SUPPLEMENTARY MATERIAL

Synthesis and antifungal activity evaluation of new heterocycle containing amide derivatives

Xuesong Wang, Sumei Gao, Jian Yang, Yang Gao, Ling Wang and Xiaorong Tang*

School of Physics and Chemistry, Xihua University, Chengdu 610039, P.R. China

*Corresponding author. Email: tangxiaorong0901 @163.com; Tel.: +86 28 8772020

Abstract

A series of heterocycle containing amide derivatives (compounds **1–28**) were synthesized by the combination of acyl chlorides (**1a**, **2a**) and heterocycle containing amines (**1–6**, **15–22**) and non-heterocycle containing amines (**7–14**, **23–28**) and their antifungal activity was evaluated against five plant pathogenic fungi i.e. *Gibberella zeae*, *Helminthosporium maydis*, *Rhizoctonia solani*, *Botrytis cinerea* and *Sclerotinia sclerotiorum*. The results indicated that some of the synthesized compounds showed good antifungal activity. Among them, compound **2** showed excellent activity against *G. zeae*, *R. solani*, and potent activity against *H. maydi*, *B. cinerea* and *S. sclerotiorum* when compared with the standard carbendazim. Compounds **1**, **8** and **10** also displayed excellent antifungal activity against *H. maydi*, *B. cinerea* and *S. sclerotiorum* and good activity against *R. solani* when compared with the standard carbendazim.

Keywords: Synthesis; amide derivatives; plant pathogenic fungi; antifungal activity

Experiment

The structure and data of compounds (**1–28**) as follow:

Compound **1** (C₉H₈N₂OS₂): light yellow crystal; yield 18%; m.p. 206–207°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 2.36 (3H, s), 7.21–7.24 (2H, m), 7.93 (1H, d, *J* = 4.8 Hz), 8.19 (1H, d, *J* = 0.6), 12.54 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 11.46 (1C), 126.71 (1C), 128.75 (1C), 130.92 (1C), 133.38 (1C), 134.17 (1C), 138.19 (1C), 157.63 (1C), 160.19 (1C).

Figure S1 ¹H NMR Spectra of compound **1**

Figure S2 ¹³C NMR Spectra of compound **1**

Compound **2** (C₁₂H₈N₂O₂S): yellow crystal; yield 25%; m.p. 186–188°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.76–6.78 (1H, m), 7.33 (1H, t, *J* = 7.5 Hz), 7.46 (1H, t, *J* = 7.5 Hz), 7.75 (1H, s), 7.78 (1H, s), 8.01 (1H, d, *J* = 7.8 Hz), 8.05 (1H, s), 12.86 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 112.79 (1C), 117.51 (1C), 120.54 (1C), 122.11 (1C), 124.03 (1C), 126.57 (1C), 131.75 (1C), 145.88 (1C), 148.03 (1C), 148.63 (1C), 156.91 (1C), 158.71 (1C).

Figure S3 ¹H NMR Spectra of compound **2**

Figure S4 ¹³C NMR Spectra of compound **2**

Compound **3** (C₁₂H₇N₂O₂SCl): white crystal; yield 20%; m.p. 231–232 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.77 (1H, dd, *J* = 1.5 Hz, *J* = 1.8 Hz), 7.48 (1H, dd, *J* = 2.1 Hz, *J* = 2.1 Hz), 7.75 (1H, s), 7.78 (1H, s), 8.06 (1H, s), 8.16 (1H, d, *J* = 1.8 Hz), 12.95 (1H, d, *J* = 0.6 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 112.62 (1C), 116.80 (1C), 121.43 (1C), 121.52 (1C), 126.48 (1C), 127.41 (1C), 133.84 (1C), 147.13 (1C), 147.43 (1C), 147.94 (1C), 158.19 (1C), 161.16 (1C).

Figure S5 ¹H NMR Spectra of compound **3**

Figure S6 ¹³C NMR Spectra of compound **3**

Compound **4** (C₁₂H₇N₂OS₂Cl): white crystal; yield 20%; m.p. 252–253 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 7.27 (1H, t, *J* = 3.6 Hz), 7.45 (1H, d, *J* = 8.1 Hz), 7.73 (1H, d, *J* = 8.4 Hz), 8.00 (1H, d, *J* = 4.5 Hz), 8.12 (1H, s), 8.30 (1H, s), 13.05 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 121.39 (1C), 126.47 (1C), 127.72 (1C), 128.63 (1C), 131.57 (2C), 133.22 (1C), 134.25 (1C), 136.74 (1C), 147.41 (1C), 159.20 (1C), 161.31 (1C).

