Supporting Information

for

Bifurcated synthesis of methylene-lactone- and methylene-lactam-fused spirolactams via electrophilic amide allylation of γ-phenylthio-functionalized γ-lactams

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Experimental procedures and characterization data
The following data are included in this material:

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Experimental procedures and characterization data  S2–S31
**General methods.** All solvents and reagents were of reagent grade quality, and used without further purification unless otherwise stated. Chloroform, acetonitrile, ethanol, toluene, dichloromethane and 1,2-dichloroethane were dried over MS 4 Å or MS 3 Å prior to use, respectively. Tetrahydrofuran was dried over Na wire under a nitrogen atmosphere. The \(^1\)H and \(^{13}\)C nuclear magnetic resonance (NMR) spectra operating at the frequencies of 300 and 75 MHz, respectively, on a JEOL JNM-AL300 spectrometer were recorded in chloroform–\(d\) (CDCl\(_3\)) unless otherwise noted. Chemical shifts are reported in parts per million (ppm) relative to TMS and the solvent used as internal standards, and the coupling constants are reported in hertz (Hz). Reactions were monitored by thin layer chromatography (TLC) using Merck TLC silica gel 60F\(_{254}\), visualized by irradiation with UV light and/or by treatment with phosphomolybdic acid or \(p\)-anisaldehyde stain followed by heating. Column chromatography was performed using silica gel 60N (spherical neutral) from Kanto Chemical Co. and eluting with the indicated solvent system. Fourier transform infrared (FTIR) spectra were recorded on a JASCO FT/IR-4100 spectrometer. Elemental analyses were performed by JSL Model JM 10 instruments. Allylating reagent \(1a\) was prepared according to the literature procedure [1].

**Experimental procedures and characterization data.**

**Synthesis and characterization of 2a.** To a solution of \(N\)-phenylphthalimide (639 mg, 2.86 mmol) in methanol (13 mL) was added sodium borohydride (130 mg, 3.43 mmol) at 0 °C. After stirring the solution at room temperature for 2 hours, the reaction was quenched by addition of water (10 mL), and the resulting solution was concentrated under reduced pressure. The resulting mixture was extracted with ethyl acetate (2 × 20 mL). The combined organic extracts were washed with brine (10 mL), dried over Na\(_2\)SO\(_4\), filtered, and concentrated in vacuo to provide a crude material (639 mg) which was used in the next step without further purification. \(R_f = 0.30\) (silica gel, hexane/EtOAc = 2/1).

To a solution of the crude material (639 mg) in dichloromethane (5.7 mL) were added triethylamine
(0.59 mL, 3.4 mmol) and acetic anhydride (0.32 mL, 3.4 mmol) at room temperature. After stirring the solution at the same temperature for 2 days, the reaction mixture was concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) followed by recrystallization (hexane/EtOAc) to give 2a [2] (301 mg, 1.13 mmol, 40% for 2 steps) as a white solid. \( R_f = 0.33 \) (silica gel, hexane/EtOAc = 4/1); m.p. 97–100 °C; IR (KBr) 1719 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \( \delta \) 7.92 (m, 1H), 7.65–7.58 (m, 5H), 7.59 (s, 1H), 7.45 (t, \( J = 7.5 \) Hz, 2H), 7.27 (m, 1H), 2.06 (s, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta \) 170.9, 166.7, 140.3, 136.2, 133.0, 131.9, 130.6, 129.2, 126.0, 124.1, 123.8, 122.7, 81.4, 21.0. Anal. Calcd for C\(_{16}\)H\(_{13}\)NO\(_3\): C, 71.90; H, 4.90; N, 5.24. Found: C, 71.56; H, 5.05; N, 5.07.

**Synthesis and characterization of 2b.** To a solution of \( N \)-phenylphthalimide (617 mg, 2.76 mmol) in methanol (14 mL) was added sodium borohydride (125 mg, 3.31 mmol) at 0 °C. After stirring the solution at room temperature for 2 hours, the reaction was quenched by addition of water (10 mL), and the resulting solution was concentrated under reduced pressure. The resulting mixture was extracted with ethyl acetate (2 × 20 mL). The combined organic extracts were washed with brine (10 mL), dried over Na\(_2\)SO\(_4\), filtered, and concentrated in vacuo to provide a crude material (623 mg) which was used in the next step without further purification. \( R_f = 0.30 \) (silica gel, hexane/EtOAc = 2/1).

To a solution of the crude material (623 mg) in dichloromethane (14 mL) were added thiophenol (365 mL, 3.31 mmol) and boron trifluoride-diethyl ether complex (392 mg, 2.76 mmol) at room temperature. After stirring the solution at the same temperature for 3 hours, the reaction mixture was quenched with sat. NaHCO\(_3\) aq (20 mL). The resulting mixture was extracted with dichloromethane (2 × 20 mL). The combined organic extracts were washed with brine (10 mL), dried over Na\(_2\)SO\(_4\), filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 5/1 to 2/1) followed by recrystallization (hexane/EtOAc) to give 2b [3] (470 mg, 1.48 mmol, 54% for 2 steps) as a white solid. \( R_f = 0.30 \) (silica gel, hexane/EtOAc = 3/1); m.p. 130–131 °C; IR (KBr) 1686 (C=O) cm\(^{-1}\); \(^1\)H
NMR (300 MHz, CDCl$_3$) $\delta$ 7.73–7.57 (m, 5H), 7.47 (t, $J = 7.5$ Hz, 2H), 7.39 (t, $J = 7.5$ Hz, 1H), 7.27 (t, $J = 7.2$ Hz, 1H), 7.14 (t, $J = 7.2$ Hz, 1H), 7.00 (t, $J = 8.1$ Hz, 2H), 6.88 (d, $J = 8.1$ Hz, 2H), 6.32 (s, 1H). $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 166.2, 142.3, 136.6, 135.9, 132.1, 131.7, 129.2, 128.9, 128.4, 127.4, 125.4, 123.7, 123.5, 123.3, 66.8. Anal. Calcd for C$_{20}$H$_{15}$NOS: C, 75.68; H, 4.76; N, 4.41. Found: C, 75.37; H, 4.94; N, 4.39.

**Preparation and characterization of 2c.** According to the synthetic procedure of 2b, 2c was prepared from N-benzylphthalimide (1.21 g, 5.10 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 5/1 to 2/1) to give 2c (1.54 g, 4.65 mmol, 91% for 2 steps) as a white solid. $R_f = 0.30$ (silica gel, hexane/EtOAc = 3/1); m.p. 89–90 °C; IR (KBr) 1686 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.62–7.50 (m, 3H), 7.37–7.25 (m, 6H), 7.20–7.13 (m, 1H), 7.10–7.04 (m, 4H), 5.50 (s, 1H), 5.45 (d, $J = 14.7$ Hz, 1H), 4.54 (d, $J = 14.7$ Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 167.2, 142.8, 136.7, 135.2, 131.6, 131.5, 129.0, 128.7, 128.6, 128.4, 127.9, 127.6, 123.7, 123.2, 65.7, 43.1. Anal. Calcd for C$_{21}$H$_{17}$NOS: C, 76.10; H, 5.17; N, 4.23. Found: C, 76.06; H, 4.94; N, 4.24.

**Preparation and characterization of 2d.** According to the synthetic procedure of 2b, 2d was prepared from N-methylphthalimide (2.52 g, 15.6 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/1) to give 2d (2.94 g, 11.5 mmol, 73% for 2 steps) as a white solid. $R_f = 0.40$ (silica gel, hexane/EtOAc = 3/1); m.p. 87–88 °C; IR (KBr) 1692 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.63 (d, $J = 7.5$ Hz, 1H), 7.53 (q, $J = 6.9$ Hz, 2H), 7.33 (t, $J = 7.5$ Hz, 1H), 7.14 (m, 1H), 7.09–7.05 (m, 4H), 5.61 (s, 1H), 3.25 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 167.4, 142.6, 135.2, 131.8, 131.4, 129.0, 128.6, 128.0, 123.5, 122.9, 68.5, 27.2. Anal. Calcd for C$_{15}$H$_{13}$NOS: C, 70.56; H, 5.13; N, 5.49. Found: C, 70.73; H, 5.12; N, 5.45.

**Preparation and characterization of 2e.** According to the synthetic procedure of 2b, 2e was prepared from N-pentylphthalimide (0.892 g, 4.12 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 5/1 to 2/1) to give 2e (1.18 g, 3.79 mmol, 92% for 2 steps) as a colorless oil. $R_f = 0.40$ (silica gel, hexane/EtOAc = 3/1); IR (KBr) 1690 (C=O)
$^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.64 (d, $J$ = 7.5 Hz, 1H), 7.54 (q, $J$ = 7.5 Hz, 2H), 7.33 (t, $J$ = 7.5 Hz, 1H), 7.15 (m, 1H), 7.09–7.03 (m, 4H), 5.73 (s, 1H), 4.05 (m, 1H), 3.53 (m, 1H), 1.71–1.57 (m, 2H), 1.39–1.28 (m, 4H), 0.89 (t, $J$ = 6.6 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 167.1, 142.6, 135.1, 131.8, 131.3, 128.8, 128.4, 128.0, 123.5, 122.9, 66.2, 39.3, 28.9, 27.7, 22.2, 13.9. Anal. Calcd for C$_{19}$H$_{21}$NOS: C, 73.27; H, 6.80; N, 4.50. Found: C, 72.98; H, 6.46; N, 4.49.

**Synthesis and characterization of 2f.** To a solution of 2,3-dimethyl-$N$-phenylmaleimide (757 mg, 3.76 mmol) in methanol (19 mL) was added sodium borohydride (213 mg, 5.64 mmol) at 0 °C. After stirring the solution at room temperature for 3 hours, the reaction was quenched by addition of water (10 mL), and the resulting solution was concentrated under reduced pressure. The resulting mixture was extracted with chloroform (2 $\times$ 20 mL). The combined organic extracts were washed with brine (10 mL), dried over Na$_2$SO$_4$, filtered, and concentrated in vacuo to provide a crude material (651 mg) which was used in the next step without further purification. $R_f$ = 0.31 (silica gel, hexane/EtOAc = 2/1).

To a solution of the crude material (651 mg) in dichloromethane (14 mL) were added thiophenol (387 mg, 3.52 mmol) and boron trifluoride-diethyl ether complex (454 mg, 3.20 mmol) at room temperature. After stirring the solution at the same temperature for 18 hours, the reaction mixture was quenched with sat. NaHCO$_3$ aq (20 mL). The resulting mixture was extracted with dichloromethane (2 $\times$ 20 mL). The combined organic extracts were washed with brine (10 mL), dried over Na$_2$SO$_4$, filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 8/1 to 4/1 to 2/1) followed by recrystallization (hexane/EtOAc) to give 2f (545 mg, 1.84 mmol, 49% for 2 steps) as a white solid. $R_f$ = 0.21 (silica gel, hexane/EtOAc = 3/1); m.p. 127–128 °C; IR (KBr) 1678 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.61 (d, $J$ = 7.8 Hz, 2H), 7.42 (t, $J$ = 7.5 Hz, 2H), 7.28 (m, 1H), 7.19 (t, $J$ = 7.5 Hz, 3H), 7.08 (d, $J$ = 8.1 Hz, 2H), 5.51 (s, 1H), 2.12 (s, 3H), 1.61 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 169.7, 146.5, 136.9, 135.5, 130.5, 129.3, 128.8, 128.5, 127.8, 124.4, 121.4, 69.4, 12.6, 8.3. Anal. Calcd for C$_{18}$H$_{17}$NOS: C, 73.19; H, 5.80; N, 4.74. Found: C, 72.85; H, 5.63; N, 4.64.
Preparation and characterization of 2g. According to the synthetic procedure of 2f, 2g was prepared from 2,3-dimethyl-N-benzylmaleimide (3.14 g, 14.6 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 8/1 to 4/1) to give 2g (4.28 g, 13.8 mmol, 95% for 2 steps) as a colorless oil. $R_f = 0.21$ (silica gel, hexane/EtOAc = 3/1); IR (KBr) 1685 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.33–7.23 (m, 10H), 5.26 (d, $J = 14.7$ Hz, 1H), 4.74 (s, 1H), 4.14 (d, $J = 14.7$ Hz, 1H), 1.95 (s, 3H), 1.59 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 170.8, 146.6, 137.3, 134.5, 130.0, 128.9, 128.8, 128.7, 128.3, 127.4, 69.2, 43.2, 12.5, 8.4. Anal. Calcd for C$_{19}$H$_{19}$NOS: C, 73.75; H, 6.19; N, 4.53. Found: C, 73.39; H, 6.49; N, 4.60.

Preparation and characterization of 2h. According to the synthetic procedure of 2f, 2h was prepared from 2,3-dimethyl-N-methylmaleimide (644 mg, 4.77 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 1/1) to give 2h (1.08 g, 4.64 mmol, 97% for 2 steps) as a white solid. $R_f = 0.32$ (silica gel, hexane/EtOAc = 1/1); IR (KBr) 1683 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.30–7.20 (m, 5H), 4.84 (s, 1H), 3.11 (s, 3H), 1.99 (s, 3H), 1.56 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 170.9, 145.8, 134.5, 130.2, 128.8, 128.7, 128.6, 71.9, 26.9, 12.3, 8.3. Anal. Calcd for C$_{13}$H$_{15}$NOS: C, 66.92; H, 6.48; N, 6.00. Found: C, 66.54; H, 6.59; N, 5.72.

