

## Supporting Information

# MgI<sub>2</sub>-Mediated Ring Expansions of Secondary Methylene-cyclopropyl Amides

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### I. General Experimental Details

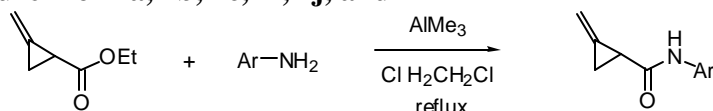
All reactions were carried out in flame-dried glassware sealed with rubber septa under a positive pressure of dry nitrogen. All commercial materials (purchased from Sigma-Aldrich®) were used without further purification. Tetrahydrofuran (THF) was distilled from sodium benzophenone ketyl. Dichloromethane and dichloroethane were distilled from CaH<sub>2</sub>. Anhydrous magnesium iodide (MgI<sub>2</sub>, ≥99%) was purchased from Fluka and stored in a glovebox under inert atmosphere. Weighing and transfer outside glovebox were performed as quickly as possible to minimize air exposure. All reactions were monitored by analytical thin layer chromatography (TLC), which was visualized by ultraviolet light (254 nm) and treatment with acidic *p*-anisaldehyde or ceric ammonium nitrate (CAM) stain followed by gentle heating. Purification of products was accomplished by flash chromatography using silica gel 60 (230-400 mesh) purchased from Silicycle.

All <sup>1</sup>H- and <sup>13</sup>C-NMR were recorded using a Varian XL 400 and Varian Mercury 300. IR spectra were obtained using a Nicolet DX FT-IR spectrometer. High resolution mass spectra were obtained on a VG70-250S (double focusing) mass spectrometer at 70 eV. Melting points were measured with a Fisher-Johns melting point apparatus.

### II. Preparation of Starting Materials

*p*-Toluenesulfonyl (Tosyl) aryl aldimines were prepared in moderate to good yields according to known procedures.<sup>1</sup> Secondary methylene-cyclopropyl amides were prepared from 2-methylene-cyclopropanecarboxylic acid ethyl ester (MCP ester) **1w** or 2-methylene-cyclopropanecarboxylic acid (MCP acid) **1z**.<sup>2</sup>

#### General procedure<sup>3</sup> for **1a**, **1b**, **1c**, **1i**, **1j**, and **1k**



<sup>1</sup> (a) Jennings, W. B.; Lovely, C. J. *Tetrahedron*, **1991**, *47*, 5561-5568. (b) Chemla, F.; Hebbe, V.; Normant, J.-F. *Synthesis* **2000**, 75.

<sup>2</sup> Lai, M.; Liu, L.; Liu, H.-w. *J. Am. Chem. Soc.* **1991**, *113*, 7388.

<sup>3</sup> Wilkerson, W. W.; Akamike, E.; Cheatham, W. W.; Hollis, A. Y.; Collins, R. D.; DeLucca, I.; Lam, P. Y. S.; Ru, Y. *J. Med. Chem.* **1996**, *39*, 4299.

To a solution of an arylamine (10 mmol) in dichloroethane (5 ml) was added 5 ml of  $\text{AlMe}_3$  (2.0 M in hexanes) slowly at room temperature for 15 min. After the bubbling of methane gas was finished, the MCP ester **1w** (5 mmol) in dichloroethane (5 ml) was added into the mixture at room temperature, which was heated at for 24 h. After cooling the flask, the reaction contents were added to a mixture of dichloromethane (10 ml) and water (10 ml) slowly at room temperature. After stirring for 1 h, the mixture was filtered through a bed of Celite. The filtrate was washed with water and brine, dried over  $\text{MgSO}_4$ , filtered and concentrated. The product was obtained by recrystallization or flash chromatography on silica gel.

**2-Methylene cyclopropanecarboxylic acid pyridin-2-ylamide (1a)** white solid; mp = 95 °C (dichloromethane/pentane); **IR** ( $\text{CHCl}_3$ )  $\nu_{\text{max}}$  ( $\text{cm}^{-1}$ ) 3272, 2992, 1687, 1575, 1523, 1462, 1346, 1295, 1170, 1104, 1037, 994, 964, 903, 775;  **$^1\text{H-NMR}$**  (300 MHz,  $\text{CDCl}_3$ )  $\delta$  8.73 (bs, 1H), 8.3-8.15 (m, 2H), 7.7 (m, 1H), 7.04 (m, 1H), 5.63 (m, 2H), 2.34 (m, 1H), 1.89 (m, 1H), 1.72 (m, 1H);  **$^{13}\text{C-NMR}$**  (75 MHz,  $\text{CDCl}_3$ )  $\delta$  169.9, 151.7, 147.8, 138.7, 130.5, 120.0, 114.5, 105.9, 21.2, 11.7; **HRMS** Calcd for  $\text{C}_{10}\text{H}_{10}\text{N}_2\text{O}$  ( $\text{M}$ )<sup>+</sup>: 174.0793 Found: 174.0791

**2-Methylene cyclopropanecarboxylic acid pyridin-3-ylamide (1b)** pale yellow solid; mp = 64-67 °C (ethyl acetate); **IR** ( $\text{CHCl}_3$ )  $\nu_{\text{max}}$  ( $\text{cm}^{-1}$ ) 3266, 3288, 3129, 3064, 3004, 1669, 1601, 1548, 1483, 1362, 1277, 1241, 1198, 1182, 1110, 1031, 966, 903, 808, 704;  **$^1\text{H-NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.73 (1H, bs), 8.3-8.15 (m, 2H), 7.7 (m, 1H), 7.04 (m, 1H), 5.63 (m, 2H), 2.34 (m, 1H), 1.89 (m, 1H), 1.72 (m, 1H);  **$^{13}\text{C-NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  169.9, 151.7, 147.8, 138.7, 130.5, 120.0, 114.5, 105.9, 21.2, 11.7; **HRMS** Calcd for  $\text{C}_{10}\text{H}_{10}\text{N}_2\text{O}$  ( $\text{M}$ )<sup>+</sup>: 174.0793 Found: 174.0791

**2-Methylene cyclopropanecarboxylic acid pyridin-4-ylamide (1c)** white solid; mp = 133-136 °C (ethyl acetate); **IR** ( $\text{CHCl}_3$ )  $\nu_{\text{max}}$  ( $\text{cm}^{-1}$ ) 3253, 3176, 3091, 3000, 1683, 1595, 1522, 1423, 1359, 1296, 1212, 1176, 1106, 1001, 902, 828, 747;  **$^1\text{H-NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.95 (bs, 1H), 8.44 (m, 2H), 7.51 (m, 2H), 5.57 (m, 2H), 2.34 (m, 1H), 1.88 (m, 1H), 1.69 (m, 1H);  **$^{13}\text{C-NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  170.5, 150.4, 145.7, 130.5, 113.9, 105.7, 21.1, 11.9; **HRMS** Calcd for  $\text{C}_{10}\text{H}_{11}\text{N}_2\text{O}$  ( $\text{M}+\text{H}$ )<sup>+</sup>: 175.0871 Found: 175.0866

**2-Methylene cyclopropanecarboxylic acid pyrimidin-2-ylamide (1i)** pale yellow solid; mp = 119-121 °C (ethyl acetate); **IR** ( $\text{CHCl}_3$ )  $\nu_{\text{max}}$  ( $\text{cm}^{-1}$ ) 3254, 3218, 3070, 3000, 1676, 1578, 1515, 1434, 1413, 1370, 1265, 1205, 1156, 1107, 1082, 1033, 962, 899, 804, 748;  **$^1\text{H-NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  9.36 (bs, 1H), 8.65 (d, 2H  $J = 5.2$  Hz), 7.02 (m, 1H), 5.58 (m, 2H), 3.22 (bs, 1H), 1.98 (m, 1H), 1.72 (m, 1H);  **$^{13}\text{C-NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  171.3, 158.6, 157.9, 131.6, 116.5, 104.9, 20.6, 12.1; **HRMS** Calcd for  $\text{C}_9\text{H}_9\text{N}_3\text{O}$  ( $\text{M}$ )<sup>+</sup>: 175.0746 Found: 175.0741

**2-Methylene cyclopropanecarboxylic acid (3-methyl-isoxazol-5-yl)-amide (1j)** pale yellow solid; mp = 106-107 °C (ethyl acetate); **IR** ( $\text{CHCl}_3$ )  $\nu_{\text{max}}$  ( $\text{cm}^{-1}$ ) 3209, 3148, 3038, 1698, 1616, 1558, 1571, 1452, 1421, 1356, 1277, 1188, 1143, 1109, 1030, 975, 903, 779;  **$^1\text{H-NMR}$**  (300 MHz,  $\text{CDCl}_3$ )  $\delta$  9.2 (bs, 1H), 6.2 (s, 1H), 5.61 (m, 2H), 2.42 (m, 1H), 2.27 (s, 3H), 1.91 (m, 1H), 1.76 (m, 1H);  **$^{13}\text{C-NMR}$**  (75 MHz,  $\text{CDCl}_3$ )  $\delta$  168.1, 161.8, 160.3, 130.1, 106.2, 90.0, 20.2, 12.2, 12.0; **HRMS** Calcd for  $\text{C}_9\text{H}_{10}\text{N}_2\text{O}_2$  ( $\text{M}$ )<sup>+</sup>: 178.0742 Found: 178.0745

**2-Methylene cyclopropanecarboxylic acid (5-methyl-isoxazol-3-yl)-amide (1k)** pale yellow solid; mp = 152-154 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3264, 3221, 3152, 3091, 3041, 2991, 2929, 1700, 1635, 1570, 1489, 1437, 1350, 1267, 1189, 1105, 1075, 1041, 1013, 932, 902, 889, 821, 753, 667; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  10.2 (bs, 1H), 6.76 (1H, s), 5.60 (m, 2H), 2.45 (m, 1H), 2.40 (s, 3H), 1.92 (m, 1H), 1.75 (m, 1H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  170.1, 170.0, 158.7, 130.7, 105.5, 97.0, 20.5, 12.9, 11.8; **HRMS** Calcd for C<sub>9</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub> (M)<sup>+</sup>: 178.0742 Found: 178.0741

**General procedure for 1d, 1e, 1f, 13a, and 13k** see: Supporting Information, *J. Am. Chem. Soc.* **2002**, *124*, 6312.

