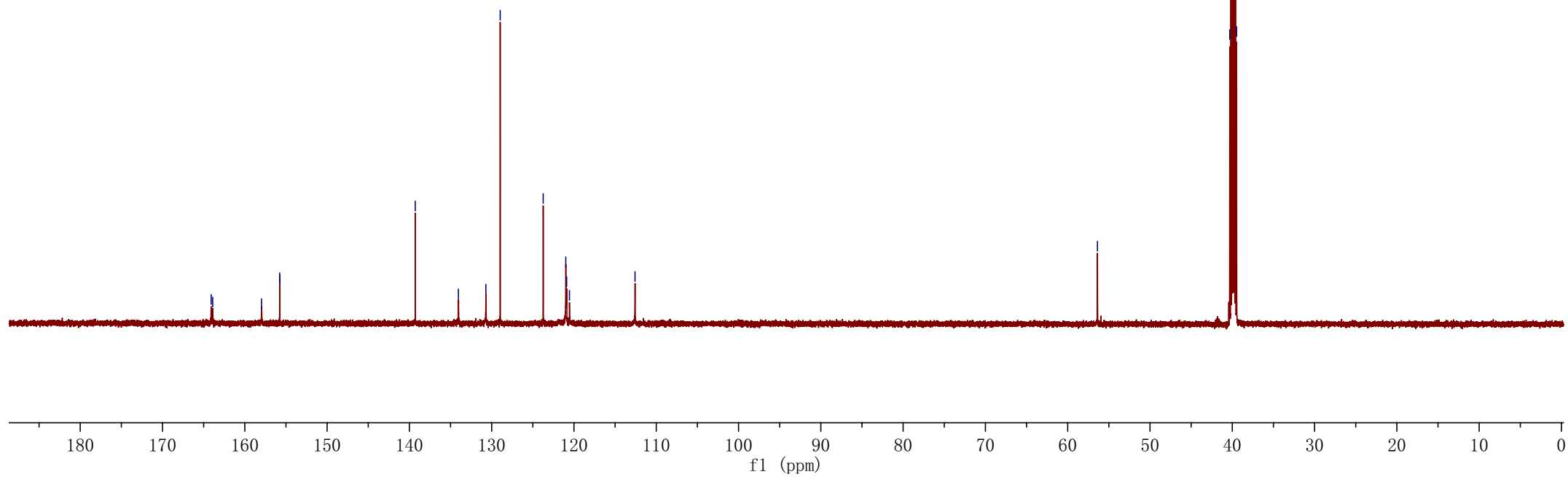


**3d**

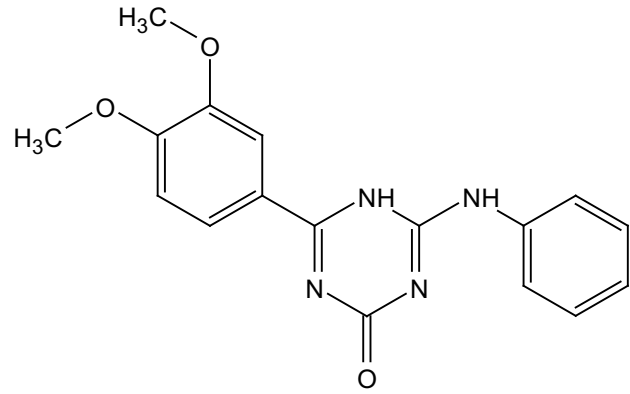
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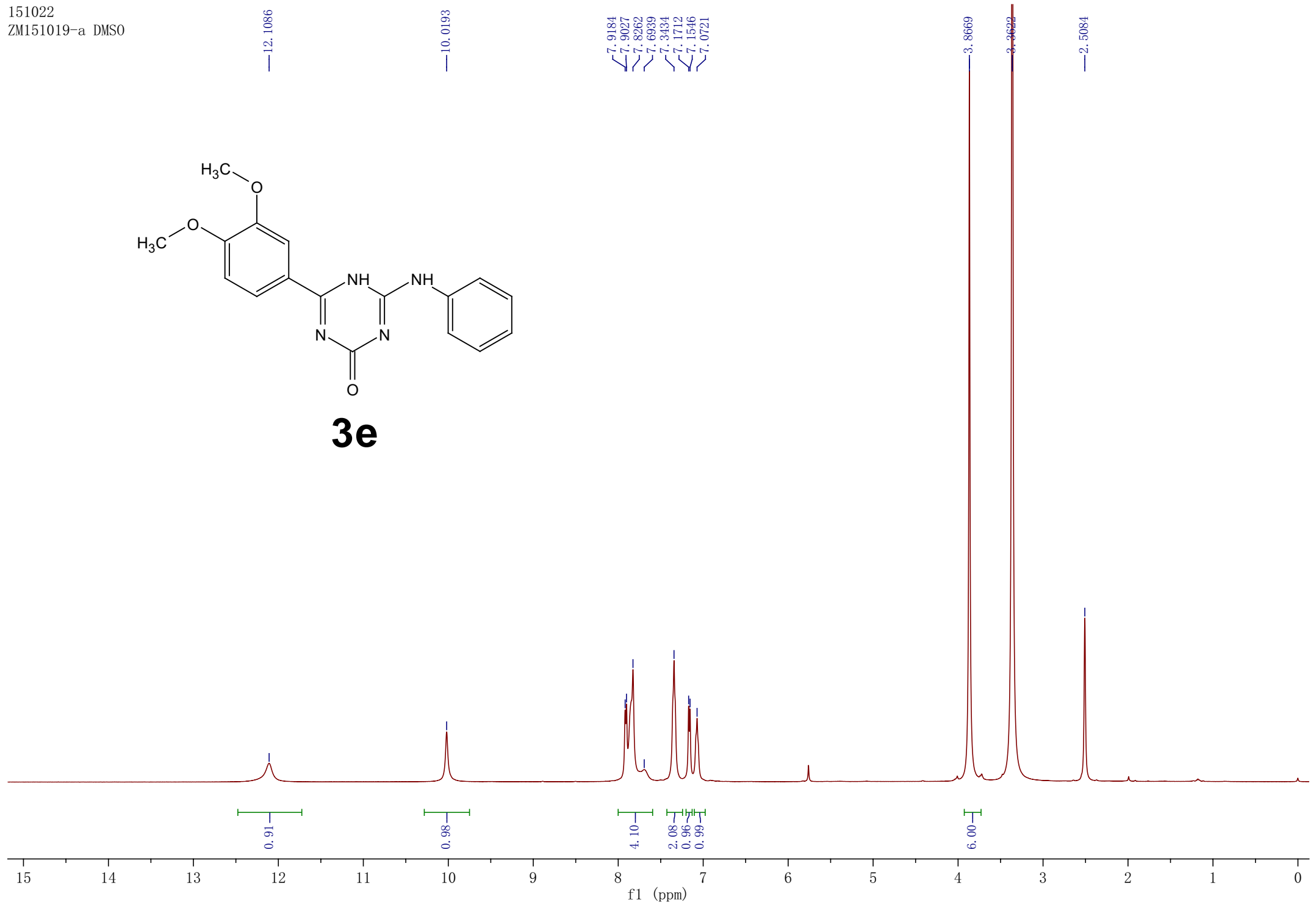
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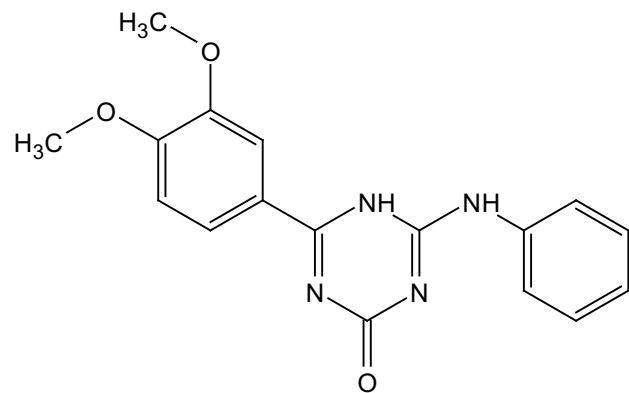
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3e



