Electronic Supplementary Information (ESI)

Highly Efficient One-pot Three-component Betti Reaction in water using Reverse Zinc Oxide Micelles as Recoverable and Reusable Catalyst

Jie Mou\textsuperscript{a,b}, Gan Gao\textsuperscript{a,b}, Chen Chen\textsuperscript{a,b}, Jie Liu\textsuperscript{a,b}, Jian Gao\textsuperscript{a,b}, Yi Liu\textsuperscript{a,b}, Dongsheng Pei\textsuperscript{c,*}

1. Comparison of size distribution and TEM of reverse ZnO nanomicelles between prior to and after reaction.

The comparison of the size distributions of nanomicelles and TEM micrographs were shown in Figure 1 and Figure 2, respectively. The size distribution of nanomicelles was narrow and maintained the normal distribution between prior to and after reaction. After the reaction, the average size of the nanoparticles increased from about 116.8 to 176.0 nm. TEM images displayed clearly that most of ZnO nanomicelles was spherical. No remarkable changes occurred after reaction.

\textbf{Fig.1} Size distribution for reversed ZnO nanomicelles. (A) Prior to the reaction, average diameter is 116.8 nm; (B) After the reaction, average diameter is 176.0 nm

\textbf{Fig.2} TEM image of reversed ZnO nanomicelles. (A) Prior to the reactions; (B) After the reactions.
2. Determination of the content of Znic oxide

According to the turbidity quantitative method, the relationship of the absorbance at 660 nm and the turbidity of the standard sample at the different concentration were investigated. The standard curve was plotted in Origin 8.0 to obtain the standard curve equation (Fig. 3). The reaction was cycled for six times. The content of ZnO of every cycle was achieved from the absorbance data. The variation tendency was shown on Fig 4. The curve illustrated that the content of ZnO maintained stable.

![Fig.3 Standard curve](image)

\[ Y = 0.1454x + 0.941 \]
\[ R^2 = 0.99881 \]

![Fig.4 The contents of ZnO in six cycle](image)

3. General procedure for the preparation of Betti base derivatives 4a~4j

To a mixture of aromatic aldehydes (1 mmol), β-naphthol (1 mmol, 0.144 g) and benzylamine (1 mmol, 0.094 g) in 30 mL water in a round bottom flask, catalytic amount of ZnO reversed nanomicelles was added and stirred at room temperature for appropriate time. After completion of the reaction as monitored by thin layer
chromatography (TLC), the aqueous layer was decanted to recycle the catalyst for another reaction. The crude product was filtered and purified by recrystallization from ethanol (95%).

1-((3-nitrophenyl)(phenylamino)methyl)naphthalen-2-ol (4a) yellow solid, yield: 0.355g, 96%; mp: 152°C (95% ethanol); IR (KBr, \(\nu, \text{ cm}^{-1}\)): 3335.63 (s), 3092.03 (w), 2893.08 (w), 1601.28 (m), 1528.37 (s), 1498.62 (m), 1344 (m), 1231.93 (m), 1216.73 (m); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 11.06 (s, 1H, Ar-OH), 8.39 (t, \(J = 2.0\) Hz, 1H, Ar-H), 8.16 (m, 1H, Ar-H), 7.82 - 7.73 (m, 4H, Ar-H), 7.51 (dd, \(J_1 = 9.1\) Hz, \(J_2 = 6.8\) Hz, 1H, Ar-H), 7.42 (m, 1H, Ar-H), 7.33 (m, 1H, Ar-H), 7.20 - 7.14 (m, 3H, Ar-H), 6.98 - 6.92 (m, 1H, Ar-H), 6.80 - 6.76 (m, 2H, Ar-H), 6.31 (s, 1H, N-H), 4.16 (s, 1H, -CH-); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 156.2, 146.2, 143.0, 134.2, 131.3, 130.8, 130.6, 129.7, 129.4, 127.3, 123.7, 123.3, 122.3, 120.9, 120.2, 116.4, 112.9, 61.5; HRMS (ESI) m/z [M-H] \(^-\): 370.4007, found: 369.1229.

