Palladium-Catalyzed Dearomatizing 2,5-Alkoxyarylation of Furan Rings: Diastereospecific Access to Spirooxindoles

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General Experimental Details

IR spectra were recorded with FT-IR as a thin film or using KBr pellets and are expressed in cm\(^{-1}\). \(^1\)H (400 MHz) and \(^{13}\)C (100 MHz) NMR spectra were recorded using CDCl\(_3\) as a solvent. Chemical shifts are reported in ppm downfield to tetramethylsilane. Coupling constants are reported and expressed in Hz; splitting patterns are designated as s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (double doublet), dt (double triplet), dq (double quartet). Infrared (IR) spectra were obtained on a Bruker Vector 22 spectrometer. Mass spectra were obtained from high resolution ESI mass spectrometer. All reactions were carried out using freshly distilled and dry solvents. Column chromatography was performed over silica gel (100-200 Mesh) using petroleum ether and ethyl acetate as the eluent.
General procedure for the preparation of 1

To a solution of 20 (3 mmol) in anhydrous THF (5 mL), at -10 °C under nitrogen atmosphere, was added a solution of n-BuLi (2.1 mL, 1.6 M in hexane, 3.3 mmol). The solution was stirred for 1 h at the same temperature and then a solution of 21 (3.3 mmol) in anhydrous THF (2 mL) was added dropwise. The reaction mixture was stirred for additional 30 mins, then was quenched with saturated aq. NH₄Cl (4 mL). The organic solvent was evaporated under reduced pressure and the aqueous layer was extracted with ethyl acetate (3 × 5 mL). The combined organic layers were washed with saturated brine, dried over sodium sulfate, concentrated under reduced pressure to provide the crude product which was submitted to the next step without further purification.

The mixture of above-made crude product 22, CH₃I (10 mmol), K₂CO₃ (9 mmol) and CH₃CN (5 mL) was stirred at 80 °C under nitrogen atmosphere for about 8 h. The reaction mixture was filtered and the filtrate was concentrated to give the residue 17 which was submitted to the next step without further purification.

To the solution of the above-made residue in THF (5 ml) was added TBAF (3.6 mL, 1 M in THF). The reaction was stirred at room temperature about 30 mins. H₂O (5 mL) was added to the reaction mixture and THF was removed under reduced pressure. The resulting mixture was extracted with AcOEt (3 × 5 mL). The combined organic extracts were washed with brine, dried over Na₂SO₄, filtered and concentrated. The residue was purified by flash chromatography on a silica gel (using petroleum ether/ethyl acetate = 1:1 as the eluent) to give product 1.
General procedure for the preparation of 2

To a stirred solution of 1 (0.3 mmol) in THF (3 mL) were added LiOEtBu (48 mg, 0.6 mmol), Pd(db)3 (14 mg, 0.015 mmol, 5 mol%), and XantPhos (17.3 mg 0.03 mmol, 10 mol %) subsequently in a Schlenk flask under nitrogen atmosphere. The reaction mixture was heated at 100 °C until the disappearance of the starting material according to the TLC. H2O (5 mL) was added to the reaction mixture. The resulting mixture was extracted with AcOEt (3× 5 mL). The combined organic extracts were washed with brine, dried over Na2SO4, filtered and concentrated. The residue was purified by flash chromatography on a silica gel (using petroleum ether/ethyl acetate = 3:1 as the eluent) to give product 2.

Details of Control Experiments

Preparation of 18a

To a stirred solution of 17a (0.3 mmol) in DCE (3 mL) were added K2CO3 (83 mg, 0.6 mmol), Pd(PPh3)4 (17 mg, 0.015 mmol, 5 mol %), and PPh3 (8 mg, 0.03 mmol, 10 mol %) subsequently in a Schlenk flask under nitrogen atmosphere. The reaction was heated at 80 °C until the disappearance of the starting material according to the TLC. H2O (5 mL) was added to the reaction and the resulting mixture was extracted with AcOEt (3× 5 mL). The combined organic extracts were washed with brine, dried over Na2SO4, filtered and concentrated. The residue was purified by flash chromatography on a silica gel (using petroleum ether/ethyl acetate = 15:1 as the eluent) to give product 18a (94 mg, 85%).
Preparation of 19a

To a solution of 18a (0.25 mmol) in THF (3 mL) were added TBAF (0.3 ml, 1 M in THF). The reaction mixture was stirred at room temperature until the disappearance of the starting material according to the TLC. H2O (5 mL) was added to the reaction mixture. The resulting mixture was extracted with AcOEt (3× 5 mL). The combined organic extracts were washed with brine, dried over Na2SO4, filtered and concentrated. The residue was purified by flash chromatography on a silica gel (using petroleum ether/ethyl acetate = 1:1 as the eluent) to give product 19a (55 mg, 87%).

Transformation of 19a into 2a

To a solution of 19a (0.2 mmol) in CH2Cl2 (3 mL) were added p-TsOH (68 mg, 0.4 mmol). The reaction mixture was stirred at room temperature about 30 mins until the disappearance of the starting material according to the TLC. H2O (5 mL) was added to the reaction and the resulting mixture was extracted with CH2Cl2 (3×3 mL). The combined organic extracts were washed with brine, dried over Na2SO4, filtered and concentrated. The residue was purified by flash chromatography on a silica gel (using petroleum ether/ethyl acetate = 3:1 as the eluent) to give product 2 (44 mg, 88%, 2a:2a1 = 1:3).

Typical procedure for the preparation of 12

To the mixture of aniline (6 mmol) in dry CH2Cl2 (20 mL) was added furan-2-carbonyl chloride
(1.16 g, 9 mmol) dropwise at 0 °C. After addition, the mixture was warmed to room temperature and stirred until aniline was disappear according to the TLC. H₂O (30 mL) was added to the reaction mixture, and the organic phase was separated. The aqueous phase was extracted with CH₂Cl₂ (3 x 10 mL), and the combined organic phase was washed with brine and dried over anhydrous Na₂SO₄. The filtrate was concentrated, and the residue was purified by flash chromatography on a silica gel (using petroleum ether : ethyl acetate = 14 : 1 as the eluent) to give product 12.

**Reaction conditions optimization for 13a**

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</table>

* Reaction conditions: unless otherwise noted, [Pd] (5 mol %), L (10 mol %), base (200 mol %), and 12a (0.3 mmol) in MeOH (3 mL) at 100 °C under N₂ atmosphere for 18 h. BINAP = (+)-2,2'-bis(diphenylphosphino)-1,1'-binaphthalene; dppf = 1,1'-bis(diphenylphosphino)ferrocene; Xanphos =...
4,5-bis-diphenylphosphanyl-9,9-dimethyl-9H-xanthene; Davepos = 2-dicyclohexylphosphino-2’-(N,N-dimethylamino)biphenyl. \(^\text{b}\) The yield was determined by \(^1\)HNMR methods using dibromomethane as an internal standard. ND = not detected. \(^5\)Pd(OAc)_2 (5 mol %), BINAP (6 mol %), CH_2OH (200 mol %) in THF (3 mL). \(^6\)Pd(OAc)_2 (5 mol %), BINAP (6 mol %), Et_3N (200 mol %), CH_3OH (200 mol %) in MeCN (3 mL). \(^7\) The solvent v_1 ( MeCN ) : v_2 ( CH_3OH ) = 2 : 1. \(^8\) The solvent v_1 ( MeCN ) : v_2 ( CH_3OH ) = 1 : 1. \(^9\) The solvent v_1 ( MeCN ) : v_2 ( CH_3OH ) = 1 : 2.

**General procedure for the preparation of 13**

To a dried Schlenk tube were added Pd(OAc)_2 (4 mg, 0.015 mmol) and BINAP (13 mg 0.018 mmol) under N_2, ROH (3.0 mL) was then introduced via syringe. The resulting mixture was stirred at room temperature for 1 h, after which 12 (0.3 mmol) and Et_3N (0.6 mmol) were added and the tube was sealed using Teflon cap. The mixture was stirred at 100 \(^\circ\)C for 18 h. The solvent was then removed under vacuum and the residue was purified by chromatography on silica gel, eluting with ethyl/petroleum ether 1:14 (v/v) to afford the products.

**Characterization of 1**

\textbf{N-(2-bromophenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1a)}

\[
\text{Colorless oil, (638 mg, 63\% over 3 steps), IR (KBr) 3655, 3321, 3096, 2979, 1695, 1470, 1237, 1061, 973, 746 cm}^{-1}; \quad \text{\(^1\)H NMR (400 MHz, CDCl}_3\) \delta 7.67 (d, \(J = 7.9\) Hz, 1H), 7.37 (t, \(J = 7.5\) Hz, 1H), 7.30 – 7.24 (m, 2H), 6.01 (s, 1H), 5.88 (s, 1H), 3.52 (t, \(J = 5.8\) Hz, 2H), 3.33 (s, 3H), 2.55 (t, \(J = 6.7\) Hz, 2H), 2.46 (s, 1H), 1.73 – 1.61 (m, 2H); \text{\(^{13}\)C NMR (100 MHz, CDCl}_3\) \delta 159.2, 158.5, 145.5, 143.2, 133.7, 130.1, 129.6, 128.7, 123.4, 117.5, 107.2, 61.3, 37.1, 30.3, 24.2; HRMS (ESI) \(m/z\) calcd for C_{15}H_{16}BrNO_3 [M + H]^+: 338.0386; Found: 338.0386.

\textbf{N-(2-bromo-4-fluorophenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1b)}
Yellow oil, (534 mg, 50% over 3 steps), IR (KBr) 3696, 3042, 2947, 1765, 1668, 1590, 1199, 967, 857, 700 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.43 – 7.41 (m, 1H), 7.28 (t, J = 7.1 Hz, 1H), 7.11 – 7.08 (m, 1H), 6.15 (s, 1H), 5.92 (s, 1H), 3.55 (t, J = 6.1 Hz, 2H), 3.32 (s, 3H), 2.57 (t, J = 7.0 Hz, 2H), 2.15 (s, 1H), 1.77 – 1.64 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 161.4, 159.2, 158.6, 145.5, 139.6, 130.9, 124.1, 120.8, 117.8, 115.7, 107.3, 61.4, 37.1, 30.3, 24.3; HRMS (ESI) m/z calec for C₁₅H₁₅BrFNO₃: [M + H]⁺: 356.0292; Found: 356.0295.

**N-(2-bromo-5-fluorophenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1c)**

Colorless oil, (596 mg, 56% over 3 steps), IR (KBr) 3655, 3434, 2946, 1738, 1586, 1357, 1184, 861, 812, 746 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.66 – 7.62 (m, 1H), 7.08 – 7.01 (m, 2H), 6.35 (s, 1H), 5.97 (s, 1H), 3.57 (t, J = 6.2 Hz, 2H), 3.36 (s, 3H), 2.58 (t, J = 7.2 Hz, 2H), 1.74 – 1.67 (m, 2H), 1.63 (s, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 163.3, 160.8, 159.0, 158.8, 145.3, 144.3, 134.3, 118.1, 117.3, 117.0, 107.4, 61.2, 36.9, 30.3, 24.3; HRMS (ESI) m/z calec for C₁₅H₁₅BrFNO₃: [M + Na]⁺: 378.0112; Found: 378.0115.

**N-(2-bromo-4-methylphenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1d)**

Colorless oil, (548 mg, 49% over 3 steps), IR (KBr) 3321, 3042, 2946, 1636, 1429, 1266, 971, 744 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.49 (s, 1H), 7.17 (s, 2H), 5.90 (d, J = 5.3 Hz, 1H), 5.88 (d, J = 5.3 Hz, 1H), 3.55 (t, J = 5.7 Hz, 2H), 3.31 (s, 3H), 2.60 (t, J = 7.1 Hz, 2H), 2.39 (s, 3H), 2.20 (s, 1H), 1.77 – 1.66 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 159.4, 158.4, 145.5, 140.4, 140.2, 134.0,
129.5, 129.4, 123.0, 117.3, 107.2, 61.4, 37.0, 30.4, 24.2, 20.8; HRMS (ESI) m/z calcd for C\textsubscript{16}H\textsubscript{18}BrNO\textsubscript{3}: [M + H]\textsuperscript{+} : 374.0362; Found: 374.0366.

**N-(2-bromo-5-methylphenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1e)**

Colorless oil, (600 mg, 57% over 3 steps), IR (KBr) 3301, 2946, 1677, 1589, 1471, 1071, 958, 860, 763, 699 cm\textsuperscript{-1}; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.53 (d, \(J = 8.1\) Hz, 1H), 7.12 (s, 1H), 7.08 (d, \(J = 8.1\) Hz, 1H), 5.98 (s, 1H), 5.89 (s, 1H), 3.55 (t, \(J = 6.1\) Hz, 2H), 3.33 (s, 3H), 2.59 (t, \(J = 7.2\) Hz, 2H), 2.33 (s, 3H), 1.76 – 1.66 (m, 2H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 159.2, 158.4, 145.6, 142.7, 139.1, 133.2, 130.5, 130.4, 119.9, 117.4, 107.2, 61.4, 37.1, 30.4, 24.2, 20.7; HRMS (ESI) m/z calcd for C\textsubscript{16}H\textsubscript{18}BrNO\textsubscript{3}: [M + H]\textsuperscript{+} : 352.0543; Found: 352.0549.