151026
ZM151019-a DMSO



3e

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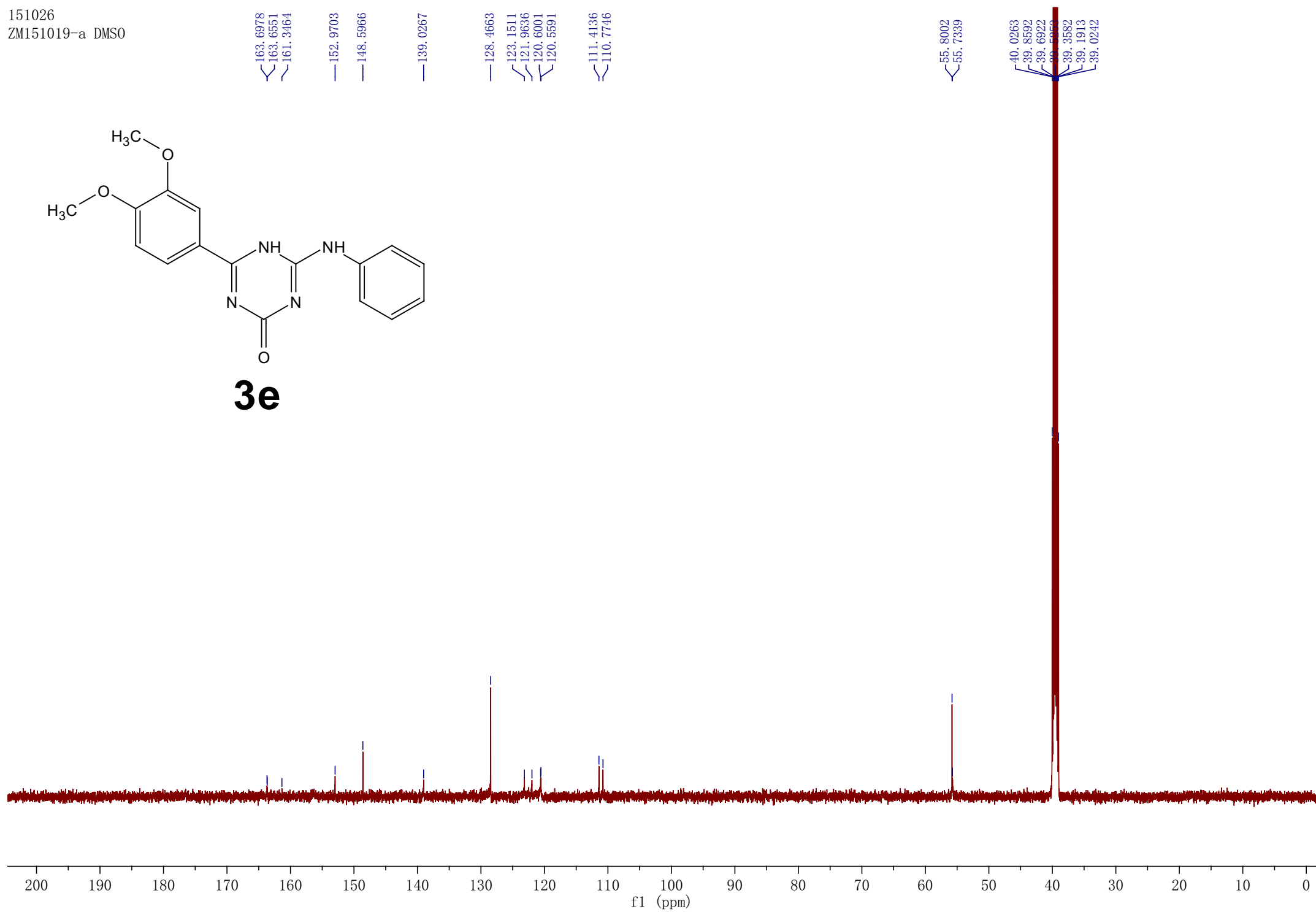
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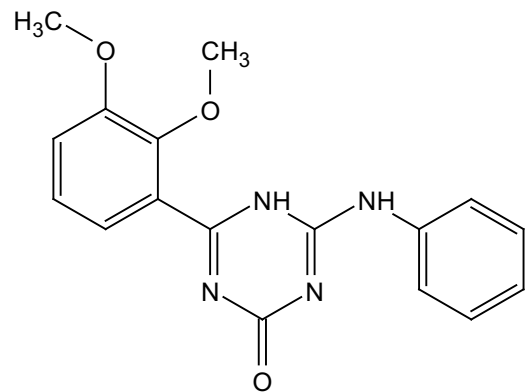