**2-Methylene cyclopropanecarboxylic acid phenylamide (1d)** white shiny powder; mp = 108-109 °C (dichloromethane/pentane); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3288, 3244, 3194, 3138, 3076, 2970, 1656, 1600, 1501, 1439, 1362, 1303, 1250, 1185, 1101, 1033, 965, 894, 748, 683; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>)  $\delta$  7.63-7.38 (m, 3H), 7.34-7.25 (m, 2H), 7.14-7.05 (m, 1H), 5.60 (dm, 2H, *J*=1.8 Hz), 2.34-2.26 (m, 1H), 1.88-1.79 (m, 1H), 1.73-1.62 (m, 1H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>)  $\delta$  169.4, 138.1, 130.8, 129.2, 124.4, 119.9, 105.8, 21.2, 11.6; **HRMS** Calcd for C<sub>11</sub>H<sub>11</sub>NO (M)<sup>+</sup>: 173.0841 Found: 173.0842

**2-Methylene cyclopropanecarboxylic acid benzylamide (1e)** pale yellow solid; mp = 96-97 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3281, 3066, 3028, 2978, 2928, 1748, 1704, 1635, 1556, 1497, 1456, 1374, 1349, 1229, 1113, 1053, 1025, 981, 896, 745; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.35-7.24 (m, 5H), 5.85 (bs, 1H), 5.55 (m, 2H), 4.44 (bs, 1H), 4.43 (bs, 1H), 2.16 (m, 1H), 1.73 (m, 1H), 1.61 (m, 1H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  171.0, 138.5, 130.8, 128.9, 128.0, 127.7, 105.5, 43.9, 20.3, 11.3; **HRMS** Calcd for C<sub>12</sub>H<sub>13</sub>NO (M)<sup>+</sup>: 187.0997 Found: 187.1000

**2-Methylene cyclopropanecarboxylic acid (pyridin-2-ylmethyl)-amide (1f)** white solid; mp = 69-71 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3285, 3083, 2937, 1655, 1600, 1556, 1477, 1438, 1350, 1236, 1216, 1152, 1118, 1048, 1004, 903, 755; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>)  $\delta$  8.51 (m, 1H), 7.64 (ddd, 1H, *J* = 7.6, 7.6, 1.8 Hz), 7.28-7.15 (m, 2H), 6.96 (bs, 1H), 5.54 (m, 2H), 4.54 (m, 2H), 2.25 (m, 1H), 1.77 (m, 1H), 1.60 (m, 1H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>)  $\delta$  171.0, 156.5, 149.1, 136.9, 130.9, 122.6, 122.3, 105.3, 45.1, 20.6, 11.6; **HRMS** Calcd for C<sub>11</sub>H<sub>11</sub>N<sub>2</sub>O (M-H)<sup>+</sup>: 187.0871 Found: 187.0870

**Cyclopropanecarboxylic acid pyridin-2-ylamide (13a)** white solid; mp = 85-87 °C (dichloromethane); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3250, 3196, 3013, 1691, 1599, 1579, 1528, 1434, 1390, 1299, 1184, 1151, 1094, 1060, 1030, 996, 955, 885, 821, 774; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  9.74 (bs, 1H), 8.25 (m, 2H), 7.70 (m, 1H), 7.02 (m, 1H), 1.61 (bs, 1H), 1.12 (m, 2H), 0.87 (m, 2H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  172.9, 152.3, 147.6, 138.7, 119.6, 114.7, 15.8, 8.5; **HRMS** Calcd for C<sub>9</sub>H<sub>10</sub>N<sub>2</sub>O (M)<sup>+</sup>: 162.0793 Found: 162.0793

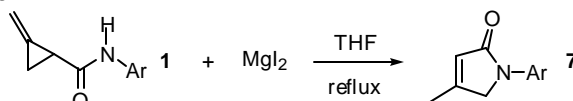
**Cyclopropanecarboxylic acid (5-methyl-isoxazol-3-yl)-amide (13k)** white solid; mp = 154-157 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3422, 3260, 3204, 3148, 3077, 3042, 2992, 2958, 1694, 1627, 1567, 1482, 1423, 1384, 1275, 1198, 1106, 1026, 951, 927, 884, 814, 768, 674; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>)  $\delta$  10.10 (bs, 1H), 6.70 (s, 1H) 2.30 (m, 3H), 1.73 (m, 1H), 1.10 (m, 2H), 0.94 (m, 2H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>)  $\delta$  172.7, 170.0, 158.8, 15.4, 12.9, 11.6, 8.8; **HRMS** Calcd for C<sub>8</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub> (M)<sup>+</sup>: 166.0742 Found: 166.0741

### Procedure for *N*-(2-Methylene cyclopropanecarbonyl)-benzamide (**1g**)

To a solution of 2-methylenecyclopropanecarboxylic acid amide<sup>4</sup> **1h** (190 mg, 1.57 mmol) in dichloromethane (5 ml) was added pyridine (0.25 ml) and benzoyl chloride (0.5 ml) at room temperature. The reaction mixture was stirred for 5 h at room temperature, then quenched with water (5 ml) and extracted with CH<sub>2</sub>Cl<sub>2</sub> (2 x 5 ml). The combined organic phases were washed with H<sub>2</sub>O (30 ml) and brine (30 ml) and dried over MgSO<sub>4</sub>, filtered and concentrated. The product **1g** was obtained as a white solid (220 mg, 79 %) by recrystallization (diethyl ether) of the crude product. mp = 138-139 °C; **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3391, 3058, 3003, 2927, 2857, 1706, 1599, 1583, 1450, 1340, 1243, 1167, 1129, 1101, 1074, 1025, 1001, 952, 901, 880, 804, 787, 769, 717, 693; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.86-7.78 (m, 2H), 7.54 (m, 1H), 7.45-7.36 (m, 2H), 5.63 (dd, 1H, *J* = 6.4, 4.0 Hz), 5.52 (dd, 1H, *J* = 6.4, 3.2 Hz), 2.69 (m, 1H), 2.05 (m, 1H), 1.78 (m, 1H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  175.4, 172.2, 133.6, 133.4, 131.4, 129.3, 128.9, 104.8, 22.7, 13.6; **HRMS** Calcd for C<sub>12</sub>H<sub>10</sub>NO<sub>2</sub> (M-H)<sup>+</sup>: 200.0712 Found: 200.0708

### III. MgI<sub>2</sub>-Mediated Ring Expansions of Secondary MCP Amides

#### General procedure for **7**



To a solution of an MCP amide (0.1 mmol) in THF (1 ml, 0.1 M) was added anhydrous MgI<sub>2</sub> (31 mg, 0.11 mmol) rapidly under a positive nitrogen pressure at room temperature. The reaction mixture was gently heated at 80 °C (oil bath temperature) for 12 h. The reaction mixture was then cooled to room temperature and quenched with small portions of saturated aqueous Na<sub>2</sub>SO<sub>3</sub> solution. The mixture was extracted with ethyl acetate (2 x 15 ml) and the combined organic phases were washed with H<sub>2</sub>O (30 ml) and brine (30 ml), dried over MgSO<sub>4</sub>, filtered and concentrated. The product **7** was isolated by flash chromatography on silica gel.

**4-Methyl-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (7a)** pale yellow solid; mp = 70-72 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3350, 3072, 3013, 2924, 2855, 1694, 1639, 1583, 1569, 1471, 1427, 1376, 1335, 1309, 1216, 1153, 1140, 1094, 1052, 1002, 953, 912, 876, 776, 740, 692; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>)  $\delta$  8.43 (d, 1H, *J* = 8.7 Hz), 8.30 (m, 1H), 7.68 (m, 1H), 6.99 (m, 1H), 5.94 (m, 1H), 4.55 (m, 2H), 2.15 (m, 3H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>)  $\delta$  171.2, 157.1, 151.7, 147.7, 138.1, 123.7, 119.1, 113.4, 55.2, 15.6; **HRMS** Calcd for C<sub>10</sub>H<sub>10</sub>N<sub>2</sub>O (M)<sup>+</sup>: 174.0793 Found: 174.0791

**4-Methylene-1-pyridin-2-yl-pyrrolidin-2-one (9a)** pale yellow solid; mp = 50-51 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3345, 3068, 3065, 2977, 1711, 1670, 1586, 1570, 1468, 1436, 1378, 1307, 1223, 1149, 994, 924, 900, 778, 740; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>)  $\delta$  8.45 (m, 1H), 8.37 (m, 1H), 7.71 (m, 1H), 7.05 (m, 1H), 5.19 (m, 2H), 4.72 (s, 2H), 3.42 (m, 3H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>)  $\delta$  172.9, 151.6, 147.7, 137.9, 135.9,

<sup>4</sup> The amide was prepared according to a known procedure. See: Nishimura, A.; Ohta, M.; Kato, H. *Bull. Chem. Soc. Jpn.* **1970**, *43*, 1530.