**N-(2-bromo-4,6-dimethylphenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1f)**

Yellow oil, (490 mg, 45% over 3 steps), IR (KBr) 3636, 3067, 2944, 1729, 1666, 1588, 1470, 1264, 963, 853, 746 cm\textsuperscript{-1}; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.33 (s, 1H), 7.05 (s, 1H), 5.87 (s, 1H), 5.83 (s, 1H), 3.56 (t, \(J = 5.7\) Hz, 2H), 3.26 (s, 3H), 2.62 (t, \(J = 7.4\) Hz, 2H), 2.34 (s, 3H), 2.31 (s, 1H), 2.19 (s, 3H), 1.76 – 1.71 (m, 2H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 159.3, 158.5, 145.5, 139.9, 138.8, 138.1, 131.6, 131.0, 123.8, 116.6, 107.3, 61.4, 35.4, 30.4, 24.3, 20.8, 18.3; HRMS (ESI) m/z calcd for C\textsubscript{17}H\textsubscript{20}BrNO\textsubscript{3}: [M + Na]\textsuperscript{+} : 388.0519; Found: 388.0514.

**N-(2-bromo-4-methoxyphenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1g)**

Yellow oil, (300 mg, 45% over 3 steps), IR (KBr) 3664, 3067, 2944, 1729, 1666, 1588, 1470, 1264, 963, 853, 746 cm\textsuperscript{-1}; \textsuperscript{1}H NMR (400 MHz, CDCl\textsubscript{3}) \(\delta\) 7.33 (s, 1H), 7.05 (s, 1H), 5.87 (s, 1H), 5.83 (s, 1H), 3.56 (t, \(J = 5.7\) Hz, 2H), 3.26 (s, 3H), 2.62 (t, \(J = 7.4\) Hz, 2H), 2.34 (s, 3H), 2.31 (s, 1H), 2.19 (s, 3H), 1.76 – 1.71 (m, 2H); \textsuperscript{13}C NMR (100 MHz, CDCl\textsubscript{3}) \(\delta\) 159.3, 158.5, 145.5, 139.9, 138.8, 138.1, 131.6, 131.0, 123.8, 116.6, 107.3, 61.4, 35.4, 30.4, 24.3, 20.8, 18.3; HRMS (ESI) m/z calcd for C\textsubscript{17}H\textsubscript{20}BrNO\textsubscript{3}: [M + Na]\textsuperscript{+} : 388.0519; Found: 388.0514.
Colorless solid, (695 mg, 63% over 3 steps), m.p. = 103.2-104.8 °C, IR (KBr) 3635, 2920, 1734, 1641, 1595, 1426, 970, 866, 721 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.21 (d, J = 6.9 Hz, 2H), 6.91 (d, J = 8.5 Hz, 1H), 5.94 (s, 1H), 5.86 (s, 1H), 5.76 (t, J = 5.9 Hz, 2H), 3.32 (s, 3H), 2.62 (t, J = 7.1 Hz, 2H), 1.91 (s, 1H), 1.80 – 1.66 (m, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 159.7, 159.5, 158.3, 145.6, 135.9, 130.3, 124.0, 118.5, 117.3, 114.4, 107.2, 61.6, 55.8, 37.1, 30.4, 24.3; HRMS (ESI) m/z calcd for C₁₆H₁₈BrNO₄: [M + H]⁺ 368.0492; Found: 368.0492.

N-(2-bromo-4-(tert-butyl)phenyl)-5-(3-hydroxypropyl)-N-methylfuran-2-carboxamide (1h)

Colorless oil, (613 mg, 52% over 3 steps), IR (KBr) 3636, 3301, 2952, 2846, 1726, 1568, 1428, 956, 839, 750, 694 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.66 (s, 1H), 7.38 (d, J = 8.2 Hz, 1H), 7.21 (d, J = 8.2 Hz, 1H), 6.06 (s, 1H), 5.90 (s, 1H), 3.55 (t, J = 6.0 Hz, 2H), 3.33 (s, 3H), 2.57 (t, J = 6.7 Hz, 2H), 2.03 (s, 1H), 1.76 – 1.62 (m, 2H), 1.35 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 159.3, 158.2, 153.4, 145.7, 140.3, 130.5, 129.3, 125.7, 123.1, 117.4, 107.3, 61.4, 34.8, 31.2, 30.3, 24.3; HRMS (ESI) m/z calcd for C₁₉H₂₄BrNO₃: [M + H]⁺ : 394.1012; Found: 394.1012.

N-(2-bromo-4-(tert-butyl)phenyl)-N-ethyl-5-(3-hydroxypropyl)furan-2-carboxamide (1i)

Colorless oil, (647 mg, 53% over 3 steps), IR (KBr) 3636, 3354, 2923, 1732, 1632, 1524, 1466, 968, 858, 828, 743, 697 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.66 (s, 1H), 7.34 (d, J = 8.2 Hz, 1H), 7.16 (d, J = 8.2 Hz, 1H), 5.98 (s, 1H), 5.88 (s, 1H), 4.25 – 4.15 (m, 1H), 3.55 (t, J = 5.9 Hz, 2H), 3.52 – 3.41 (m, 1H), 2.55 (t, J = 6.5 Hz, 2H), 2.00 (s, 1H), 1.74 – 1.63 (m, 2H), 1.35 (s, 9H), 1.22 (t, J = 7.1 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃) δ 158.8, 158.1, 153.3, 145.9, 138.6, 130.6, 130.4, 125.3, 123.7, 117.2, 107.2, 61.5, 44.4, 34.8, 31.2, 30.4, 24.3, 12.7; HRMS (ESI) m/z calcd for C₂₀H₂₆BrNO₃: [M + H]⁺ : 408.1169; Found: 408.1169.
$N$-(2-bromo-4-(tert-butyl)phenyl)-5-(3-hydroxypropyl)-$N$-isopropylfuran-2-carboxamide (1k)

\[
\begin{align*}
&\text{N-Br} \quad \text{O} \\
&\text{O} \\
&\text{H} \\
&\text{N} \\
&\text{Br} \\
&\text{tBu} \\
&\text{O}
\end{align*}
\]

Colorless oil, (631 mg, 50% over 3 steps), IR (KBr) 3635, 3067, 2947, 1720, 1583, 1490, 1261, 971, 751, 696 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.64 (s, 1H), 7.39 (d, $J = 8.3$ Hz, 1H), 7.22 (d, $J = 8.3$ Hz, 1H), 5.87 (s, 2H), 4.92 – 4.85 (m, 1H), 3.56 (t, $J = 6.2$ Hz, 2H), 2.56 (t, $J = 7.3$ Hz, 2H), 2.10 (s, 1H), 1.72 – 1.66 (m, 2H), 1.36 (s, 12H), 1.13 (d, $J = 6.9$ Hz, 3H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 158.9, 158.0, 153.5, 146.4, 136.5, 130.9, 130.6, 125.8, 125.1, 116.9, 107.2, 61.4, 49.6, 34.8, 31.2, 30.4, 24.3, 21.9; HRMS (ESI) m/z calcld for C$_{21}$H$_{28}$BrNO$_3$: [M + H]$^+$: 422.1325; Found: 422.1323.

$N$-(2-bromophenyl)-5-(4-hydroxybutyl)-$N$-methylfuran-2-carboxamide (1l)

\[
\begin{align*}
&\text{H} \\
&\text{O} \\
&\text{O} \\
&\text{Br} \\
&\text{N} \\
&\text{O}
\end{align*}
\]

Colorless oil, (473 mg, 45% over 3 steps), IR (KBr) 3635, 3043, 2946, 1741, 1677, 1584, 1479, 1185, 972, 857, 764, 692 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.68 (d, $J = 7.9$ Hz, 1H), 7.37 (t, $J = 7.5$ Hz, 1H), 7.30 – 7.23 (m, 2H), 6.07 (s, 1H), 5.87 (s, 1H), 3.60 (t, $J = 5.3$ Hz, 2H), 3.35 (s, 3H), 2.47 (t, $J = 7.0$ Hz, 2H), 1.81 (s, 1H), 1.55 – 1.45 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 159.2, 158.7, 145.5, 143.2, 133.6, 130.0, 129.5, 128.7, 123.5, 117.5, 107.1, 62.2, 37.0, 31.9, 27.6, 23.6; HRMS (ESI) m/z calcld for C$_{16}$H$_{18}$BrNO$_3$ [M + H]$^+$: 352.0543; Found: 352.0540.

$N$-(2-bromo-5-methylphenyl)-5-(4-hydroxybutyl)-$N$-methylfuran-2-carboxamide (1m)

\[
\begin{align*}
&\text{H} \\
&\text{O} \\
&\text{O} \\
&\text{Br} \\
&\text{N} \\
&\text{O}
\end{align*}
\]

Colorless oil, (536 mg, 49% over 3 steps), IR (KBr) 3636, 3056, 2921, 1736, 1631, 1591, 1426, 1359, 939, 807, 741, 704 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.52 (d, $J = 8.1$ Hz, 1H), 7.11 (s, 1H), 7.07 (d, $J = 8.1$ Hz, 1H), 5.98 (s, 1H), 5.87 (s, 1H), 3.60 (t, $J = 6.1$ Hz, 2H), 3.31 (s, 3H), 2.49
1H NMR (400 MHz, CDCl₃) δ 7.53 (d, J = 8.6 Hz, 1H), 7.08 (d, J = 5.9 Hz, 2H), 5.92 (s, 1H), 5.85 (s, 1H), 4.20 – 4.10 (m, 1H), 3.60 (t, J = 6.1 Hz, 2H), 3.54 – 3.45 (m, 1H), 2.50 (s, 1H), 2.49 (t, J = 7.0 Hz, 2H), 2.33 (s, 3H), 1.59 – 1.45 (m, 4H), 1.22 (t, J = 7.1 Hz, 3H); 13C NMR (100 MHz, CDCl₃) δ 158.6, 158.7, 145.4, 140.4, 140.1, 134.0, 129.5, 129.4, 123.0, 117.3, 107.0, 62.1, 37.0, 31.9, 27.6, 23.7, 20.8; HRMS (ESI) m/z calcld for C₁₇H₂₀BrNO₃ [M + Na]+: 388.0516; Found: 388.0519.
Colorless oil, (602 mg, 53% over 3 steps), IR (KBr) 3596, 3041, 2945, 1635, 1428, 1264, 930, 744, 701 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.32 (s, 1H), 7.04 (s, 1H), 5.85 (d, J = 2.7 Hz, 1H), 5.83 (d, J = 2.7 Hz, 1H), 3.61 (t, J = 6.1 Hz, 2H), 3.25 (s, 3H), 2.53 (t, J = 6.6 Hz, 2H), 2.34 (s, 3H), 2.19 (s, 3H), 1.60 – 1.45 (m, 4H); ¹³C NMR (100 MHz, CDCl₃) δ 159.3, 158.8, 145.4, 139.8, 138.8, 138.1, 131.6, 131.0, 123.8, 116.6, 107.1, 62.2, 35.3, 31.9, 27.7, 23.6, 20.8, 18.3; HRMS (ESI) m/z calcd for C₁₈H₂₂BrNO₃ [M + H]⁺: 380.0856; Found: 380.0855.

N-(2-bromo-4-(tert-butyl)phenyl)-5-(4-hydroxybutyl)-N-methylfuran-2-carboxamide (1q)

Colorless solid, (683 mg, 56% over 3 steps), m.p. = 77.8 – 78.4°C, IR (KBr) 3635, 3043, 2947, 1724, 1582, 1491, 1193, 968, 853, 750, 694 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.66 (s, 1H), 7.37 (d, J = 8.2 Hz, 1H), 7.21 (d, J = 8.2 Hz, 1H), 7.02 (s, 1H), 5.87 (s, 1H), 5.97 (s, 1H), 3.61 (t, J = 5.7 Hz, 2H), 3.33 (s, 3H), 2.47 (t, J = 6.4 Hz, 2H), 1.82 (s, 1H), 1.58 – 1.45 (m, 4H), 1.35 (s, 9H); ¹³C NMR (100 MHz, CDCl₃) δ 159.2, 158.6, 153.4, 145.6, 140.3, 130.5, 129.3, 125.7, 123.0, 117.4, 107.1, 62.2, 37.0, 34.8, 31.9, 31.2, 27.6, 23.6; HRMS (ESI) m/z calcd for C₂₀H₂₆BrNO₃ [M + H]⁺: 408.1169; Found: 408.1169.