1-((2-nitrophenyl)(phenylamino)methyl)naphthalen-2-ol (4b) yellow solid, yield: 0.341g, 92%; mp: 131.7-133.9°C (95% ethanol); IR (KBr, \(\nu, \text{ cm}^{-1}\)): 3335.02 (s), 1625.79 (w), 1597.2 (m), 1531.68 (s), 1497.49 (m), 1232.54 (m), 1218.5 (m), 813.76 (m); \(^1\)H NMR(400 MHz, CDCl\(_3\)) \(\delta\) (ppm): 11.01 (s, 1H, Ar-OH), 8.39 (t, \(J = 2.0\) Hz, 1H, Ar-H), 8.16 (m, 1H, Ar-H), 7.79 (m, 5H, Ar-H), 7.51 (dd, \(J_1 = 9.4\) Hz, \(J_2 = 6.5\) Hz, 1H, Ar-H), 7.42 (m, 1H, Ar-H), 7.36 - 7.29 (m, 1H, Ar-H), 7.21 - 7.11 (m, 3H, Ar-H), 6.98 - 6.91 (m, 1H, Ar-H), 6.82 - 6.74 (m, 2H, Ar-H), 6.31 (s, 1H, N-H), 4.11 (s, 1H, -CH-); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\): 156.2, 146.2, 143.0, 134.2, 131.3, 130.8, 130.6, 129.7, 129.4, 127.3, 123.3, 122.3, 120.9, 120.2, 116.4, 112.9, 61.5; HRMS (ESI) m/z [M-H] \(^-\): 370.4007, found: 369.1248.

1-((4-nitrophenyl)(phenylamino)methyl)naphthalen-2-ol (4c) yellow solid, yield: 0.352g, 95%; mp: 136.1-138.4°C...
9°C (95% ethanol); IR (KBr, \text{cm}^{-1}): 3333.88 (m), 1625.89 (w), 1603.52 (m), 1525.25 (s), 1500.09 (m), 1234.52 (m), 818.01 (w); 1H NMR (400 MHz, CDCl$_3$) $\delta$ (ppm): 11.92 (s, 1H, Ar-OH), 8.22-8.17 (m, 2H, Ar-H), 7.41 (m, 1H, Ar-H), 7.32 (m, 1H, Ar-H), 7.20-7.12 (m, 3H, Ar-H), 6.97-6.92 (m, 1H, Ar-H), 6.82-6.76 (m, 2H, Ar-H), 6.30 (s, 1H, Ar-H), 5.29 (m, 1H, N-H), 4.14 (s, 1H, -CH-);

13C NMR (100 MHz, CDCl$_3$) $\delta$: 155.9, 147.9, 146.3, 131.3, 130.8, 129.7, 129.3, 129.1, 127.3, 124.7, 123.3, 122.3, 120.9, 120.1, 116.3, 113.1, 61.5; HRMS (ESI) m/z [M-H$^-$]: 370.4007, found: 369.1241.

1-((3-bromophenyl)(phenylamino)methyl)naphthalen-2-ol (4d) brown solid, yield: 0.375g, 93%; mp: 139.2-141.9°C (95% ethanol); IR (KBr, \text{cm}^{-1}): 3334.97 (s), 2887.41 (w), 1601.03 (s), 1496.65 (m), 1229.43 (s), 744.37 (m); 1H NMR (400 MHz, CDCl$_3$) $\delta$ (ppm): 11.34 (s, 1H, Ar-OH), 7.82-7.72 (m, 3H, Ar-H), 7.65 (d, $J = 1.4$ Hz, 1H, Ar-H), 7.46-7.37 (m, 3H, Ar-H), 7.35-7.28 (m, 1H, Ar-H), 7.24-7.12 (m, 4H, Ar-H), 6.93 (t, $J = 7.4$ Hz, 1H, Ar-H), 6.76 (d, $J = 8.2$ Hz, 2H, Ar-H), 6.14 (s, 1H, N-H), 4.13 (s, 1H, -CH-);

13C NMR (100 MHz, CDCl$_3$) $\delta$: 156.3, 146.5, 143.2, 131.9, 131.4, 131.1, 130.4, 129.6, 129.2, 127.1, 126.8, 123.5, 123.1, 122.2, 121.3, 120.2, 116.4, 113.1, 62.2; HRMS (ESI) m/z [M-H$^-$]: 404.2992, found: 404.0485.