Figure S7 ¹H NMR Spectra of compound **4**

Figure S8 ¹³C NMR Spectra of compound **4**

Compound **5** (C₁₃H₁₀N₂O₂S): white powder; yield 20%; m.p. 187–188°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 2.43 (3H, s), 6.76 (1H, m), 7.28 (1H, dd, *J* = 1.2 Hz, *J* = 1.2 Hz), 7.64–7.67 (1H, m), 7.72–7.73 (1H, m), 7.79 (1H, s), 8.04 (1H, s), 12.76 (1H, t, *J* = 1.2 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 20.96 (1C), 112.36 (1C), 116.98 (1C), 119.76 (1C), 121.29 (1C), 127.50 (1C), 131.50 (1C), 133.14 (1C), 145.58 (1C), 145.95 (1C), 147.53 (1C), 156.55 (1C), 157.51 (1C).

Figure S9 ¹H NMR Spectra of compound **5**

Figure S10 ¹³C NMR Spectra of compound **5**

Figure S11 ^1H NMR Spectra of compound **6**

Compound **7** (C₁₂H₁₁NO₂): light yellow crystal; yield 60%; m.p. 115–116°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 4.44 (2H, d, *J* = 6.3 Hz), 6.62 (1H, d, *J* = 1.5 Hz), 7.15 (1H, d, *J* = 3.3 Hz), 7.23–7.26 (1H, m), 7.31–7.35 (4H, m), 7.84 (1H, s), 8.93–8.95 (1H, m); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 41.88 (1C), 111.78 (1C), 113.41 (1C), 126.73 (1C), 127.22 (2C), 128.23 (2C), 139.49 (1C), 144.97 (1C), 147.89 (1C), 157.79 (1C).

Figure S13 ¹H NMR Spectra of compound **7**

Figure S14 ¹³C NMR Spectra of compound **7**

Compound **8** (C₁₂H₁₁NOS): white crystal; yield 40%; m.p. 126–127°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 4.47 (2H, d, *J* = 6.0 Hz), 7.15 (1H, t, *J* = 4.2 Hz), 7.22–7.27 (1H, m), 7.29–7.36 (4H, m), 7.76 (1H, d, *J* = 4.8 Hz), 7.83 (1H, d, *J* = 3.3 Hz), 9.06 (1H, t, *J* = 5.1 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 42.99 (1C), 127.29 (1C), 127.74 (2C), 128.37 (1C), 128.60 (1C), 128.78 (2C), 131.25 (1C), 139.97 (1C), 140.40 (1C), 161.66 (1C).

Figure S15 ¹H NMR Spectra of compound **8**

Figure S16 ¹³C NMR Spectra of compound **8**

Compound **9** (C₁₃H₁₃NO₂): yellow liquid; yield 44%; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 2.82 (2H, t, *J* = 7.5 Hz), 3.39–3.49 (2H, m), 6.60 (1H, d, *J* = 1.5 Hz), 7.07 (1H, d, *J* = 3.3 Hz), 7.19–7.31 (5H, m), 7.81 (1H, s), 8.43 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 35.13 (1C), 40.04 (1C), 111.71 (1C), 113.08 (1C), 126.06 (1C), 128.30 (2C), 128.57 (2C), 139.35 (1C), 144.77 (1C), 148.03 (1C), 157.67 (1C).

Figure S17 ¹H NMR Spectra of compound **9**

Figure S18 ¹³C NMR Spectra of compound **9**

Compound **10** (C₁₃H₁₃NOS): yellow crystal; yield 71%; m.p. 114–115°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 2.83 (2H, t, *J* = 7.5 Hz), 3.42–3.49 (2H, m), 7.13 (1H, t, *J* = 4.2 Hz), 7.20–7.32 (5H, m), 7.72–7.73 (2H, m), 8.58 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 35.67 (1C), 41.23 (1C), 126.58 (1C), 128.27 (1C), 128.31 (2C), 128.81 (2C), 129.11 (1C), 130.96 (1C), 139.90 (1C), 140.63 (1C), 161.55 (1C).