N-(2-bromo-4-methoxyphenyl)-5-(4-hydroxybutyl)-N-methylfuran-2-carboxamide (1r)

Colorless solid, (720 mg, 63% over 3 steps), m.p. = 91.5 – 92.8°C, IR (KBr) 3065, 2946, 1736, 1588, 1438, 1144, 949, 862, 749 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.23 – 7.07 (m, 2H), 6.93 – 6.83 (m, 1H), 5.91 (s, 1H), 5.86 (s, 1H), 3.84 (s, 3H), 3.59 (t, J = 5.7 Hz, 2H), 3.29 (s, 3H), 2.52 (t,
$J = 5.7 \text{ Hz, 2H}$, 1.59 – 1.48 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 159.6, 159.5, 158.7, 145.4, 135.8, 130.3, 123.9, 118.5, 117.3, 114.4, 107.0, 62.1, 55.8, 37.1, 31.9, 27.7, 23.7; HRMS (ESI) m/z calcd for C$_{17}$H$_{20}$BrNO$_4$ [M + H]$^+$: 382.0648; Found: 382.0648.

$N$-(2-bromo-4-fluorophenyl)-5-(4-hydroxybutyl)-$N$-methylfuran-2-carboxamide (1s)

Yellow oil, (610 mg, 55% over 3 steps), IR (KBr) 3634, 3041, 2946, 1735, 1668, 1591, 1489, 1241 971, 855, 742, 703 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) δ 7.46 – 7.37 (m, 1H), 7.37 – 7.24 (m, 1H), 7.16 – 7.05 (m, 1H), 6.19 (s, 1H), 5.91 (s, 1H), 3.59 (t, $J = 6.1$ Hz, 2H), 3.31 (s, 3H), 2.54 (s, 1H), 2.48 (t, $J = 7.0$ Hz, 2H), 1.59 – 1.41 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 161.5, 159.2, 158.9, 145.4, 139.5, 130.9, 124.1, 120.7, 117.8, 115.7, 107.1, 62.1, 37.1, 31.8, 27.6, 23.7; HRMS (ESI) m/z calcd for C$_{16}$H$_{17}$BrFNO$_3$ [M + H]$^+$: 370.0449; Found: 370.0449.

$N$-(2-bromo-5-fluorophenyl)-5-(4-hydroxybutyl)-$N$-methylfuran-2-carboxamide (1t)

Colorless oil, (444 mg, 40% over 3 steps), IR (KBr) 3435, 3066, 2921, 1775, 1650, 1584, 1471, 1193, 967, 859, 746 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) δ 7.65 – 7.61 (m, 1H), 7.14 – 6.97 (m, 2H), 6.33 (s, 1H), 5.92 (s, 1H), 3.62 (t, $J = 6.5$ Hz, 2H), 3.34 (s, 3H), 2.48 (t, $J = 7.0$ Hz, 2H), 1.94 (s, 1H), 1.55 – 1.45 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$) δ 163.3, 160.8, 158.9, 145.4, 134.3, 118.0, 117.5, 117.3, 116.9, 116.7, 107.2, 62.2, 36.9, 31.9, 27.7, 23.7; HRMS (ESI) m/z calcd for C$_{16}$H$_{17}$BrFNO$_3$: [M + H]$^+$: 370.0449; Found: 370.0447.

$N$-(2-bromophenyl)-5-(5-hydroxypentyl)-$N$-methylfuran-2-carboxamide (1u)

$N$-(2-bromophenyl)-5-(5-hydroxypentyl)-$N$-methylfuran-2-carboxamide (1u)
Yellow oil, (438 mg, 40% over 3 steps), IR (KBr) 3643, 3094, 1733, 1650, 1183, 917, 812, 746 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.65 (d, \(J = 7.1\) Hz, 1H), 7.35 (t, \(J = 7.1\) Hz, 1H), 7.28 – 7.22 (m, 2H), 6.06 (s, 1H), 5.83 (s, 1H), 3.59 (t, \(J = 6.5\) Hz, 2H), 3.32 (s, 3H), 2.48 (t, \(J = 7.0\) Hz, 2H), 2.28 (s, 1H), 1.47 – 1.41 (m, 2H), 1.27 – 1.25 (m, 2H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 159.2, 158.9, 145.5, 133.7, 130.0, 129.7, 128.7, 123.4, 117.5, 116.0, 62.4, 37.0, 32.2, 27.8, 27.1, 25.1; HRMS (ESI) \textit{m/z} calcd for C\(_{17}\)H\(_{20}\)BrNO\(_3\) [M + H]\(^+\): 366.0699; Found: 366.0698.

\(N\)-(2-bromophenyl)-5-(6-hydroxyhexyl)-N-methylfuran-2-carboxamide (1v)

Yellow oil, (530 mg, 46% over 3 steps), IR (KBr) 3615, 3206, 2945, 1660, 1584, 1473, 1187, 945, 747 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.67 (d, \(J = 7.9\) Hz, 1H), 7.36 (t, \(J = 7.5\) Hz, 1H), 7.23 – 7.29 (m, 2H), 6.08 (s, 1H), 5.84 (s, 1H), 3.62 (t, \(J = 6.4\) Hz, 2H), 3.34 (s, 3H), 2.48 (t, \(J = 7.0\) Hz, 2H), 1.69 (s, 1H), 1.55 – 1.49 (m, 2H), 1.46 – 1.37 (m, 2H), 1.36 – 1.25 (m, 2H), 1.25 – 1.22 (m, 2H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 159.2, 159.1, 145.5, 143.2, 133.7, 130.1, 129.5, 128.6, 123.5, 117.5, 106.8, 62.7, 37.0, 32.5, 28.6, 27.8, 27.3, 25.3; HRMS (ESI) \textit{m/z} calcd for C\(_{18}\)H\(_{22}\)BrNO\(_3\) [M + Na]\(^+\): 402.0675; Found: 402.0671.

\(N\)-(2-bromophenyl)-5-(2-hydroxyethyl)-N-methylfuran-2-carboxamide (1w)

Colorless oil, (406 mg, 42% over 3 steps), IR (KBr) 3606, 3051, 2948, 1733, 1588, 1431, 1265, 945, 743 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.67 (d, \(J = 7.9\) Hz, 1H), 7.36 (t, \(J = 7.5\) Hz, 1H), 7.27 (dd, \(J = 13.5, 6.9\) Hz, 2H), 6.00 (s, 1H), 5.96 (s, 1H), 3.67 (t, \(J = 5.6\) Hz, 2H), 3.33 (s, 3H), 2.72 (t, \(J = 5.6\) Hz, 2H), 2.60 (s, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 159.2, 156.0, 145.8, 143.0, 133.7, 130.0, 129.7, 128.7, 123.4, 117.5, 108.4, 60.0, 37.0, 31.6; HRMS (ESI) \textit{m/z} calcd for C\(_{14}\)H\(_{14}\)BrNO\(_3\)[M + Na]\(^+\): 346.0049; Found: 346.0043.
Characterization of 2

1'-methyl-spiro[2,3’]oxindole-spiro[2,2’’]tetrahydrofuran-2,5-dihydrofuran (2a)

Yellow oil, (63 mg, 82%), IR (KBr) 2944, 2847, 1730, 1609, 1490, 1348, 1001, 864, 751, 692 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.34 (t, J = 7.6 Hz, 1H), 7.13 – 7.06 (m, 2H), 6.83 (d, J = 7.8 Hz, 1H), 6.15 (d, J = 5.6 Hz, 1H), 5.87 (d, J = 5.6 Hz, 1H), 4.28 – 4.16 (m, 1H), 4.05 – 3.89 (m, 1H), 3.20 (s, 3H), 2.31 – 2.23 (m, 2H), 2.23 – 2.12 (m, 1H), 2.06 – 1.99 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 173.7, 144.0, 132.0, 130.7, 130.2, 127.7, 124.2, 122.9, 120.6, 108.4, 89.0, 69.0, 37.7, 26.5, 24.7; HRMS (ESI) m/z calcd for C₁₅H₁₅NO₃ [M + Na]⁺: 280.0944; Found: 280.0951.

1'-methyl-spiro[2,3’]5'-fluoro-oxindole-spiro[2,2’’]tetrahydrofuran-2,5-dihydrofuran (2b)

Yellow oil, (76 mg, 85%), IR (KBr) 2925, 2849, 1730, 1494, 1110, 980, 804, 747, 699 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.11 (d, J = 7.4 Hz, 1H), 7.03 (t, J = 8.8 Hz, 1H), 6.79 – 3.71 (m, 1H), 6.15 (d, J = 5.7 Hz, 1H), 5.84 (d, J = 5.7 Hz, 1H), 4.24 – 4.10 (m, 1H), 3.98 – 3.92 (m, 1H), 3.20 (s, 3H), 2.47 (q, J = 11.4 Hz, 1H), 2.29 – 2.15 (m, 2H), 2.05 (t, J = 11.3 Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 174.3, 159.7, 139.2, 132.3, 130.2, 129.5, 121.0, 116.4, 113.5, 108.8, 89.0, 69.0, 37.0, 26.6, 24.7; HRMS (ESI) m/z calcd for C₁₅H₁₄FNO₃ [M + Na]⁺: 298.0850; Found: 298.0858.

1'-methyl-spiro[2,3’]6'-fluoro-oxindole-spiro[2,2’’]tetrahydrofuran-2,5-dihydrofuran (2c)

Yellow solid, (68 mg, 83%), m.p. = 124.8-125.5 °C, IR (KBr) 2947, 2823, 1735, 1581, 1264, 1186, 965, 748 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.14 – 7.00 (m, 1H), 6.74 (t, J = 8.8 Hz, 1H), 6.57 (d, J = 8.2 Hz, 1H), 6.16 (d, J = 5.7 Hz, 1H), 5.84 (d, J = 5.7 Hz, 1H), 4.23 – 4.18 (m, 1H), 3.98 (q,
$J = 7.4 \text{ Hz, } 1\text{H}$), 3.19 (s, 3H), 2.33 – 2.12 (m, 3H), 2.09 – 1.98 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.0, 164.3, 145.7, 132.4, 130.4, 125.6, 123.0, 120.5, 109.4, 97.4, 88.4, 69.0, 37.7, 26.6, 24.7; HRMS (ESI) $m/z$ calcd for C$_{15}$H$_{14}$FNO$_3$ [M + Na]$^+$: 298.0850; Found: 298.0856.

$1'$-methyl-spiro[2,3']5'-methyl-oxindole-spiro[2,2'']tetrahydrofuran-2,5-dihydrofuran (2d)

Yellow oil, (61 mg, 75%), IR (KBr) 2948, 2824, 1725, 1583, 1491, 1262, 749 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.11 (d, $J = 7.9$ Hz, 1H), 6.91 (s, 1H), 6.70 (d, $J = 7.9$ Hz, 1H), 6.12 (d, $J = 5.7$ Hz, 1H), 5.84 (d, $J = 5.7$ Hz, 1H), 4.22 – 4.17 (m, 1H), 3.96 (q, $J = 7.5$ Hz, 1H), 3.16 (s, 3H), 2.31 (s, 3H), 2.26 (t, $J = 6.9$ Hz, 2H), 2.18 – 2.14 (m, 1H), 2.07 – 1.96 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 173.7, 141.6, 132.5, 131.9, 130.9, 130.9, 127.6, 125.0, 120.5, 108.2, 89.2, 69.0, 37.7, 26.5, 24.7, 20.9; HRMS (ESI) $m/z$ calcd for C$_{16}$H$_{17}$NO$_3$ [M + Na]$^+$: 294.1101; Found: 294.1105.

$1'$-methyl-spiro[2,3']6'-methyl-oxindole-spiro[2,2'']tetrahydrofuran-2,5-dihydrofuran (2e)

Yellow oil, (65 mg, 80%), IR (KBr) 2946, 2845, 1728, 1582, 1466, 1262, 948, 835, 751, 699 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.00 (d, $J = 7.5$ Hz, 1H), 6.88 (d, $J = 7.5$ Hz, 1H), 6.65 (s, 1H), 6.14 (d, $J = 5.6$ Hz, 1H), 5.85 (d, $J = 5.6$ Hz, 1H), 4.27 – 4.17 (m, 1H), 4.00 – 3.95 (m, 1H), 3.19 (s, 3H), 2.40 (s, 3H), 2.28 – 2.13 (m, 3H), 2.07 – 1.96 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.0, 144.1, 140.7, 131.9, 130.8, 124.7, 124.0, 123.4, 120.4, 109.3, 88.9, 68.9, 37.7, 26.4, 24.7, 21.9; HRMS (ESI) $m/z$ calcd for C$_{16}$H$_{17}$NO$_3$ [M + Na]$^+$: 294.1101; Found: 294.1105.

$1'$-methyl-spiro[2,3']5',7'-dimethyl-oxindole-spiro[2,2'']tetrahydrofuran-2,5-dihydrofuran (2f)
Yellow oil, (60 mg, 70%), IR (KBr) 2944, 2828, 1725, 1678, 1585, 1473, 1264, 1161, 990, 746 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 6.87 (s, 1H), 6.76 (s, 1H), 6.12 (d, $J = 5.6$ Hz, 1H), 5.84 (d, $J = 5.6$ Hz, 1H), 4.24 – 4.19 (m, 1H), 3.98 (q, $J = 7.5$ Hz, 1H), 3.46 (s, 3H), 2.52 (s, 3H), 2.28 (s, 3H), 2.27 – 2.16 (m, 3H), 2.05 – 1.99 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.4, 139.2, 134.3, 132.4, 131.7, 131.1, 128.3, 122.9, 120.4, 119.8, 88.7, 68.9, 37.7, 29.9, 24.7, 20.6, 18.7; HRMS (ESI) m/z calcd for C$_{17}$H$_{19}$NO$_3$ [M + Na]$^+$: 308.1257; Found: 308.1264.