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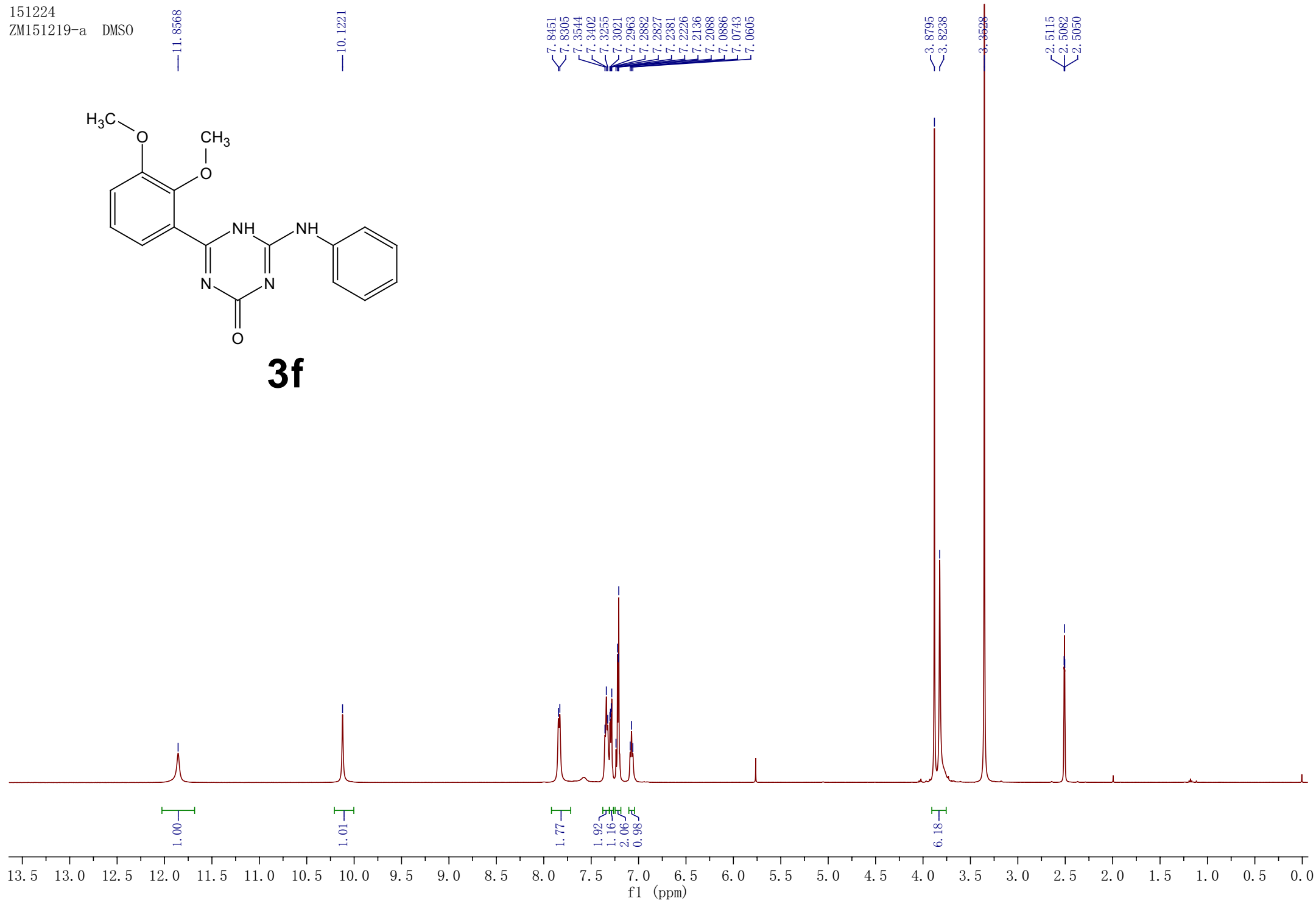
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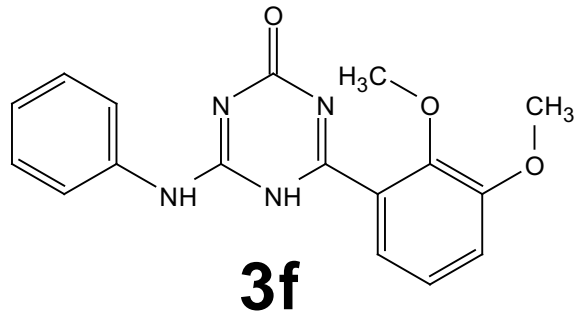