Preparation and characterization of 2i. According to the synthetic procedure of 2f, 2i was prepared from 2,3-dimethyl-N-pentylmaleimide (3.42 g, 15.9 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 2i (3.95 g, 13.6 mmol, 86% for 2 steps) as a yellow oil. $R_f = 0.21$ (silica gel, hexane/EtOAc = 3/1); m.p. 57–58 °C; IR (KBr) 1686 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.28–7.19 (m, 5H), 4.94 (s, 1H), 3.87 (m, 1H), 3.45 (m, 1H), 1.99 (s, 3H), 1.56–1.46 (m, 2H), 1.37–1.25 (m, 4H), 0.89 (t, $J = 6.6$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 170.8, 145.7, 134.5, 130.3, 128.93, 128.85, 128.7, 69.9, 39.5, 29.0, 28.2, 22.3, 13.9, 12.4, 8.3. Anal. Calcd for C$_{17}$H$_{23}$NOS: C, 70.55; H, 8.01; N, 4.84. Found: C, 70.38; H, 7.63; N, 4.86.

General procedure for the synthesis of 3b-o. All the experiments for the synthesis of 3b-o were
carried out as described in the following typical procedure. The reaction of 2b with 1a for the synthesis of 3b was exemplified as follows.

**Synthesis and characterization of 3b.** To a stirred solution of 2b (31.7 mg, 0.100 mmol) in tetrahydrofuran (0.5 mL) was added sodium hydride (60% oil suspension, 10.0 mg, 0.250 mmol) at -10 °C under an argon atmosphere. After stirring the solution at the same temperature for 10 min, 1a (26.3 mg, 0.120 mmol) was added. The mixture was stirred for additional 1 hour, and then the reaction was quenched by addition of water (10 mL). The resulting mixture was extracted with dichloromethane (2 × 20 mL). The combined organic extracts were washed with brine (10 mL), dried over Na₂SO₄, filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3b (49.4 mg, 0.0971 mmol, 97%) as a white solid. $R_f = 0.30$ (silica gel, hexane/EtOAc = 2/1); m.p. 182–183 °C; IR (KBr) 3312 (N–H), 1695 (C=O), 1672 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃) δ 8.30 (d, $J = 7.8$ Hz, 2H), 7.71 (d, $J = 6.0$ Hz, 1H), 7.49 (t, $J = 7.8$ Hz, 2H), 7.43–7.26 (m, 3H), 7.17–7.02 (m, 7H), 6.95 (d, $J = 3.6$ Hz, 4H), 5.45 (s, 1H), 4.82 (s, 1H), 3.95 (d, $J = 14.4$ Hz, 1H), 3.44 (d, $J = 14.4$ Hz, 1H); $^{13}$C NMR (75 MHz, CDCl₃) δ 167.7, 167.0, 145.1, 139.6, 137.8, 137.0, 135.9, 132.1, 129.9, 129.2, 128.83, 128.78, 128.34, 128.32, 128.26, 126.2, 124.6, 124.3, 123.8, 122.8, 122.4, 119.7, 79.2, 35.6. Anal. Calcd for C₃₀H₂₄N₂O₂S: C, 75.61; H, 5.08; N, 5.88. Found: C, 75.23; H, 5.31; N, 5.80.

**Synthesis and characterization of 3c.** According to the synthetic procedure of 3b, 3c was synthesized from 2c (66.3 mg, 0.200 mmol) and 1a (52.6 mg, 0.240 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 3/1) to give 3c (93.7 mg, 0.191 mmol, 95%) as a white solid. $R_f = 0.37$ (silica gel, hexane/EtOAc = 2/1); m.p. 120–121 °C; IR (KBr) 3296 (N–H), 1686 (C=O), 1670 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃) δ 7.64 (t, $J = 8.4$ Hz, 3H), 7.46 (d, $J = 6.9$ Hz, 1H), 7.37–7.30 (m, 4H), 7.28–7.21 (m, 2H), 7.16 (t, $J = 5.7$ Hz, 3H), 7.12–7.03 (m, 2H), 6.95 (t, $J = 7.5$ Hz, 2H), 6.78 (d, $J = 7.2$ Hz, 2H), 6.47 (brs, 1H), 5.15 (d, $J = 15.0$ Hz, 1H), 5.01 (s, 1H), 4.81 (d, $J = 15.0$ Hz, 1H), 3.98 (s, 1H), 3.67 (d, $J = 14.4$ Hz, 1H), 3.08
(d, J = 14.4 Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 168.4, 166.9, 144.9, 139.4, 138.3, 137.3, 135.5, 131.5, 130.6, 129.8, 129.2, 128.51, 128.46, 128.43, 128.39, 128.2, 127.5, 124.3, 124.1, 122.4, 121.2, 119.9, 79.5, 44.0, 36.7. Anal. Calcd for C$_{31}$H$_{26}$N$_2$O$_2$S: C, 75.89; H, 5.34; N, 5.71. Found: C, 76.07; H, 5.73; N, 5.64.

**Synthesis and characterization of 3d.** According to the synthetic procedure of 3b, 3d was synthesized from 2d (51.1 mg, 0.200 mmol) and 1a (52.6 mg, 0.240 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3d (74.0 mg, 0.179 mmol, 90%) as a white solid. $R_f = 0.37$ (silica gel, hexane/EtOAc = 1/2); m.p. 155–156 °C; IR (KBr) 3300 (N–H), 1689 (C=O), 1669 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.67 (d, J = 7.8 Hz, 1H), 7.38 (t, J = 7.5 Hz, 1H), 7.28 (t, J = 7.5 Hz, 1H), 7.24–7.15 (m, 4H), 7.11 (m, 1H), 7.08–7.02 (m, 2H), 6.96 (t, J = 7.8 Hz, 2H), 6.86 (d, J = 6.9 Hz, 2H), 5.44 (s, 1H), 5.12 (s, 1H), 3.63 (d, J = 14.4 Hz, 1H), 3.26 (d, J = 14.4 Hz, 1H), 3.19 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 167.7, 166.7, 144.7, 140.4, 137.2, 135.7, 131.5, 129.3, 128.6, 128.53, 128.47, 128.39, 124.4, 124.0, 122.3, 121.0, 120.2, 78.2, 36.8, 25.2. Anal. Calcd for C$_{25}$H$_{22}$N$_2$O$_2$S: C, 72.44; H, 5.35; N, 6.76. Found: C, 72.08; H, 5.40; N, 6.56.

**Synthesis and characterization of 3e.** According to the synthetic procedure of 3b, 3e was synthesized from 2e (97.1 mg, 0.312 mmol) and 1a (82.0 mg, 0.374 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3e (135 mg, 0.287 mmol, 92%) as a white solid. $R_f = 0.37$ (silica gel, hexane/EtOAc = 2/1); m.p. 158–160 °C; IR (KBr) 3355 (N–H), 1689 (C=O), 1662 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.53 (d, J = 7.5 Hz, 1H), 7.44 (d, J = 7.5 Hz, 1H), 7.34 (t, J = 7.5 Hz, 1H), 7.25 (d, J = 4.2 Hz, 3H), 7.13 (m, 3H), 7.02–6.91 (m, 5H), 5.47 (s, 1H), 5.11 (s, 1H), 3.65 (d, J = 14.4 Hz, 1H), 3.59 (m, 2H), 3.26 (d, J = 14.4 Hz, 1H), 1.94–1.80 (m, 2H), 1.40 (brs, 4H), 0.92 (t, J = 6.9 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 168.3, 166.8, 144.9, 140.4, 137.3, 134.9, 131.6, 131.5, 129.5, 129.0, 128.7, 128.6, 128.4, 124.4, 124.1, 122.4, 121.3, 120.1, 78.5, 41.3, 37.6, 29.8, 28.4, 22.4, 14.0. Anal. Calcd for C$_{29}$H$_{30}$N$_2$O$_2$S: C, 74.01; H, 6.43; N, 5.95. Found: C, 73.69; H, 6.58; N, 5.81.
Synthesis and characterization of 3f. According to the synthetic procedure of 3b, 3f was synthesized from 2b (66.1 mg, 0.208 mmol) and 1b [4] (54.8 mg, 0.250 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3f (95.1 mg, 0.195 mmol, 94%) as a white solid. $R_f = 0.33$ (silica gel, hexane/EtOAc = 2/1); m.p. 178–179 °C; IR (KBr) 3316 (N–H), 1698 (C=O), 1664 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃) δ 8.30–8.27 (m, 2H), 7.69 (m, 1H), 7.52–7.24 (m, 5H), 7.13–7.08 (m, 2H), 7.01–6.95 (m, 8H), 5.39 (s, 1H), 4.79 (s, 1H), 3.89 (d, $J = 14.4$ Hz, 1H), 3.43 (d, $J = 14.4$ Hz, 1H), 2.27 (s, 3H); $^{13}$C NMR (75 MHz, CDCl₃) δ 167.6, 166.8, 145.1, 140.0, 137.0, 135.9, 135.0, 133.6, 132.2, 130.1, 129.3, 129.0, 128.8, 128.4, 126.2, 124.7, 124.2, 122.7, 121.9, 119.9, 79.1, 35.8, 20.8. Anal. Calcd for C₃₁H₂₆N₂O₂S: C, 75.89; H, 5.34; N, 5.71. Found: C, 75.73; H, 5.73; N, 5.67.

Synthesis and characterization of 3g. According to the synthetic procedure of 3b, 3g was synthesized from 2a (64.3 mg, 0.203 mmol) and 1c [4] (60.8 mg, 0.244 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3g (97.8 mg, 0.193 mmol, 95%) as a white solid. $R_f = 0.30$ (silica gel, hexane/EtOAc = 2/1); m.p. 164–165 °C; IR (KBr) 3327 (N–H), 1699 (C=O), 1678 (C=O), 1662 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃) δ 8.29 (d, $J = 7.8$ Hz, 2H), 7.70 (m, 1H), 7.52–7.40 (m, 3H), 7.32 (t, $J = 7.2$ Hz, 1H), 7.20–7.07 (m, 4H), 7.03–6.92 (m, 5H), 6.73–6.69 (m, 2H), 5.40 (s, 1H), 4.78 (s, 1H), 3.90 (d, $J = 14.4$ Hz, 1H), 3.76 (s, 3H), 3.43 (d, $J = 14.4$ Hz, 1H); $^{13}$C NMR (75 MHz, CDCl₃) δ 167.6, 166.8, 156.1, 145.2, 140.0, 137.0, 135.9, 132.2, 130.7, 130.1, 129.3, 128.9, 128.8, 128.4, 126.2, 124.7, 124.3, 122.8, 121.9, 121.6, 113.6, 79.1, 55.3, 35.9. Anal. Calcd for C₃₁H₂₆N₂O₃S: C, 74.33; H, 6.02; N, 5.98. Found: C, 74.47; H, 6.15; N, 5.87.

Synthesis and characterization of 3h. According to the synthetic procedure of 3b, 3h was synthesized from 2a (65.7 mg, 0.207 mmol) and 1d (52.9 mg, 0.248 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3h (91.1 mg, 0.193 mmol, 93%) as a white solid. $R_f = 0.26$ (silica gel, hexane/EtOAc = 2/1); m.p. 155–156 °C; IR (KBr) 3356 (N–H), 1699 (C=O), 1658 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃) δ 8.24 (d, $J =
7.8 Hz, 2H), 7.69 (d, $J = 7.8$ Hz, 1H), 7.57–7.22 (m, 6H), 7.15–7.08 (m, 1H), 6.99–6.93 (m, 4H), 5.16 (s, 1H), 5.00 (brs, 1H), 4.60 (s, 1H), 3.83 (d, $J = 14.4$ Hz, 1H), 3.36 (d, $J = 14.4$ Hz, 1H), 2.92–2.67 (m, 2H), 1.28–1.01 (m, 6H), 0.84 (t, $J = 6.9$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 168.7, 167.5, 145.3, 140.0, 137.0, 135.9, 131.9, 130.4, 129.4, 128.83, 128.77, 128.4, 128.3, 126.1, 124.8, 124.3, 122.5, 121.0, 78.9, 39.5, 36.0, 28.9, 28.7, 22.2, 13.9. Anal. Calcd for C$_{29}$H$_{30}$N$_2$O$_2$S: C, 74.01; H, 6.43; N, 5.95. Found: C, 73.66; H, 6.25; N, 5.80.