$1'$-methyl-spiro[2,3'']/5'-methoxy-oxindole-spiro[2,2''']tetrahydrofuran-2,5-dihydrofuran (2g)

Yellow oil, (63 mg, 75%), IR (KBr) 2947, 2823, 1726, 1582, 1492, 1265, 1188, 924, 856, 743 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 6.85 – 6.82 (m, 1H), 6.78 – 6.65 (m, 2H), 6.13 (d, $J = 5.6$ Hz, 1H), 5.85 (d, $J = 5.6$ Hz, 1H), 4.28 – 4.16 (m, 1H), 3.96 (q, $J = 7.4$ Hz, 1H), 3.78 (s, 3H), 3.16 (s, 3H), 2.29 – 2.12 (m, 3H), 2.06 – 1.98 (m, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 173.4, 156.3, 137.4, 132.0, 130.7, 129.0, 120.6, 114.3, 111.7, 108.8, 89.3, 69.0, 55.8, 37.7, 26.6, 24.7; HRMS (ESI) m/z calcd for C$_{16}$H$_{17}$NO$_4$ [M + Na]$^+$: 310.1050; Found: 310.1057.

$1'$-methyl-spiro[2,3'']/5'-(tert-butyl)-oxindole-spiro[2,2''']tetrahydrofuran-2,5-dihydrofuran (2h)

Yellow oil, (68 mg, 72%), IR (KBr) 2951, 2823, 1730, 1581, 1494, 1264, 1190, 947, 747 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.34 (d, $J = 7.4$ Hz, 1H), 7.11 (s, 1H), 6.74 (d, $J = 8.2$ Hz, 1H), 6.14 (d, $J = 5.7$ Hz, 1H), 5.86 (d, $J = 5.7$ Hz, 1H), 4.23 – 4.18 (m, 1H), 3.97 (q, $J = 7.5$ Hz, 1H), 3.17 (s, 3H), 2.92 – 2.16 (m, 3H), 2.08 – 1.97 (m, 1H), 1.30 (s, 9H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 173.8,
146.2, 141.6, 132.0, 127.3, 126.9, 121.2, 120.5, 107.9, 89.3, 68.9, 37.8, 34.5, 31.5, 26.5, 24.7; HRMS (ESI) m/z calc'd for C_{19}H_{23}NO_{3} [M + Na]^+: 336.1570; Found: 336.1577.

1'-ethyl-spiro[2,3']5'- tert-butyl]-oxindole-spiro[2,2'']tetrahydrofuran-2,5-dihydrofuran (2i)

Yellow oil, (64 mg, 65%), IR (KBr) 2960, 1730, 1599, 1469, 1210, 976, 878, 832, 744 cm\(^{-1}\); 
\(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.33 (d, \(J = 7.5\) Hz, 1H), 7.11 (s, 1H), 6.76 (d, \(J = 8.2\) Hz, 1H), 6.13 (d, \(J = 5.7\) Hz, 1H), 5.86 (d, \(J = 5.7\) Hz, 1H), 4.24 – 4.19 (m, 1H), 3.97 (q, \(J = 7.4\) Hz, 1H), 3.81 – 3.62 (m, 2H), 2.34 – 2.12 (m, 3H), 2.04 – 2.01 (m, 1H), 1.30 (s, 9H), 1.26 (t, \(J = 7.2\) Hz, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 173.3, 145.9, 140.7, 131.8, 131.0, 127.5, 126.9, 121.4, 120.5, 108.1, 89.4, 69.0, 37.8, 35.0, 34.5, 31.5, 24.8, 12.6; HRMS (ESI) m/z calc'd for C\(_{20}\)H\(_{25}\)NO\(_{3}\) [M + Na]^+: 350.1727; Found: 350.1735.

1'-methyl-spiro[2,3']oxindole-spiro[2,2'']tetrahydro-2H-pyran-2,5-dihydrofuran (2l)

Yellow oil, (59 mg, 73%), IR (KBr) 2943, 2848, 1731, 1609, 1492, 1368, 1265, 1001, 976, 943, 866, 749 cm\(^{-1}\); \(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.33 (t, \(J = 7.6\) Hz, 1H), 7.14 – 7.02 (m, 2H), 6.82 (d, \(J = 7.8\) Hz, 1H), 6.15 (d, \(J = 5.7\) Hz, 1H), 5.81 (d, \(J = 5.7\) Hz, 1H), 4.04 (t, \(J = 11.8\) Hz, 1H), 3.91 – 3.82 (m, 1H), 2.10 – 1.96 (m, 1H), 1.91 (d, \(J = 12.4\) Hz, 2H), 1.80 – 1.60 (m, 2H), 1.53 (d, \(J = 13.4\) Hz, 1H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 173.8, 143.9, 134.4, 130.2, 130.1, 127.9, 124.4, 122.9, 112.1, 108.4, 89.9, 63.0, 35.3, 26.5, 24.7, 19.3; HRMS (ESI) m/z calc'd for C\(_{16}\)H\(_{17}\)NO\(_{3}\) [M + Na]^+: 294.1101; Found: 294.1108.

1'-methyl-spiro[2,3']6'-methyl-oxindole-spiro[2,2'']tetrahydro-2H-pyran-2,5-dihydrofuran (2m)

Yellow oil, (86 mg, 65%), IR (KBr) 2960, 1730, 1599, 1469, 1210, 976, 878, 832, 744 cm\(^{-1}\); \(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.33 (d, \(J = 7.5\) Hz, 1H), 7.11 (s, 1H), 6.76 (d, \(J = 8.2\) Hz, 1H), 6.13 (d, \(J = 5.7\) Hz, 1H), 5.86 (d, \(J = 5.7\) Hz, 1H), 4.24 – 4.19 (m, 1H), 3.97 (q, \(J = 7.4\) Hz, 1H), 3.81 – 3.62 (m, 2H), 2.34 – 2.12 (m, 3H), 2.04 – 2.01 (m, 1H), 1.30 (s, 9H), 1.26 (t, \(J = 7.2\) Hz, 3H); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 173.3, 145.9, 140.7, 131.8, 131.0, 127.5, 126.9, 121.4, 120.5, 108.1, 89.4, 69.0, 37.8, 35.0, 34.5, 31.5, 24.8, 12.6; HRMS (ESI) m/z calc'd for C\(_{20}\)H\(_{25}\)NO\(_{3}\) [M + Na]^+: 350.1727; Found: 350.1735.
Yellow oil, (57 mg, 69%), IR (KBr) 2943, 2849, 1733, 1619, 1370, 1213, 1003, 978, 944, 807, 702 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 6.91 (d, \(J = 7.5\) Hz, 1H), 6.78 (d, \(J = 7.5\) Hz, 1H), 6.57 (s, 1H), 6.06 (d, \(J = 5.7\) Hz, 1H), 5.71 (d, \(J = 5.7\) Hz, 1H), 4.02 – 3.92 (m, 1H), 3.79 (t, \(J = 9.7\) Hz, 1H), 3.10 (s, 3H), 2.31 (s, 3H), 1.96 – 1.92 (m, 1H), 1.89 – 1.77 (m, 2H), 1.69 – 1.55 (m, 2H), 1.45 (d, \(J = 13.1\) Hz, 1H); \(^1^3\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 174.1, 144.0, 140.7, 134.2, 130.4, 125.0, 124.1, 123.4, 111.9, 109.3, 89.8, 63.0, 35.3, 26.4, 24.7, 21.9, 19.3; HRMS (ESI) \(m/z\) calcd for C\(_{17}\)H\(_{19}\)NO\(_3\) [M + Na\(^+\)]: 308.1257; Found: 308.1263.

\(1\)'-ethyl-spiro\[2,3']\(6\)'-methyl-oxindole-spiro\[2,2''\]tetrahydro-2H-pyran-2,5-dihydrofuran (2n)

Colorless oil, (60 mg, 67%), IR (KBr) 2925, 2850, 1730, 1464, 1212, 1101, 947, 801, 748, 699 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 6.91 (d, \(J = 7.5\) Hz, 1H), 6.77 (d, \(J = 7.5\) Hz, 1H), 6.59 (s, 1H), 6.06 (d, \(J = 5.7\) Hz, 1H), 5.71 (d, \(J = 5.7\) Hz, 1H), 3.97 (t, \(J = 11.2\) Hz, 1H), 3.79 (t, \(J = 7.5\) Hz, 1H), 3.68 – 3.61 (m, 2H), 2.31 (s, 3H), 1.93 – 1.89 (m, 1H), 1.83 (d, \(J = 12.6\) Hz, 2H), 1.67 (d, \(J = 5.1\) Hz, 2H), 1.51 – 1.39 (m, 1H), 1.20 (t, \(J = 7.3\) Hz, 3H); \(^1^3\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 173.7, 143.1, 140.6, 134.0, 130.5, 125.2, 124.3, 123.1, 112.0, 109.4, 89.9, 63.0, 35.3, 34.9, 24.7, 21.9, 19.4, 12.6; HRMS (ESI) \(m/z\) calcd for C\(_{18}\)H\(_{21}\)NO\(_3\) [M + Na\(^+\)]: 322.1414; Found: 322.1416.

\(1\)'-methyl-spiro\[2,3']\(5\)'-methyl-oxindole-spiro\[2,2''\]tetrahydro-2H-pyran-2,5-dihydrofuran (2o)

Colorless oil, (59 mg, 72%), IR (KBr) 2950, 2823, 1735, 1582, 1264, 939, 855, 747 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.12 (d, \(J = 7.8\) Hz, 1H), 6.90 (s, 1H), 6.70 (d, \(J = 7.8\) Hz, 1H), 6.14 (d, \(J = 5.7\) Hz, 1H), 5.80 (d, \(J = 5.7\) Hz, 1H), 4.04 (t, \(J = 11.7\) Hz, 1H), 3.87 (d, \(J = 10.5\) Hz, 1H), 3.18 (s, 3H), 2.32 (s, 3H), 2.06 – 1.95 (m, 3H), 1.79 – 1.61 (m, 2H), 1.54 (d, \(J = 13.2\) Hz, 1H); \(^1^3\)C NMR (100 MHz, CDCl\(_3\)) \(\delta\) 173.8, 141.5, 134.2, 132.5, 130.4, 130.4, 127.9, 125.1, 112.1, 108.1,
90.0, 63.0, 35.3, 26.5, 24.7, 21.0, 19.4; HRMS (ESI) \( m/z \) caled for \( \text{C}_{17}\text{H}_{19}\text{NO}_3 \ [\text{M} + \text{Na}]^+ \): 308.1257; Found: 308.1264.

\[ \text{1'}-\text{methyl-spiro}[2,3']5',7'-\text{dimethyl-oxindole-spiro}[2,2'']\text{tetrahydro-2H-pyran-2,5-dihydrofuran (2p)} \]

Colorless oil, (58 mg, 65%), IR (KBr) 2946, 2823, 1728, 1583, 1481, 1264, 944, 747 cm\(^{-1}\); \( ^1\text{H} \) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 6.88 (s, 1H), 6.75 (s, 1H), 6.15 (d, \( J = 5.7 \) Hz, 1H), 5.80 (d, \( J = 5.7 \) Hz, 1H), 4.06 (t, \( J = 11.7 \) Hz, 1H), 3.89 (d, \( J = 10.5 \) Hz, 1H), 3.47 (s, 3H), 2.53 (s, 3H), 2.28 (s, 3H), 2.12 – 1.87 (m, 3H), 1.82 – 1.71 (m, 2H), 1.56 (d, \( J = 13.3 \) Hz, 1H); \( ^{13}\text{C} \) NMR (100 MHz, CDCl\(_3\)) \( \delta \) 174.5, 139.0, 134.3, 134.0, 132.4, 130.7, 128.6, 123.0, 119.8, 112.0, 89.6, 63.0, 35.3, 29.9, 24.7, 20.6, 19.4, 18.7; HRMS (ESI) \( m/z \) caled for \( \text{C}_{18}\text{H}_{21}\text{NO}_3 \ [\text{M} + \text{Na}]^+ \): 322.1414; Found: 322.1416.

\[ \text{1'}-\text{methyl-spiro}[2,3']5'-(\text{ tert-butyl} )-\text{oxindole-spiro}[2,2'']\text{tetrahydro-2H-pyran-2,5-dihydrofuran (2q)} \]