3f

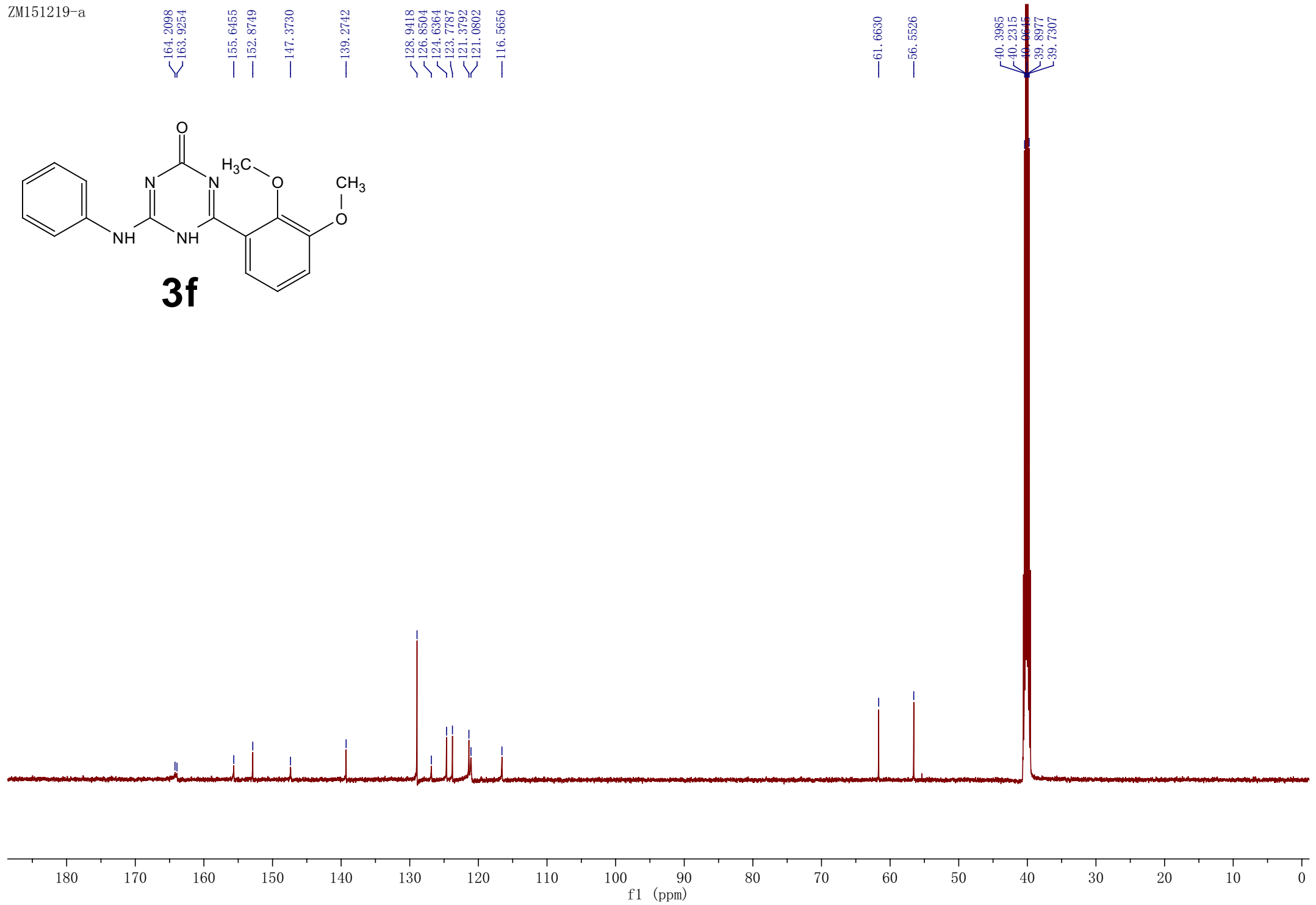


ZM151219-a

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12.0693