Figure S19 ¹H NMR Spectra of compound **10**

Figure S20 ¹³C NMR Spectra of compound **10**

Compound **11** (C₁₇H₁₃NO₃): pink crystal; yield 56%; m.p. 159–160°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ(ppm): 6.70 (1H, dd, *J* = 1.5 Hz, *J* = 1.5 Hz), 7.01 (4H, t, *J* = 9.3 Hz), 7.11 (1H, t, *J* = 7.2 Hz), 7.32 (1H, d, *J* = 3.6 Hz), 7.38 (2H, t, *J* = 7.8 Hz), 7.75–7.78 (2H, m), 7.93 (1H, s), 10.22 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ(ppm): 112.59 (1C), 115.09 (1C), 118.49 (2C), 119.70 (2C), 122.60 (2C), 123.52 (1C), 130.42 (2C), 134.81 (1C), 146.06 (1C), 148.05 (1C), 152.74 (1C), 156.59 (1C), 157.73 (1C).

Figure S21 ¹H NMR Spectra of compound **11**

Figure S22 ¹³C NMR Spectra of compound **11**

Compound **12** (C₁₇H₁₃NO₂S): grey crystal; yield 67%; m.p. 160–161 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.98–7.05 (4H, m), 7.13 (1H, t, *J* = 7.2 Hz), 7.23 (1H, t, *J* = 4.2 Hz), 7.38 (2H, t, *J* = 7.8 Hz), 7.74 (2H, d, *J* = 9.0 Hz), 7.85 (1H, d, *J* = 4.8 Hz), 8.01 (1H, d, *J* = 3.6 Hz), 10.25 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 118.03 (2C), 119.18 (2C), 122.08 (2C), 123.06 (1C), 127.98 (1C), 128.98 (1C), 129.94 (2C), 131.69 (1C), 134.47 (1C), 139.97 (1C), 152.26 (1C), 157.18 (1C), 159.71 (1C).

Compound **13** (C₁₈H₁₅NO₂): white crystal; yield 58%; m.p. 170–171 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.37 (1H, d, *J* = 9.0 Hz), 6.63 (1H, d, *J* = 1.5 Hz), 7.27–7.36 (11H, m), 7.85 (1H, s), 9.16 (1H, d, *J* = 9.0 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 56.14 (1C), 112.24 (1C), 114.39 (1C), 127.52 (2C), 128.14 (4C), 128.79 (4C), 142.50 (2C), 145.69 (1C), 148.04 (1C), 157.72 (1C).

Figure S25 ¹H NMR Spectra of compound **13**

Figure S26 ¹³C NMR Spectra of compound **13**

Compound **14** (C₁₈H₁₅NOS): white crystal; yield 64%; m.p. 184–185°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.38 (1H, d, *J* = 8.7 Hz), 7.16 (1H, t, *J* = 4.2 Hz), 7.26–7.36 (10H, m), 7.78 (1H, d, *J* = 4.8 Hz), 8.03 (1H, d, *J* = 3.6 Hz), 9.29 (1H, d, *J* = 8.7 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 56.16 (1C), 127.03 (2C), 127.62 (4C), 127.82 (1C), 128.31 (4C), 128.66 (1C), 131.11 (1C), 139.62 (1C), 142.00 (2C), 160.54 (1C).

Figure S27 ¹H NMR Spectra of compound **14**

Figure S28 ¹³C NMR Spectra of compound **14**

Compound **15** (C₉H₁₁NO₃): colorless liquid; yield 45%; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 3.63 (4H, s), 3.65 (4H, s), 6.62 (1H, dd, *J* = 1.5 Hz, *J* = 1.8 Hz), 7.01 (1H, d, *J* = 3.3 Hz), 7.83 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 44.61 (2C), 66.27 (2C), 111.37 (1C), 115.81 (1C), 144.79 (1C), 146.92 (1C), 158.48 (1C).

Figure S29 ¹H NMR Spectra of compound **15**

Figure S30 ¹³C NMR Spectra of compound **15**

Compound **16** (C₉H₁₁NO₂S): milky white crystal; yield 65%; m.p. 60–61 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ(ppm): 3.63 (8H, s), 7.13 (1H, t, *J* = 4.5 Hz), 7.42 (1H, d, *J* = 3.6 Hz), 7.76 (1H, d, *J* = 5.1 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ(ppm): 45.80 (2C), 66.59 (2C), 127.55 (1C), 129.62 (1C), 130.02 (1C), 137.39 (1C), 162.88 (1C).