119.9, 115.1, 109.7, 53.2, 40.1; **HRMS** Calcd for C<sub>10</sub>H<sub>10</sub>N<sub>2</sub>O (M)<sup>+</sup>: 174.0793 Found: 174.0792

**4-Methyl-1-pyridin-3-yl-1,5-dihydro-pyrrol-2-one (7b)** pale yellow solid; mp = 113-116 °C (dichloromethane); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3415, 3084, 2922, 2859, 1683, 1581, 1486, 1430, 1384, 1321, 1208, 1145, 972, 944, 913, 835, 811, 705; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.72 (bs, 1H), 8.37 (m, 2H), 7.31 (m, 1H), 5.98 (d, 1H, *J* = 1.2 Hz), 4.35 (s, 2H), 2.17 (d, 3H, *J* = 0.8 Hz); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  171.3, 155.7, 145.0, 139.4, 136.3, 125.9, 124.1, 123.9, 55.3, 15.6; **HRMS** Calcd for C<sub>10</sub>H<sub>10</sub>N<sub>2</sub>O (M)<sup>+</sup>: 174.0793 Found: 174.0788

**4-Methyl-1-pyridin-4-yl-1,5-dihydro-pyrrol-2-one (7c)** white solid; mp = 145-151 °C (dichloromethane); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3409, 3060, 2923, 2855, 1689, 1600, 1559, 1508, 1440, 1430, 1386, 1331, 1265, 1208, 1137, 1096, 993, 979, 945, 846, 826, 737; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.52 (d, 1H, *J* = 5.6 Hz), 7.64 (m, 2H), 5.98 (d, 1H, *J* = 1.2 Hz), 4.29 (s, 2H), 2.18 (d, 3H, *J* = 0.8 Hz); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  171.5, 156.2, 151.0, 145.8, 124.3, 111.7, 55.0, 15.7; **HRMS** Calcd for C<sub>10</sub>H<sub>10</sub>N<sub>2</sub>O (M)<sup>+</sup>: 174.0793 Found: 174.0786

**4-Methyl-1-phenyl-1,5-dihydro-pyrrol-2-one (7d)** white solid; mp = 79-81 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3063, 2915, 1682, 1599, 1504, 1433, 1385, 1326, 1207, 1134, 937, 830, 748; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>)  $\delta$  7.68 (d, 2H, *J* = 7.8 Hz), 7.36 (m, 2H), 7.10 (t, 1H, *J* = 7.5 Hz), 5.95 (d, 1H, *J* = 1.2 Hz), 4.29 (s, 2H), 2.12 (d, 3H, *J* = 0.9 Hz); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>)  $\delta$  171.0, 154.8, 139.5, 129.3, 124.4, 123.9, 118.7, 56.1, 15.5; **HRMS** Calcd for C<sub>11</sub>H<sub>11</sub>NO (M)<sup>+</sup>: 173.0841 Found: 173.0851

**4-Methylene-1-phenyl-pyrrolidin-2-one (9d)** pale yellow solid; mp = 52-54 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3115, 3081, 2926, 2878, 1697, 1670, 1599, 1501, 1454, 1387, 1303, 1276, 1219, 1158, 1131, 927, 899, 872, 751; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.65 (d, 2H, *J* = 8.0 Hz), 7.39 (m, 2H), 7.17 (m, 1H), 5.18 (m, 2H), 4.49 (d, 2H, *J* = 1.6 Hz), 3.36 (d, 2H, *J* = 2.0 Hz); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  172.2, 139.1, 136.1, 129.2, 125.0, 120.3, 109.8, 54.4, 39.3; **HRMS** Calcd for C<sub>11</sub>H<sub>11</sub>NO (M)<sup>+</sup>: 173.0841 Found: 173.0844

**4-Methyl-1-pyrimidin-2-yl-1,5-dihydro-pyrrol-2-one (7i)** pale yellow solid; mp = 117-120 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3451, 3085, 2922, 1711, 1645, 1564, 1423, 1388, 1342, 1310, 1282, 1201, 1166, 1145, 1085, 997, 941, 909, 839, 811, 705; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.64 (d, 2H, *J* = 6.4 Hz), 6.98 (t, 1H, *J* = 6.4 Hz), 5.98 (d, 1H, *J* = 1.6 Hz), 4.53 (s, 2H), 2.16 (s, 3H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  169.8, 158.2, 157.2, 123.9, 116.11, 116.09, 55.9, 15.8; **HRMS** Calcd for C<sub>9</sub>H<sub>9</sub>N<sub>3</sub>O (M)<sup>+</sup>: 175.0746 Found: 175.0744

**4-Methyl-1-(3-methyl-isoxazol-5-yl)-1,5-dihydro-pyrrol-2-one (7j)** white solid; mp = 124-126 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3162, 3098, 2929, 2859, 1718, 1602, 1507, 1437, 1373, 1331, 1282, 1205, 1145, 1106, 1032, 941, 849, 765, 673; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  6.23 (s, 1H), 5.98 (m, 1H), 4.42 (s, 2H), 2.27 (s, 3H), 2.18 (s, 3H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  168.2, 161.9, 160.1, 158.1, 122.3, 87.22, 87.19, 53.9, 16.0, 12.2; **HRMS** Calcd for C<sub>9</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub> (M)<sup>+</sup>: 178.0742 Found: 178.0741

**4-Methyl-1-(5-methyl-isoxazol-3-yl)-1,5-dihydro-pyrrol-2-one (7k)** white solid; mp = 115-118 °C (dichloromethane); **IR** (CHCl<sub>3</sub>)  $\nu_{\max}$  (cm<sup>-1</sup>) 3169, 2929, 2862, 1712, 1609, 1514, 1454, 1437, 1321, 1272, 1208, 1180, 1145, 1113, 1008, 930, 898, 814, 741; **<sup>1</sup>H-**

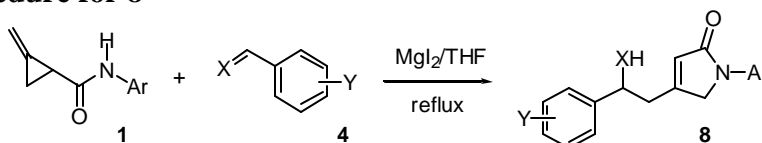
**NMR** (400 MHz, CDCl<sub>3</sub>) δ 6.82 (s, 1H), 5.93 (s, 1H), 4.35 (s, 2H), 2.40 (s, 3H), 2.16 (s, 3H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>) δ 170.2, 157.9, 122.6, 94.9, 54.3, 15.7, 12.9; **HRMS** Calcd for C<sub>9</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub> (M)<sup>+</sup>: 178.0742 Found: 178.0749

#### Procedure for 3-Azidomethyl-but-3-enoic acid amide (**11**)

The crude product obtained from **1h** according to the above general procedure was dissolved in acetone (2 ml) followed by the addition of sodium azide (0.3 mmol). The mixture was stirred at room temperature for 16 h. The reaction was extracted with EtOAc (10 ml x 2), washed with brine (50 ml), dried over MgSO<sub>4</sub>, filtered and concentrated. The product **11** was isolated as brown sticky oil by flash chromatography on silica gel. **IR** (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3352, 3183, 2922, 2096, 1659, 1634, 1409, 1247, 1198, 1132, 913, 884, 744; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>) δ 5.58 (bs, 2H), 5.28 (s, 1H), 5.21 (s, 1H), 3.90 (s, 2H), 3.07 (s, 2H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>) δ 172.0, 138.1, 118.4, 55.8, 41.6; **HRMS** Calcd for C<sub>5</sub>H<sub>8</sub>NO (M-N<sub>3</sub>)<sup>+</sup>: 98.0606 Found: 98.0608

### IV. MgI<sub>2</sub>-Mediated Alkylative Ring Expansions of Secondary MCP Amides

#### General procedure for **8**



To a solution of an MCP amide **1** (0.1 mmol) and an aryl aldehyde (0.2 mmol) or aldimine (0.15 mmol) in THF (1 ml, 0.1 M) was added anhydrous MgI<sub>2</sub> (31 mg, 0.11 mmol) rapidly under a positive nitrogen pressure at room temperature. The reaction mixture was quickly placed to a preheated oil bath of 80 °C and refluxed for 2 h (30 min for **1k** with aldehydes). The reaction mixture was then cooled to room temperature and quenched with small portion of saturated aqueous Na<sub>2</sub>SO<sub>3</sub> solution. The mixture was extracted with ethyl acetate (2 x 15 ml) and the combined organic phases were washed with H<sub>2</sub>O (30 ml) and brine (30 ml), dried over MgSO<sub>4</sub>, filtered and concentrated. The product **8** was isolated by flash chromatography on silica gel.