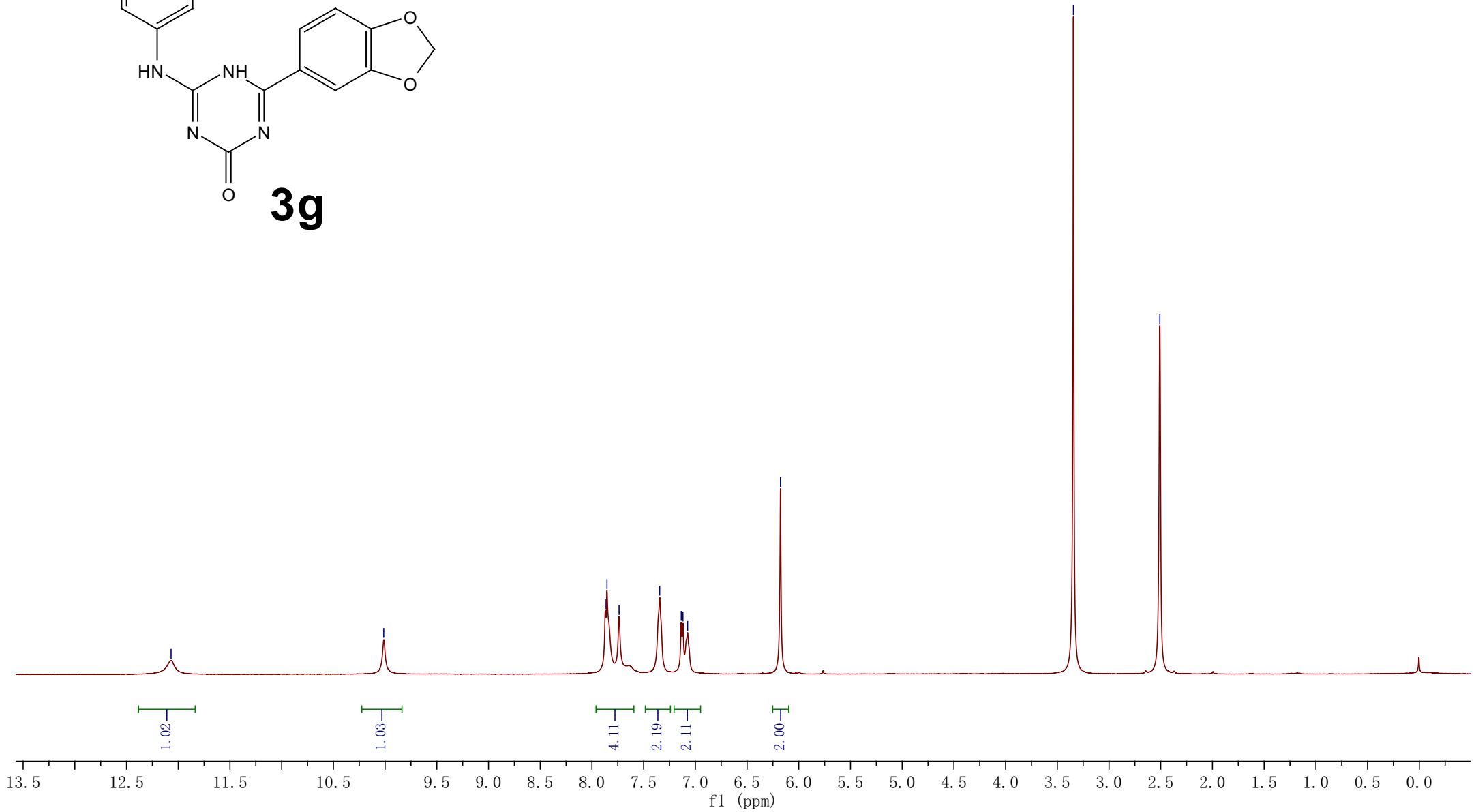
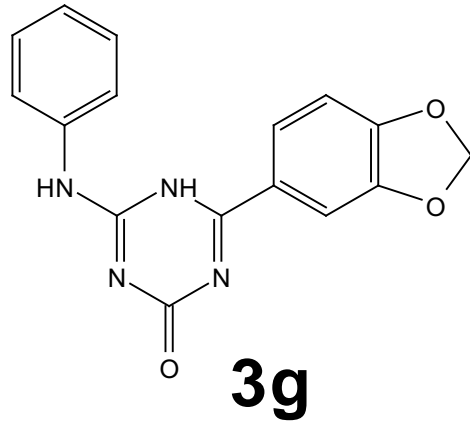
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2.5084