1-((3-chlorophenyl)(phenylamino)methyl)naphthalen-2-ol (4e) white solid, yield: 0.313g, 87%; mp: 141.6 - 143.3°C (95% ethanol); IR (KBr, \text{cm}^{-1}): 1624.74 (m), 1601.08 (s), 1498.54 (m), 1269.79 (m), 1235.61 (m), 743.92 (m); 1H NMR (400 MHz, CDCl$_3$) $\delta$ (ppm): 11.63 (s, 1H, Ar-OH), 7.79 (dd, $J_1 = 8.3$ Hz, $J_2 = 3.4$ Hz, 2H, Ar-H), 7.58 (d, $J = 8.5$ Hz, 1H, Ar-H), 7.51 (d, $J = 8.0$ Hz, 1H, Ar-H), 7.41-7.34 (m, 1H, Ar-H), 7.31 (d, $J = 7.7$ Hz, 1H, Ar-H), 7.27 (dd, $J_1 = 7.5$ Hz, $J_2 = 1.8$ Hz, 1H, Ar-H), 7.20-7.15 (m, 3H, Ar-H), 7.15-7.13 (m, 1H, Ar-H), 7.11 (dd, $J_1 = 7.7$ Hz, $J_2 = 0.9$ Hz, 1H, Ar-H), 6.94 (t, $J = 7.4$ Hz, 1H, Ar-H), 6.82 (d, $J = 7.8$ Hz, 2H, Ar-H), 6.55 (s, 1H, -CH-), 3.99 d, $J = 77.8$ Hz, 1H, N-H);

13C NMR (100 MHz, CDCl$_3$) $\delta$: 157.1, 147.0, 137.5, 133.9, 131.5, 130.3, 129.5, 129.1, 127.9, 127.2, 116.6, 112.8, 59.6; HRMS (ESI) m/z [M-H$^-$]: 359.8479, found: 358.0988.
1-((phenylamino)(p-tolyl)methyl)naphthalen-2-ol (4f) white solid, yield: 0.282g, 83 %, mp: 133.1-135.5 ºC (95%ethanol); IR (KBr, ν, cm⁻¹): 3352.17(s), 2973.76 (w), 1603.48 (s), 1496.03 (m), 1230.1(s), 1466.49 (m), 1378.51(m); ¹H NMR (400 MHz, CDCl₃) δ (ppm): 11.5 (s, 1H, Ar-OH), 7.76 (dd, J₁ = 16.4 Hz, J₂ = 8.6 Hz, 3H, Ar-H), 7.37 (t, J = 9.3 Hz, 3H, Ar-H), 7.28 (t, J = 7.5 Hz, 1H, Ar-H), 7.17-7.12 (m, 5H, Ar-H), 6.91 (t, J = 7.4 Hz, 1H, Ar-H), 6.76 (d, J = 7.9 Hz, 2H, Ar-H), 6.14 (s, 1H, N–H), 4.13 (s, 1H, -CH- ), 2.31 (s, 3H, -CH₃); ¹³C NMR (100 MHz, CDCl₃) δ: 156.2, 146.8, 138.5, 131.6, 130.1, 130.0, 129.6, 129.2, 129.1, 128.0, 126.9, 122.9, 121.9, 121.5, 120.1, 116.4, 114.0, 62.6, 21.2; HRMS (ESI) m/z [M-H]⁻: 339.4297, found: 338.1531.

1-((2,4-dimethoxyphenyl)(phenylamino)methyl)naphthalen-2-ol (4g) yellow solid, yield: 0.112g, 29 % ; mp: 135.7-137.1 ºC (95%ethanol); ¹H NMR (400 MHz, CDCl₃) δ 8.88 (s, 1H, Ar–OH), 7.77 (t, J = 9.6 Hz, 2H, Ar-H), 7.67 (d, J = 8.1 Hz, 1H, Ar-H), 7.44 (dd, J₁ = 14.2 Hz, J₂=7.0 Hz, 2H, Ar-H), 7.37- 7.31 (m, 2H, Ar-H), 7.29 (s, 4H, Ar-H), 7.00 (t, J = 7.2 Hz, 1H, Ar-H), 6.92 (d, J = 7.5 Hz, 1H, Ar-H), 6.65 (dd, J₁ = 8.9 Hz, J₂ =2.3 Hz, 1H, Ar-H), 6.53 (d, J = 6.2 Hz, 1H, Ar-H), 6.49 (d, J = 2.3 Hz, 1H, Ar-H), 3.91 (s, 3H, -OCH₃), 3.52 (s, 3H, -OCH₃); ¹³C NMR (100 MHz, CDCl₃) δ 153.6, 134.6, 129.8, 128.9, 128.7, 127.8, 126.4, 123.5, 121.1, 118.9, 117.9, 109.5, 98.1, 58.5, 55.7, 50.9; HRMS(ESI) m/z[M-H]⁻: 385.4551, found: 384.1573.