Synthesis and characterization of 3i. According to the synthetic procedure of 3b, 3i was synthesized from 2f (72.6 mg, 0.246 mmol) and 1a (64.6 mg, 0.295 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3i (107 mg, 0.235 mmol, 96%) as a white solid. $R_f$ = 0.37 (silica gel, hexane/EtOAc = 2/1); m.p. 153–154 °C; IR (KBr) 3314 (N–H), 1692 (C=O), 1673 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 8.23 (dd, $J = 9.0$, 1.5 Hz, 2H), 7.46–7.36 (m, 4H), 7.32–7.25 (m, 4H), 7.24–7.16 (m, 4H), 7.10 (m, 1H), 5.38 (s, 1H), 4.73 (s, 1H), 3.45 (dd, $J = 14.4$, 1.2 Hz, 1H), 3.17 (d, $J = 14.4$ Hz, 1H), 2.02 (q, $J = 1.2$ Hz, 3H), 1.29 (q, $J = 1.2$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 170.6, 166.4, 150.4, 139.7, 137.6, 135.3, 130.0, 129.6, 129.4, 128.8, 128.71, 128.66, 125.2, 124.4, 123.3, 121.9, 120.0, 81.1, 34.0, 11.6, 8.0. Anal. Calcd for C$_{28}$H$_{26}$N$_2$O$_2$S: C, 73.98; H, 5.77; N, 6.16. Found: C, 74.35; H, 5.92; N, 6.35.

Synthesis and characterization of 3j. According to the synthetic procedure of 3b, 3j was synthesized from 2g (72.3 mg, 0.234 mmol) and 1a (61.6 mg, 0.281 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3j (102 mg, 0.218 mmol, 93%) as a white solid. $R_f$ = 0.33 (silica gel, hexane/EtOAc = 2/1); IR (KBr) 3424 (N–H), 1682 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.54 (dd, $J = 7.5$, 1.8 Hz, 2H), 7.39 (dd, $J = 8.7$, 1.2 Hz, 2H), 7.32–7.24 (m, 6H), 7.18 (t, $J = 7.8$ Hz, 2H), 7.11 (d, $J = 7.5$ Hz, 1H), 7.07-7.03 (m, 2H), 6.86 (brs, 1H), 5.08 (s, 1H), 4.99 (d, $J = 14.7$ Hz, 1H), 4.63 (d, $J = 14.7$ Hz, 1H), 4.53 (s, 1H), 3.25 (d, $J = 15.9$ Hz, 1H), 2.83 (d, $J = 15.9$ Hz, 1H), 1.92 (s, 3H), 1.40 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 171.9, 166.6, 149.6, 140.0, 138.5, 137.4, 135.2, 130.0, 129.8, 129.4, 129.2, 128.9,
Synthesis and characterization of 3k. According to the synthetic procedure of 3b, 3k was synthesized from 2h (99.0 mg, 0.424 mmol) and 1a (112 mg, 0.509 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3k (153 mg, 0.390 mmol, 92%) as a white solid. \( R_f = 0.33 \) (silica gel, hexane/EtOAc = 1/1); m.p. 177–178 °C; IR (KBr) 3291 (N–H), 1685 (C=O), 1670 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \( \delta \) 7.46 (brs, 1H), 7.43 (7.20 (t, \( J = 7.8 \) Hz, 2H), 7.10 (t, \( J = 7.2 \) Hz, 3H), 5.57 (s, 1H), 5.33 (s, 1H), 3.31 (d, \( J = 14.1 \) Hz, 1H), 3.09 (s, 3H), 2.89 (d, \( J = 14.1 \) Hz, 1H), 1.95 (s, 3H), 1.30 (s, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta \) 170.9, 166.5, 148.9, 140.8, 137.6, 135.0, 131.0, 129.3, 128.7, 128.6, 124.4, 120.6, 120.3, 80.4, 35.4, 25.5, 11.4, 8.1. Anal. Calcd for C\(_{29}\)H\(_{28}\)N\(_2\)O\(_2\)S: C, 74.33; H, 6.02; N, 5.98. Found: C, 74.20; H, 6.41; N, 6.36.

Synthesis and characterization of 3l. According to the synthetic procedure of 3b, 3l was synthesized from 2i (57.9 mg, 0.200 mmol) and 1a (52.6 mg, 0.240 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3l (86.1 mg, 0.192 mmol, 96%) as a white solid. \( R_f = 0.35 \) (silica gel, hexane/EtOAc = 2/1); m.p. 156–157 °C; IR (KBr) 3344 (N–H), 1679 (C=O), 1664 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \( \delta \) 7.47 (dd, \( J = 8.7, 1.2 \) Hz, 2H), 7.40 (brs, 1H), 7.31 (t, \( J = 7.5 \) Hz, 2H), 7.26–7.22 (m, 2H), 7.20 (t, \( J = 1.8 \) Hz, 1H), 7.19–7.17 (m, 2H), 7.12 (m, 1H), 5.60 (s, 1H), 5.32 (s, 1H), 3.52 (m, 1H), 3.37 (m, 1H), 3.30 (dd, \( J = 15.0, 0.9 \) Hz, 1H), 2.95 (d, \( J = 15.0 \) Hz, 1H), 1.84 (q, \( J = 0.9 \) Hz, 3H), 1.82–1.74 (m, 2H), 1.40 (q, \( J = 0.9 \) Hz, 3H), 1.37–1.31 (m, 4H), 0.89 (t, \( J = 6.9 \) Hz, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta \) 171.5, 166.4, 148.9, 140.8, 137.4, 133.8, 131.2, 130.5, 128.92, 128.86, 128.5, 124.6, 120.5, 120.1, 80.7, 41.5, 35.4, 29.7, 28.2, 22.3, 14.0, 11.4, 8.1. Anal. Calcd for C\(_{27}\)H\(_{32}\)N\(_2\)O\(_2\)S: C, 72.29; H, 7.19; N, 6.24. Found: C, 72.38; H, 6.84; N, 6.12.

Synthesis and characterization of 3m. According to the synthetic procedure of 3b, 3m was synthesized from 2f (59.7 mg, 0.202 mmol) and 1b (56.5 mg, 0.242 mmol). The crude product was
purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3m (87.0 mg, 0.186 mmol, 92%) as a white solid. $R_f$ = 0.33 (silica gel, hexane/EtOAc = 2/1); m.p. 170–171 °C; IR (KBr) 3325 (N–H), 1696 (C=O), 1660 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 8.25–8.22 (m, 2H), 7.46–7.41 (m, 2H), 7.32–7.16 (m, 8H), 7.09 (d, $J$ = 8.4 Hz, 2H), 5.36 (s, 1H), 4.70 (s, 1H), 3.45 (d, $J$ = 14.4 Hz, 1H), 3.16 (d, $J$ = 14.4 Hz, 1H), 2.30 (s, 3H), 2.02 (s, 3H), 1.31 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 170.6, 166.4, 150.4, 139.8, 137.6, 135.3, 134.9, 134.1, 130.0, 129.6, 129.3, 128.7, 128.6, 125.2, 123.3, 121.6, 120.1, 81.0, 34.1, 20.8, 11.6, 8.0. Anal. Calcd for C$_{29}$H$_{28}$N$_2$O$_2$S: C, 74.33; H, 6.02; N, 5.98. Found: C, 74.47; H, 6.15; N, 5.87.

**Synthesis and characterization of 3n.** According to the synthetic procedure of 3b, 3n was synthesized from 2f (59.5 mg, 0.201 mmol) and 1c (60.1 mg, 0.241 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3n (92.6 mg, 0.191 mmol, 95%) as a white solid. $R_f$ = 0.33 (silica gel, hexane/EtOAc = 2/1); m.p. 153–154 °C; IR (KBr) 3328 (N–H), 1684 (C=O), 1660 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 8.24–8.21 (m, 2H), 7.54–7.39 (m, 2H), 7.31–7.16 (m, 8H), 6.83–6.78 (m, 2H), 5.37 (s, 1H), 4.70 (s, 1H), 3.77 (s, 3H), 3.45 (d, $J$ = 14.7 Hz, 1H), 3.15 (d, $J$ = 14.7 Hz, 1H), 2.02 (d, $J$ = 0.9 Hz, 3H), 1.30 (d, $J$ = 0.9 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 170.7, 166.4, 150.4, 139.8, 137.6, 135.3, 134.9, 134.1, 130.0, 129.9, 129.6, 129.4, 128.7, 128.6, 125.2, 123.3, 121.9, 121.5, 114.0, 81.0, 55.4, 34.2, 11.6, 8.0. Anal. Calcd for C$_{29}$H$_{28}$N$_2$O$_3$S: C, 71.88; H, 5.82; N, 5.78. Found: C, 72.01; H, 5.83; N, 5.63.

**Synthesis and characterization of 3o.** According to the synthetic procedure of 3b, 3o was synthesized from 2f (61.8 mg, 0.209 mmol) and 1d (53.5 mg, 0.251 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 3o (92.9 mg, 0.207 mmol, 99%) as a white solid. $R_f$ = 0.37 (silica gel, hexane/EtOAc = 2/1); m.p. 110–111 °C; IR (KBr) 3397 (N–H), 1684 (C=O), 1660 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 8.19–8.17 (m, 2H), 7.42 (t, $J$ = 7.5 Hz, 2H), 7.31–7.16 (m, 6H), 5.49 (t, $J$ = 5.4 Hz, 1H), 5.17 (s, 1H), 4.55 (s, 1H), 3.39 (d, $J$ = 14.4 Hz, 1H), 3.13–3.05 (m, 3H), 2.04 (d, $J$ = 0.6 Hz, 3H), 1.45–1.16 (m, 6H), 1.40 (d, $J$ = 0.6 Hz, 3H), 0.88 (t, $J$ = 7.2 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 170.6, 168.3, 150.3, 139.7,
137.6, 135.4, 129.6, 128.6, 125.1, 123.2, 120.7, 81.0, 39.6, 34.1, 29.2, 28.9, 22.2, 13.9, 11.5, 8.0. Anal. Calcd for C_{27}H_{32}N_{2}O_{2}S: C, 72.29; H, 7.19; N, 6.24. Found: C, 72.58; H, 7.20; N, 6.15.

**Synthesis and characterization of 3p.** According to the synthetic procedure of 3b, 3p was synthesized from 2d (255 mg, 1.00 mmol) and 1b (280 mg, 1.20 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/2) to give 3p (364 mg, 0.849 mmol, 85%) as a white solid. \( R_f = 0.33 \) (silica gel, hexane/EtOAc = 1/2); m.p. 185–186 °C; IR (KBr) 3278 (N–H) 1696 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \( \delta 7.67 \) (m, 1H), 7.44–7.37 (m, 2H), 7.19–6.95 (m, 8H), 6.89–6.85 (m, 2H), 6.73 (brs, 1H), 5.39 (s, 1H), 5.09 (s, 1H), 3.59 (dd, \( J = 14.1, 0.6 \) Hz, 1H), 3.27 (d, \( J = 14.1 \) Hz, 1H), 3.20 (s, 3H), 2.28 (s, 3H); \(^13\)C NMR (75 MHz, CDCl\(_3\)) \( \delta 167.6, 166.6, 144.7, 140.4, 135.7, 134.6, 134.0, 131.4, 129.3, 129.1, 128.5, 128.3, 124.0, 122.2, 120.9, 120.4, 78.3, 36.7, 25.1, 20.8. Anal. Calcd for C_{26}H_{24}N_{2}O_{2}S: C, 72.87; H, 5.65; N, 6.54. Found: C, 72.96; H, 5.71; N, 6.21.

**General procedure for the synthesis of 4a–n.** All the experiments for the synthesis of 4a–n were carried out as described in the following typical procedure. The reaction of 3b for the synthesis of 4a was exemplified as follows.

**Synthesis and characterization of 4a.** To a stirred solution of 3b (47.7 mg, 0.100 mmol) in tetrahydrofuran/water (1/1, 1.0 mL) was added copper (I) bromide (43.2 mg, 0.301 mmol) at room temperature. After stirring the solution at the same temperature for 4 hours, water (1.0 mL) was added to the solution and the resulting mixture was extracted with ethyl acetate (2 × 10 mL). The combined organic extracts were washed with brine (10 mL), dried over Na\(_2\)SO\(_4\), filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, CH\(_2\)Cl\(_2\)/EtOAc = 4/1) to give 6a (34.7 mg, 0.0903 mmol, 90%) as a white solid. \( R_f = 0.30 \) (silica gel, hexane/EtOAc = 1/1); m.p. 177–178 °C; IR (KBr) 3444 (O–H), 3366 (N–H), 1664 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)/CD\(_3\)OD = 1/1) \( \delta 7.81 \) (d, \( J = 7.5 \) Hz, 1H), 7.71 (d, \( J = 7.5 \) Hz, 2H), 7.64 (d, \( J = 7.5 \) Hz, 2H), 7.55 (m, 1H), 7.49–7.45 (m, 3H), 7.39–7.32 (m, 3H), 7.27 (t, \( J = 7.5 \) Hz, 1H), 7.09 (m, 1H), 5.79 (s, 1H), 5.18 (s, 1H), 3.38 (d, \( J = 14.7 \) Hz, 1H), 3.28 (s, 3H).
2.89 (d, J = 14.7 Hz, 1H); \(^{13}\text{C}\) NMR (75 MHz, CDCl\(_3\)/CD\(_3\)OD = 1/1) \(\delta\) 167.7, 167.1, 145.4, 138.9, 137.2, 134.9, 132.0, 130.0, 129.2, 128.3, 128.0, 126.8, 126.6, 124.0, 123.9, 123.2, 122.6, 120.2, 91.6, 39.2. Anal. Calcd for C\(_{24}\)H\(_{20}\)N\(_2\)O\(_3\): C, 74.98; H, 5.24; N, 7.29. Found: C, 74.66; H, 5.41; N, 7.10.