**N-[1-(4-Bromo-phenyl)-2-(5-oxo-1-pyridin-2-yl-2,5-dihydro-1H-pyrrol-3-yl)-ethyl]-4-methyl-benzenesulfonamide (8aa)** white solid; mp = 134-141 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3259, 2921, 2852, 1697, 1675, 1584, 1469, 1440, 1375, 1309, 1154, 1093, 1068, 1009, 809, 774; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>) δ 8.39 (d, 1H, *J* = 8.4 Hz), 8.29 (dm, 1H, *J* = 8.1 Hz), 7.69 (ddd, 1H, *J* = 8.4, 7.5, 2.1 Hz), 7.52 (d, 1H, *J* = 8.4 Hz), 7.33 (d, 1H, *J* = 8.1 Hz), 7.09 (d, 1H, *J* = 8.1 Hz), 7.01 (m, 2H), 5.91 (s, 1H), 5.45 (d, 1H, *J* = 7.5 Hz), 4.51 (m, 1H), 4.39 (dm, 1H, *J* = 20.4 Hz), 4.24 (dd, 1H, *J* = 19.8, 1.2 Hz), 2.93 (dd, 1H, *J* = 15.3, 8.7 Hz), 2.78 (dd, 1H, *J* = 15.0, 6.0 Hz), 2.22 (s, 3H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>) δ 170.0, 155.3, 151.4, 147.8, 144.1, 138.9, 138.2, 137.0, 132.2, 129.8, 128.3, 127.2, 126.2, 122.4, 119.4, 113.5, 56.4, 53.8, 37.7, 21.6; **HRMS** Calcd for C<sub>24</sub>H<sub>22</sub>BrN<sub>3</sub>O<sub>3</sub>S (M)<sup>+</sup>: 511.0565 Found: 511.0552

**N-[1-(2,4-Dimethyl-phenyl)-2-(5-oxo-1-pyridin-2-yl-2,5-dihydro-1H-pyrrol-3-yl)-ethyl]-4-methyl-benzenesulfonamide (8ab)** pale yellow solid; mp = 172-174 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3270, 3061, 2926, 2865, 1697, 1677, 1586, 1471, 1434,

1377, 1330, 1310, 1219, 1158, 1094, 1064, 973, 942, 868, 777, 734; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 8.39 (d, 1H, *J* = 8.4 Hz), 8.29 (m, 1H), 7.67 (m, 1H), 7.57 (d, 2H, *J* = 8.4 Hz), 7.01 (m, 3H), 6.99 (m, 1H), 6.87 (m, 2H), 5.85 (d, 1H, *J* = 0.8 Hz), 5.49 (d, 1H, *J* = 7.2 Hz), 4.75 (m, 1H), 4.39 (d, 1H, *J* = 20.4 Hz), 4.24 (d, 1H, *J* = 20.0 Hz), 2.94 (dd, 1H, *J* = 15.2, 8.2 Hz), 2.78 (dd, 1H, *J* = 15.2, 6.8 Hz), 2.29 (s, 3H), 2.22 (s, 3H), 2.19 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.3, 156.3, 151.5, 147.7, 143.7, 138.1, 137.8, 137.3, 135.2, 134.6, 131.7, 129.7, 127.7, 127.1, 125.6, 119.3, 119.1, 113.5, 54.0, 52.6, 37.3, 21.5, 21.1, 19.3; HRMS Calcd for C<sub>26</sub>H<sub>27</sub>N<sub>3</sub>O<sub>3</sub>S (M)<sup>+</sup>: 461.1773 Found: 461.1772

***N*-[1-(4-Methoxy-phenyl)-2-(5-oxo-1-pyridin-2-yl-2,5-dihydro-1*H*-pyrrol-3-yl)-ethyl]-4-methyl-benzenesulfonamide (8ac)** white solid; mp = 175-176 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3263, 2916, 2848, 1684, 1610, 1586, 1513, 1471, 1434, 1377, 1310, 1249, 1179, 1157, 1093, 1062, 1033, 979, 950, 853, 831, 813, 779, 754, 693; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 8.37 (d, 1H, *J* = 8.4 Hz), 8.28 (m, 1H), 7.67 (m, 1H), 7.57 (m, 2H), 7.09 (m, 2H), 6.99 (m, 3H), 6.71 (m, 2H), 5.85 (s, 1H), 5.55 (d, 1H, *J* = 7.2 Hz), 4.48 (dd, 1H, *J* = 14.8, 7.6 Hz), 4.39 (d, 1H, *J* = 20.0 Hz), 4.33 (d, 1H, *J* = 20.0 Hz), 3.74 (s, 3H), 2.97 (dd, 1H, *J* = 15.2, 8.0 Hz), 2.82 (dd, 1H, *J* = 15.6, 7.2 Hz), 2.23 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.3, 159.5, 156.2, 151.5, 148.0, 143.6, 138.1, 137.4, 131.9, 129.7, 127.8, 127.2, 125.7, 119.3, 114.4, 113.4, 56.5, 55.5, 54.0, 37.8, 21.5; HRMS Calcd for C<sub>25</sub>H<sub>25</sub>N<sub>3</sub>O<sub>4</sub>S (M)<sup>+</sup>: 463.1566 Found: 463.1572

**4-Methyl-*N*-[2-(5-oxo-1-pyridin-2-yl-2,5-dihydro-1*H*-pyrrol-3-yl)-1-phenyl-ethyl]-benzenesulfonamide (8ad)** white solid; mp = 168-169 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3263, 1684, 1586, 1471, 1434, 1378, 1310, 1156, 1093, 1064, 813, 779, 700; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 8.36 (d, 1H, *J* = 8.4 Hz), 8.26 (m, 1H), 7.60 (m, 1H), 7.56 (m, 1H), 7.33 (d, 1H, *J* = 8.1 Hz), 7.24 (d, 1H, *J* = 1.6 Hz), 7.21 (m, 3H), 7.09 (m, 4H), 6.98 (m, 1H), 5.83 (s, 1H), 5.15 (d, 1H, *J* = 7.2 Hz), 4.50 (dd, 1H, *J* = 15.2, 7.6 Hz), 4.35 (d, 1H, *J* = 19.6 Hz), 4.21 (d, 1H, *J* = 20.0 Hz), 2.97 (dd, 1H, *J* = 15.2, 8.4 Hz), 2.84 (dd, 1H, *J* = 15.2, 7.2 Hz), 2.22 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.1, 155.8, 151.5, 147.8, 143.9, 139.8, 138.1, 137.1, 129.8, 128.5, 127.2, 126.5, 126.0, 119.0, 113.5, 57.0, 54.0, 37.9, 21.6; HRMS Calcd for C<sub>24</sub>H<sub>23</sub>N<sub>3</sub>O<sub>3</sub>S (M)<sup>+</sup>: 433.1460 Found: 433.1470

**4-Methyl-*N*-[2-(5-oxo-1-pyridin-2-yl-2,5-dihydro-1*H*-pyrrol-3-yl)-1-(2-trifluoromethyl-phenyl)-ethyl]-benzenesulfonamide (8ae)** pale yellow solid; mp = 253-255 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3262, 3116, 2927, 1684, 1587, 1436, 1381, 1335, 1314, 1259, 1226, 1159, 1117, 1077, 1059, 1038, 974, 910, 871, 813, 774, 731; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 8.42 (d, 1H, *J* = 8.4 Hz), 8.32 (dd, 1H, *J* = 4.8, 1.2 Hz), 7.73 (m, 1H), 7.62 (m, 3H), 7.50 (m, 1H), 7.36 (dd, 1H, *J* = 8.0, 7.2 Hz), 7.04 (m, 2H), 5.98 (s, 1H), 5.69 (s, 1H), 4.87 (m, 1H), 4.35 (d, 1H, *J* = 20.4 Hz), 4.00 (d, 1H, *J* = 20.0 Hz), 2.71 (m, 2H), 2.03 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 169.9, 155.2, 151.4, 147.9, 144.1, 138.1, 136.1, 132.8, 129.8, 128.1, 128.0, 127.3, 126.6, 126.3, 126.2, 119.4, 113.5, 53.2, 52.3, 39.0, 21.3; HRMS Calcd for C<sub>25</sub>H<sub>22</sub>F<sub>3</sub>N<sub>3</sub>O<sub>3</sub>S (M)<sup>+</sup>: 501.1334 Found: 501.1338

**4-(2-Hydroxy-2-phenyl-ethyl)-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (8af)** white solid; mp = 138-140 °C (dichloromethane); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3385, 3068, 2926, 1683, 1586, 1471, 1438, 1377, 1310, 1219, 1151, 1054, 777; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 8.40 (dd, 1H, *J* = 8.4, 1.2 Hz), 8.30 (dm, 1H, *J* = 5.2 Hz), 7.60 (ddd, 1H, *J* = 8.4, 7.6, 2.0 Hz), 7.34 (m, 6H), 6.97 (m, 1H), 6.00 (m, 1H), 4.98 (m, 1H), 4.63 (m, 2H), 2.92 (dd, 1H, *J* = 14.8, 8.4 Hz), 2.82 (dd, 1H, *J* = 14.8, 4.8 Hz), 2.42 (d, 2H, *J* = 2.0 Hz);

<sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.9, 157.8, 151.7, 147.7, 143.5, 138.1, 129.0, 128.5, 125.9, 124.9, 119.2, 113.6, 73.1, 54.7, 39.6; HRMS Calcd for C<sub>17</sub>H<sub>16</sub>N<sub>2</sub>O<sub>2</sub> (M)<sup>+</sup>: 280.1212 Found: 280.1218

**4-(2-Benzo[1,3]dioxol-5-yl-2-hydroxy-ethyl)-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (8ag)** white solid; mp = 160-162 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3373, 2894, 1690, 1673, 1598, 1469, 1434, 1374, 1311, 1244, 1152, 1092, 1040, 927, 864, 811, 776, 737; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 8.40 (dd, 1H, J = 8.4, 1.2 Hz), 8.30 (dm, 1H, J = 5.1 Hz), 7.67 (ddd, 1H, J = 8.4, 7.6, 2.1 Hz), 7.00 (m, 1H), 6.90 (s, 1H), 6.80 (m, 2H), 5.99 (s, 1H), 5.90 (s, 2H), 4.91 (m, 1H), 4.62 (m, 2H), 2.90 (dd, 1H, J = 15.2, 8.4 Hz), 2.80 (dd, 1H, J = 15.2, 5.8 Hz), 2.40 (s, 1H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.9, 157.7, 151.7, 148.3, 147.7, 147.6, 138.1, 137.6, 124.9, 119.5, 119.2, 113.6, 108.6, 106.3, 101.4, 73.0, 54.7, 39.6; HRMS Calcd for C<sub>18</sub>H<sub>16</sub>N<sub>2</sub>O<sub>4</sub> (M)<sup>+</sup>: 324.1110 Found: 324.1111