Figure S31 ¹H NMR Spectra of compound **16**

Figure S32 ¹³C NMR Spectra of compound **16**

Compound **17** (C₁₁H₁₅NO₂): light yellow liquid; yield 50%; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 0.90–0.93 (3H, m), 1.00–1.12 (2H, m), 1.65 (2H, s), 1.69 (1H, s), 2.92–2.93 (2H, m), 4.25 (1H, s), 4.28 (1H, s), 6.59–6.60 (1H, m), 6.92 (1H, d, *J* = 3.3 Hz), 7.81 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 21.49 (1C), 30.42 (1C), 33.95 (2C), 45.40 (2C), 111.10 (1C), 114.79 (1C), 144.27 (1C), 147.38 (1C), 158.26 (1C).

Figure S33 ¹H NMR Spectra of compound **17**

Figure S34 ¹³C NMR Spectra of compound **17**

Compound **18** (C₁₁H₁₅NOS): white crystal; yield 24%; m.p. 105–106°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 0.91–1.02 (3H, m), 1.05–1.14 (2H, m), 1.64 (2H, s), 1.69 (1H, s), 2.95 (2H, s), 4.20–4.24 (2H, m), 7.11 (1H, t, *J* = 3.6 Hz), 7.35 (1H, d, *J* = 3.6 Hz), 7.72 (1H, d, *J* = 5.1 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 22.00 (1C), 30.90 (1C), 34.38 (2C), 45.49 (2C), 127.42 (1C), 128.93 (1C), 129.40 (1C), 138.07 (1C), 162.60 (1C).

Figure S35 ¹H NMR Spectra of compound **18**

Figure S36 ¹³C NMR Spectra of compound **18**

Figure S37 ^1H NMR Spectra of compound **19**

Compound **20** (C₈H₆N₂OS): milky white crystal; yield 54%; m.p. 36–37 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.71 (1H, s), 7.30 (1H, t, *J* = 4.5 Hz), 8.02 (1H, s), 8.19 (1H, d, *J* = 5.1 Hz), 8.38 (1H, d, *J* = 3.0 Hz), 8.57 (1H, d, *J* = 2.7 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 110.81 (1C), 128.31 (1C), 130.68 (1C), 132.15 (1C), 139.06 (1C), 139.34 (1C), 145.26 (1C), 158.62 (1C).

Figure S39 ¹H NMR Spectra of compound **20**

Figure S40 ¹³C NMR Spectra of compound **20**

Compound **21** (C₈H₅N₂O₂Br): white crystal; yield 55%; m.p. 113–114°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.84 (1H, dd, *J* = 1.2 Hz, *J* = 1.5 Hz), 7.97 (1H, d, *J* = 3.6 Hz), 8.12 (1H, s), 8.23 (1H, s), 8.81 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 98.61 (1C), 113.13 (1C), 125.02 (1C), 130.46 (1C), 143.21 (1C), 145.17 (1C), 150.01 (1C), 153.13 (1C).

Figure S41 ¹H NMR Spectra of compound **21**

Figure S42 ¹³C NMR Spectra of compound **21**

Compound **22** (C₈H₅N₂OSBr): milky white crystal; yield 67%; m.p. 99–100°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 7.32 (1H, t, *J* = 4.8 Hz), 8.16 (1H, s), 8.22 (1H, d, *J* = 4.8 Hz), 8.36 (1H, d, *J* = 3.9 Hz), 8.83 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 99.58 (1C), 128.45 (1C), 130.80 (1C), 131.24 (1C), 139.44 (1C), 139.67 (1C), 145.35 (1C), 157.71 (1C).

Figure S43 ¹H NMR Spectra of compound **22**

Figure S44 ¹³C NMR Spectra of compound **22**

Compound **23** (C₁₈H₁₆N₂O₄): milky white crystal; yield 65%; m.p. 187–188°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 4.41 (4H, d, *J* = 6.0 Hz), 6.62 (2H, d, *J* = 1.2 Hz), 7.12 (2H, d, *J* = 3.3 Hz), 7.17–7.30 (4H, m), 7.83 (2H, s), 8.93 (2H, t, *J* = 6.0 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 42.36 (2C), 112.27 (2C), 113.88 (2C), 126.30 (2C), 126.64 (1C), 128.73 (1C), 140.06 (2C), 145.46 (2C), 148.36 (2C), 158.23 (2C).