1-((3-nitrophenyl)(piperidin-1-yl)methyl)naphthalen-2-ol (4h) yellow solid, yield:0.337g, 93 %, mp: 185.8-186.5 ºC (95%ethanol); IR (KBr, ν, cm⁻¹): 3626.29 (w), 2953.47 (w), 2811.51(w), 1620.41(m), 1449.05 (m), 1343.15 (s), 1237.06 (m); ¹H NMR (400 MHz, CDCl₃) δ (ppm): 8.40 (s, 1H, Ar-OH), 8.06 ( m, 1H, Ar-H), 7.93 (s, 1H,Ar-H), 7.78 (d, J = 8.6Hz, 1H,Ar-H), 7.70 (dd, J₁ = 15.9 Hz, J₂= 7.8 Hz, 2H, Ar-H), 7.41(m, 2H, Ar-H), 7.27-7.21 (m, 2H, Ar-H), 7.16 (d, J = 8.9Hz, 1H,Ar-H), 5.19 (s, 1H, -CH-), 3.34 (s, 1H, -CH₂- ), 2.61 (s, 1H, -CH₂-), 2.08 (d, J = 49.1 Hz, 2H, -CH₂-), 1.65
N-((2-hydroxynaphthalen-1-yl)(3-nitrophenyl)methyl)benzamide (4i) white solid, yield: 0.291 g, 73 %; mp: 217.7-219.5 °C (95 % ethanol), ^1^H NMR (400 MHz, DMSO-d$_6$) δ (ppm): 9.73 (s, 1H, Ar-OH), 8.63 (s, 1H, Ar-H), 7.89 (d, J = 8.4 Hz, 2H, Ar-H), 7.80 - 7.71 (m, 4H, Ar-H), 7.67 (d, J = 8.2 Hz, 1H, Ar-H), 7.41 (d, J$_1$ = 15.1 Hz, J$_2$ = 8.0 Hz, 3H, Ar-H), 7.26 (dd, J$_1$ = 15.4 Hz, J$_2$ = 7.6 Hz, 4H, Ar-H), 7.14 - 7.05 (m, 2H, -NH- and -CH-).

N-((4-bromophenyl)(2-hydroxynaphthalen-1-yl)methyl)-2-hydroxybenzamide (4j) white solid, yield: 0.318 g, 71 %; mp: 181.2-183.1 °C (95 % ethanol), IR (KBr, ν, cm$^{-1}$): 3312.32 (w), 3127.51 (w), 1600.81 (w), 1504.17 (w), 1401.65 (s), 1228.1 (m), 1068.96 (m), 1014.96 (m), 813.09 (m); ^1^H NMR (400 MHz, CDCl$_3$) δ: 11.25 (s, 1H, Ar-OH), 8.60 (s, 1H, Ar-H), 7.80 (t, J = 11.6 Hz, 2H, Ar-H), 7.65 (dd, J$_1$ = 18.8 Hz, J$_2$ = 8.4 Hz, 1H, Ar-H), 7.57-7.52 (m, 2H, Ar-H), 7.46 (dd, J$_1$ = 15.0 Hz, J$_2$ = 7.4 Hz, 3H, Ar-H), 7.40 - 7.32 (m, 4H, Ar-H), 7.31-7.21 (m, 4H, Ar-H), 6.42 (s, 1H, N-H), 5.62 (s, 1H, -CH-); ^13^C NMR (100 MHz, CDCl$_3$) δ: 161.3, 152.3, 141.6, 137.9, 132.4, 131.5, 131.1, 129.6, 129.2, 128.9, 128.7, 128.0, 126.9, 123.6, 122.7, 121.6, 119.3, 113.8, 81.7; HRMS (ESI) m/z [M-H$^-$]: 448.3086, found: 447.1367.