To a solution of 6a (38.9 mg, 0.101 mmol) in dichloromethane (1.0 mL) was added \(p\)-toluenesulfonic acid monohydrate (21.4 mg, 0.121 mmol) at room temperature. After stirring the solution at the same temperature for 24 hours, the reaction was quenched with sat. NaHCO\(_3\) aq (1.0 mL). The resulting mixture was extracted with dichloromethane (2 \(\times\) 10 mL). The combined organic extracts were washed with brine (10 mL), dried over Na\(_2\)SO\(_4\), filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 1/1) to give 4a (36.0 mg, 0.0982 mmol, 97%) as a white solid. \(R_f = 0.32\) (silica gel, hexane/EtOAc = 1/1); m.p. 218–219 °C; IR (KBr) 1714 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 7.85 (d, \(J = 8.1\) Hz, 1H), 7.56 (m, 1H), 7.50–7.32 (m, 7H), 7.23–7.10 (m, 5H), 6.10 (t, \(J = 2.7\) Hz, 1H), 5.33 (t, \(J = 2.1\) Hz, 1H), 3.37 (dt, \(J = 17.4, 2.7\) Hz, 1H), 3.20 (dt, \(J = 17.4, 2.1\) Hz, 1H); \(^{13}\text{C}\) NMR (75 MHz, CDCl\(_3\)) \(\delta\) 167.2, 166.6, 144.7, 135.8, 135.4, 134.6, 133.3, 131.2, 130.0, 129.6, 129.0, 127.9, 127.3, 127.0, 125.3, 121.8, 118.2, 83.0, 37.5. Anal. Calcd for C\(_{24}\)H\(_{18}\)N\(_2\)O\(_2\): C, 78.67; H, 4.95; N, 7.65. Found: C, 78.27; H, 4.94; N, 7.52.

**Synthesis and characterization of 4b.** According to the synthetic procedure of 6a, 6b was synthesized from 3c (48.9 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to CHCl\(_3\)/MeOH = 10/1) to give 6b (35.2 mg, 0.0886 mmol, 89%) as a white solid. \(R_f = 0.23\) (silica gel, hexane/EtOAc = 1/1); m.p. 89–90 °C; IR (KBr) 3302 (O–H), 1684 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 7.90 (s, 1H), 7.73 (d, \(J = 6.9\) Hz, 1H), 7.47–7.13 (m, 13H), 5.95 (s, 1H), 5.78 (s, 1H), 5.08 (s, 1H), 4.78 (t, \(J = 15.6\) Hz, 1H), 4.65 (d, \(J = 15.6\) Hz, 1H), 3.21 (d, \(J = 13.8\) Hz, 1H), 2.60 (d, \(J = 13.8\) Hz, 1H); \(^{13}\text{C}\) NMR (75 MHz, CDCl\(_3\)) \(\delta\) 167.6, 167.4, 145.1, 137.4, 136.1, 134.4, 132.7, 131.1, 130.0, 129.0, 128.6, 127.9, 127.8, 127.7, 126.7, 123.7, 121.8, 118.9, 82.5, 42.5, 36.5. Anal. Calcd for C\(_{25}\)H\(_{22}\)N\(_2\)O\(_3\): C, 75.36; H, 5.57;
N, 7.03. Found: C, 75.26; H, 5.38; N, 6.92.

According to the synthetic procedure of 4a, 4b was synthesized from 6b (39.7 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 4b (35.2 mg, 0.0886 mmol, 89%) as a white solid. $R_f = 0.33$ (silica gel, hexane/EtOAc = 1/1); m.p. 210–211 °C; IR (KBr) 1714 (C=O), 1698 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.76 (dd, $J = 6.3$, 1.2 Hz, 1H), 7.57 (m, 1H), 7.46 (t, $J = 7.8$ Hz, 2H), 7.38–7.26 (m, 5H), 7.18–7.13 (m, 3H), 6.81–6.77 (m, 2H), 6.35 (t, $J = 2.4$ Hz, 1H), 5.40 (t, $J = 2.4$ Hz, 1H), 5.23 (d, $J = 15.6$ Hz, 1H), 4.15 (d, $J = 15.6$ Hz, 1H), 3.23 (dt, $J = 17.7$, 2.4 Hz, 1H), 2.93 (dt, $J = 17.7$, 2.4 Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 167.5, 167.4, 145.0, 137.3, 136.1, 134.4, 132.7, 131.1, 130.0, 129.0, 128.6, 127.9, 127.8, 127.7, 126.6, 123.7, 121.8, 118.9, 82.5, 42.4, 36.4. Anal. Calcd for C$_{25}$H$_{20}$N$_2$O$_2$: C, 78.93; H, 5.30; N, 7.36. Found: C, 78.74; H, 5.16; N, 7.38.

Synthesis and characterization of 4c. According to the synthetic procedure of 6a, 6c was synthesized from 3d (41.5 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1) to give 6c (30.8 mg, 0.0955 mmol, 95%) as a white solid. $R_f = 0.23$ (silica gel, hexane/EtOAc = 1/3); m.p. 176–177 °C; IR (KBr) 3303 (O–H), 1691 (C=O), 1664 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$/CD$_3$OD = 1/1) $\delta$ 7.69 (d, $J = 7.5$ Hz, 1H), 7.61 (m, 1H), 7.51 (m, 1H), 7.41 (m, 1H), 7.35–7.24 (m, 4H), 7.08 (m, 1H), 5.63 (s, 1H), 5.21 (s, 1H), 3.34 (d, $J = 12.6$ Hz, 1H), 3.26 (d, $J = 13.5$ Hz, 1H), 3.05 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$/CD$_3$OD = 1/1) $\delta$ 167.6, 167.4, 145.6, 139.1, 137.1, 131.4, 130.7, 128.9, 127.9, 123.9, 122.5, 122.3, 121.9, 120.5, 89.6, 37.9, 22.9. Anal. Calcd for C$_{19}$H$_{18}$N$_2$O$_3$: C, 70.79; H, 5.63; N, 8.69. Found: C, 70.99; H, 5.78; N, 8.52.

According to the synthetic procedure of 4a, 4c was synthesized from 6c (32.2 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1 to 1/2) to give 4c (29.3 mg, 0.0962 mmol, 96%) as a white solid. $R_f = 0.33$ (silica gel, hexane/EtOAc = 1/3); m.p. 232–233 °C; IR (KBr) 1697 (C=O), 1658 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.72 (d, $J = 7.5$ Hz, 1H), 7.57 (t, $J = 7.5$ Hz, 1H), 7.46 (q, $J = 6.3$ Hz, 2H), 7.20–7.11 (m, 3H), 6.49 (d, $J = 6.3$ Hz, 1H), 5.19 (s, 1H), 3.74 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) $\delta$ 167.6, 167.4, 145.6, 139.1, 137.1, 131.4, 130.7, 128.9, 127.9, 123.9, 122.5, 122.3, 121.9, 120.5, 89.6, 37.9, 22.9. Anal. Calcd for C$_{19}$H$_{18}$N$_2$O$_3$: C, 70.79; H, 5.63; N, 8.69. Found: C, 70.99; H, 5.78; N, 8.52.
6.84–6.81 (m, 2H), 6.40 (t, \( J = 2.7 \) Hz, 1H), 5.68 (t, \( J = 2.1 \) Hz, 1H), 3.40 (dt, \( J = 17.7, 2.7 \) Hz, 1H), 3.19 (dt, \( J = 17.7, 2.1 \) Hz, 1H), 3.03 (s, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta 167.3, 166.6, 144.9, 136.1, 134.5, 132.5, 131.4, 129.9, 129.0, 127.9, 126.4, 123.5, 121.8, 118.8, 81.7, 36.1, 24.1. \)

**Synthesis and characterization of 4d.** According to the synthetic procedure of 6a, 6d was synthesized from 3e (47.1 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to CHCl\(_3\)/MeOH = 10/1) to give 6d (34.8 mg, 0.0919 mmol, 92%) as a white solid. \( R_f = 0.32 \) (silica gel, hexane/EtOAc = 1/1); m.p. 170–171 °C; IR (KBr) 3358 (N=H), 3211 (O=H), 1657 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)/CD\(_3\)OD = 1/1) \( \delta 7.68 \) (d, \( J = 7.2 \) Hz, 1H), 7.59 (t, \( J = 9.9 \) Hz, 1H), 7.49 (t, \( J = 7.5 \) Hz, 1H), 7.41 (dd, \( J = 7.2, 0.9 \) Hz, 1H), 7.37–7.34 (m, 2H), 7.27 (t, \( J = 7.5 \) Hz, 2H), 7.09 (m, 1H), 5.67 (s, 1H), 5.18 (s, 1H), 3.63 (m, 1H), 3.37 (d, \( J = 14.1 \) Hz, 1H), 3.37–3.27 (m, 1H), 3.09 (d, \( J = 14.1 \) Hz, 1H), 1.87–1.69 (m, 2H), 1.40–1.35 (m, 4H), 0.92 (t, \( J = 6.6 \) Hz, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)/CD\(_3\)OD = 1/1) \( \delta 167.6, 167.5, 145.5, 139.1, 137.2, 131.3, 130.9, 128.9, 127.9, 123.8, 122.6, 122.5, 121.8, 120.4, 90.4, 39.0, 38.4, 28.9, 28.1, 21.7, 13.0. \)

According to the synthetic procedure of 4a, 4d was synthesized from 6d (37.8 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1) to give 4d (33.8 mg, 0.0938 mmol, 94%) as a white solid. \( R_f = 0.37 \) (silica gel, hexane/EtOAc = 1/1); m.p. 98–100 °C; IR (KBr) 1713 (C=O), 1697 (C=O) cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)) \( \delta 7.70 \) (d, \( J = 7.8 \) Hz, 1H), 6.93 (t, \( J = 7.2 \) Hz, 1H), 7.44 (dd, \( J = 6.6, 5.1 \) Hz, 2H), 7.18–7.08 (m, 3H), 6.84–6.81 (m, 2H), 6.39 (t, \( J = 2.7 \) Hz, 1H), 5.68 (t, \( J = 2.1 \) Hz, 1H), 3.58 (m, 1H), 3.44 (dt, \( J = 17.4, 2.7 \) Hz, 1H), 3.25 (dt, \( J = 17.4, 2.1 \) Hz, 1H), 3.18 (m, 1H), 1.82 (m, 1H), 1.62 (m, 1H), 1.40–1.26 (m, 4H), 0.90 (t, \( J = 6.9 \) Hz, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta 167.4, 167.0, 144.8, 136.4, 134.7, 132.5, 131.6, 130.0, 128.9, 127.7, 126.2, 123.4, 121.7, 118.5, 82.2, 39.8, 37.5, 29.5, 28.5, 22.2, 13.9. \)

Calcd for C\(_{23}\)H\(_{26}\)N\(_2\)O\(_3\): C, 72.99; H, 6.92; N, 7.40. Found: C, 72.93; H, 6.64; N, 7.23.

Calcd for C\(_{23}\)H\(_{24}\)N\(_2\)O\(_2\): C, 76.64; H, 6.71; N, 7.77. Found: C, 76.35; H, 6.79; N, 7.92.
**Synthesis and characterization of 4e.** According to the synthetic procedure of 6a, 6e was synthesized from 3f (94.8 mg, 0.194 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/1 to CHCl₃/MeOH = 30/1) to give 6e (69.5 mg, 0.174 mmol, 90%) as a white solid. $R_f = 0.27$ (silica gel, hexane/EtOAc = 1/1); m.p. 194–195 °C; IR (KBr) 3325 (N–H), 1691 (C=O), 1661 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃/CD₃OD=1/1) δ 7.81 (m, 1H), 7.71–7.67 (m, 2H), 7.63–7.44 (m, 5H), 7.36 (m, 1H), 7.25–7.20 (m, 2H), 7.08 (d, $J = 8.1$ Hz, 2H), 5.82 (s, 1H), 5.18 (s, 1H), 3.34 (d, $J = 14.1$ Hz, 1H), 2.83 (d, $J = 14.1$ Hz, 1H), 2.30 (s, 3H); $^{13}$C NMR (75 MHz, CDCl₃) δ 167.6, 167.1, 145.4, 138.8, 134.9, 134.6, 133.6, 132.0, 130.0, 129.2, 128.5, 128.4, 126.8, 126.7, 124.1, 123.3, 122.7, 120.3, 91.6, 39.4, 19.9. Anal. Calcd for C$_{25}$H$_{22}$N$_2$O$_3$: C, 75.36; H, 5.57; N, 7.03. Found: C, 75.19; H, 5.51; N, 6.91.

