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# Facile Synthesis of Spiro[cyclohexane-1,3'-indoline]-2,2'-diones

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**Abstract:** Spiro[cyclohexane-1,3'-indoline]-2,2'-diones were easily prepared in good to high yields by the oxidation of *N*-aryl-*N*-methyl-2-oxocyclohexane-1-carboxamides in one pot with a short reaction time. The spiroindolinediones could be important for the total synthesis of natural products.

**Keywords:** spiro[cyclohexane-1,3'-indoline]-2,2'-diones; oxidative cyclization; 5-*exo* cyclization; radicals; heterocycles.

Carbon-carbon and carbon-heteroatom bond formations are some of the most important goals in organic synthesis [1], and the second is cyclization from the point of kinetic and thermodynamic control [2]. Especially, these ingenious techniques are sometimes needed for the total synthesis of both simple and complex natural products [3,4]. For example, the C-C bond formation using boronic acid esters is well-known as a typical Suzuki-Miyaura cross-coupling reaction [5-9], and the cyclization using Grubbs reagents as a ring-closing metathesis (RCM) [10-12]. However, these reactions are needed to set the complicated stage for the coupling and cyclization, and sometimes under special conditions. Recently, we reported the synthesis of 3,4-dihydro-2(1*H*)-quinolinoes by the Mn(III)-based oxidative 6-*endo-trig* cyclization of 2-[2-(*N*-arylamino)-2-oxoethyl]malonates [13], and 3-acetylindolin-2-ones by the oxidative *5-exo-trig* cyclization of *N*-arylbutanamides [14]. Both reactions are fully satisfied as the goal in organic synthesis, in addition, they are simple and convenient synthetic methods suitable for substituted quinolines and indoles without special conditions and techniques. In the course of these studies, we envisioned that the oxidation of *N*-aryl-2-oxocyclohexane-1-carboxamide might give spiro[cyclohexane-1,3'-indoline]-2,2'-diones via the formal 5-*exo-trig* cyclization. In order to confirm the hypothesis, *N*-methyl-2-oxo-*N*-phenylcyclohexane-1-carboxamide (**1a**) was prepared by the direct condensation of *N*-methylaniline with ethyl 2-oxocyclohexane-1-carboxylate and subjected to the Mn(III)-based oxidation.

The reaction was carried out in AcOH at room temperature using a stoichiometric amount of $Mn(OAc)_3$. Although the oxidant was consumed for 2 days, the desired product **2a** was obtained as a racemic mixture in a low yield from the reaction mixture (Scheme 1 and Table 1, Entry 1). A typical methine peak at $\delta$ 3.23 (1H, dd, $J$ = 11.6, 5.8 Hz, H-1) and one of the *ortho* aromatic protons at $\delta$ 7.17 (2H, dd, $J$ = 8.5, 1.4 Hz) in the $^1$H NMR spectrum of **1a** disappeared in that of **2a**. In addition, a typical methine carbon at $\delta$ 54.9 in the $^{13}$C NMR spectrum of **1a** became a spiro quaternary carbon at $\delta$ 63.4, and furthermore, five aromatic C-H carbons of **1a** reduced to four in that of **2a**. These spectroscopic data clearly showed that the desired cyclization took place, that is, the product **2a** should be 1'-methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione [15,16]. Very recently, the same spirocyclic oxindole obtained by Cu(II)-mediated radical cross-dehydrogenative coupling using **1a** was reported by Taylor et al. [17] and the spectroscopic data of **2a** was in complete accordance with that of the reported compound. We were encouraged by the result, and optimized the Mn(III)-based reaction under various conditions (Entries 2-6). As a result, when the reaction was conducted using $Mn(OAc)_3$ (2.5 eq.) in boiling AcOH, the reaction finished within only 4 min and the spiroindolinedione **2a** was produced in 69% maximum yield (Entry 5) which is similar to that of Taylor et al. (65% yield) in boiling toluene for 1.5 h. In order to apply the cyclization to other substituted oxocyclohexanecarboxamides, we examined the reactions of **1b-j** [18] under the optimized conditions. Gratifyingly, the results were very good as expected, giving 75-96% isolated yields of the corresponding new spiroindolinediones **2b-j** (Entries 7-15).

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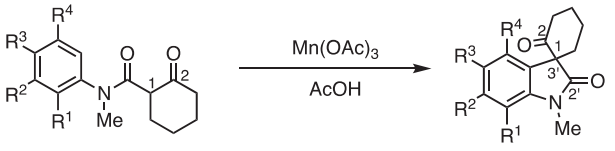
In conclusion, a simple and convenient one-pot synthesis of spiro[cyclohexane-1,3'-indoline]-2,2'-diones **2a-j** was demonstrated. The spiro compounds would be important for the total synthesis of several natural products as the starting material [19-22]. The scope of the reaction using the *N*-aryl-2-oxocycloalkane-1-carboxamides and synthetic applications using the spiro compounds are currently underway.