Yellow oil, (68 mg, 70%), IR (KBr) 2949, 2824, 1734, 1583, 1491, 1266, 942, 744 cm\(^{-1}\); \( ^1\text{H} \) NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.41 (s, 1H), 7.36 (d, \( J = 8.1 \) Hz, 1H), 6.77 (d, \( J = 8.1 \) Hz, 1H), 6.15 (d, \( J = 5.7 \) Hz, 1H), 5.85 (d, \( J = 5.7 \) Hz, 1H), 3.99 (t, \( J = 11.5 \) Hz, 1H), 3.85 (d, \( J = 8.9 \) Hz, 1H), 3.21 (s, 3H), 2.21 (d, \( J = 9.8 \) Hz, 1H), 1.96 (t, \( J = 9.5 \) Hz, 2H), 1.78 – 1.69 (m, 2H), 1.56 (d, \( J = 12.6 \) Hz, 1H), 1.32 (s, 9H); \( ^{13}\text{C} \) NMR (100 MHz, CDCl\(_3\)) \( \delta \) 174.8, 146.7, 141.0, 134.1, 130.6, 127.8, 126.5, 122.8, 112.1, 107.7, 90.3, 62.9, 34.6, 34.2, 31.4, 26.5, 24.8, 19.3; HRMS (ESI) \( m/z \) caled for \( \text{C}_{20}\text{H}_{25}\text{NO}_3 \ [\text{M} + \text{Na}]^+ \): 350.1724; Found: 350.1730.

\[ \text{1'}-\text{methyl-spiro}[2,3']5'-\text{methoxy-oxindole-spiro}[2,2'']\text{tetrahydro-2H-pyran-2,5-dihydrofuran (2r)} \]
Yellow oil, (64 mg, 72%), IR (KBr) 2924, 2849, 1728, 1589, 1496, 1353, 1269, 1116, 1027, 980, 795, 747 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 6.97 (d, J = 1.8 Hz, 1H), 6.92 – 6.79 (m, 1H), 6.75 (d, J = 8.4 Hz, 1H), 6.14 (d, J = 5.7 Hz, 1H), 5.82 (d, J = 5.7 Hz, 1H), 3.99 (t, J = 11.7 Hz, 1H), 3.85 (s, 1H), 3.80 (s, 3H), 3.20 (s, 3H), 2.21 (d, J = 9.1 Hz, 1H), 1.96 (d, J = 9.0 Hz, 2H), 1.79 – 1.76 (m, 1H), 1.69 (d, J = 14.1 Hz, 1H), 1.56 (d, J = 13.4 Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 174.4, 156.6, 136.8, 134.2, 130.4, 114.9, 112.3, 112.2, 108.7, 90.3, 63.1, 55.9, 34.3, 26.5, 24.8, 19.3; HRMS (ESI) m/z calcd for C₁₇H₁₉NO₄ [M + Na⁺]: 324.1206; Found: 324.1212.

1'-methyl-spiro[2,3'5'-fluoro-oxindole-spiro[2,2'']tetrahydro-2H-pyran-2,5-dihydrofuran (2s)

Yellow oil, (70 mg, 80%), m.p. = 127.9 – 128.5 °C, IR (KBr) 2945, 2846, 1733, 1493, 1266, 1190, 1002, 980, 802, 700 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.00 (d, J = 7.4 Hz, 1H), 6.95 (t, J = 8.8 Hz, 1H), 6.72 – 6.61 (m, 1H), 6.06 (d, J = 5.7 Hz, 1H), 5.71 (d, J = 5.7 Hz, 1H), 3.87 (t, J = 11.0 Hz, 1H), 3.75 (d, J = 7.8 Hz, 1H), 3.12 (s, 3H), 2.09 (d, J = 8.1 Hz, 1H), 1.85 (p, J = 13.1 Hz, 2H), 1.68 (d, J = 11.0 Hz, 1H), 1.61 (t, J = 7.1 Hz, 1H), 1.47 (t, J = 12.8 Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 174.4, 159.7, 139.2, 134.6, 129.9, 116.3, 113.5, 112.5, 108.9, 108.8, 89.9, 63.1, 34.2, 26.6, 24.7, 19.3; HRMS (ESI) m/z calcd for C₁₆H₁₆FNO₃ [M + Na⁺]: 312.1006; Found: 312.1014.

1'-methyl-spiro[2,3'6'-fluoro-oxindole-spiro[2,2''']tetrahydro-2H-pyran-2,5-dihydrofuran (2t)

Yellow oil, (67 mg, 78%), IR (KBr) 2947, 2823, 1736, 1581, 1265, 932, 839, 746 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.29 – 7.27 (m, 1H), 6.87 – 6.65 (m, 1H), 6.63 – 6.50 (m, 1H), 6.14 (d, J = 5.7 Hz, 1H), 5.79 (d, J = 5.7 Hz, 1H), 3.95 (t, J = 10.7 Hz, 1H), 3.83 – 3.80 (m, 1H), 3.21 (s, 3H),
2.16 (t, $J = 10.4$ Hz, 1H), 1.93 (q, $J = 13.1$ Hz, 2H), 1.77 (d, $J = 11.5$ Hz, 1H), 1.69 – 1.64 (m, 1H), 1.56 (d, $J = 12.8$ Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.9, 164.3, 145.1, 134.5, 130.0, 126.8, 123.5, 112.3, 109.3, 97.2, 89.4, 63.1, 34.3, 26.6, 24.8, 19.3; HRMS (ESI) m/z calcld for C$_{16}$H$_{16}$FNO$_3$ [M + Na]$^+$: 312.1006; Found: 312.1011.

1'-methyl-spiro[2,3']oxindole-spiro[2,2'']oxepane-2,5-dihydrofuran (2u)

Yellow oil, (41 mg, 50%), IR (KBr) 2941, 2848, 1729, 1580, 1468, 1349, 1268, 1153, 955, 864, 747 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.31 (t, $J = 8.7$ Hz, 2H), 7.13 – 7.01 (m, 1H), 6.80 (d, $J = 7.7$ Hz, 1H), 6.27 (d, $J = 5.7$ Hz, 1H), 5.74 (d, $J = 5.7$ Hz, 1H), 4.00 – 3.86 (m, 1H), 3.78 (d, $J = 12.7$ Hz, 1H), 3.19 (s, 3H), 2.42-2.31 (m, 2H), 1.88 (d, $J = 12.3$ Hz, 1H), 1.78 (d, $J = 7.2$ Hz, 1H), 1.70 (d, $J = 20.1$ Hz, 2H), 1.61 – 1.36 (m, 4H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.7, 143.4, 133.8, 130.0, 128.9, 128.2, 125.6, 123.2, 117.3, 108.2, 89.2, 64.1, 38.2, 30.9, 29.6, 26.4, 23.2; HRMS (ESI) m/z calcld for C$_{17}$H$_{19}$NO$_3$ [M + Na]$^+$: 308.1257; Found: 308.1259.

Characterization of 15a

1'-methyl-spiro[2,3']oxindole-spiro[2,2'']tetrahydrofuran-tetrahydrofuran (15a)

Yellow oil, (44 mg, 85%), IR (KBr) 2947, 2822, 1731, 1581, 1266, 936, 855, 746 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.46 (d, $J = 7.3$ Hz, 1H), 7.27 (d, $J = 6.7$ Hz, 1H), 7.08 (t, $J = 7.5$ Hz, 1H), 6.76 (d, $J = 7.7$ Hz, 1H), 4.03 – 3.92 (m, 2H), 3.15 (s, 3H), 2.66 – 2.58 (m, 1H), 2.48 – 2.41 (m, 1H), 2.32 (dt, $J = 19.9$, 10.0 Hz, 2H), 2.23 (dd, $J = 11.9$, 7.1 Hz, 1H), 2.15 – 2.01 (m, 2H), 1.95 (dd, $J = 20.7$, 14.5 Hz, 1H); $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 177.2, 143.5, 131.1, 129.4, 124.6, 123.3, 117.1, 108.0, 83.1, 67.2, 35.7, 35.3, 34.3, 26.0, 24.2; HRMS (ESI) m/z calcld for C$_{12}$H$_{17}$NO$_3$ [M + Na]$^+$: 282.1101; Found: 282.1105.
Characterization of 16a

*1'-methyl-spiro[2,3'oxindole-spiro[2,2''tetrahydrofuran-tetrahydrofuran-3,4-diol (16a)

![Image of molecule 16a]

White solid, (45 mg, 78%), m.p. = 168.1 – 169.7 °C, IR (KBr) 2947, 2846, 1713, 1610, 1469, 1352, 1185, 1013, 967, 693 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.61 (d, J = 7.3 Hz, 1H), 7.29 (t, J = 7.8 Hz, 1H), 7.05 (t, J = 7.5 Hz, 1H), 6.76 (d, J = 7.7 Hz, 1H), 4.63 (d, J = 4.8 Hz, 1H), 4.42 (s, 1H), 4.16 – 3.99 (m, 1H), 3.95 – 3.73 (m, 2H), 3.22 (t, J = 17.7 Hz, 1H), 3.10 (s, 3H), 2.35 – 2.29 (m, 1H), 2.18 – 2.07 (m, 1H), 2.06 – 1.96 (m, 1H), 1.90 (s, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 176.8, 144.2, 130.0, 127.3, 126.0, 122.9, 116.7, 108.2, 85.3, 75.9, 75.8, 68.5, 32.5, 26.4, 23.6; HRMS (ESI) m/z calcd for C₁₅H₁₇NO₅ [M + Na]⁺: 314.0999; Found: 314.1003.

Characterization of 20a

*N-(2-bromophenyl)-5-(3-((tert-butyldimethylsilyl)oxy)propyl)-N-methylfuran-2-carboxamide (20a)

![Image of molecule 20a]

Yellow oil, (903 mg, 68%), IR (KBr) 2923, 2849, 1734, 1582, 1475, 1264, 1155, 969, 747 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.65 (d, J = 7.9 Hz, 1H), 7.34 (t, J = 7.5 Hz, 1H), 7.29 – 7.16 (m, 2H), 6.08 (s, 1H), 5.85 (s, 1H), 3.48 (t, J = 5.7 Hz, 2H), 3.33 (s, 3H), 2.50 (t, J = 6.9 Hz, 2H), 1.66 – 1.53 (m, 2H), 0.86 (s, 9H), 0.00 (s, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 159.2, 158.6, 145.6, 143.3, 133.6, 130.0, 129.4, 128.6, 123.5, 117.4, 107.0, 61.8, 37.0, 30.2, 25.9, 24.4, 18.2, -5.3; HRMS (ESI) m/z calcd for C₂₁H₃₀BrNO₃Si [M + Na]⁺: 474.1071; Found: 474.1058.

Characterization of 21a

*5-(3-((tert-butyldimethylsilyl)oxy)propylidene)-1'-methyl-5H-spiro[furan-2,3'-indolin]-2'-one (21a)

![Image of molecule 21a]
Yellow oil, (94 mg, 85%), IR (KBr) 2948, 2823, 1578, 1266, 945, 747 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.38 (t, J = 7.7 Hz, 1H), 7.21 (d, J = 7.2 Hz, 1H), 7.09 (t, J = 7.4 Hz, 1H), 6.87 (d, J = 7.7 Hz, 1H), 6.50 (d, J = 5.6 Hz, 1H), 5.91 (d, J = 5.6 Hz, 1H), 4.65 (t, J = 7.4 Hz, 1H), 3.67 (t, J = 5.7 Hz, 2H), 3.23 (s, 3H), 2.48 – 2.35 (m, 2H), 0.90 (s, 9H), 0.06 (s, 6H); ¹³C NMR (100 MHz, CDCl₃) δ 173.1, 158.8, 143.6, 130.6, 129.9, 129.0, 126.8, 125.0, 123.2, 108.5, 96.7, 90.9, 62.8, 29.2, 26.5, 25.9, 18.3, -5.2; HRMS (ESI) m/z calcld for C₂₁H₂₉NO₃Si [M + Na]⁺: 394.1809; Found: 394.1810.

Characterization of 22a

5-(3-hydroxypropylidene)-1'-methyl-5H-spiro[furan-2,3'-indolin]-2'-one (22a)

Yellow oil, (55 mg, 87%), IR (KBr) 2948, 2825, 1726, 1580, 1471, 1348, 1265, 944, 857, 750 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.36 (t, J = 7.7 Hz, 1H), 7.20 (d, J = 7.2 Hz, 1H), 7.08 (t, J = 7.5 Hz, 1H), 6.86 (d, J = 7.8 Hz, 1H), 6.50 (d, J = 5.7 Hz, 1H), 5.92 (d, J = 5.7 Hz, 1H), 4.64 (t, J = 7.6 Hz, 1H), 3.67 (t, J = 5.7 Hz, 2H), 3.21 (s, 3H), 2.49 – 2.37 (m, 2H), 1.89 (s, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 173.0, 159.8, 143.6, 130.8, 130.4, 128.9, 126.5, 125.0, 123.4, 108.7, 96.1, 91.0, 62.4, 29.1, 26.6; HRMS (ESI) m/z calcld for C₁₅H₁₅NO₃ [M + Na]⁺: 280.0944; Found: 280.0945.