**4-[2-Hydroxy-2-(4-trifluoromethyl-phenyl)-ethyl]-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (8ah)** pale yellow solid; mp = 149-151 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3391, 1679, 1587, 1470, 1436, 1382, 1327, 1276, 1167, 1115, 1067, 1016, 849, 818, 764, 750; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 8.38 (dm, 1H, J = 8.4 Hz), 8.27 (m, 1H), 7.65 (m, 1H), 7.50 (m, 2H), 6.98 (m, 1H), 6.01 (m, 1H), 5.07 (m, 1H), 4.65 (d, 2H, J = 1.5 Hz), 2.88 (m, 2H), 2.41 (s, 1H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 170.3, 156.7, 151.4, 147.5, 147.1, 138.0, 126.1, 125.8, 125.1, 119.2, 113.5, 101.5, 72.6, 54.8, 43.9, 39.8; HRMS Calcd for C<sub>18</sub>H<sub>15</sub>F<sub>3</sub>N<sub>2</sub>O<sub>2</sub> (M)<sup>+</sup>: 348.1086 Found: 348.1089

**N-{1-(4-Methoxy-phenyl)-2-[1-(5-methyl-isoxazol-3-yl)-5-oxo-2,5-dihydro-1H-pyrrol-3-yl]-ethyl}-4-methyl-benzenesulfonamide (8kc)** white solid; mp = 181-184 °C (dichloromethane); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3275, 2926, 2845, 1716, 1699, 1612, 1518, 1458, 1324, 1250, 1160, 1094, 1064, 1037, 936, 813, 729; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 7.58 (m, 2H), 7.16 (m, 2H), 6.97 (m, 2H), 6.75 (m, 3H), 5.83 (m, 1H), 5.13 (d, 1H, J = 6.9 Hz), 4.42 (m, 1H), 4.17 (dm, 1H, J = 18.3 Hz), 4.05 (dm, 1H, J = 19.8 Hz), 3.75 (s, 3H), 3.01 (dd, 1H, J = 15.3, 7.2 Hz), 2.85 (dd, 1H, J = 15.3, 7.5 Hz), 2.40 (s, 3H), 2.34 (s, 3H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 170.3, 169.5, 159.7, 157.7, 150.0, 143.9, 137.2, 131.4, 129.8, 129.3, 128.5, 128.3, 127.7, 127.6, 127.3, 124.5, 114.6, 113.9, 94.9, 56.5, 55.5, 53.2, 37.7, 21.6, 12.9; HRMS Calcd for C<sub>24</sub>H<sub>26</sub>N<sub>3</sub>O<sub>5</sub>S (M+H)<sup>+</sup>: 468.1593 Found: 468.1605

**N-{1-Benzo[1,3]dioxol-5-yl-2-[1-(5-methyl-isoxazol-3-yl)-5-oxo-2,5-dihydro-1H-pyrrol-3-yl]-ethyl}-4-methyl-benzenesulfonamide (8ki)** white solid; mp = 169-172 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3427, 2929, 2884, 1697, 1608, 1512, 1490, 1453, 1323, 1242, 1153, 1090, 1042, 939, 806, 754, 658; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 7.58 (m, 2H), 7.18 (m, 2H), 6.78 (s, 1H), 6.63 (m, 1H), 6.53 (m, 2H), 5.92 (m, 2H), 5.58 (s, 1H), 5.08 (d, 1H, J = 7.2 Hz), 4.38 (dd, 1H, J = 14.7, 7.5 Hz), 4.19 (dm, 1H, J = 19.5 Hz), 4.06 (dm, 1H, J = 18.3 Hz), 2.98 (dd, 1H, J = 15.6, 7.5 Hz), 2.82 (dd, 1H, J = 15.3, 7.5 Hz), 2.40 (s, 3H), 2.35 (s, 3H); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 170.3, 169.4, 157.7, 156.7, 148.4, 147.8, 144.0, 137.1, 133.2, 129.8, 127.3, 124.6, 120.3, 108.7, 106.7, 101.6, 94.9, 56.8, 53.1, 37.8, 21.6, 12.9; HRMS Calcd for C<sub>24</sub>H<sub>23</sub>N<sub>3</sub>O<sub>6</sub>S (M)<sup>+</sup>: 481.1308 Found: 481.1292

**4-(2-Hydroxy-2-phenyl-ethyl)-1-(5-methyl-isoxazol-3-yl)-1,5-dihydro-pyrrol-2-one (8kb)** pale yellow solid; mp = 107-109 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3408, 2922, 1697, 1652, 1617, 1557, 1539, 1522, 1490, 1455, 1360, 1339, 1272, 1223, 1117,

1057, 913, 797, 751, 706; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 7.49-7.27 (m, 5H), 6.80 (s, 1H), 5.97 (s, 1H), 4.96 (dd, 1H, *J* = 8.4, 4.6 Hz), 4.45 (d, 1H, *J* = 19.6 Hz), 4.40 (d, 1H, *J* = 18.8 Hz), 2.60 (bs, 1H), 2.38 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.3, 170.1, 158.8, 158.0, 143.4, 129.0, 128.5, 125.8, 123.7, 94.9, 73.0, 53.9, 39.6, 12.8; HRMS Calcd for C<sub>16</sub>H<sub>16</sub>N<sub>2</sub>O<sub>3</sub> (M)<sup>+</sup>: 284.1161 Found: 284.1171

**4-[2-Hydroxy-2-(2-trifluoromethyl-phenyl)-ethyl]-1-(5-methyl-isoxazol-3-yl)-1,5-dihydro-pyrrol-2-one (8kj)** pale yellow solid; mp = 124-126 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3415, 2958, 2922, 2866, 1697, 1613, 1518, 1454, 1310, 1275, 1159, 1117, 1054, 1033, 966, 913, 772; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 7.85 (d, 1H, *J* = 8.0 Hz), 7.63 (m, 2H), 7.42 (m, 1H), 6.78 (d, 1H, *J* = 0.8 Hz), 6.02 (s, 1H), 5.36 (m, 1H), 4.52 (m, 2H), 3.10 (s, 1H), 2.79 (m, 2H), 2.37 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.3, 170.1, 158.9, 157.9, 142.9, 132.8, 128.2, 127.5, 126.0, 125.9, 125.85, 125.80, 123.8, 96.2, 94.9, 68.35, 68.33, 53.8, 39.8, 12.8; HRMS Calcd for C<sub>17</sub>H<sub>15</sub>F<sub>3</sub>N<sub>2</sub>O<sub>3</sub> (M)<sup>+</sup>: 352.1035 Found: 352.1030

**4-[2-Hydroxy-2-(4-trifluoromethyl-phenyl)-ethyl]-1-(5-methyl-isoxazol-3-yl)-1,5-dihydro-pyrrol-2-one (8kh)** pale yellow solid; mp = 146-149 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3326, 3000, 2922, 1770, 1760, 1697, 1612, 1513, 1457, 1418, 1383, 1326, 1249, 1154, 1115, 1066, 1020, 910, 847, 829, 794; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 7.70-7.60 (m, 2H), 7.55-7.45 (m, 2H), 6.80 (s, 1H), 6.00 (s, 1H), 5.05 (m, 1H), 4.50 (m, 2H), 2.87 (m, 2H), 2.61 (d, 1H, *J* = 2.4 Hz), 2.39 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ 170.4, 169.9, 158.1, 157.9, 147.3, 126.2, 126.1, 126.0, 125.99, 125.96, 124.0, 94.9, 72.4, 53.9, 39.5, 12.9; HRMS Calcd for C<sub>17</sub>H<sub>15</sub>F<sub>3</sub>N<sub>2</sub>O<sub>3</sub> (M)<sup>+</sup>: 352.1035 Found: 352.1027

**4-(2-Benzo[1,3]dioxol-5-yl-2-hydroxy-ethyl)-1-(5-methyl-isoxazol-3-yl)-1,5-dihydro-pyrrol-2-one (8kg)** white solid; mp = 129-131 °C (ethyl acetate); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3401, 2923, 1705, 1613, 1515, 1486, 1444, 1356, 1275, 1240, 1117, 1092, 1039, 930, 867, 797, 751, 726; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 6.88 (m, 1H), 6.84-6.74 (m, 3H), 5.96 (s, 1H), 4.87 (m, 1H), 4.44 (dm, 1H, *J* = 19.8 Hz), 4.38 (dm, 1H, *J* = 19.2 Hz), 2.87 (dd, 1H, *J* = 15.0, 7.5 Hz), 2.79 (dd, 1H, *J* = 15.3, 4.3 Hz), 2.60 (s, 1H), 2.38 (d, 3H, *J* = 0.6 Hz); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 170.3, 170.1, 158.8, 157.9, 148.3, 147.7, 137.5, 123.6, 119.4, 108.5, 106.3, 101.4, 94.9, 72.8, 53.8, 39.6, 12.8; HRMS Calcd for C<sub>17</sub>H<sub>16</sub>N<sub>2</sub>O<sub>5</sub> (M)<sup>+</sup>: 328.1059 Found: 328.1062