1-((2,4-dinitrophenyl)(phenylamino)methyl)naphthalen-2-ol (4k) yellow solid, yield: 0.219 g, 53 %; mp: 143.3 - 144.1 °C (95 % ethanol); ^1^H NMR (400 MHz, CDCl$_3$) δ: 10.30 (s, 1H, Ar-OH), 8.46 (s, 1H, Ar-H), 7.96-7.78 (m, 3H, Ar-H), 7.51 (d, J = 9.1 Hz, 1H, Ar-H), 7.47 - 7.32 (m, 4H, Ar-H), 7.24 (dd, J$_1$ = 17.3 Hz, J$_2$ = 8.2 Hz, 3H, Ar-H), 7.15-6.95
1-(((4-chloro-2-nitrophenyl)amino)(3-nitrophenyl)methyl)naphthalen-2-ol (4l) yellow solid, yield: 0.202g, 45%, mp: 150.9 - 151.8 °C (95 % ethanol); IR (KBr, v, cm⁻¹): 3322.6 (m), 1623.21 (m), 1598.18 (m), 1528.65 (s), 1470.24 (m), 1347.86 (s), 1211.58 (m), 710.94 (m); ¹H NMR (400 MHz, DMSO-d₆) δ (ppm): 10.08 (s, 1H, Ar-OH), 8.21 (s, 1H, Ar-H), 8.04-7.96 (m, 3H, Ar-H), 7.70 (dd, J₁ = 10.3Hz, J₂ = 4.9 Hz, 4H, Ar-H), 7.52 (t, J = 8.0 Hz, 1H, Ar-H), 7.24 - 7.10 (m, 4H, Ar-H), 6.77 (s, 1H, N–H), 6.44 (s, 1H, -CH-); ¹³C NMR (100 MHz, DMSO-d₆) δ 161.6, 155.7, 133.6, 133.2, 131.0, 128.8, 128.2, 127.9, 127.2, 123.6, 122.4, 118.5, 117.9, 110.7, 60.5; HRMS (ESI) m/z [M-H]-: 415.3983, found: 414.0639.

N-((2-hydroxynaphthalen-1-yl)(3-nitrophenyl)methyl)acrylamide (4m) brown solid, yield: 0.056 g, 16 %; mp: 119.2-121.2 °C (253 – 254 °C)(95 % ethanol); IR (KBr, v, cm⁻¹): 3229.05 (m), 3107.44 (m), 1624.27 (m), 1596.4 (m), 1529.51 (s), 1462.62 (m), 1404.1 (m), 1283.64 (m), 1206.22 (m), 1013.92 (m), 913.59 (w); ¹H NMR (400 MHz,DMSO-d₆ ) δ (ppm) : 10.06 (s, 1H, Ar-OH), 8.22 (s, 1H, Ar-H), 8.00 (dd, J₁ = 8.2 Hz, J₂ = 2.6 Hz, 3H, Ar-H), 7.70 ( m, 4H, Ar-H ), 7.52 (t, J = 8.0 Hz, 1H, Ar-H ), 7.23 - 7.12 (m, 4H, Ar-H ), 6.77 (s, 1H, N–H ), 6.44 (s, 1H, -CH- ); ¹³C NMR (100 MHz, DMSO-d₆) δ 152.9, 148.6, 148.2, 132.6, 130.1, 129.3, 128.8, 126.2, 125.4, 122.9, 121.8, 120.9, 120.4, 118.6, 100.0, 66.5.
N-((2-hydroxynaphthalen-1-yl)(3-nitrophenyl)methyl)ethanethioamide (4n) brown solid, yield: 0.126 g, 36%; mp: 135.0 - 136.8 °C (234 - 236 °C(4)); IR (KBr, ν, cm⁻¹): 2974.83 (w), 2896.7 (w), 1622.41 (m), 1606.24 (s), 1498.48 (m), 1409.48 (m), 1379.94 (m), 1312.77 (s), 946.2 (m); ¹H NMR (400 MHz, CDCl₃) δ (ppm): 11.55 (s, 1H, Ar-OH), 7.75 (dd, J₁ = 16.3 Hz, J₂ = 8.7 Hz, 3H, Ar-H), 7.37 (m, 3H, Ar-H), 7.14 (m, 5H, Ar-H), 6.94 - 6.88 (m, 1H, Ar-H), 6.76 (dd, J₁ = 8.6 Hz, J₂ = 1.0 Hz, 2H, Ar-H), 6.13 (s, 1H, N-H), 4.13 (s, 1H, -CH₂).; ¹³C NMR (100 MHz, CDCl₃) δ 156.2, 146.8, 138.5, 138.2, 131.6, 130.1, 129.5, 129.1, 128.0, 126.9, 122.9, 121.9, 121.5, 120.1, 116.4, 114.0, 62.6, 21.2.