According to the synthetic procedure of 4a, 4e was synthesized from 6e (56.4 mg, 0.142 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/1 to 1/1) to give 4e (53.5 mg, 0.141 mmol, 99%) as a white solid. $R_f = 0.33$ (silica gel, hexane/EtOAc = 1/1); m.p. 206–207 °C; IR (KBr) 1705 (C=O), 1671 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃) δ 7.84 (d, $J = 7.5$ Hz, 1H), 7.59–7.31 (m, 8H), 7.03–6.96 (m, 4H), 6.09 (t, $J = 2.7$ Hz, 1H), 5.32 (t, $J = 2.7$ Hz, 1H), 3.36 (dt, $J = 17.4$, 2.7 Hz, 1H), 3.19 (dt, $J = 17.4$, 2.7 Hz, 1H), 2.21 (s, 3H); $^{13}$C NMR (75 MHz, CDCl₃) δ 167.2, 166.6, 144.8, 137.1, 135.8, 134.7, 133.2, 132.6, 131.1, 129.9, 129.5, 127.7, 126.8, 125.2, 124.0, 121.8, 117.9, 83.0, 37.3, 20.8. Anal. Calcd for C$_{25}$H$_{20}$N$_2$O$_2$: C, 78.93; H, 5.30; N, 7.36. Found: C, 79.26; H, 5.37; N, 7.39.

**Synthesis and characterization of 4f.** According to the synthetic procedure of 6a, 6f was synthesized from 3g (50.7 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to CHCl₃/MeOH = 10/1) to give 6f (37.4 mg, 0.0902 mmol, 90%) as a white solid. $R_f = 0.25$ (silica gel, hexane/EtOAc = 1/1); m.p. 177–178 °C; IR (KBr) 3337 (N–H), 3302 (O–H), 1665 (C=O), 1657 (C=O) cm⁻¹; $^1$H NMR (300 MHz, CDCl₃/CD₃OD=1/1) δ 7.81 (m, 1H), 7.73–7.70 (m, 2H), 7.65–7.45 (m, 5H), 7.36 (m, 1H), 7.25–7.20 (m, 2H), 6.85–6.79 (m, 2H), 5.76 (s, 1H), 5.16 (s, 3H), 3.79 (s, 3H), 3.37 (d, $J = 13.8$ Hz, 1H), 2.88
(d, J = 13.8 Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$/CD$_3$OH = 1/1) δ 167.5, 167.0, 156.0, 145.4, 138.8, 134.9, 131.9, 130.2, 130.0, 129.1, 128.2, 126.7, 126.6, 123.6, 123.2, 122.6, 122.0, 113.1, 91.6, 54.5, 39.1. Anal. Calcd for C$_{25}$H$_{22}$N$_2$O$_4$: C, 72.45; H, 5.35; N, 6.76. Found: C, 72.73; H, 5.42; N, 6.73.

According to the synthetic procedure of 4a, 4f was synthesized from 6f (37.4 mg, 0.0902 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 4f (35.5 mg, 0.0895 mmol, 99%) as a white solid. $R_f$ = 0.32 (silica gel, hexane/EtOAc = 1/1); m.p. 91–92 °C; IR (KBr) 1704 (C=O), 1670 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.83 (d, J = 2.4 Hz, 1H), 7.58 (m, 1H), 7.50–7.31 (m, 7H), 7.05–7.00 (m, 2H), 6.73–6.67 (m, 2H), 6.11 (t, J = 2.7 Hz, 1H), 5.34 (t, J = 2.1 Hz, 1H), 3.69 (s, 3H), 3.37 (dt, J = 17.7, 2.7 Hz, 1H), 3.20 (dt, J = 17.7, 2.1 Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 167.3, 166.6, 158.3, 144.9, 135.9, 134.8, 133.2, 131.1, 129.9, 129.6, 127.8, 127.6, 126.9, 126.6, 124.0, 121.8, 117.9, 114.2, 83.0, 55.2, 36.9. Anal. Calcd for C$_{25}$H$_{20}$N$_2$O$_3$: C, 75.74; H, 5.09; N, 7.07. Found: C, 75.40; H, 4.94; N, 6.98.

Synthesis and characterization of 4g. According to the synthetic procedure of 6a, 6g was synthesized from 3h (120 mg, 0.255 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/2) to give 6g (89.2 mg, 0.236 mmol, 93%) as a white solid. $R_f$ = 0.26 (silica gel, hexane/EtOAc = 1/1); m.p. 170–171 °C; IR (KBr) 3357 (N–H), 3223 (O–H), 1691 (C=O), 1652 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$/CD$_3$OD=1/1) δ 7.80 (m, 1H), 7.69–7.44 (m, 7H), 7.36 (m, 1H), 5.64 (s, 1H), 5.05 (s, 1H), 3.26 (d, J = 13.8 Hz, 1H), 3.06–2.88 (m, 2H), 2.76 (d, J = 13.8 Hz, 1H), 1.41–1.16 (m, 6H), 0.90 (t, J = 6.9 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$/CD$_3$OH = 1/1) δ 169.3, 166.9, 145.6, 138.3, 134.9, 131.7, 129.9, 129.0, 128.2, 126.6, 123.2, 122.5, 91.3, 39.4, 39.0, 28.4, 28.0, 21.6, 12.9. Anal. Calcd for C$_{23}$H$_{26}$N$_2$O$_3$: C, 72.99; H, 6.92; N, 7.40. Found: C, 73.27; H, 7.20; N, 7.00.

According to the synthetic procedure of 4a, 4g was synthesized from 6g (61.1 mg, 0.161 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 4g (52.3 mg, 0.145 mmol, 90%) as a white solid. $R_f$ = 0.38 (silica gel, hexane/EtOAc = 1/1); m.p. 115–116 °C; IR (KBr) 1719 (C=O), 1698 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.96 (m, 1H),
7.70–7.58 (m, 2H), 7.49–7.30 (m, 4H), 7.17–7.13 (m, 2H), 5.94 (t, \( J = 2.7 \) Hz, 1H), 5.20 (t, \( J = 2.4 \) Hz, 1H), 3.44 (m, 1H), 3.23 (dt, \( J = 17.7, 2.7 \) Hz, 1H), 3.04 (dt, \( J = 17.7, 2.4 \) Hz, 1H), 2.76 (m, 1H), 1.49 (m, 1H), 1.25–0.92 (m, 5H), 0.72 (t, \( J = 6.9 \) Hz, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta \) 167.9, 166.7, 145.1, 135.8, 134.2, 132.9, 131.1, 130.3, 129.6, 128.0, 127.3, 124.2, 122.4, 116.4, 82.5, 40.6, 36.0, 29.0, 27.8, 21.8, 13.6. Anal. Calcd for C\(_{23}\)H\(_{24}\)N\(_2\)O\(_2\): C, 76.64; H, 6.71; N, 7.77. Found: C, 76.73; H, 6.42; N, 7.66.

**Synthesis and characterization of 4h.** According to the synthetic procedure of 6a, 6h was synthesized from 3i (50.9 mg, 0.112 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1) to give 6h (36.8 mg, 0.102 mmol, 91%) as a white solid. \( R_f = 0.37 \) (silica gel, hexane/EtOAc = 1/1); m.p. 188–189 °C; IR (KBr) 3386 (O–H), 3303 (N–H), 1685 (C=O), 1679 (C=O), 1655 (C=O) \( \text{cm}^{-1} \); \(^{1}\)H NMR (300 MHz, CDCl\(_3\)/CD\(_3\)OD = 1/1) \( \delta \) 7.75 (dd, \( J = 9.0, 1.5 \) Hz, 2H), 7.51 (dd, \( J = 9.0, 1.5 \) Hz, 2H), 7.39 (dd, \( J = 7.2, 1.8 \) Hz, 1H), 7.36–7.29 (m, 3H), 7.24 (m, 1H), 7.12 (m, 1H), 5.63 (s, 1H), 5.01 (s, 1H), 3.17 (dd, \( J = 14.1, 0.9 \) Hz, 1H), 2.83 (d, \( J = 14.1, 0.9 \) Hz, 1H), 1.99 (d, \( J = 0.9 \) Hz, 3H), 1.73 (d, \( J = 0.9 \) Hz, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)/CD\(_3\)OD = 1/1) \( \delta \) 170.3, 167.4, 152.2, 138.9, 137.4, 135.8, 128.2, 128.1, 127.9, 125.4, 124.7, 123.9, 122.6, 120.2, 92.4, 36.7, 9.7, 7.2. Anal. Calcd for C\(_{23}\)H\(_{24}\)N\(_2\)O\(_2\): C, 76.64; H, 6.71; N, 7.77. Found: C, 76.73; H, 6.42; N, 7.66.

According to the synthetic procedure of 4a, 4h was synthesized from 6h (36.9 mg, 0.102 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/2) to give 4h (34.2 mg, 0.0993 mmol, 97%) as a white solid. \( R_f = 0.27 \) (silica gel, hexane/EtOAc = 1/1); m.p. 151–152 °C; IR (KBr) 1703 (C=O), 1661 (C=O) \( \text{cm}^{-1} \); \(^{1}\)H NMR (300 MHz, CDCl\(_3\)) \( \delta \) 7.40–7.24 (m, 10H), 6.05 (t, \( J = 2.4 \) Hz, 1H), 5.29 (t, \( J = 2.4 \) Hz, 1H), 3.06 (dt, \( J = 17.4, 2.4 \) Hz, 1H), 2.86 (dt, \( J = 17.4, 2.4 \) Hz, 1H), 1.81 (s, 3H), 1.77 (s, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_3\)) \( \delta \) 169.8, 167.3, 148.3, 135.7, 135.5, 135.2, 131.7, 129.5, 129.1, 127.3, 127.1, 125.9, 124.7, 118.2, 84.3, 33.6, 10.0, 8.6. Anal. Calcd for C\(_{22}\)H\(_{20}\)N\(_2\)O\(_2\): C, 76.72; H, 5.85; N, 8.13. Found: C, 76.41; H, 5.52; N, 7.94.

**Synthesis and characterization of 4i.** According to the synthetic procedure of 6a, 6i was
synthesized from 3j (93.3 mg, 0.200 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to CHCl₃/MeOH = 10/1) to give 6i (71.1 mg, 0.189 mmol, 94%) as a white solid. R_f = 0.37 (silica gel, hexane/EtOAc = 1/1); m.p. 158–159 °C; IR (KBr) 3412 (O–H), 3296 (N–H), 1686 (C=O), 1656 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃/CD₃OD = 1/1) δ 7.52 (dd, J = 8.7, 1.2 Hz, 2H), 7.40 (dd, J = 8.7, 1.2 Hz, 2H), 7.35–7.27 (m, 3H), 7.26–7.18 (m, 2H), 7.12 (m, 1H), 5.65 (s, 1H), 5.23 (s, 1H), 4.64 (d, J = 15.3 Hz, 1H), 4.44 (d, J = 15.3 Hz, 1H), 3.11 (dd, J = 14.1, 0.9 Hz, 1H), 2.94 (d, J = 14.1 Hz, 1H), 1.91 (d, J = 1.5 Hz, 3H), 1.66 (d, J = 1.2 Hz, 3H); ¹³C NMR (75 MHz, CDCl₃/CD₃OH = 1/1) δ 171.2, 167.4, 151.7, 139.4, 137.8, 137.4, 128.5, 128.1, 127.6, 127.5, 126.3, 123.9, 121.8, 120.3, 91.4, 42.4, 36.9, 9.4, 7.1. Anal. Calcd for C₂₃H₂₄N₂O₃: C, 73.38; H, 6.43; N, 7.44. Found: C, 73.01; H, 6.27; N, 7.32.

According to the synthetic procedure of 4a, 4i was synthesized from 6i (75.3 mg, 0.200 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 4i (71.3 mg, 0.199 mmol, 99%) as a white solid. R_f = 0.30 (silica gel, hexane/EtOAc = 1/1); m.p. 103–104 °C; IR (KBr) 1692 (C=O), 1664 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.33–7.21 (m, 8H), 6.99 (d, J = 6.9 Hz, 2H), 6.26 (t, J = 2.7 Hz, 1H), 5.33 (t, J = 2.4 Hz, 1H), 5.02 (d, J = 15.6 Hz, 1H), 4.06 (d, J = 15.6 Hz, 1H), 2.89 (dt, J = 17.7, 2.7 Hz, 1H), 2.60 (dt, J = 17.7, 2.4 Hz, 1H), 1.76 (s, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 170.4, 167.4, 147.6, 137.4, 136.0, 134.8, 131.3, 128.9, 128.3, 127.8, 127.5, 127.4, 125.3, 118.5, 83.7, 42.5, 33.0, 9.9, 8.5. Anal. Calcd for C₂₃H₂₂N₂O₂: C, 77.07; H, 6.19; N, 7.82. Found: C, 77.05; H, 6.23; N, 7.54.

Synthesis and characterization of 4j. According to the synthetic procedure of 6a, 6j was synthesized from 3k (78.5 mg, 0.200 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to CHCl₃/MeOH = 10/1) to give 6j (58.0 mg, 0.193 mmol, 96%) as a white solid. R_f = 0.22 (silica gel, hexane/EtOAc = 1/3); m.p. 167–168 °C; IR (KBr) 3370 (O–H), 3294 (N–H), 1686 (C=O), 1675 (C=O), 1656 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃/CD₃OD = 1/1) δ 7.50 (dd, J = 8.7, 1.2 Hz, 2H), 7.31 (t, J = 7.2 Hz, 2H), 7.11 (m, 1H), 5.67 (s, 1H), 5.42 (s, 1H), 3.05 (dd, J = 13.8, 0.9 Hz, 1H), 2.90 (d, J = 13.8 Hz, 1H), 2.88 (s, 3H),
1.93 (d, $J = 0.9$ Hz, 3H), 1.64 (d, $J = 0.9$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$/CD$_3$OH = 1/1) δ 171.0, 167.3, 151.4, 139.8, 137.3, 128.4, 128.0, 123.9, 121.0, 120.4, 90.3, 36.4, 23.0, 9.2, 7.1. Anal. Calcd for C$_{17}$H$_{20}$N$_2$O$_3$: C, 67.98; H, 6.71; N, 9.33. Found: C, 67.64; H, 6.35; N, 9.15.