**4-[2-Hydroxy-2-(4-methoxy-phenyl)-ethyl]-1-(5-methyl-isoxazol-3-yl)-1,5-dihydro-pyrrol-2-one (8kk)** white solid; mp = 140-142 °C (dichloromethane); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3415, 2923, 2852, 1711, 1613, 1514, 1454, 1352, 1303, 1247, 1177, 1033, 913, 836, 808, 730; <sup>1</sup>H-NMR (300 MHz, CDCl<sub>3</sub>) δ 6.88 (m, 1H), 6.84-6.74 (m, 3H), 5.96 (s, 1H), 4.87 (m, 1H), 4.44 (dm, 1H, *J* = 19.8 Hz), 4.38 (dm, 1H, *J* = 19.2 Hz), 2.87 (dd, 1H, *J* = 15.0, 7.5 Hz), 2.79 (dd, 1H, *J* = 15.3, 4.3 Hz), 2.60 (s, 1H), 2.38 (d, 3H, *J* = 0.6 Hz); <sup>13</sup>C-NMR (75 MHz, CDCl<sub>3</sub>) δ 187.1, 158.7, 135.4, 127.2, 123.7, 114.4, 95.0, 72.8, 55.6, 53.9, 39.0, 12.9; HRMS Calcd for C<sub>17</sub>H<sub>19</sub>N<sub>2</sub>O<sub>4</sub> (M+H)<sup>+</sup>: 315.1345 Found: 315.1343

**4-Methylene-2-phenyl-1-(toluene-4-sulfonyl)-pyrrolidine-3-carboxylic acid phenyl amide (2dd)** pale yellow solid; mp = 198-200 °C (diethyl ether/dichloromethane); IR (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3345, 3061, 3027, 2919, 1688, 1670, 1539, 1495, 1441, 1340, 1262, 1158, 1094, 909, 815, 751; <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>) δ 7.62 (m, 2H), 7.46-7.22 (m, 9H), 7.12 (m, 3H), 5.49 (s, 1H), 5.39 (s, 1H), 5.17 (s, 1H), 4.27 (dm, 1H, *J* = 14.4 Hz), 4.22 (dm, 1H, *J* = 14.8 Hz), 3.74 (s, 1H), 2.20 (s, 3H); <sup>13</sup>C-NMR (100 MHz, CDCl<sub>3</sub>) δ

166.7, 144.0, 145.3, 141.5, 137.4, 134.3, 129.8, 129.1, 128.9, 128.0, 127.9, 126.4, 124.9, 119.8, 113.7, 66.5, 62.1, 52.4, 21.6; **HRMS** Calcd for C<sub>25</sub>H<sub>24</sub>N<sub>2</sub>O<sub>3</sub>S (M)<sup>+</sup>: 432.1508 Found: 432.1517

#### V. Mg(OTf)<sub>2</sub>-Mediated Direct Aldol Reaction of 4-Methyl-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (7a)

To a solution of MCP amide **1a** (17.4 mg, 0.1 mmol) in THF (0.5 ml) was slowly added 0.1 ml of 1.0 M solution of LiHMDS in THF at -78 °C. After stirring for 30 min, a solution of Mg(OTf)<sub>2</sub> (32.2 mg, 0.1 mmol) in THF was added followed by benzaldehyde (15.2 µl, 0.15 mmol). After stirring for 5 min at -78 °C, the reaction mixture was quenched with small portions of saturated aqueous NH<sub>4</sub>Cl solution. The mixture was extracted with EtOAc (2 x 15 ml) and the combined organic phases were washed with H<sub>2</sub>O (30 ml), brine (30 ml), dried over MgSO<sub>4</sub>, filtered and concentrated. The crude mixture was purified by flash chromatography on silica gel (ethyl acetate:hexanes 1:2 → 1:1), which furnished **12 anti** (15.0 mg, 54 %) as a white solid and **12 syn** as a colorless oil (6.5 mg, 23%).

**Anti-5-(Hydroxy-phenyl-methyl)-4-methyl-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (12 anti)** white solid; mp 124-125 °C (ethyl acetate); **IR** (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3408, 3055, 2917, 2867, 1690, 1594, 1471, 1435, 1381, 1334, 1306, 1266, 1202, 1155, 1101, 1061, 1029, 1008, 924, 863, 777, 727, 705; **<sup>1</sup>H-NMR** (300 MHz, CDCl<sub>3</sub>) δ 8.42-8.35 (m, 2H), 8.13 (bs, 1H), 7.74 (m, 1H), 7.20-7.06 (m, 3H), 6.99 (m, 2H), 5.81 (s, 1H) 5.28 (s, 2H) 2.27 (s, 3H); **<sup>13</sup>C-NMR** (75 MHz, CDCl<sub>3</sub>) δ 170.9, 158.2, 151.9, 146.3, 139.4, 138.7, 128.0, 127.9, 126.1, 125.0, 119.6, 114.5, 73.9, 72.7, 16.3; **HRMS** Calcd for C<sub>17</sub>H<sub>14</sub>N<sub>2</sub>O (M-H<sub>2</sub>O)<sup>+</sup>: 262.1106 Found: 262.1100

**Syn-5-(Hydroxy-phenyl-methyl)-4-methyl-1-pyridin-2-yl-1,5-dihydro-pyrrol-2-one (12 syn)** colorless oil; **IR** (CHCl<sub>3</sub>) ν<sub>max</sub> (cm<sup>-1</sup>) 3396, 2928, 2851, 1683, 1586, 1472, 1437, 1388, 1343, 1307, 1158, 1136, 1094, 1058, 912, 844, 773; **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>) δ 8.36-8.29 (m, 2H), 7.75 (m, 1H), 7.25-7.20 (m, 3H), 7.15-7.03 (m, 3H), 5.70 (s, 1H), 5.47 (m, 1H), 5.39 (m, 1H), 3.59 (m, 1H), 2.06 (s, 3H); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>) δ 160.5, 151.5, 147.7, 139.3, 138.6, 128.3, 128.2, 126.3, 124.7, 119.4, 115.3, 74.3, 69.3, 17.1; **HRMS** Calcd for C<sub>17</sub>H<sub>14</sub>N<sub>2</sub>O (M-H<sub>2</sub>O)<sup>+</sup>: 262.1106 Found: 262.1102

## V. X-ray Crystallography<sup>5</sup>

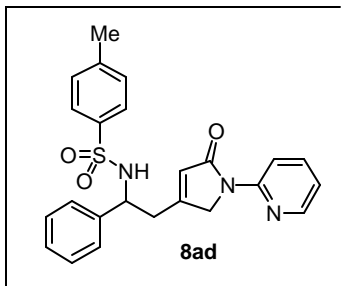


Table 1. Crystal data and structure refinement for k01223

Identification code	k01223	
Empirical formula	C <sub>24</sub> H <sub>23</sub> N <sub>3</sub> O <sub>3</sub> S	
Formula weight	433.51	
Temperature	150(1) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2(1)/c	
Unit cell dimensions	a = 15.0245(4) Å	α = 90°.
	b = 7.5900(2) Å	β = 100.117(2)°.
	c = 19.2583(5) Å	γ = 90°.
Volume	2161.99(10) Å <sup>3</sup>	
Z	4	
Density (calculated)	1.332 Mg/m <sup>3</sup>	
Absorption coefficient	0.181 mm <sup>-1</sup>	
F(000)	912	
Crystal size	0.25 x 0.25 x 0.22 mm <sup>3</sup>	
Theta range for data collection	2.75 to 25.03°	
Index ranges	0 ≤ h ≤ 17, 0 ≤ k ≤ 9, -22 ≤ l ≤ 22	
Reflections collected	12508	
Independent reflections	3801 [R(int) = 0.034]	
Completeness to theta = 25.03°	99.7 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.9613 and 0.9561	
Refinement method	Full-matrix least-squares on F <sup>2</sup>	
Data / restraints / parameters	3801 / 0 / 286	

<sup>5</sup> We thank Dr. Alan Lough for X-ray crystallography.

Goodness-of-fit on $F^2$	1.071
Final R indices [ $I > 2\sigma(I)$ ]	$R1 = 0.0364$ , $wR2 = 0.0887$
R indices (all data)	$R1 = 0.0451$ , $wR2 = 0.0947$
Extinction coefficient	0.0078(15)
Largest diff. peak and hole	0.316 and -0.384 e. $\text{\AA}^{-3}$

Table 2. Atomic coordinates ( $\times 10^4$ ) and equivalent isotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for k01223.  $U(\text{eq})$  is defined as one third of the trace of the orthogonalized  $U^{ij}$  tensor

	x	y	z	U(eq)
S(1)	4677(1)	6100(1)	1026(1)	26(1)
O(1)	8113(1)	2751(2)	2231(1)	40(1)
O(2)	4933(1)	6465(2)	1765(1)	32(1)
O(3)	5188(1)	6878(2)	536(1)	31(1)
N(1)	7475(1)	240(2)	1652(1)	29(1)
N(2)	4752(1)	4006(2)	922(1)	27(1)
N(3)	8025(1)	-2423(2)	1352(1)	38(1)
C(1)	7453(1)	1898(2)	1949(1)	30(1)
C(2)	6497(1)	2404(2)	1854(1)	30(1)
C(3)	5980(1)	1121(2)	1527(1)	28(1)
C(4)	6562(1)	-362(2)	1358(1)	32(1)
C(5)	4970(1)	997(2)	1333(1)	31(1)
C(6)	4465(1)	2715(2)	1410(1)	27(1)
C(7)	3448(1)	2414(2)	1304(1)	27(1)
C(8)	3058(1)	2033(2)	1889(1)	34(1)
C(9)	2134(1)	1751(3)	1823(1)	43(1)
C(10)	1595(1)	1862(3)	1167(1)	44(1)
C(11)	1973(1)	2205(3)	578(1)	40(1)
C(12)	2897(1)	2474(2)	644(1)	32(1)
C(13)	8228(1)	-837(2)	1630(1)	30(1)
C(14)	8717(1)	-3539(3)	1340(1)	45(1)
C(15)	9604(1)	-3138(3)	1593(1)	45(1)
C(16)	9800(1)	-1475(3)	1867(1)	46(1)
C(17)	9110(1)	-285(3)	1886(1)	39(1)
C(18)	3543(1)	6734(2)	756(1)	27(1)