Figure S45 ¹H NMR Spectra of compound **23**

Figure S46 ¹³C NMR Spectra of compound **23**

Compound **24** (C₁₈H₁₆N₂O₂S₂): milky white crystal; yield 66%; m.p. 199–201 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 4.44 (4H, d, *J* = 6.0 Hz), 7.14 (2H, t, *J* = 4.8 Hz), 7.19–7.32 (4H, m), 7.75–7.76 (2H, m), 7.78 (2H, d, *J* = 3.6 Hz), 9.05 (2H, t, *J* = 6.0 Hz); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 42.41 (2C), 125.82 (2C), 126.11 (1C), 127.84 (2C), 128.05 (2C), 128.31 (1C), 130.72 (2C), 139.59 (2C), 139.84 (2C), 161.06 (2C).

Figure S47 ¹H NMR Spectra of compound **24**

Figure S48 ¹³C NMR Spectra of compound **24**

Compound **25** (C₂₃H₁₇N₃O₅): light yellow powder; yield 68%; m.p. > 300°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 6.70–6.71 (1H, m), 6.73–6.74 (1H, m), 7.32 (1H, d, *J* = 3.3 Hz), 7.40 (1H, d, *J* = 3.3 Hz), 7.70–7.76 (4H, m), 7.90–7.99 (6H, m), 10.15 (1H, s), 10.16 (1H, s), 10.44 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 112.57 (1C), 112.74 (1C), 114.96 (1C), 115.73 (1C), 119.93 (2C), 121.10 (2C), 121.15 (2C), 128.88 (2C), 130.22 (1C), 134.63 (1C), 135.65 (1C), 142.01 (1C), 146.05 (1C), 146.50 (1C), 147.74 (1C), 148.11 (1C), 156.52 (1C), 156.84 (1C), 165.16 (1C).

Figure S49 ¹H NMR Spectra of compound **25**

Figure S50 ¹³C NMR Spectra of compound **25**

Compound **26** (C₂₃H₁₇N₃O₃S₂): white powder; yield 72%; m.p. > 300°C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 7.22–7.27 (2H, m), 7.69 (2H, d, *J* = 9.0 Hz), 7.76 (2H, d, *J* = 9.0 Hz), 7.84–7.91 (4H, m), 7.98 (1H, s), 8.01 (1H, s), 8.02 (1H, s), 8.08 (1H, d, *J* = 3.0 Hz), 10.17 (1H, s), 10.22 (1H, s), 10.47 (1H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 119.92 (2C), 121.11 (2C), 121.20 (2C), 128.50 (1C), 128.63 (1C), 128.94 (2C), 129.39 (1C), 130.04 (1C), 130.20 (1C), 132.14 (1C), 132.83 (1C), 134.81 (1C), 135.67 (1C), 140.15 (1C), 140.64 (1C), 142.19 (1C), 160.16 (1C), 160.60 (1C), 165.15 (1C).

Figure S51 ¹H NMR Spectra of compound **26**

Figure S52 ¹³C NMR Spectra of compound **26**

Compound **27** (C₂₃H₁₈N₂O₄): dark green crystal; yield 61%; m.p. 199–200 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 3.87 (2H, s), 6.69–6.70 (2H, m), 7.19 (4H, d, *J* = 8.4 Hz), 7.31 (2H, d, *J* = 3.3 Hz), 7.66 (4H, d, *J* = 8.4 Hz), 7.92 (2H, s), 10.12 (2H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 40.66 (1C), 112.56 (2C), 114.99 (2C), 121.02 (4C), 129.25 (4C), 136.96 (2C), 137.28 (2C), 146.05 (2C), 148.08 (2C), 156.57 (2C).

Figure S53 ¹H NMR Spectra of compound **27**

Figure S54 ¹³C NMR Spectra of compound **27**

Compound **28** (C₂₃H₁₈N₂O₂S₂): light yellow crystal; yield 67%; m.p. 261–263 °C; ¹H NMR (300 MHz, DMSO-*d*₆) δ (ppm): 3.89 (2H, s), 7.19 (2H, s), 7.22 (4H, s), 7.64 (4H, d, *J* = 8.4 Hz), 7.84 (2H, d, *J* = 4.8 Hz), 8.00 (2H, d, *J* = 3.9 Hz), 10.18 (2H, s); ¹³C NMR (300 MHz, DMSO-*d*₆) δ (ppm): 40.14 (1C), 120.51 (4C), 127.96 (2C), 128.80 (4C), 128.91 (2C), 131.65 (2C), 136.66 (2C), 136.76 (2C), 140.10 (2C), 159.71 (2C).

Figure S55 ¹H NMR Spectra of compound **28**

Figure S56 ¹³C NMR Spectra of compound **28**