Characterization of 12

Furan-2-carboxylic acid (2-bromo-phenyl)-ethyl-amide (12a)
White solid (747mg, 85%), m.p. = 70.3–72.8 °C, IR (KBr) 2986, 2833, 1730, 1620, 1453, 1260, 1020, 758 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.60 (d, J = 7.9 Hz, 1H), 7.33–7.28 (m, 1H), 7.19 (t, J = 7.7 Hz, 3H), 6.12 (br, 1H), 5.78 (br, 1H), 4.17 - 4.08 (m, 1H), 3.46–3.41 (m, 1H), 1.14 (t, J = 7.1 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 158.7, 147.2, 144.4, 141.1, 133.8, 131.1, 129.7, 128.4, 124.1, 115.7, 111.0, 44.4, 12.5; HRMS (ESI) m/z calcd for C₁₃H₁₂BrNO₂ [M+Na]⁺: 315.99585, Found: 315.99585.

**Furan-2-carboxylic acid (2-bromo-4-methyl-phenyl)-ethyl-amide (12b)**

White solid (810 mg, 88%), m.p. = 106.2–108.8 °C, IR (KBr) 2976, 1735, 1640, 1458, 1250, 880 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.51 (s, 1H), 7.33 (s, 1H), 7.18–7.12 (m, 2H), 6.20 (br, 1H), 5.81 (br, 1H), 4.25–4.18 (m, 1H), 3.55–3.47 (m, 1H), 2.40 (s, 3H), 1.21 (t, J = 7.0 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 158.8, 147.1, 144.3, 140.2, 138.4, 134.2, 130.7, 129.2, 123.7, 115.6, 111.00, 44.4, 20.8, 12.6; HRMS (ESI) m/z calcd for C₁₄H₁₄BrNO₂ [M+Na]⁺: 330.01151, Found: 330.01151.

**Furan-2-carboxylic acid (2-bromo-5-methyl-phenyl)-ethyl-amide (12c)**

White solid (810 mg, 88%), m.p. = 106.2–108.8 °C, IR (KBr) 2976, 1735, 1640, 1458, 1250, 880 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.51 (s, 1H), 7.33 (s, 1H), 7.18–7.12 (m, 2H), 6.20 (br, 1H), 5.81 (br, 1H), 4.25–4.18 (m, 1H), 3.55–3.47 (m, 1H), 2.40 (s, 3H), 1.21 (t, J = 7.0 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 158.8, 147.1, 144.3, 140.2, 138.4, 134.2, 130.7, 129.2, 123.7, 115.6, 111.00, 44.4, 20.8, 12.6; HRMS (ESI) m/z calcd for C₁₄H₁₄BrNO₂ [M+Na]⁺: 330.01151, Found: 330.01151.
White solid (801 mg, 87%), m.p. = 106.7–108.5 °C, IR (KBr) 2945, 1745, 1650, 1240, 1040, 885 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.54 (d, J = 8.5 Hz, 1H), 7.32 (s, 1H), 7.08 (s, 2H), 6.20 (br, 1H), 5.81 (br, 1H), 4.21–4.12 (m, 1H), 3.57–3.52 (m, 6.8 Hz, 1H), 2.34 (s, 3H), 1.23 (t, J = 7.2 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 158.7, 147.2, 144.3, 140.8, 138.8, 133.4, 131.6, 130.6, 120.6, 115.6, 111.0, 44.5, 20.8, 12.6; HRMS (ESI) m/z calcd for C₁₄H₁₄BrNO₂ [M+Na]⁺: 330.01166, Found: 330.01169.

**Furan-2-carboxylic acid (2-bromo-4,6-dimethyl-phenyl)-ethyl-amide (12d)**

![12d](image)

White solid (869 mg, 90%), m.p. = 108.7–109.8 °C, IR (KBr) 2978, 1764, 1620, 1458, 1265, 1002.865 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.35 (s, 2H), 7.05 (s, 1H), 6.37–6.09 (m, 1H), 5.72 (d, J = 3.1 Hz, 1H), 3.90–3.95 (m, 1H), 3.74–3.79 (m, 1H), 2.35 (s, 3H), 2.20 (s, 3H), 1.24 (t, J = 7.2 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 159.1, 147.3, 144.4, 139.9, 138.8, 137.4, 131.9, 131.2, 124.6, 114.8, 111.1, 44.6, 20.8, 18.8, 12.7; HRMS (ESI) m/z calcd for C₁₅H₁₆BrNO₂ [M+Na]⁺: 344.02728, Found: 344.02728.

**Furan-2-carboxylic acid (2-bromo-4-tert-butyl-phenyl)-ethyl-amide (12e)**

![12e](image)

White solid (932 mg, 89%), m.p. = 106.1–108.3 °C, IR (KBr) 2965, 1729, 1646, 1475, 1121, 1019, 931, 830 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.67 (d, J = 2.1 Hz, 1H), 7.37 (dd, J = 8.2, 2.2 Hz, 1H), 7.32 (s, 1H), 7.17 (d, J = 8.2 Hz, 1H), 6.20 (br, 1H), 5.75 (br, 1H), 4.19-4.24 (m, 1H), 3.47-3.52 (m, 1H), 1.35 (s, 9H), 1.23 (t, J = 7.2 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 158.8,
Furan-2-carboxylic acid (2-bromo-4-methoxy-phenyl)-ethyl-amide (12f)

White solid (853 mg, 88%), m.p. = 105.2–107.8 °C, IR (KBr) 2995, 1733, 1480, 1268, 1023, 872 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.35 (s, 1H), 7.23 (s, 1H), 7.17 (d, J = 8.6 Hz, 1H), 6.91 (d, J = 8.5 Hz, 1H), 6.23 (br, 1H), 5.82 (br, 1H), 4.19–4.24 (m, 1H), 3.86 (s, 3H), 3.45–3.50 (m, 1H), 1.23 (t, J = 7.0 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 159.8, 159.0, 147.3, 144.4, 133.8, 131.5, 124.6, 118.8, 115.5, 114.1, 111.0, 55.8, 44.4, 12.6; HRMS m/z (ESI) calcd for C₁₇H₂₀BrNO₂ [M+Na]⁺: 372.05856, Found: 372.05856.

Furan-2-carboxylic acid (2-bromo-4-fluoro-phenyl)-ethyl-amide (12g)

White solid (774 mg, 83%), m.p. = 126.2–127.5 °C, IR (KBr) 2942, 1721, 1610, 1435, 1253, 1045, 875 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.43 (d, J = 7.3 Hz, 1H), 7.29 (s, 1H), 7.27–7.23 (m, 1H), 7.10 (t, J = 8.1 Hz, 1H), 6.25 (br, 1H), 6.08 (br, 1H), 4.24–4.16 (m, 1H), 3.52–3.57 (m, 1H), 1.22 (t, J = 7.1 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 161.6, 158.8, 147.3, 144.5, 137.6, 132.0, 124.7, 121.0, 116.0, 115.5, 111.1, 44.5, 12.6; HRMS (ESI) m/z calcd for C₁₃H₁₁BrFNO₂ [M+Na]⁺: 333.98642, Found: 333.98654.

Furan-2-carboxylic acid (2-bromo-5-fluoro-phenyl)-ethyl-amide (12h)
White solid (784 mg, 84%), m.p. = 125.9–127.8 °C, IR (KBr) 2972, 1746, 1650, 1433, 1273, 885 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.65–7.61 (m, 1H), 7.29 (s, 1H), 7.03 (dd, J = 5.6, 3.2 Hz, 2H), 6.27 (br, 1H), 6.20 (br, 1H), 4.21–4.12 (m, 1H), 3.60–3.55 (m, 1H), 1.25 (d, J = 7.1 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 161.9, 158.5, 147.2, 144.6, 142.6, 134.5, 118.5, 118.3, 117.1, 116.5, 111.2, 44.6, 12.7; HRMS (ESI) m/z calcd for C₁₃H₁₁BrFNO₂ [M+Na]⁺: 333.68957, Found: 333.68957.

Characterization of 13

I'-Ethyl-5-methoxy-5H-spiro[furan-2,3'-indolin]-2'-one (13a)

Yellow oil, (53 mg, 72%), IR (KBr) 2986, 2928, 1724, 1608, 1463, 1201, 943, 857, 757 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.32 (t, J = 7.6 Hz, 1H), 7.12 (d, J = 7.2 Hz, 1H), 7.04 (t, J = 7.4 Hz, 1H), 6.85 (d, J = 7.8 Hz, 1H), 6.20 (s, 2H), 5.95 (d, J = 5.4 Hz, 1H), 3.78-3.72 (m, 2H), 3.55 (s, 3H), 1.82 (t, J = 7.1 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 173.2, 143.0, 132.5, 130.3, 129.9, 127.7, 124.5, 122.9, 110.5, 108.7, 98.6, 54.1, 35.0, 12.5; HRMS m/z (ESI) calculated for C₁₄H₁₅NO₃ [M+Na]⁺: 268.09558; Found: 268.09558.

I'-Ethyl-5-methoxy-5'-methyl-5H-spiro[furan-2,3'-indolin]-2'-one (13b)
Yellow oil, (54 mg, 70%), IR (KBr) 3087, 2977, 1726, 1494, 1372, 1210, 948, 875, 747 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.11 (d, $J = 7.9$ Hz, 1H), 6.95 (s, 1H), 6.74 (d, $J = 7.9$ Hz, 1H), 6.19 (d, $J = 7.1$ Hz, 2H), 5.94 (d, $J = 5.7$ Hz, 1H), 3.75-3.70 (m, 2H), 3.55 (s, 3H), 2.30 (s, 3H), 1.27 (t, $J = 7.1$ Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 173.1, 140.5, 132.7, 132.5, 130.5, 129.7, 127.6, 125.2, 110.5, 108.4, 89.7, 54.1, 35.0, 20.9, 12.5; HRMS m/z (ESI) calculated for C$_{15}$H$_{17}$NO$_3$ [M+Na]$^+$: 282.11124; Found: 282.11124.

$1'$-Ethyl-5-methoxy-6'-methyl-5H-spiro[furan-2,3'-indolin]-2'-one (13c)

![13c](image)

Yellow oil, (47 mg, 60%), IR (KBr) 2977, 1727, 1619, 1455, 1203, 947, 816, 748 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.00 (d, $J = 7.4$ Hz, 1H), 6.85 (d, $J = 7.5$ Hz, 1H), 6.67 (s, 1H), 6.18 (s, 2H), 5.93 (d, $J = 5.8$ Hz, 1H), 3.76-3.70 (m, 2H), 3.54 (s, 3H), 2.38 (s, 3H), 1.28 (t, $J = 7.1$ Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 173.5, 143.1, 140.7, 132.7, 129.7, 124.7, 124.2, 123.3, 110.4, 109.5, 89.5, 54.1, 34.9, 21.9, 12.6; HRMS m/z (ESI) calculated for C$_{15}$H$_{17}$NO$_3$ [M+Na]$^+$: 282.11108; Found: 282.11115.

$1'$-Ethyl-5,5'-dimethoxy-5H-spiro[furan-2,3'-indolin]-2'-one (13d)

![13d](image)

Yellow oil, (41 mg, 50%), IR (KBr) 2985, 2925, 1722, 1645, 1473, 1342, 1266, 1224, 949, 862 cm$^{-1}$; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 6.87 (s, 1H), 6.77 (s, 1H), 6.25 – 6.08 (m, 2H), 5.91 (d, $J = 5.5$ Hz, 1H), 3.98-3.92 (m, 2H), 3.55 (s, 3H), 2.47 (s, 3H), 2.25 (s, 3H), 1.28 (t, $J = 7.2$ Hz, 3H); $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 174.2, 138.3, 134.5, 133.0, 132.4, 129.4, 128.5, 123.0, 119.4, 110.4, 89.3, 54.0, 36.8, 20.5, 18.6, 14.6; HRMS m/z (ESI) Calculated for C$_{16}$H$_{19}$NO$_3$ [M+Na]$^+$: 296.12686; Found: 296.12692.

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5’-(Tert-butyl)-1’-ethyl-5-methoxy-5H-spiro[furan-2,3’-indolin]-2’-one (13e)

![Chemical Structure](image)

Yellow oil, (58 mg, 64%), IR (KBr) 2962, 2915, 1728, 1619, 1494, 1372, 1206, 948, 876, 744 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.35-7.33 (m, 1H), 7.14 (d, \(J = 1.9\) Hz, 1H), 6.78 (d, \(J = 8.2\) Hz, 1H), 6.21 (d, \(J = 5.6\) Hz, 2H), 5.96 (d, \(J = 5.4\) Hz, 1H), 3.75-3.72 (m, 2H), 3.56 (s, 3H), 1.29 (d, \(J = 8.2\) Hz, 12H); \(^13\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 173.3, 146.2, 140.6, 132.8, 129.8, 127.0, 121.5, 110.5, 108.2, 89.9, 54.3, 35.0, 34.5, 31.5, 12.6; HRMS m/z (ESI) calculated for C\(_{18}\)H\(_{23}\)NO\(_3\) [M+Na]\(^+\): 324.15839; Found: 324.15839.