C(19)	2979(1)	6918(2)	1246(1)	35(1)
C(20)	2073(1)	7287(3)	1016(1)	41(1)
C(21)	1724(1)	7471(2)	304(1)	37(1)
C(22)	2305(1)	7300(2)	-177(1)	36(1)
C(23)	3210(1)	6926(2)	39(1)	33(1)
C(24)	734(1)	7850(3)	47(1)	56(1)

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Table 3. Bond lengths [ $\text{\AA}$ ] and angles [ $^\circ$ ] for k01223

S(1)-O(2)	1.4348(11)
S(1)-O(3)	1.4431(12)
S(1)-N(2)	1.6080(14)
S(1)-C(18)	1.7596(16)
O(1)-C(1)	1.227(2)
N(1)-C(1)	1.385(2)
N(1)-C(13)	1.403(2)
N(1)-C(4)	1.462(2)
N(2)-C(6)	1.474(2)
N(3)-C(13)	1.332(2)
N(3)-C(14)	1.345(2)
C(1)-C(2)	1.467(2)
C(2)-C(3)	1.332(2)
C(3)-C(4)	1.496(2)
C(3)-C(5)	1.500(2)
C(5)-C(6)	1.529(2)
C(6)-C(7)	1.523(2)
C(7)-C(8)	1.388(2)
C(7)-C(12)	1.391(2)
C(8)-C(9)	1.388(2)
C(9)-C(10)	1.378(3)
C(10)-C(11)	1.381(3)
C(11)-C(12)	1.386(2)
C(13)-C(17)	1.394(2)
C(14)-C(15)	1.370(3)
C(15)-C(16)	1.380(3)

C(16)-C(17)	1.380(3)
C(18)-C(19)	1.381(2)
C(18)-C(23)	1.391(2)
C(19)-C(20)	1.384(3)
C(20)-C(21)	1.386(3)
C(21)-C(22)	1.385(3)
C(21)-C(24)	1.510(3)
C(22)-C(23)	1.381(2)

O(2)-S(1)-O(3)	119.26(7)
O(2)-S(1)-N(2)	107.55(7)
O(3)-S(1)-N(2)	105.46(7)
O(2)-S(1)-C(18)	108.49(7)
O(3)-S(1)-C(18)	107.08(7)
N(2)-S(1)-C(18)	108.61(7)
C(1)-N(1)-C(13)	128.28(14)
C(1)-N(1)-C(4)	110.80(13)
C(13)-N(1)-C(4)	120.89(14)
C(6)-N(2)-S(1)	122.91(12)
C(13)-N(3)-C(14)	116.92(16)
O(1)-C(1)-N(1)	125.84(16)
O(1)-C(1)-C(2)	127.90(16)
N(1)-C(1)-C(2)	106.26(14)
C(3)-C(2)-C(1)	110.14(15)
C(2)-C(3)-C(4)	109.78(14)
C(2)-C(3)-C(5)	130.06(15)
C(4)-C(3)-C(5)	120.15(14)
N(1)-C(4)-C(3)	102.99(13)
C(3)-C(5)-C(6)	114.79(14)
N(2)-C(6)-C(7)	114.42(13)
N(2)-C(6)-C(5)	107.40(13)
C(7)-C(6)-C(5)	111.25(13)
C(8)-C(7)-C(12)	118.69(15)
C(8)-C(7)-C(6)	118.62(14)
C(12)-C(7)-C(6)	122.67(14)
C(7)-C(8)-C(9)	121.06(16)

C(10)-C(9)-C(8)	119.47(17)
C(9)-C(10)-C(11)	120.23(17)
C(10)-C(11)-C(12)	120.20(17)
C(11)-C(12)-C(7)	120.30(16)
N(3)-C(13)-C(17)	123.42(16)
N(3)-C(13)-N(1)	114.17(15)
C(17)-C(13)-N(1)	122.40(16)
N(3)-C(14)-C(15)	124.10(19)
C(14)-C(15)-C(16)	117.94(18)
C(15)-C(16)-C(17)	119.85(18)
C(16)-C(17)-C(13)	117.73(18)
C(19)-C(18)-C(23)	120.72(15)
C(19)-C(18)-S(1)	120.29(13)
C(23)-C(18)-S(1)	118.83(13)
C(18)-C(19)-C(20)	119.27(16)
C(19)-C(20)-C(21)	121.10(16)
C(22)-C(21)-C(20)	118.57(16)
C(22)-C(21)-C(24)	119.91(17)
C(20)-C(21)-C(24)	121.52(17)
C(23)-C(22)-C(21)	121.44(16)
C(22)-C(23)-C(18)	118.89(16)

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Symmetry transformations used to generate equivalent atoms:

Table 4. Anisotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for k01223. The anisotropic displacement factor exponent takes the form:  $-2\pi^2 [h^2 a^{*2}U^{11} + \dots + 2 h k a^* b^* U^{12}]$

	U <sup>11</sup>	U <sup>22</sup>	U <sup>33</sup>	U <sup>23</sup>	U <sup>13</sup>	U <sup>12</sup>
S(1)	25(1)	25(1)	27(1)	-2(1)	2(1)	-2(1)
O(1)	30(1)	41(1)	46(1)	-9(1)	-1(1)	-5(1)
O(2)	33(1)	34(1)	28(1)	-4(1)	-1(1)	-2(1)
O(3)	31(1)	30(1)	34(1)	-2(1)	8(1)	-8(1)
N(1)	23(1)	28(1)	35(1)	0(1)	0(1)	-2(1)
N(2)	28(1)	24(1)	27(1)	-1(1)	5(1)	0(1)
N(3)	37(1)	33(1)	43(1)	-2(1)	5(1)	3(1)

C(1)	30(1)	33(1)	25(1)	1(1)	2(1)	-3(1)
C(2)	30(1)	30(1)	30(1)	-1(1)	3(1)	2(1)
C(3)	27(1)	28(1)	28(1)	5(1)	2(1)	0(1)
C(4)	25(1)	28(1)	39(1)	0(1)	-1(1)	-2(1)
C(5)	26(1)	28(1)	38(1)	1(1)	2(1)	-1(1)
C(6)	26(1)	26(1)	28(1)	1(1)	2(1)	-1(1)
C(7)	27(1)	22(1)	31(1)	0(1)	3(1)	0(1)
C(8)	33(1)	40(1)	29(1)	0(1)	4(1)	-2(1)
C(9)	36(1)	52(1)	43(1)	-1(1)	13(1)	-6(1)
C(10)	26(1)	52(1)	53(1)	1(1)	5(1)	-5(1)
C(11)	31(1)	47(1)	38(1)	4(1)	-5(1)	-6(1)
C(12)	31(1)	34(1)	30(1)	2(1)	3(1)	-5(1)
C(13)	29(1)	33(1)	27(1)	5(1)	2(1)	2(1)
C(14)	48(1)	38(1)	49(1)	-2(1)	8(1)	9(1)
C(15)	38(1)	50(1)	46(1)	5(1)	7(1)	14(1)
C(16)	28(1)	56(1)	52(1)	3(1)	3(1)	6(1)
C(17)	29(1)	42(1)	44(1)	-1(1)	1(1)	1(1)
C(18)	28(1)	23(1)	29(1)	-2(1)	3(1)	0(1)
C(19)	35(1)	42(1)	28(1)	-4(1)	4(1)	5(1)
C(20)	34(1)	55(1)	36(1)	-3(1)	10(1)	9(1)
C(21)	30(1)	37(1)	41(1)	2(1)	2(1)	6(1)
C(22)	36(1)	40(1)	31(1)	6(1)	0(1)	0(1)
C(23)	32(1)	39(1)	29(1)	4(1)	5(1)	1(1)
C(24)	34(1)	77(2)	54(1)	5(1)	0(1)	14(1)

Table 5. Hydrogen coordinates ( $\times 10^4$ ) and isotropic displacement parameters ( $\text{\AA}^2 \times 10^{-3}$ )  
for k01223

	x	y	z	U(eq)
H(2N)	4728(13)	3710(30)	486(11)	41(6)
H(2A)	6278	3490	2003	36
H(4A)	6415	-1471	1584	38
H(4B)	6491	-546	842	38

H(5A)	4754	88	1633	37
H(5B)	4813	596	837	37
H(6A)	4666	3157	1902	33
H(8A)	3430	1965	2341	41
H(9A)	1876	1483	2227	51
H(10A)	960	1702	1121	52
H(11A)	1600	2258	126	48
H(12A)	3155	2699	237	38
H(14A)	8583	-4677	1144	54
H(15A)	10069	-3979	1581	54
H(16A)	10409	-1149	2042	55
H(17A)	9231	871	2068	47
H(19A)	3210	6792	1735	42
H(20A)	1683	7417	1352	50
H(22A)	2075	7442	-665	43
H(23A)	3600	6801	-296	40
H(24A)	476	8404	427	84
H(24B)	415	6745	-92	84
H(24C)	669	8645	-359	84

Table 6. Hydrogen bonds for k01223 [ $\text{\AA}$  and  $^\circ$ ]

D-H...A	d(D-H)	d(H...A)	d(D...A)	$\angle$ (DHA)
N(2)-H(2N)...O(3)#1	0.87(2)	2.04(2)	2.9051(18)	173.5(18)