According to the synthetic procedure of 4a, 4j was synthesized from 6j (60.1 mg, 0.200 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 4j (55.3 mg, 0.196 mmol, 98%) as a white solid. $R_f = 0.23$ (silica gel, hexane/EtOAc = 1/2); m.p. 136–137 °C; IR (KBr) 1691 (C=O), 1666 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.34–7.22 (m, 3H), 7.02 (d, $J = 8.4$ Hz, 2H), 6.30 (t, $J = 2.4$ Hz, 1H), 5.61 (t, $J = 2.1$ Hz, 1H), 3.08 (dt, $J = 17.7$, 2.4 Hz, 1H), 2.88 (s, 3H), 2.85 (dt, $J = 17.7$, 2.1 Hz, 1H), 1.79 (s, 3H), 1.72 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 169.8, 167.2, 147.4, 136.1, 135.0, 131.7, 129.1, 127.6, 125.3, 118.5, 83.1, 32.7, 24.1, 9.9, 8.5. Anal. Calcd for C$_{17}$H$_{18}$N$_2$O$_2$: C, 72.32; H, 6.43; N, 9.92. Found: C, 72.14; H, 6.34; N, 9.71.

**Synthesis and characterization of 4k.** According to the synthetic procedure of 6a, 6k was synthesized from 3l (90.5 mg, 0.202 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 6k (71.8 mg, 0.201 mmol, 99%) as a white solid. $R_f = 0.39$ (silica gel, hexane/EtOAc = 1/1); m.p. 148–149 °C; IR (KBr) 3289 (O–H), 3138 (N–H), 1693 (C=O), 1676 (C=O), 1650 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$/CD$_3$OD = 1/1) δ 7.50 (dd, $J = 8.4$, 0.9 Hz, 2H), 7.31 (t, $J = 7.5$ Hz, 2H), 7.12 (m, 1H), 5.67 (s, 1H), 5.38 (s, 1H), 3.45 (m, 1H), 3.13 (m, 1H), 3.09 (d, $J = 13.8$ Hz, 1H), 2.90 (d, $J = 13.8$ Hz, 1H), 1.90 (d, $J = 1.2$ Hz, 3H), 1.77–1.56 (m, 2H), 1.63 (d, $J = 1.2$ Hz, 3H), 1.40–1.27 (m, 4H), 0.91 (t, $J = 6.9$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$/CD$_3$OH = 1/1) δ 171.0, 167.3, 151.1, 139.7, 137.4, 128.6, 128.1, 123.9, 121.3, 120.3, 91.3, 39.2, 36.4, 28.8, 28.2, 21.7, 13.0, 9.2, 7.1. Anal. Calcd for C$_{21}$H$_{28}$N$_2$O$_3$: C, 67.98; H, 6.71; N, 9.33. Found: C, 67.64; H, 6.35; N, 9.15.

According to the synthetic procedure of 4a, 4k was synthesized from 6k (47.4 mg, 0.133 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1 to 1/2) to give 4k (42.6 mg, 0.126 mmol, 95%) as a white solid. $R_f = 0.30$ (silica gel, hexane/EtOAc = 1/1);
IR (KBr) 1697 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.33–7.21 (m, 3H), 7.05 (d, J = 7.5 Hz, 2H), 6.32 (t, J = 2.4 Hz, 1H), 5.61 (t, J = 2.1 Hz, 1H), 3.36 (m, 1H), 3.12 (m, 1H), 3.10 (dt, J = 17.7, 2.4 Hz, 1H), 2.89 (dt, J = 17.7, 2.1 Hz, 1H), 1.73 (s, 6H), 1.71–1.52 (m, 2H), 1.31–1.24 (m, 4H), 0.86 (t, J = 6.9 Hz, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 170.3, 167.3, 147.1, 136.4, 135.2, 131.7, 128.9, 127.3, 125.0, 118.3, 83.5, 39.8, 34.0, 29.3, 28.4, 22.1, 13.8, 9.9, 8.4. Anal. Calcd for C₂₁H₂₆N₂O₂: C, 74.53; H, 7.74; N, 8.28. Found: C, 74.13; H, 7.73; N, 8.46.

**Synthesis and characterization of 4l.** According to the synthetic procedure of 6a, 6l was synthesized from 3m (65.7 mg, 0.140 mmol). The crude product was purified by column chromatography (silica gel, CHCl₃/MeOH = 40/1) to give 6l (47.7 mg, 0.127 mmol, 91%) as a white solid. Rᵣ = 0.42 (silica gel, hexane/EtOAc = 1/1); m.p. 200–201 °C; IR (KBr) 3327 (N–H), 3267 (O–H), 1687 (C=O), 1655 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃/CD₃OD = 1/1) δ 7.76–7.72 (m, 2H), 7.42–7.36 (m, 4H), 7.24 (m, 1H), 7.15–7.11 (m, 2H), 5.61 (s, 1H), 5.00 (s, 1H), 3.16 (d, J = 14.1 Hz, 1H), 2.81 (d, J = 14.1 Hz, 1H), 2.32 (s, 3H), 1.98 (d, J = 1.2 Hz, 3H), 1.73 (d, J = 1.2 Hz, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 170.3, 167.3, 152.3, 139.0, 135.8, 134.8, 133.6, 128.6, 128.2, 127.9, 125.4, 124.7, 122.5, 120.3, 92.4, 36.9, 19.8, 9.7, 7.3. Anal. Calcd for C₂₃H₂₆N₂O₂: C, 73.43; H, 6.43; N, 7.44. Found: C, 73.44; H, 6.38; N, 7.63.

According to the synthetic procedure of 4a, 4l was synthesized from 6l (44.5 mg, 0.118 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 4l (39.7 mg, 0.111 mmol, 94%) as a white solid. Rᵣ = 0.30 (silica gel, hexane/EtOAc = 1/1); m.p. 141–142 °C; IR (KBr) 1699 (C=O), 1657 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.39–7.11 (m, 9H), 6.04 (t, J = 2.4 Hz, 1H), 5.28 (t, J = 2.4 Hz, 1H), 3.04 (dt, J = 17.7, 3.0 Hz, 1H), 2.85 (dt, J = 17.7, 2.4 Hz, 1H), 2.33 (s, 3H), 1.80 (d, J = 1.2 Hz, 3H), 1.77 (d, J = 1.2 Hz, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 169.8, 167.2, 148.3, 137.1, 135.8, 135.2, 132.7, 131.5, 129.6, 129.4, 126.9, 125.8, 124.5, 117.9, 84.2, 33.4, 20.9, 10.0, 8.5. Anal. Calcd for C₂₃H₂₂N₂O₂: C, 78.93; H, 5.30; N, 7.36. Found: C, 78.57; H, 5.56; N, 7.72.

**Synthesis and characterization of 4m.** According to the synthetic procedure of 6a, 6m was
synthesized from 3n (48.9 mg, 0.101 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to CHCl₃/MeOH = 10/1) to give 6m (36.1 mg, 0.0920 mmol, 92%) as a white solid. Rᵢ = 0.30 (silica gel, hexane/EtOAc = 1/1); m.p. 196–197 °C; IR (KBr) 3386 (N–H), 3264 (O–H), 1672 (C=O), 1656 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃/CD₃OD=1/1) δ 7.74 (d, J = 7.8 Hz, 2H), 7.42–7.35 (m, 4H), 7.23 (t, J = 7.2 Hz, 1H), 6.87 (d, J = 8.7 Hz, 2H), 5.60 (s, 1H), 4.98 (s, 1H), 3.79 (s, 3H), 3.15 (d, J = 14.1 Hz, 1H), 2.81 (d, J = 13.2 Hz, 1H), 1.98 (s, 3H), 1.73 (s, 3H); ¹³C NMR (75 MHz, CDCl₃/CD₃OH = 1/1) δ 170.3, 167.3, 156.0, 152.3, 138.9, 135.9, 130.5, 128.1, 127.9, 125.4, 124.7, 122.4, 113.3, 92.4, 54.6, 36.9, 9.7, 7.3. Anal. Calcd for C₂₃H₂₄N₂O₄: C, 70.39; H, 6.16; N, 7.14. Found: C, 70.30; H, 5.76; N, 7.06.

According to the synthetic procedure of 4a, 4m was synthesized from 6m (36.1 mg, 0.0920 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 4m (34.1 mg, 0.0911 mmol, 99%) as a white solid. Rᵢ = 0.30 (silica gel, hexane/EtOAc = 1/1); m.p. 159–160 °C; IR (KBr) 1700 (C=O), 1665 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.40–7.21 (m, 7H), 6.89–6.84 (m, 2H), 6.06 (t, J = 2.7 Hz, 1H), 5.29 (t, J = 2.1 Hz, 1H), 3.79 (s, 3H), 3.04 (dt, J = 17.7, 2.7 Hz, 1H), 2.86 (d, J = 17.7, 2.1 Hz, 1H), 1.79 (s, 3H), 1.78 (s, 3H); ¹³C NMR (75 MHz, CDCl₃) δ 169.7, 167.2, 158.3, 148.3, 135.7, 135.2, 131.4, 129.3, 127.9, 126.8, 126.1, 125.4, 117.8, 114.2, 84.2, 55.2, 33.0, 9.9, 8.4. Anal. Calcd for C₂₃H₂₂N₂O₃: C, 75.74; H, 5.09; N, 7.07. Found: C, 76.04; H, 5.27; N, 7.37.

Synthesis and characterization of 4n. According to the synthetic procedure of 6a, 6n was synthesized from 3o (50.5 mg, 0.113 mmol). The crude product was purified by column chromatography (silica gel, CHCl₃/MeOH = 50/1 to 30/1) to give 6n (39.4 mg, 0.111 mmol, 98%) as a white solid. Rᵢ = 0.23 (silica gel, hexane/EtOAc = 1/1); m.p. 162–163 °C; IR (KBr) 3357 (N–H), 3281 (O–H), 1682 (C=O), 1652 (C=O) cm⁻¹; ¹H NMR (300 MHz, CDCl₃/CD₃OD = 1/1) δ 7.71–7.67 (m, 2H), 7.41–7.35 (m, 2H), 7.24 (m, 1H), 5.46 (s, 1H), 4.90 (s, 1H), 3.15–3.04 (m, 3H), 2.75 (d, J = 14.1 Hz, 1H), 1.98 (d, J = 1.2 Hz, 3H), 1.81 (d, J = 1.2 Hz, 3H), 1.54–1.44 (m, 2H), 1.40–1.24 (m, 4H), 0.92 (t, J = 6.9 Hz, 3H); ¹³C NMR (75 MHz, CDCl₃/CD₃OH = 1/1) δ 170.2,
169.1, 152.3, 138.6, 127.8, 127.6, 125.3, 124.6, 121.9, 92.3, 39.1, 36.8, 28.43, 28.38, 21.6, 12.9, 9.6, 7.2. Anal. Calcd for C_{23}H_{28}N_{2}O_{3}: C, 70.76; H, 7.92; N, 7.86. Found: C, 70.45; H, 7.73; N, 7.95.

According to the synthetic procedure of 4a, 4n was synthesized from 6n (53.7 mg, 0.151 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 4n (43.9 mg, 0.130 mmol, 86%) as a white solid. R_{f} = 0.30 (silica gel, hexane/EtOAc = 1/1); m.p. 80–81 °C; IR (KBr) 1701 (C=O) cm\(^{-1}\); \(^{1}\)H NMR (300 MHz, CDCl\(_{3}\)) \(\delta\) 7.38–7.13 (m, 5H), 6.00 (t, \(J = 2.7\) Hz, 1H), 5.24 (t, \(J = 2.1\) Hz, 1H), 3.32 (m, 1H), 2.86 (dt, \(J = 18.0, 2.7\) Hz, 1H), 2.96 (m, 1H), 2.77 (dt, \(J = 18.0, 2.7\) Hz, 1H), 1.95 (d, \(J = 1.2\) Hz, 3H), 1.87 (d, \(J = 0.9\) Hz, 3H), 1.67 (m, 1H), 1.44–1.20 (m, 5H), 0.87 (t, \(J = 7.2\) Hz, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_{3}\)) \(\delta\) 170.1, 167.9, 149.1, 136.0, 135.2, 130.6, 129.3, 126.7, 125.2, 116.5, 83.6, 40.2, 32.0, 29.3, 27.4, 22.0, 13.7, 10.2, 8.7. Anal. Calcd for C_{21}H_{26}N_{2}O_{3}: C, 76.64; H, 6.71; N, 7.77. Found: C, 76.78; H, 6.64; N, 7.99.