1’-Ethyl-5-methoxy-5’,7’-dimethyl-5H-spiro[furan-2,3’-indolin]-2’-one and (13f)

Yellow oil, (52 mg, 63%), IR (KBr) 2936, 2836, 1723, 1603, 1492, 1344, 1279, 1103, 1031, 946, 862, 703, 627 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 6.86-6.83 (m, 1H), 6.76 (d, \(J = 8.5\) Hz, 1H), 6.73 (d, \(J = 2.5\) Hz, 1H), 6.20-6.19 (m, 2H), 5.96-5.94 (m, 1H), 3.77 (s, 3H), 3.77-3.71 (m, 2H), 3.55 (s, 3H), 1.27 (t, \(J = 7.2\) Hz, 3H); \(^13\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 172.9, 156.3, 136.2, 132.6, 129.8, 128.9, 115.0, 111.4, 110.6, 109.2, 89.9, 55.9, 54.2, 35.1, 12.5; HRMS m/z (ESI) calculated for C\(_{15}\)H\(_{17}\)NO\(_4\) [M+Na]\(^+\): 298.10620; Found: 298.10617.

1’-Ethyl-5’-fluoro-5-methoxy-5H-spiro[furan-2,3’-indolin]-2’-one (13g)
Yellow oil, (52 mg, 66%), IR (KBr) 3086, 2936, 1728, 1615, 1343, 1266, 1102, 1024, 946, 878, 734 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.02 (t, \(J = 8.8\) Hz, 1H), 6.87 (d, \(J = 7.4\) Hz, 1H), 6.80-6.77 (m, 1H), 6.26-6.17 (m, 2H), 5.94 (d, \(J = 5.8\) Hz, 1H), 3.73-3.75 (m, 2H), 3.55 (s, 3H), 1.28 (t, \(J = 6.8\) Hz, 3H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 173.0, 159.3, 138.8, 132.1, 130.27, 129.38, 116.5, 112.6, 110.66, 109.3, 89.5, 54.2, 35.2, 12.4; HRMS m/z (ESI) calculated for C\(_{14}\)H\(_{14}\)FNO\(_3\) [M+Na]\(^+\): 286.08615; Found: 286.08606.

\(1'\)-Ethyl-6'-fluoro-5-methoxy-5H-spiro[furan-2,3'-indolin]-2'-one (13h)

Yellow oil, (57 mg, 72%), IR (KBr) 2980, 2937, 1733, 1614, 1499, 1545, 1374, 1200, 953, 830, 742 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.13 – 7.03 (m, 1H), 6.72 (t, \(J = 8.8\) Hz, 1H), 6.59 (d, \(J = 8.9\) Hz, 1H), 6.21 (d, \(J = 5.8\) Hz, 1H), 6.17 (s, 1H), 5.92 (d, \(J = 5.8\) Hz, 1H), 3.71-3.75 (m, 2H), 3.54 (s, 3H), 1.28 (t, \(J = 7.2\) Hz, 3H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 173.5, 163.13, 144.64, 132.23, 130.15, 125.9, 122.97, 110.50, 108.9, 97.6, 89.1, 54.3, 35.3, 12.5; HRMS m/z (ESI) calculated for C\(_{14}\)H\(_{14}\)FNO\(_3\) [M+Na]\(^+\): 286.08618; Found: 286.08615.

5-Ethoxy-1'-ethyl-5H-spiro[furan-2,3'-indolin]-2'-one (13i)

Yellow oil, (57 mg, 72%), IR (KBr) 3086, 2936, 1728, 1615, 1489, 1343, 1266, 1102, 1024, 946, 878, 734 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.02 (t, \(J = 8.8\) Hz, 1H), 6.87 (d, \(J = 7.4\) Hz, 1H), 6.80-6.77 (m, 1H), 6.26-6.17 (m, 2H), 5.94 (d, \(J = 5.8\) Hz, 1H), 3.73-3.75 (m, 2H), 3.55 (s, 3H), 1.28 (t, \(J = 6.8\) Hz, 3H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 173.0, 159.3, 138.8, 132.1, 130.27, 129.38, 116.5, 112.6, 110.66, 109.3, 89.5, 54.2, 35.2, 12.4; HRMS m/z (ESI) calculated for C\(_{14}\)H\(_{14}\)FNO\(_3\) [M+Na]\(^+\): 286.08615; Found: 286.08606.
Yellow oil, (54 mg, 69%), IR (KBr) 2977, 2932, 1728, 1611, 1463, 1359, 1290, 940, 859, 753 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.31 (t, J = 7.3 Hz, 1H), 7.12 (d, J = 7.1 Hz, 1H), 7.04 (t, J = 7.3 Hz, 1H), 6.84 (d, J = 7.7 Hz, 1H), 6.26 (s, 1H), 6.21 (d, J = 5.6 Hz, 1H), 5.93 (d, J = 5.6 Hz, 1H), 3.88-3.83 (dd, J = 13.4, 6.7 Hz, 2H), 3.75 (t, J = 7.1 Hz, 2H), 1.28 (t, J = 7.0 Hz, 2H); ¹³C NMR (101 MHz, CDCl₃) δ 173.2, 143.0, 132.2, 130.2, 130.2, 127.8, 124.5, 122.8, 109.6, 108.6, 89.6, 62.6, 35.0, 15.4, 12.6; HRMS m/z (ESI) calculated for C₁₅H₁₇NO₃ [M+Na]⁺: 282.1115, Found: 282.11121.

5-Ethoxy-1'-ethyl-5'-methyl-5H-spiro[furan-2,3'-indolin]-2'-one (13j)

Yellow oil, (44 mg 54%), IR (KBr) 2978, 2930, 1728, 1633, 1493, 1372, 1251, 1105, 943, 812, 738 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.11 (d, J = 7.9 Hz, 1H), 6.94 (s, 1H), 6.73 (d, J = 7.9 Hz, 1H), 6.26 (s, 1H), 6.19 (d, J = 5.8 Hz, 1H), 5.92 (d, J = 5.8 Hz, 1H), 3.86-3.83 (m, 2H), 3.76-3.70 (m, 2H), 2.30 (s, 3H), 1.29-1.25 (m, 6H); ¹³C NMR (101 MHz, CDCl₃) δ 173.2, 140.5, 132.4, 130.4, 128.3, 127.5, 125.2, 109.6, 108.4, 89.7, 62.5, 35.0, 20.9, 15.4, 12.6; HRMS m/z (ESI) calculated for C₁₆H₁₉NO₃ [M+Na]⁺: 296.12701; Found: 296.12695.

5-Ethoxy-1'-ethyl-6'-methyl-5H-spiro[furan-2,3'-indolin]-2'-one (13k)

Yellow oil, (46 mg, 56%), IR (KBr) 2977, 2930, 1728, 1619, 1452, 1212, 1024, 944, 833, 752 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.00 (d, J = 7.5 Hz, 1H), 6.84 (d, J = 7.5 Hz, 1H), 6.66 (s, 1H), 6.24 (s, 1H), 6.18 (d, J = 5.8 Hz, 1H), 5.91 (d, J = 5.8 Hz, 1H), 3.85-3.83 (m, 2H), 3.73 (q, J
= 7.1 Hz, 2H), 2.38 (s, 3H), 1.27 (t, \( J = 7.1 \) Hz, 6H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 173.5, 143.1, 140.6, 132.4, 130.0, 124.8, 124.2, 123.3, 109.5, 109.5, 89.5, 62.5, 34.9, 22.0, 15.4, 12.6; HRMS \( m/z \) (ESI) calculated for C\(_{16}\)H\(_{18}\)NO\(_3\) [M+Na\(^+\)]: 296.12689; Found: 296.12704.

5'-Ethoxy-1'-ethyl-5',7'-dimethyl-5H-spiro[furan-2,3'-indolin]-2'-one (13l)

Yellow oil, (35 mg, 40%), IR (KBr) 2979, 2933, 1730, 1619, 1488, 1266, 1020, 942, 879, 758 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 6.86 (s, 1H), 6.77 (s, 1H), 6.25 (s, 1H), 6.17 (d, \( J = 6.0 \) Hz, 1H), 5.89 (d, \( J = 5.8 \) Hz, 1H), 3.97-3.90 (m, 2H), 3.88 – 3.68 (m, 2H), 2.47 (s, 3H), 2.25 (s, 3H), 1.27 (t, \( J = 7.0 \) Hz, 6H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 174.3, 138.3, 134.5, 132.7, 132.4, 129.7, 128.6, 123.0, 119.4, 109.6, 89.3, 62.5, 36.8, 20.5, 18.6, 15.4, 14.6; HRMS \( m/z \) (ESI) calculated for C\(_{17}\)H\(_{21}\)NO\(_3\) [M+Na\(^+\)]: 310.10264; Found: 310.10274.

5'-{(Tert-butyl)-5-ethoxy-1'-ethyl-5H-spiro[furan-2,3'-indolin]-2'-one (13m)

Yellow oil, (54 mg, 57%), IR (KBr) 2977, 2934, 1724, 1639, 1494, 1275, 1209, 1030, 942, 878, 742 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.33 (d, \( J = 8.2 \) Hz, 1H), 7.13 (s, 1H), 6.78 (d, \( J = 8.2 \) Hz, 1H), 6.28 (s, 1H), 6.21 (d, \( J = 5.8 \) Hz, 1H), 5.94 (d, \( J = 5.8 \) Hz, 1H), 3.87-3.83 (m, 2H), 3.73 (q, \( J = 7.1 \) Hz, 2H), 1.28 (d, \( J = 10.4 \) Hz, 15H); \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 173.3, 146.2, 140.6, 132.5, 130.1, 127.3, 126.9, 121.5, 109.6, 108.1, 89.9, 62.7, 35.0, 34.5, 31.5, 15.4, 12.6; HRMS \( m/z \) (ESI) calculated for C\(_{19}\)H\(_{25}\)NO\(_3\) [M+Na\(^+\)]: 338.17411; Found: 338.17440.
**5-Ethoxy-1′-ethyl-5′-methoxy-5H-spiro[ furan-2,3′-indolin]-2′-one (13n)**

Yellow oil, (49 mg, 56%), IR (KBr) 2975, 2928, 1723, 1649, 1540, 1472, 1266, 1017, 946, 863, 740 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 6.88-6.85 (m, 1H), 6.80 – 6.66 (m, 3H), 6.28 (s, 1H), 6.22 (t, J = 4.6 Hz, 1H), 5.95 (d, J = 5.8 Hz, 1H), 3.89-3.86 (m, 2H), 3.79 (s, 3H), 3.78-3.71 (m, 2H), 1.32-1.27 (m, 6H); ¹³C NMR (101 MHz, CDCl₃) δ 173.0, 156.3, 136.3, 132.3, 130.1, 129.0, 115.0, 111.4, 109.7, 109.1, 89.9, 62.5, 55.9, 35.1, 15.4, 12.6; HRMS m/z (ESI) calculated for C₁₆H₁₉NO₄ [M+Na]⁺: 312.12216; Found: 312.12238.

**5-Ethoxy-1′-ethyl-5′-fluoro-5H-spiro[furan-2,3′-indolin]-2′-one (13o)**

Yellow oil, (60 mg, 72%), IR (KBr) 2979, 2936, 1734, 1614, 1498, 1375, 1202, 949, 831, 741 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.06-7.00 (m, 1H), 6.90-6.88 (m, 1H), 6.80-6.78 (m, 1H), 6.27 (s, 1H), 6.25 (d, J = 5.9 Hz, 1H), 5.95-5.93 (m, 1H), 3.87-3.83 (m, 2H), 3.77-3.74 (m, 2H), 1.31-1.27 (m, 6H); ¹³C NMR (101 MHz, CDCl₃) δ 173.5, 165.4, 144.7, 131.92, 130.45, 125.8, 123.1, 109.3, 108.8, 97.4, 89.04, 62.72, 35.21, 15.37, 12.46; HRMS m/z (ESI) calculated for C₁₅H₁₆FNO₃ [M+Na]⁺: 300.10196; Found: 300.10202.

**5-Ethoxy-1′-ethyl-5′-fluoro-5H-spiro[furan-2,3′-indolin]-2′-one (13p)**
Yellow oil, (62 mg, 74%), IR (KBr) 3086, 2979, 2936, 1734, 1614, 1498, 1375, 1202, 949, 831, 741 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.01 (t, J = 8.8 Hz, 1H), 6.87 (d, J = 7.3 Hz, 1H), 6.78-6.75 (m, 1H), 6.26-6.22 (m, 2H), 5.92 (d, J = 5.8 Hz, 1H), 3.85-3.83 (m, 2H), 3.74 (q, J = 7.2 Hz, 2H), 1.27 (t, J = 6.9 Hz, 6H); ¹³C NMR (101 MHz, CDCl₃) δ 173.0, 159.3, 138.8, 131.8, 130.6, 129.4, 116.4, 112.5, 109.8, 109.2, 89.5, 62.7, 35.1, 15.4, 12.5; HRMS m/z (ESI) calculated for C₁₅H₁₆FNO₃ [M+Na]⁺: 300.10205; Found: 300.10196.