20170926-C13-WHF-ZM-170328

20170926-C13-WHF-ZM-170328

DMSO

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40.2010

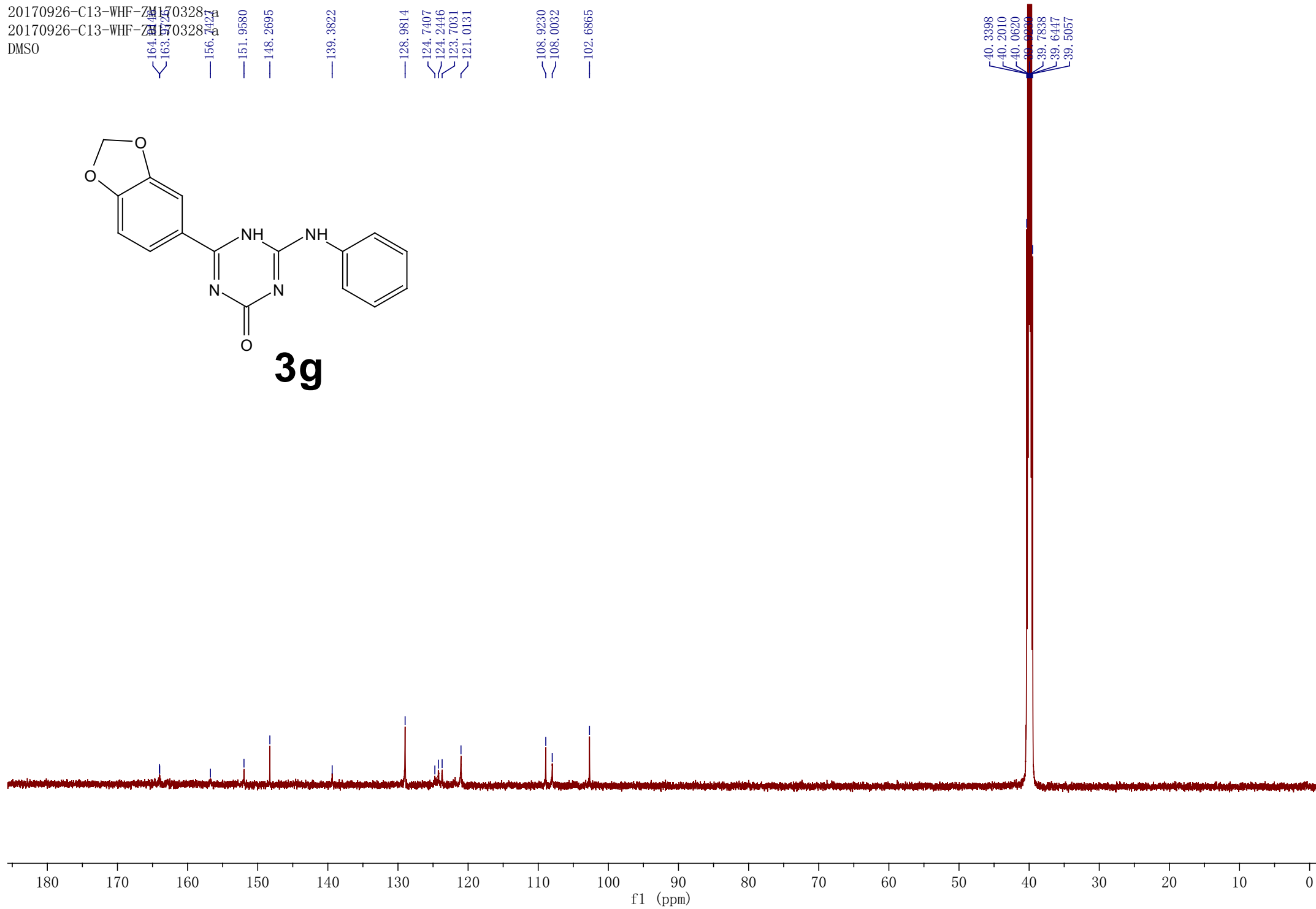
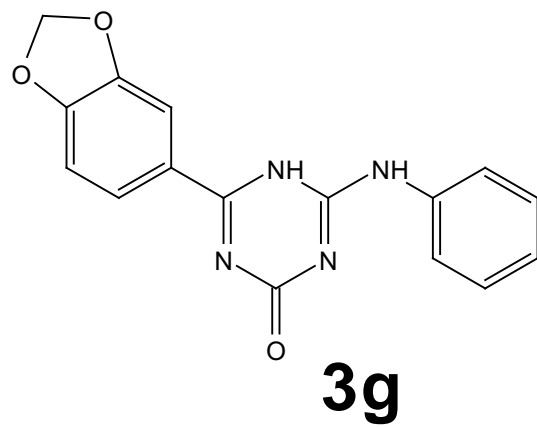
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39.5057