Synthesis and characterization of 4o. According to the synthetic procedure of 6a, 6o was synthesized from 3p (364 mg, 0.849 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1 to 1/2) to give 6o (256 mg, 0.761 mmol, 90%) as a white solid. R_{f} = 0.23 (silica gel, hexane/EtOAc = 1/3); m.p. 168–169 °C; IR (KBr) 3361 (N–H), 3230 (O–H), 1663 (C=O), 1649 (C=O) cm\(^{-1}\); \(^{1}\)H NMR (300 MHz, CDCl\(_{3}/CD_{3}OD = 1/1\)) \(\delta\) 7.69 (m, 1H), 7.60 (m, 1H), 7.51 (m, 1H), 7.41 (m, 1H), 7.22–7.18 (m, 2H), 7.07 (d, \(J = 8.1\) Hz, 2H), 5.62 (s, 1H), 5.19 (s, 1H), 3.33 (d, \(J = 13.2\) Hz, 1H), 3.10 (d, \(J = 13.5\) Hz, 1H), 3.34 (s, 3H), 2.30 (s, 3H); \(^{13}\)C NMR (75 MHz, CDCl\(_{3}/CD_{3}OH = 1/1\)) \(\delta\) 167.6, 167.3, 145.6, 139.1, 134.5, 133.6, 131.4, 130.7, 128.9, 128.4, 122.5, 122.3, 121.9, 120.6, 89.6, 38.1, 22.9, 19.9. Anal. Calcd for C_{20}H_{20}N_{2}O_{3}: C, 71.41; H, 5.99; N, 8.33. Found: C, 71.19; H, 5.90; N, 7.98.

According to the synthetic procedure of 4a, 4o was synthesized from 6o (256 mg, 0.761 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 1/1 to 1/3) to give 4o (220 mg, 0.691 mmol, 91%) as a white solid. R_{f} = 0.30 (silica gel, hexane/EtOAc = 1/3); m.p. 191–192 °C; IR (KBr) 1702 (C=O), 1662 (C=O) cm\(^{-1}\); \(^{1}\)H NMR (300 MHz, CDCl\(_{3}\)) \(\delta\) 7.71 (d,
$J = 7.5$ Hz, 1H), 7.60–7.43 (m, 3H), 6.95 (d, $J = 8.4$ Hz, 2H), 6.71–6.66 (m, 2H), 6.38 (t, $J = 2.7$ Hz, 1H), 5.66 (t, $J = 2.4$ Hz, 1H), 3.39 (dt, $J = 17.7, 2.7$ Hz, 1H), 3.17 (dt, $J = 17.7, 2.4$ Hz, 1H), 3.02 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 167.3, 166.5, 145.0, 137.7, 136.1, 132.4, 131.7, 131.4, 129.8, 129.6, 126.2, 123.4, 121.7, 118.4, 81.7, 35.8, 24.0, 20.8. Anal. Calcd for C$_{20}$H$_{18}$N$_2$O$_2$: C, 74.45; H, 5.70; N, 8.80. Found: C, 75.20; H, 5.87; N, 8.72.

**General procedure for the synthesis of 5a–n.** All the experiments for the synthesis of 5a–n were carried out as described in the following typical procedure. The reaction of 3b for the synthesis of 5a was exemplified as follows.

**Synthesis and characterization of 5a.** To a stirred solution of 3b (95.3 mg, 0.200 mmol) in acetonitrile (2.0 mL) were added N,N-dimethyl-4-aminopyridine (29.3 mg, 0.240 mmol) and di-tert-butyl dicarbonate (Boc$_2$O, 87.3 mg, 0.400 mmol) at room temperature. After stirring the solution at the same temperature for 2 hours, the reaction was quenched with sat. NH$_4$Cl aq (2.0 mL). The resulting mixture was extracted with ethyl acetate ($2 \times 20$ mL). The combined organic extracts were washed with brine (10 mL), dried over Na$_2$SO$_4$, filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 7a (106 mg, 0.184 mmol, 92%) as a white solid. $R_f = 0.35$ (silica gel, hexane/EtOAc = 2/1); m.p. 165–166 °C; IR (KBr) 1752 (C=O), 1712 (C=O), 1684 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 8.18 (d, $J = 7.5$ Hz, 2H), 7.63 (d, $J = 7.5$ Hz, 1H), 7.54–7.42 (m, 4H), 7.32–7.24 (m, 5H), 7.14 (m, 1H), 7.01–6.96 (m, 4H), 6.63 (m, 2H), 5.31 (s, 1H), 4.68 (s, 1H), 3.89 (d, $J = 15.0$ Hz, 1H), 3.40 (d, $J = 15.0$ Hz, 1H), 1.24 (s, 9H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 171.5, 167.5, 151.9, 144.6, 138.7, 138.3, 137.0, 136.1, 131.8, 131.5, 129.4, 129.1, 128.8, 128.7 128.4, 128.1, 127.5, 126.3, 125.7, 124.0, 123.9, 122.6, 83.0, 78.8, 37.6, 27.6. Anal. Calcd for C$_{35}$H$_{32}$N$_2$O$_4$: C, 72.89; H, 5.59; N, 4.86. Found: C, 72.62; H, 5.67; N, 4.77.

To a stirred solution of 7a (84.3 mg, 0.146 mmol) in tetrahydrofuran/water (9/1, 1.0 mL) was added copper (I) bromide (62.8 mg, 0.438 mmol) at room temperature. After stirring the suspension at the same temperature for 12 hours, the reaction mixture was diluted with water (1.0 mL). The resulting
solution was extracted with ethyl acetate (2 × 10 mL). The combined organic extracts were washed with brine (10 mL), dried over Na₂SO₄, filtered, and concentrated in vacuo to provide a crude material. This material was purified by column chromatography (silica gel, hexane/EtOAc = 1/1) to give 5a (40.9 mg, 0.140 mmol, 96%) as a white solid. \( R_f = 0.35 \) (silica gel, hexane/EtOAc = 1/1); m.p. 125–126 °C; IR (KBr) 1771 (C=O), 1710 (C=O) cm⁻¹; \(^1\)H NMR (300 MHz, CDCl₃) δ 7.93 (m, 1H), 7.71–7.59 (m, 2H), 7.53–7.34 (m, 6H), 6.21 (t, \( J = 2.7 \) Hz, 1H), 5.58 (t, \( J = 2.7 \) Hz, 1H), 3.39 (dt, \( J = 18.0, 2.7 \) Hz, 1H), 3.22 (dt, \( J = 18.0, 2.7 \) Hz, 1H); \(^1\)C NMR (75 MHz, CDCl₃) δ 167.7, 166.4, 143.7, 133.4, 132.8, 130.7, 130.0, 129.7, 128.7, 128.0, 124.0, 123.1, 121.6, 95.1, 35.8.

Synthesis and characterization of 5b. According to the synthetic procedure of 7a, 7b was synthesized from 3c (390 mg, 0.795 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 7b (466 mg, 0.789 mmol, 99%) as a white solid. \( R_f = 0.35 \) (silica gel, hexane/EtOAc = 2/1); m.p. 161–162 °C; IR (KBr) 1748 (C=O), 1708 (C=O), 1689 (C=O) cm⁻¹; \(^1\)H NMR (300 MHz, CDCl₃) δ 7.68 (d, \( J = 8.4 \) Hz, 1H), 7.56–7.53 (m, 2H), 7.46 (t, \( J = 6.6 \) Hz, 2H), 7.31–7.22 (m, 7H), 7.13 (t, \( J = 7.5 \) Hz, 1H), 6.97 (t, \( J = 7.5 \) Hz, 2H), 6.79 (t, \( J = 8.4 \) Hz, 4H), 5.23 (d, \( J = 15.0 \) Hz, 1H), 5.22 (s, 1H), 4.79 (d, \( J = 15.0 \) Hz, 1H), 4.32 (s, 1H), 3.60 (d, \( J = 15.0 \) Hz, 1H), 2.96 (d, \( J = 15.0 \) Hz, 1H), 1.27 (s, 9H); \(^1\)C NMR (75 MHz, CDCl₃) δ 172.0, 168.4, 152.0, 144.5, 138.8, 138.5, 138.4, 136.0, 131.8, 131.1, 129.4, 129.2, 128.8, 128.6, 128.3, 127.6, 127.3, 125.0, 124.9, 122.5, 82.9, 80.0, 43.8, 38.9, 27.6. Anal. Calcd for C₁₈H₁₃NO₃: C, 74.22; H, 4.50; N, 4.81. Found: C, 74.28; H, 4.63; N, 4.69.

According to the synthetic procedure of 5a, 5b was synthesized from 7b (150 mg, 0.254 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 5b (74.7 mg, 0.245 mmol, 96%) as a white solid. \( R_f = 0.40 \) (silica gel, hexane/EtOAc = 1/1); m.p. 170–172 °C; IR (KBr) 1789 (C=O), 1716 (C=O) cm⁻¹; \(^1\)H NMR (300 MHz, CDCl₃) δ 7.89 (m, 1H), 7.66–7.56 (m, 2H), 7.44 (m, 1H), 7.33–7.25 (m, 5H), 6.42 (t, \( J = 3.0 \) Hz, 1H), 5.67 (t, \( J = 3.0 \) Hz, 1H), 5.03 (d, \( J = 15.9 \) Hz, 1H), 4.31 (d, \( J = 15.9 \) Hz, 1H), 3.27 (dt, \( J = 18.0, 2.7 \) Hz, 1H), 3.05 (dt, \( J
= 18.0, 2.7 Hz, 1H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 167.8, 167.4, 144.1, 137.0, 133.2, 133.1, 130.7, 130.2, 128.7, 127.7, 127.5, 123.9, 121.4, 94.8, 42.2, 35.7. Anal. Calcd for C$_{19}$H$_{15}$NO$_3$: C, 74.74; H, 4.95; N, 4.59. Found: C, 74.38; H, 4.72; N, 4.49.

**Synthesis and characterization of 5c.** According to the synthetic procedure of 7a, 7e was synthesized from 3d (41.5 mg, 0.100 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/1) to give 7c (51.0 mg, 0.0991 mmol, 99%) as a white solid. $R_f$ = 0.40 (silica gel, hexane/EtOAc = 1/1); m.p. 127–128 °C; IR (KBr) 1717 (C=O), 1696 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.67 (d, $J = 6.9$ Hz, 1H), 7.49 (t, $J = 7.5$ Hz, 1H), 7.39 (d, $J = 7.5$ Hz, 1H), 7.33–7.23 (m, 4H), 7.12 (t, $J = 7.5$ Hz, 1H), 6.98 (t, $J = 8.1$ Hz, 2H), 6.84 (m, 4H), 5.45 (s, 1H), 5.02 (s, 1H), 3.60 (d, $J = 15.3$ Hz, 1H), 3.32 (d, $J = 15.3$ Hz, 1H), 3.22 (s, 3H), 1.33 (s, 9H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 171.7, 167.5, 152.4, 144.8, 139.1, 138.4, 136.1, 131.9, 131.2, 129.4, 128.9, 128.4, 128.3, 127.6, 127.4, 123.4, 123.3, 122.5, 83.2, 78.2, 36.6, 27.7, 24.9. Anal. Calcd for C$_{30}$H$_{30}$N$_2$O$_4$: C, 70.02; H, 5.88; N, 5.44. Found: C, 70.24; H, 5.84; N, 5.36.

According to the synthetic procedure of 5a, 5c was synthesized from 7e (145 mg, 0.251 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/1 to 2/1) to give 5c (57.4 mg, 0.250 mmol, 99%) as a white solid. $R_f$ = 0.40 (silica gel, hexane/EtOAc = 1/2); m.p. 163–164 °C; IR (KBr) 1771 (C=O), 1709 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.82 (m, 1H), 7.65–7.54 (m, 2H), 7.47 (m, 1H), 6.50 (t, $J = 3.0$ Hz, 1H), 5.90 (t, $J = 3.0$ Hz, 1H), 3.44 (dt, $J = 18.0$, 3.0 Hz, 1H), 3.01 (d, $J = 18.0$, 3.0 Hz, 1H), 2.99 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 167.8, 166.6, 143.6, 133.1, 132.9, 130.6, 130.5, 123.9, 123.5, 121.4, 94.4, 35.0, 23.5. Anal. Calcd for C$_{13}$H$_{11}$NO$_3$: C, 68.11; H, 4.84; N, 6.11. Found: C, 68.03; H, 4.85; N, 6.03.

**Synthesis and characterization of 5d.** According to the synthetic procedure of 7a, 7d was synthesized from 3e (55.4 mg, 0.118 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 7d (65.0 mg, 0.114 mmol, 97%) as a colorless oil. $R_f$ = 0.32 (silica gel, hexane/EtOAc = 2/1); IR (KBr) 1724 (C=O), 1702 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.62 (d, $J = 7.5$ Hz, 1H), 7.45 (t, $J = 7.5$ Hz, 2H), 7.37–7.23 (m, 4H),
7.13 (t, J = 7.5 Hz, 1H), 6.98 (t, J = 7.5 Hz, 4H), 6.85 (dd, J = 8.1, 1.2 Hz, 2H), 5.55 (s, 1H), 4.99 (s, 1H), 3.76–3.63 (m, 2H), 3.63 (d, J = 15.9 Hz, 1H), 3.23 (d, J = 15.9 Hz, 1H), 1.92 (m, 1H), 1.69 (m, 1H), 1.45–1.39 (m, 4H), 1.36 (s, 9H), 0.92 (t, J = 6.9 Hz, 3H); 13C NMR (75 MHz, CDCl3) δ 172.3, 167.8, 152.6, 144.9, 140.2, 138.4, 136.0, 131.6, 131.3, 129.3, 128.9, 128.6, 128.3, 127.7, 127.6, 123.7, 122.9, 122.4, 83.3, 78.7, 40.8, 37.8, 29.8, 28.3, 27.7, 22.4, 14.0. Anal. Calcd for C34H38N2O4S: C, 71.55; H, 6.71; N, 4.91. Found: C, 71.84; H, 6.62; N, 4.76.