Symmetry transformations used to generate equivalent atoms: #1  $-x+1, -y+1, -z$

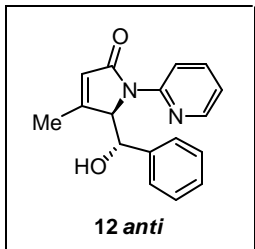


Table 7. Crystal data and structure refinement for k02207

Identification code	k02207	
Empirical formula	C <sub>34</sub> H <sub>32</sub> N <sub>4</sub> O <sub>4</sub>	
Formula weight	560.64	
Temperature	150(1) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	Pbca	
Unit cell dimensions	a = 7.46000(10) Å	α = 90°.
	b = 18.4570(3) Å	β = 90°.
	c = 20.7190(5) Å	γ = 90°.
Volume	2852.78(9) Å <sup>3</sup>	
Z	4	
Density (calculated)	1.305 Mg/m <sup>3</sup>	
Absorption coefficient	0.087 mm <sup>-1</sup>	
F(000)	1184	
Crystal size	0.35 x 0.30 x 0.20 mm <sup>3</sup>	
Theta range for data collection	2.96 to 27.49°	
Index ranges	-9 ≤ h ≤ 9, -23 ≤ k ≤ 23, -26 ≤ l ≤ 26	
Reflections collected	18863	
Independent reflections	3258 [R(int) = 0.0426]	
Completeness to theta = 27.49°	99.6 %	
Absorption correction	None	
Max. and min. transmission	0.9828 and 0.9702	
Refinement method	Full-matrix least-squares on F <sup>2</sup>	
Data / restraints / parameters	3258 / 0 / 196	
Goodness-of-fit on F <sup>2</sup>	1.016	
Final R indices [I > 2σ(I)]	R1 = 0.0376, wR2 = 0.0904	
R indices (all data)	R1 = 0.0506, wR2 = 0.0983	

Extinction coefficient	0.0085(11)
Largest diff. peak and hole	0.180 and -0.167 e.Å <sup>-3</sup>

Table 8. Atomic coordinates ( x 10<sup>4</sup>) and equivalent isotropic displacement parameters (Å<sup>2</sup> x 10<sup>3</sup>) for k02207. U(eq) is defined as one third of the trace of the orthogonalized U<sup>ij</sup> tensor

	x	y	z	U(eq)
O(1)	5419(1)	2409(1)	2750(1)	37(1)
O(2)	1836(1)	3327(1)	1365(1)	30(1)
N(1)	4500(1)	2231(1)	1690(1)	24(1)
N(2)	3027(1)	1292(1)	1181(1)	29(1)
C(1)	5349(2)	2600(1)	2179(1)	28(1)
C(2)	6135(2)	3249(1)	1889(1)	34(1)
C(3)	5740(2)	3282(1)	1266(1)	30(1)
C(4)	4545(2)	2653(1)	1087(1)	24(1)
C(5)	6345(2)	3845(1)	795(1)	41(1)
C(6)	2625(2)	2888(1)	883(1)	24(1)
C(7)	2622(2)	3284(1)	243(1)	24(1)
C(8)	1788(2)	3955(1)	180(1)	29(1)
C(9)	1806(2)	4319(1)	-409(1)	35(1)
C(10)	2640(2)	4017(1)	-938(1)	35(1)
C(11)	3442(2)	3343(1)	-887(1)	33(1)
C(12)	3435(2)	2979(1)	-300(1)	28(1)
C(13)	3859(2)	1512(1)	1714(1)	24(1)
C(14)	4161(2)	1064(1)	2247(1)	32(1)
C(15)	3567(2)	355(1)	2208(1)	38(1)
C(16)	2684(2)	114(1)	1660(1)	38(1)
C(17)	2446(2)	603(1)	1165(1)	35(1)

Table 9. Bond lengths [Å] and angles [°] for k02207

O(1)-C(1)	1.2355(14)
O(2)-C(6)	1.4142(13)
N(1)-C(1)	1.3742(14)

N(1)-C(13)	1.4128(14)
N(1)-C(4)	1.4740(14)
N(2)-C(13)	1.3301(15)
N(2)-C(17)	1.3448(15)
C(1)-C(2)	1.4618(17)
C(2)-C(3)	1.3259(18)
C(3)-C(5)	1.4953(17)
C(3)-C(4)	1.5095(16)
C(4)-C(6)	1.5547(16)
C(6)-C(7)	1.5149(15)
C(7)-C(8)	1.3923(16)
C(7)-C(12)	1.3958(16)
C(8)-C(9)	1.3924(17)
C(9)-C(10)	1.3796(19)
C(10)-C(11)	1.3845(19)
C(11)-C(12)	1.3887(17)
C(13)-C(14)	1.3975(16)
C(14)-C(15)	1.3831(17)
C(15)-C(16)	1.3856(19)
C(16)-C(17)	1.3778(18)
C(1)-N(1)-C(13)	126.62(10)
C(1)-N(1)-C(4)	110.65(9)
C(13)-N(1)-C(4)	122.26(9)
C(13)-N(2)-C(17)	117.31(11)
O(1)-C(1)-N(1)	125.65(11)
O(1)-C(1)-C(2)	127.58(11)
N(1)-C(1)-C(2)	106.77(10)
C(3)-C(2)-C(1)	110.38(11)
C(2)-C(3)-C(5)	126.92(12)
C(2)-C(3)-C(4)	109.61(11)
C(5)-C(3)-C(4)	123.47(11)
N(1)-C(4)-C(3)	102.16(9)
N(1)-C(4)-C(6)	110.88(9)
C(3)-C(4)-C(6)	113.40(9)
O(2)-C(6)-C(7)	109.98(9)
O(2)-C(6)-C(4)	110.56(9)

C(7)-C(6)-C(4)	111.90(9)
C(8)-C(7)-C(12)	118.50(10)
C(8)-C(7)-C(6)	120.75(10)
C(12)-C(7)-C(6)	120.75(10)
C(7)-C(8)-C(9)	120.43(11)
C(10)-C(9)-C(8)	120.41(12)
C(9)-C(10)-C(11)	119.81(11)
C(10)-C(11)-C(12)	119.95(12)
C(11)-C(12)-C(7)	120.87(11)
N(2)-C(13)-C(14)	123.46(11)
N(2)-C(13)-N(1)	114.56(10)
C(14)-C(13)-N(1)	121.92(10)
C(15)-C(14)-C(13)	117.48(12)
C(14)-C(15)-C(16)	120.25(12)
C(17)-C(16)-C(15)	117.46(11)
N(2)-C(17)-C(16)	124.03(12)

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Symmetry transformations used to generate equivalent atoms:

Table 10. Anisotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for k02207. The anisotropic displacement factor exponent takes the form:  $-2\pi^2 [ h^2 a^{*2} U^{11} + \dots + 2 h k a^* b^* U^{12} ]$

	U <sup>11</sup>	U <sup>22</sup>	U <sup>33</sup>	U <sup>23</sup>	U <sup>13</sup>	U <sup>12</sup>
O(1)	52(1)	34(1)	24(1)	0(1)	-9(1)	-6(1)
O(2)	40(1)	26(1)	25(1)	3(1)	10(1)	5(1)
N(1)	30(1)	22(1)	21(1)	1(1)	-3(1)	-2(1)
N(2)	34(1)	23(1)	30(1)	-3(1)	-5(1)	1(1)
C(1)	33(1)	27(1)	25(1)	-2(1)	-5(1)	0(1)
C(2)	37(1)	28(1)	37(1)	-1(1)	-8(1)	-8(1)
C(3)	28(1)	27(1)	34(1)	3(1)	-1(1)	-4(1)
C(4)	28(1)	24(1)	21(1)	2(1)	1(1)	-2(1)
C(5)	40(1)	38(1)	45(1)	12(1)	-3(1)	-13(1)
C(6)	27(1)	22(1)	22(1)	0(1)	3(1)	0(1)
C(7)	24(1)	25(1)	23(1)	1(1)	-1(1)	-3(1)
C(8)	32(1)	28(1)	28(1)	2(1)	1(1)	1(1)

C(9)	36(1)	33(1)	35(1)	10(1)	-2(1)	2(1)
C(10)	34(1)	45(1)	26(1)	11(1)	-2(1)	-6(1)
C(11)	31(1)	45(1)	23(1)	-1(1)	2(1)	-4(1)
C(12)	29(1)	30(1)	25(1)	0(1)	0(1)	0(1)
C(13)	27(1)	21(1)	25(1)	-2(1)	2(1)	2(1)
C(14)	45(1)	26(1)	27(1)	2(1)	-1(1)	-1(1)
C(15)	56(1)	26(1)	33(1)	5(1)	4(1)	1(1)
C(16)	47(1)	21(1)	45(1)	-4(1)	4(1)	-3(1)
C(17)	41(1)	25(1)	39(1)	-7(1)	-5(1)	0(1)

Table 11. Hydrogen coordinates ( $\times 10^4$ ) and isotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for k02207

	x	y	z	U(eq)
H(10)	1380(20)	3013(9)	1673(9)	63(5)
H(2A)	6830	3597	2116	41
H(4A)	5113	2361	735	29
H(5A)	7297	4138	990	61
H(5B)	5331	4157	681	61
H(5C)	6804	3608	405	61
H(6A)	1878	2441	835	28
H(8A)	1203	4166	541	35
H(9A)	1240	4778	-446	42
H(10A)	2664	4270	-1337	42
H(11A)	3997	3129	-1253	39
H(12A)	3990	2518	-268	34
H(14A)	4752	1239	2622	39
H(15A)	3766	33	2558	46
H(16A)	2257	-370	1628	45
H(17A)	1835	443	789	42

Table 12. Hydrogen bonds for k02207 [ $\text{\AA}$  and  $^\circ$ ]

D-H...A	d(D-H)	d(H...A)	d(D...A)	$\angle(\text{DHA})$
O(2)-H(1O)...O(1)#1	0.926(19)	1.785(19)	2.7109(12)	177.9(18)

Symmetry transformations used to generate equivalent atoms: #1  $x-1/2, y, -z+1/2$