**1'-Ethyl-5-propoxy-5H-spiro[furan-2,3'-indolin]-2'-one (13q)**

Yellow oil, (37 mg, 45%), IR (KBr) 3082, 2976, 2884, 1727, 1613, 1466, 1356, 1279, 1146, 940, 850, 745 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.31 (t, J = 7.6 Hz, 1H), 7.12 (d, J = 7.3 Hz, 1H), 7.04 (t, J = 7.4 Hz, 1H), 6.84 (d, J = 7.8 Hz, 1H), 6.25 (s, 1H), 6.21 (d, J = 5.8 Hz, 1H), 5.93 (d, J = 5.8 Hz, 1H), 3.77-3.72 (m, 4H), 1.72-1.63 (m, 2H), 1.28 (t, J = 7.2 Hz, 3H), 0.96 (t, J = 7.4 Hz, 3H); ¹³C NMR (101 MHz, CDCl₃) δ 173.2, 143.0, 132.2, 130.2, 130.2, 128.8, 124.5, 122.8, 109.9, 108.6, 89.6, 68.9, 35.0, 23.1, 12.6, 10.6; HRMS m/z (ESI) Calculated for C₁₆H₁₉NO₃ [M+Na]⁺: 296.12714; Found: 296.12708.

**1'-Ethyl-5-isopropoxy-5H-spiro[furan-2,3'-indolin]-2'-one (13r)**
Yellow oil, (39 mg, 47%), IR (KBr) 2972, 2921, 1730, 1649, 1364, 1209, 1107, 1022, 938, 850, 749 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.31 (d, J = 7.4 Hz, 1H), 7.12 (d, J = 7.2 Hz, 1H), 7.03 (t, J = 7.5 Hz, 1H), 6.83 (d, J = 7.7 Hz, 1H), 6.29 (s, 1H), 6.18 (d, J = 5.8 Hz, 1H), 5.91 (d, J = 5.7 Hz, 1H), 4.21-4.15 (m, 1H), 3.77-3.73 (m, 2H), 1.28 (s, 3H), 1.26-1.20 (m, 6H); ¹³C NMR (101 MHz, CDCl₃) δ 173.2, 143.1, 131.9, 130.5, 130.2, 127.8, 124.4, 122.7, 108.5, 108.5, 89.6, 69.9, 35.0, 23.7, 22.5, 12.6; HRMS m/z (ESI) calculated for C₁₆H₁₉NO₃ [M+Na]⁺: 296.12686; Found: 296.12686.
X-Ray crystal structure of 2r (CCDC 1476097):

Table S1. Crystal data and structure refinement for sad1.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Identification code</td>
<td>sad1</td>
</tr>
<tr>
<td>Empirical formula</td>
<td>C_{17}H_{19}NO_{4}</td>
</tr>
<tr>
<td>Formula weight</td>
<td>301.33</td>
</tr>
<tr>
<td>Temperature</td>
<td>571(2) K</td>
</tr>
<tr>
<td>Wavelength</td>
<td>0.71073 A</td>
</tr>
<tr>
<td>Crystal system, space group</td>
<td>Monoclinic, P2(1)/n</td>
</tr>
<tr>
<td>Unit cell dimensions</td>
<td>a = 14.349(3) Å, alpha = 90 deg.</td>
</tr>
<tr>
<td></td>
<td>b = 7.2477(14) Å, beta = 105.12(3) deg.</td>
</tr>
<tr>
<td></td>
<td>c = 14.692(3) Å, gamma = 90 deg.</td>
</tr>
<tr>
<td>Volume</td>
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</tr>
<tr>
<td>Z, Calculated density</td>
<td>4, 1.357 Mg/m^3</td>
</tr>
<tr>
<td>Absorption coefficient</td>
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</tr>
<tr>
<td>F(000)</td>
<td>640</td>
</tr>
<tr>
<td>Crystal size</td>
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</tr>
<tr>
<td>Theta range for data collection</td>
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</tr>
<tr>
<td>Limiting indices</td>
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</tr>
<tr>
<td>Reflections collected / unique</td>
<td>13577 / 3358 [R(int) = 0.1194]</td>
</tr>
<tr>
<td>Completeness to theta</td>
<td>99.4 %</td>
</tr>
<tr>
<td>Max. and min. transmission</td>
<td>0.9828 and 0.9753</td>
</tr>
<tr>
<td>Refinement method</td>
<td>Full-matrix least-squares on F^2</td>
</tr>
<tr>
<td>Data / restraints / parameters</td>
<td>3358 / 0 / 199</td>
</tr>
<tr>
<td>Goodness-of-fit on F^2</td>
<td>0.845</td>
</tr>
<tr>
<td>Final R indices [I&gt;2sigma(I)]</td>
<td>R_1 = 0.0476, wR_2 = 0.0894</td>
</tr>
<tr>
<td>R indices (all data)</td>
<td>R_1 = 0.1560, wR_2 = 0.1202</td>
</tr>
<tr>
<td>Largest diff. peak and hole</td>
<td>0.203 and -0.237 e.A^-3</td>
</tr>
</tbody>
</table>
X-Ray crystal structure of \textbf{13\textit{h}} (CCDC 1476096):

![Crystal Structure Image]

\begin{table}[h]
\centering
\caption{Crystal data and structure refinement for sad.}
\begin{tabular}{ll}
\hline
Identification code & sad \\
Empirical formula & C\textsubscript{14}H\textsubscript{14}FNO\textsubscript{3} \\
Formula weight & 263.26 \\
Temperature & 293(2) K \\
Wavelength & 0.71073 Å \\
Crystal system, space group & Orthorhombic, P2(1)2(1)2(1) \\
Unit cell dimensions & a = 8.2754(17) Å, alpha = 90 deg. \\
& b = 12.082(2) Å, beta = 90 deg. \\
& c = 13.332(3) Å, gamma = 90 deg. \\
Volume & 1333.0(5) Å\textsuperscript{3} \\
Z, Calculated density & 4, 1.312 Mg/m\textsuperscript{3} \\
Absorption coefficient & 0.102 mm\textsuperscript{-1} \\
F(000) & 552 \\
Crystal size & 0.25 x 0.20 x 0.20 mm \\
Theta range for data collection & 3.06 to 27.45 deg. \\
Limiting indices & -10<=h<=10, -15<=k<=15, -15<=l<=17 \\
Reflections collected / unique & 12993 / 3044 [R(int) = 0.0433] \\
Completeness to theta = 27.45 & 99.5% \\
Max. and min. transmission & 0.9800 and 0.9751 \\
Refinement method & Full-matrix least-squares on F\textsuperscript{2} \\
Data / restraints / parameters & 3044 / 0 / 173 \\
Goodness-of-fit on F\textsuperscript{2} & 1.008 \\
Final R indices [I>2\sigma(I)] & R\textsubscript{1} = 0.0330, wR\textsubscript{2} = 0.0777 \\
R indices (all data) & R\textsubscript{1} = 0.0513, wR\textsubscript{2} = 0.0902 \\
Absolute structure parameter & -0.1(9) \\
Extinction coefficient & 0.0069(19) \\
Largest diff. peak and hole & 0.139 and -0.120 eÅ\textsuperscript{-3} \\
\hline
\end{tabular}
\end{table}
Spectra of all the new compounds

$^1$H NMR spectrum of 1a

$^{13}$C NMR spectrum of 1a
$^1$H NMR spectrum of 1b
$^1$H NMR spectrum of 1d

$^{13}$C NMR spectrum of 1d
$^{1}H$ NMR spectrum of 1e

$^{13}C$ NMR spectrum of 1e
$^1$H NMR spectrum of If

$^{13}$C NMR spectrum of If
\(^1\)H NMR spectrum of \(1g\)

\(^{13}\)C NMR spectrum of \(1g\)
$^1$H NMR spectrum of 1h

$^{13}$C NMR spectrum of 1h
$^1$H NMR spectrum of Ii

$^{13}$C NMR spectrum of Ii
$^1$H NMR spectrum of II

$^{13}$C NMR spectrum of II
$^{1}$H NMR spectrum of $^{1}$m

$^{13}$C NMR spectrum of $^{1}$m
$^1$H NMR spectrum of In

$^{13}$C NMR spectrum of In
$^1$H NMR spectrum of Io

$^{13}$C NMR spectrum of Io
1H NMR spectrum of \textbf{1r}

13C NMR spectrum of \textbf{1r}
$^1$H NMR spectrum of 1s

$^{13}$C NMR spectrum of 1s
$^1$H NMR spectrum of It

$^{13}$C NMR spectrum of It
$^1$H NMR spectrum of \textbf{1u}

$^{13}$C NMR spectrum of \textbf{1u}
$^{1}$H NMR spectrum of \( 1v \)

$^{13}$C NMR spectrum of \( 1v \)
$^1$H NMR spectrum of 1w

$^{13}$C NMR spectrum of 1w
$^1$H NMR spectrum of 2a

$^{13}$C NMR spectrum of 2a
$^{1}$H NMR spectrum of 2e

$^{13}$C NMR spectrum of 2e
$^1$H NMR spectrum of 2d

$^{13}$C NMR spectrum of 2d
$\text{H NMR spectrum of 2e}$

$\text{C NMR spectrum of 2e}$
$^1$H NMR spectrum of 2f

$^{13}$C NMR spectrum of 2f
$^1$H NMR spectrum of 2g

$^{13}$C NMR spectrum of 2g
$^1$H NMR spectrum of 2h

$^{13}$C NMR spectrum of 2h
$^1$H NMR spectrum of 2i

$^{13}$C NMR spectrum of 2i
1H NMR spectrum of 2I

13C NMR spectrum of 2I
$^1$H NMR spectrum of 2m

$^{13}$C NMR spectrum of 2m
$^1$H NMR spectrum of 2n

$^{13}$C NMR spectrum of 2n
\[ ^1H \text{ NMR spectrum of } 2p \]

\[ ^{13}C \text{ NMR spectrum of } 2p \]
$^1$H NMR spectrum of 2q

$^{13}$C NMR spectrum of 2q
$^1$H NMR spectrum of 2r

$^{13}$C NMR spectrum of 2r
$^{1}H$ NMR spectrum of $2t$

$^{13}C$ NMR spectrum of $2t$
$^1$H NMR spectrum of 2u

$^{13}$C NMR spectrum of 2u
$^1$H NMR spectrum of 15a

$^{13}$C NMR spectrum of 15a
$^1$H NMR spectrum of 16a

$^{13}$C NMR spectrum of 16a
$^1$H NMR spectrum of 17a

$^{13}$C NMR spectrum of 17a
$^1$H NMR spectrum of 18a

$^{13}$C NMR spectrum of 18a
$^{1}$H NMR spectrum of 19a

$^{13}$C NMR spectrum of 19a
$^1$H NMR spectrum of 12a

$^{13}$C NMR spectrum of 12a
$^1$H NMR spectrum of 12b

$^{13}$C NMR spectrum of 12b
$^{1}$H NMR spectrum of 12c

$^{13}$C NMR spectrum of 12c
$^1$H NMR spectrum of 12d

$^{13}$C NMR spectrum of 12d
$^1$H NMR spectrum of 12e

$^{13}$C NMR spectrum of 12e
$^1$H NMR spectrum of 12f

$^{13}$C NMR spectrum of 12f
\(^1\text{H NMR spectrum of 12g}\)

\(^{13}\text{C NMR spectrum of 12g}\)
$^1$H NMR spectrum of 12h

$^{13}$C NMR spectrum of 12h
$^1$H NMR spectrum of 13a

$^{13}$C NMR spectrum of 13a
$^1$H NMR spectrum of 13b

$^{13}$C NMR spectrum of 13b
$^1$H NMR spectrum of 13c

$^{13}$C NMR spectrum of 13c
$^1$H NMR spectrum of 13d

$^{13}$C NMR spectrum of 13d
$^{1}H$ NMR spectrum of 13e

$^{13}C$ NMR spectrum of 13e
$^1$H NMR spectrum of 13f

$^{13}$C NMR spectrum of 13f
$^{1}H$ NMR spectrum of 13g

$^{13}C$ NMR spectrum of 13g
$^1$H NMR spectrum of 13i

$^{13}$C NMR spectrum of 13i
$^1$H NMR spectrum of 13j

$^{13}$C NMR spectrum of 13j

103
$^1$H NMR spectrum of 13k

$^{13}$C NMR spectrum of 13k
$^1$H NMR spectrum of 13l

$^{13}$C NMR spectrum of 13l
$^1$H NMR spectrum of 13m

$^{13}$C NMR spectrum of 13m
$^1$H NMR spectrum of 13n

$^{13}$C NMR spectrum of 13n
$^1$H NMR spectrum of $^{13}$o

$^{13}$C NMR spectrum of $^{13}$o
$^1$H NMR spectrum of 13p

$^{13}$C NMR spectrum of 13p
$^{1}$H NMR spectrum of $^{13}$q

$^{13}$C NMR spectrum of $^{13}$q
$^1$H NMR spectrum of 13r

$^{13}$C NMR spectrum of 13r