According to the synthetic procedure of 5a, 5d was synthesized from 7d (115 mg, 0.201 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 5d (52.0 mg, 0.182 mmol, 91%) as a colorless oil. Rf = 0.39 (silica gel, hexane/EtOAc = 1/1); IR (KBr) 1783 (C=O), 1706 (C=O) cm⁻¹; 1H NMR (300 MHz, CDCl3) δ 7.82 (m, 1H), 7.64–7.53 (m, 2H), 7.44 (m, 1H), 6.50 (t, J = 2.7 Hz, 1H), 5.88 (t, J = 2.7 Hz, 1H), 3.55 (m, 1H), 3.45 (dt, J = 18.3, 2.7 Hz, 1H), 3.25 (m, 1H), 3.29 (dt, J = 18.3, 2.7 Hz, 1H), 1.76–1.63 (m, 2H), 1.37–1.30 (m, 4H), 0.90 (t, J = 6.9 Hz, 3H); 13C NMR (75 MHz, CDCl3) δ 167.9, 167.0, 143.9, 133,3, 132.9, 130.60, 130.55, 123.7, 123.5, 121.3, 95.0, 39.3, 36.0, 29.2, 28.7, 22.2, 13.9. Anal. Calcd for C17H19NO3: C, 71.56; H, 6.71; N, 4.91. Found: C, 71.19; H, 6.73; N, 4.83.

Synthesis and characterization of 5e. According to the synthetic procedure of 7a, 7e was synthesized from 3f (95.3 mg, 0.210 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/1) to give 7e (111 mg, 0.200 mmol, 95%) as a colorless oil. Rf = 0.32 (silica gel, hexane/EtOAc = 2/1); m.p. 149–150 °C; IR (KBr) 1727 (C=O), 1702 (C=O) cm⁻¹; 1H NMR (300 MHz, CDCl3) δ 8.10 (dd, J = 9.0, 1.5 Hz, 2H), 7.43–7.19 (m, 11H), 6.96 (dd, J = 9.0, 1.5 Hz, 2H), 5.43 (s, 1H), 4.83 (s, 1H), 3.31 (d, J = 16.5 Hz, 1H), 3.25 (d, J = 16.5 Hz, 1H), 2.01 (d, J = 1.2 Hz, 3H), 1.45 (d, J = 1.2 Hz, 3H), 1.29 (s, 9H); 13C NMR (75 MHz, CDCl3) δ 171.5, 170.5, 152.4, 148.5, 139.0, 138.4, 137.2, 135.6, 130.2, 129.6, 129.5, 128.9, 128.5, 127.6, 127.4, 125.3, 124.1, 123.1, 83.2, 81.3, 33.6, 27.5, 11.2, 8.0. Anal. Calcd for C33H34N2O4S: C, 71.45; H, 6.18; N, 5.05. Found: C, 71.18; H, 6.11; N, 4.91.

According to the synthetic procedure of 5a, 5e was synthesized from 7e (194 mg, 0.350 mmol). The
crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1) to give 5e (92.4 mg, 0.343 mmol, 98%) as a white solid. $R_f = 0.26$ (silica gel, hexane/EtOAc = 1/1); m.p. 138–139 °C; IR (KBr) 1766 (C=O), 1716 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.43–7.25 (m, 5H), 6.17 (t, $J = 2.7$ Hz, 1H), 5.54 (t, $J = 2.7$ Hz, 1H), 3.06 (dt, $J = 18.0$, 2.7 Hz, 1H), 2.94 (dt, $J = 18.0$, 2.7 Hz, 1H), 1.93 (s, 3H), 1.92 (s, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 169.7, 168.0, 147.4, 133.9, 133.0, 130.2, 129.6, 128.0, 123.1, 96.7, 32.8, 9.5, 8.5. Anal. Calcd for C$_{16}$H$_{15}$NO$_3$: C, 71.36; H, 5.61; N, 5.20. Found: C, 71.21; H, 5.66; N, 5.09.

**Synthesis and characterization of 5f.** According to the synthetic procedure of 7a, 7f was synthesized from 3g (94.6 mg, 0.203 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1) to give 7f (113 mg, 0.192 mmol, 95%) as a colorless oil. $R_f = 0.30$ (silica gel, hexane/EtOAc = 2/1); IR (KBr) 1749 (C=O), 1737 (C=O), 1692 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.49 (d, $J = 6.9$ Hz, 2H), 7.36–7.16 (m, 9H), 7.06 (d, $J = 8.1$ Hz, 1H), 6.96 (d, $J = 8.1$ Hz, 2H), 5.22 (s, 1H), 4.95 (d, $J = 15.0$ Hz, 1H), 4.64 (d, $J = 15.0$ Hz, 1H), 4.56 (s, 1H), 3.09 (d, $J = 16.8$ Hz, 1H), 3.01 (d, $J = 16.8$ Hz, 1H), 1.94 (s, 3H), 1.48 (s, 3H), 1.33 (s, 9H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 171.9, 171.7, 152.5, 148.5, 138.6, 138.5, 137.9, 135.5, 129.9, 129.5, 129.4, 128.8, 128.3, 128.1, 127.4, 127.3, 127.0, 122.5, 82.9, 82.0, 44.3, 33.8, 27.5, 11.1, 8.0. Anal. Calcd for C$_{34}$H$_{36}$N$_2$O$_4$S: C, 71.80; H, 6.38; N, 4.93. Found: C, 71.45; H, 6.29; N, 4.80.

According to the synthetic procedure of 5a, 5f was synthesized from 7f (128 mg, 0.225 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 5/1 to 2/1) to give 5f (61.0 mg, 0.215 mmol, 96%) as a white solid. $R_f = 0.32$ (silica gel, hexane/EtOAc = 1/1); IR (KBr) 1773 (C=O), 1709 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.31–7.21 (m, 5H), 6.31 (t, $J = 2.7$ Hz, 1H), 5.60 (t, $J = 2.7$ Hz, 1H), 4.76 (d, $J = 16.2$ Hz, 1H), 4.25 (d, $J = 16.2$ Hz, 1H), 2.94 (dt, $J = 18.6$, 2.7 Hz, 1H), 2.78 (dt, $J = 18.6$, 2.7 Hz, 1H), 1.88 (d, $J = 0.9$ Hz, 3H), 1.84 (d, $J = 0.9$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 170.7, 168.0, 147.2, 137.3, 133.1, 130.3, 128.6, 127.6, 123.7, 123.6, 96.2, 42.3, 32.6, 9.3, 8.6. Anal. Calcd for C$_{17}$H$_{17}$NO$_3$: C, 72.07; H, 6.05; N, 4.94. Found: C,
Synthesis and characterization of 5g. According to the synthetic procedure of 7a, 7g was synthesized from 3h (78.5 mg, 0.200 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 3/1 to 2/1) to give 7g (94.5 mg, 0.192 mmol, 96%) as a colorless oil. $R_f = 0.40$ (silica gel, hexane/EtOAc = 1/1); m.p. 105–106 °C; IR (KBr) 1731 (O–H), 1691 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.37 (t, $J = 6.9$ Hz, 2H), 7.29 (t, $J = 6.9$ Hz, 2H), 7.22 (t, $J = 8.1$ Hz, 2H), 7.09 (m, 4H), 5.53 (s, 1H), 5.17 (s, 1H), 3.15 (d, $J = 16.2$ Hz, 1H), 3.08 (s, 3H), 3.04 (d, $J = 16.2$ Hz, 1H), 1.97 (s, 3H), 1.41 (s, 3H), 1.37 (s, 9H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 171.8, 170.9, 152.6, 147.7, 139.6, 138.5, 135.6, 130.6, 129.5, 129.2, 129.0, 128.5, 127.7, 127.6, 121.3, 83.3, 80.7, 33.7, 27.7, 25.1, 11.0, 8.1. Anal. Calcd for C$_{28}$H$_{32}$N$_2$O$_4$S: C, 68.27; H, 6.55; N, 5.69. Found: C, 67.92; H, 6.27; N, 5.46.

According to the synthetic procedure of 5a, 5g was synthesized from 7g (81.7 mg, 0.166 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 2/1 to 1/2) to give 5g (34.1 mg, 0.165 mmol, 99%) as a white solid. $R_f = 0.35$ (silica gel, hexane/EtOAc = 1/2); IR (KBr) 1772 (C=O), 1706 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 6.41 (t, $J = 2.7$ Hz, 1H), 5.83 (t, $J = 2.7$ Hz, 1H), 3.11 (dt, $J = 18.0$, 2.7 Hz, 1H), 2.99 (dt, $J = 18.0$, 2.7 Hz, 1H), 2.84 (s, 3H), 1.88 (d, $J = 0.9$ Hz, 3H), 1.84 (d, $J = 0.9$ Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 169.9, 168.0, 146.5, 133.1, 130.5, 123.7, 95.8, 31.9, 23.4, 9.1, 8.4. Anal. Calcd for C$_{11}$H$_{13}$NO$_3$: C, 63.76; H, 6.32; N, 6.76. Found: C, 63.37; H, 6.06; N, 6.95.

Synthesis and characterization of 5h. According to the synthetic procedure of 7a, 7h was synthesized from 3i (88.8 mg, 0.198 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 7h (108 mg, 0.197 mmol, 99%) as a white solid. $R_f = 0.32$ (silica gel, hexane/EtOAc = 2/1); IR (KBr) 1739 (C=O), 1690 (C=O), 1684 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 7.39 (t, $J = 7.2$ Hz, 2H), 7.31 (t, $J = 7.2$ Hz, 2H), 7.23 (t, $J = 7.2$ Hz, 2H), 7.15–7.06 (m, 4H), 5.49 (s, 1H), 3.58–3.45 (m, 2H), 3.18 (d, $J = 17.4$ Hz, 1H), 3.05 (d, $J = 17.4$ Hz, 1H), 1.94 (d, $J = 0.9$ Hz, 3H), 1.74 (m, 1H), 1.60 (m, 1H), 1.43 (d, $J = 0.9$ Hz, 3H), 1.37 (d, $J = 0.9$ Hz, 3H).
1.38 (s, 9H), 1.36–1.31 (m, 4H), 0.89 (t, J = 7.2 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 172.5, 171.2, 152.8, 148.1, 140.5, 138.3, 135.8, 129.7, 129.5, 129.2, 128.9, 128.3, 127.6, 127.4, 119.0, 83.2, 81.2, 40.8, 32.9, 29.6, 28.1, 27.5, 22.2, 13.9, 10.7, 7.8. Anal. Calcd for C$_{32}$H$_{40}$N$_2$O$_4$S: C, 70.04; H, 7.35; N, 5.11. Found: C, 70.14; H, 7.07; N, 4.94.

According to the synthetic procedure of 5a, 5h was synthesized from 7h (100 mg, 0.182 mmol). The crude product was purified by column chromatography (silica gel, hexane/EtOAc = 4/1 to 2/1) to give 5h (44.2 mg, 0.176 mmol, 97%) as a white solid. $R_f$ = 0.30 (silica gel, hexane/EtOAc = 2/1); IR (KBr) 1693 (C=O) cm$^{-1}$; $^1$H NMR (300 MHz, CDCl$_3$) δ 6.41 (t, J = 2.7 Hz, 1H), 5.82 (t, J = 2.7 Hz, 1H), 3.44 (m, 1H), 3.12 (dt, J = 18.3, 2.7 Hz, 1H), 3.06 (m, 1H), 3.01 (dt, J = 18.3, 2.7 Hz, 1H), 1.86 (d, J = 1.2 Hz, 3H), 1.83 (d, J = 1.2 Hz, 3H), 1.62–1.53 (m, 2H), 1.34–1.22 (m, 4H), 0.88 (t, J = 6.9 Hz, 3H); $^{13}$C NMR (75 MHz, CDCl$_3$) δ 170.3, 168.0, 146.5, 133.3, 130.3, 123.4, 96.3, 39.1, 32.6, 29.0, 28.6, 22.1, 13.8, 9.1, 8.3. Anal. Calcd for C$_{15}$H$_{21}$NO$_3$: C, 68.42; H, 8.04; N, 5.32. Found: C, 68.75; H, 8.37; N, 5.59.

Cytotoxicity Test. P388 cells were seeded in 96-well plates (Iwaki) and cultured overnight in RPMI1640 medium (Sigma) supplemented with 10% fetal bovine serum (FBS) (Cellgro), and antibiotics (100 U/mL penicillin and 100 μg/mL streptomycin, Nakarai Tesque) at 37 °C in 5% CO$_2$-humidified incubator. Then 0.1 μg/mL, 1 μg/mL, 10 μg/mL and 100 μg/mL of samples were added and incubated for 4 days under the same condition. The cell proliferation was measured by using the cell counting kit-8 (Dojin Kagaku).

References