1-((benzylamino)(3-nitrophenyl)methyl)naphthalen-2-ol (4o) yellow solid, yield: 0.342 g, 87%; mp: 136.1 - 138.4 °C (95% ethanol); IR (KBr, ν, cm⁻¹): 3312.73 (w), 2922.98 (w), 2851.77 (w), 1703.14 (s), 1619.83 (m), 1599.01 (m), 1530.58 (s), 1239.01 (m), 813.55 (m); ¹H NMR (400 MHz, CDCl₃) δ 10.12 (s, 1H, Ar-OH), 8.72 (s, 1H, Ar-H), 8.49 (d, J = 8.2 Hz, 1H, Ar-H), 8.32 (s, 1H, Ar-H), 8.24 (d, J = 7.6 Hz, 1H, Ar-H), 8.08 (d, J = 8.2 Hz, 1H, Ar-H), 7.70 (d, J = 8.6 Hz, 1H, Ar-H), 7.43 (dd, J₁ = 13.5 Hz, J₂ = 5.7 Hz, 2H, Ar-H), 7.41 - 7.36 (m, 3H, Ar-H), 7.35 - 7.30 (m, 3H, Ar-H), 7.29 - 7.23 (m, 2H, Ar-H), 5.91 (s, 1H, N-H), 4.12 (m, 2H, -CH₂).; ¹³C NMR (100 MHz, CDCl₃) δ 189.8, 171.2, 156.8, 148.5, 143.2, 137.5, 134.7, 134.1, 132.3, 130.7, 129.1, 128.7, 128.1, 126.9, 124.5, 123.2, 122.9, 120.6, 120.3, 112.0, 61.7, 52.7; MS (ESI) m/z [M + H⁺]: 384.4273, found: 383.1394.
Fig. 5 IR spectrum of 4a

Fig. 6 $^1$H NMR spectrum of 4a
Fig. 7 $^{13}$C NMR spectrum of 4a

Fig. 8 HRMS spectrum of 4a

Fig. 9 IR spectrum of 4b
Fig. 10 $^1$H NMR spectrum of 4b

Fig. 11 $^{13}$C NMR spectrum of 4b
Fig. 12 HRMS spectrum of 4b

Fig. 13 IR spectrum of 4c

Fig. 14 $^1$H NMR spectrum of 4c
Fig. 15 $^{13}$C NMR spectrum of 4c

Fig. 16 HRMS spectrum of 4c

Fig. 17 IR spectrum of 4c
Fig. 17 IR spectrum of 4d

Fig. 18 $^1$H NMR spectrum of 4d

Fig. 19 $^{13}$C NMR spectrum of 4d
Fig. 20 HRMS spectrum of 4d

Fig. 21 IR spectrum of 4e

Fig. 22 $^1$H NMR spectrum of 4e
Fig. 23 $^{13}$C NMR spectrum of 4e

Fig. 24 HRMS spectrum of 4e
Fig. 25 IR spectrum of 4f

Fig. 26 $^1$H NMR spectrum of 4f

Fig. 27 $^{13}$C NMR spectrum of 4f
Fig. 28 HRMS spectrum of 4f

Fig. 29 $^1$H NMR spectrum of 4g

Fig. 30 $^{13}$C NMR spectrum of 4g
**Fig. 31** HRMS spectrum of 4g

**Fig. 32** IR spectrum of 4h

**Fig. 33** $^1$H NMR spectrum of 4h
Fig. 34 $^{13}$C NMR spectrum of 4h

Fig. 35 HRMS spectrum of 4h
Fig. 36 $^1$H NMR spectrum of 4i

Fig. 37 IR spectrum of 4j
Fig. 38 $^1$H NMR spectrum of 4j

Fig. 39 $^{13}$C NMR spectrum of 4j
Fig. 40 HRMS spectrum of 4j

Fig. 41 $^1$H NMR spectrum of 4k
Fig. 42 $^{13}$C NMR spectrum of 4k

Fig. 43 HRMS spectrum of 4k

Fig. 44 IR spectrum of 4l

Fig. 45 $^1$H NMR spectrum of 4l
Fig. 46 $^{13}$C NMR spectrum of 4l

Fig. 47 HRMS spectrum of 4l

Fig. 48 IR spectrum of 4m
Fig. 49 $^1$H NMR spectrum of 4m

Fig. 50 $^{13}$C NMR spectrum of 4m

Fig. 51 IR spectrum of 4n
Fig. 52 $^1$H NMR spectrum of 4n

Fig. 53 $^{13}$C NMR spectrum of 4n
Fig. 54 IR spectrum of 4o

Fig. 55 $^1H$ NMR spectrum of 4o

Fig. 56 $^{13}C$ NMR spectrum of 4o
4. References