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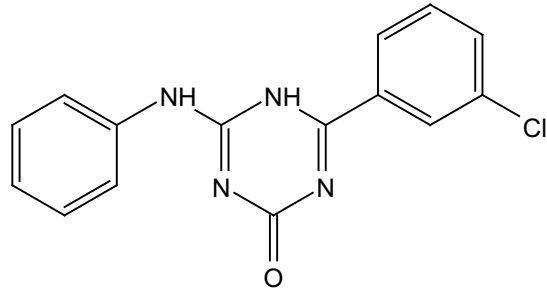
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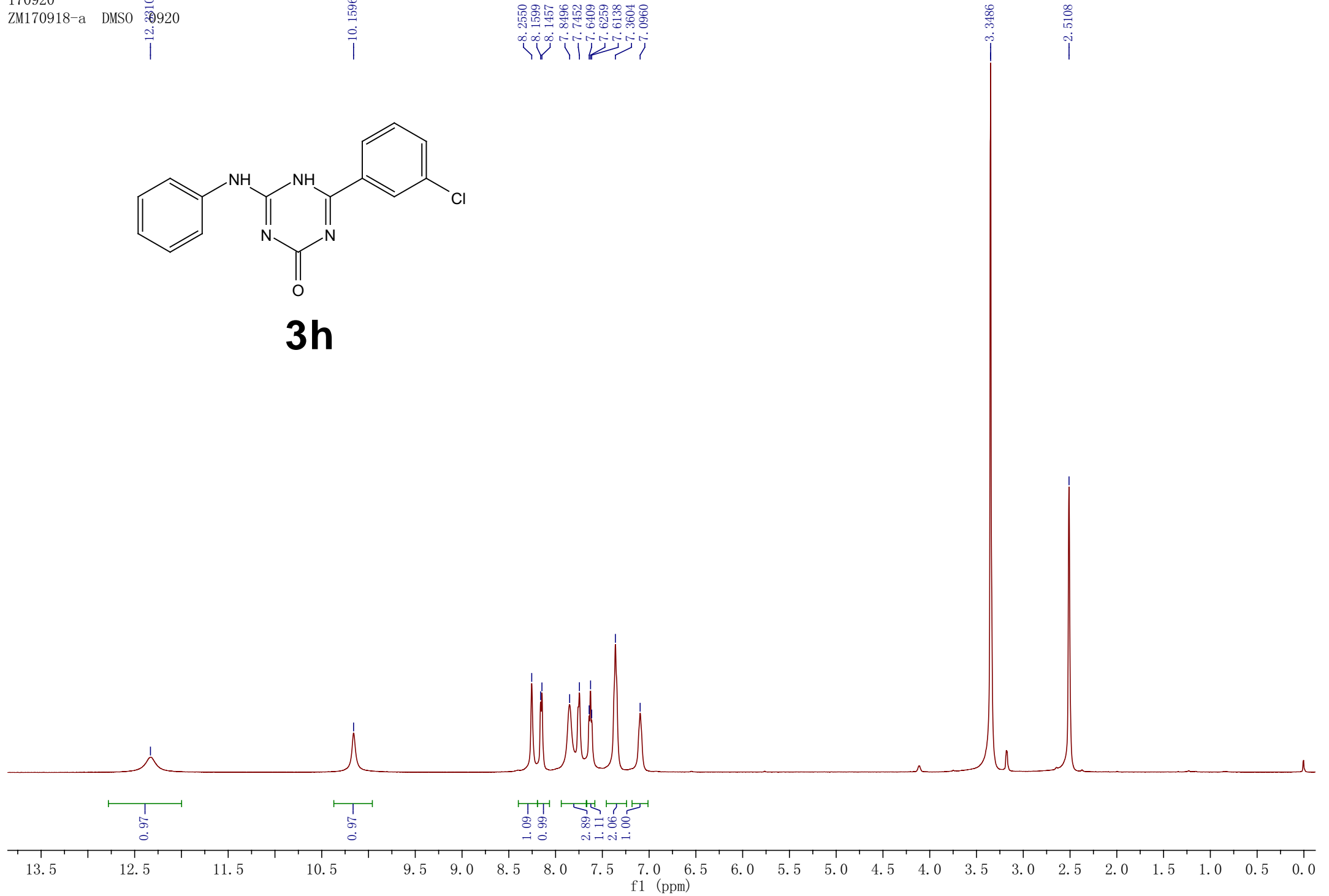
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7.3604
7.0960

3.3486

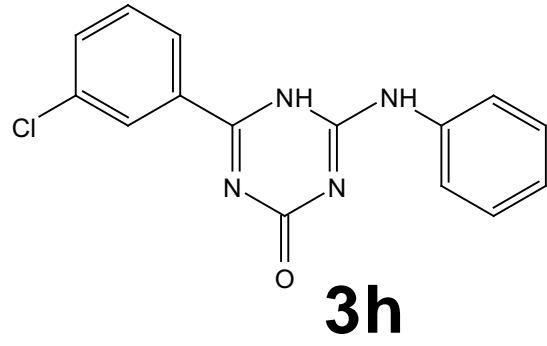
2.5108



3h



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164.1148
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157.1022
155.3967

138.9440

134.2397
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130.6685
128.7604

128.4249
126.9189

123.8679
121.4338

79.3928
79.1295
78.8665

40.7277
40.5598
40.3935
40.2272
39.0591
39.8920
39.7248