## Experimental

Melting points were taken using a MP-J3 Yanagimoto micromelting point apparatus and are uncorrected. The IR spectra were measured in $CHCl_3$ or KBr using a Shimadzu 8400 FT IR spectrometer and expressed in $cm^{-1}$. The NMR spectra were recorded using a JNM ECX 500 spectrometer at 500 MHz for the $^1H$ and at 125 MHz for $^{13}C$, with tetramethylsilane as the internal standard. The chemical shifts are reported as $\delta$ values (ppm) and the coupling constants in Hz. The following abbreviations are used for the multiplicities: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; and brs, broad singlet for the NMR spectra. The high-resolution mass spectra using a JEOL JMS-700 MStation were obtained at the Instrumental Analysis Center, Kumamoto University, Kumamoto, Japan.




**1a-j** **2a-j**

**a** : $R^1 = R^2 = R^3 = R^4 = H$
**b** : $R^1 = R^2 = R^4 = H$, $R^3 = Me$
**c** : $R^1 = R^2 = R^4 = H$, $R^3 = OMe$
**d** : $R^1 = R^2 = R^4 = H$, $R^3 = Cl$
**e** : $R^1 = R^2 = R^4 = H$, $R^3 = F$
**f** : $R^1 = Me$, $R^2 = R^3 = R^4 = H$
**g** : $R^1 = OMe$, $R^2 = R^3 = R^4 = H$
**h** : $R^1 = Cl$, $R^2 = R^3 = R^4 = H$
**i** : $R^1 = R^2 = Me$, $R^3 = R^4 = H$
**j** : $R^1 = R^3 = H$, $R^2 = R^4 = Me$

**Scheme 1**

### Preparation of Materials

A mixture of *N*-methylaniline (0.650 mL) and ethyl 2-oxocyclohexane-1-carboxylate (0.170 g) was heated under reflux for 24 h, and the crude products were separated by silica gel column chromatography eluting with EtOAc/hexane/acetone (2:7:1 v/v), giving *N*-methyl-2-oxo-*N*-phenylcyclohexane-1-carboxamide (**1a**) (0.126 g; 54% yield). Other 2-oxocyclohexane-1-carboxamides **1b-j** were prepared according to a procedure similar to that described above. Manganese(III) acetate dihydrate, $Mn(OAc)_3 \bullet 2H_2O$, was synthesized according to our modified method [14].

**Table 1** Oxidation of *N*-Methyl-2-oxocyclohexane-1-carboxamides **1a-j** with $Mn(OAc)_3$[a]

| Entry | Carboxamide 1/ | 1:$Mn(OAc)_3$[b] | Temp/°C | Time/min | Product yield/%[c] |
|---|---|---|---|---|---|
| 1 | **1a** : $R^1 = R^2 = R^3 = R^4 = H$ | 1:2 | rt | 2 d | **2a** (15) |
| 2 | **1a** : $R^1 = R^2 = R^3 = R^4 = H$ | 1:2 | 70 | 70 | **2a** (35) |
| 3 | **1a** : $R^1 = R^2 = R^3 = R^4 = H$ | 1:2 | 100 | 7 | **2a** (48) |
| 4 | **1a** : $R^1 = R^2 = R^3 = R^4 = H$ | 1:2 | reflux | 2 | **2a** (60) |
| 5 | **1a** : $R^1 = R^2 = R^3 = R^4 = H$ | 1:2.5 | reflux | 4 | **2a** (69) |
| 6 | **1a** : $R^1 = R^2 = R^3 = R^4 = H$ | 1:3 | reflux | 5 | **2a** (55) |
| 7 | **1b** : $R^1 = R^2 = R^4 = H$, $R^3 = Me$ | 1:2 | reflux | 1 | **2b** (84) |
| 8 | **1c** : $R^1 = R^2 = R^4 = H$, $R^3 = OMe$ | 1:2 | reflux | 1 | **2c** (86) |
| 9 | **1d** : $R^1 = R^2 = R^4 = H$, $R^3 = Cl$ | 1:2.5 | reflux | 1 | **2d** (75) |
| 10 | **1e** : $R^1 = R^2 = R^4 = H$, $R^3 = F$ | 1:2.5 | reflux | 1 | **2e** (90) |
| 11 | **1f** : $R^1 = Me$, $R^2 = R^3 = R^4 = H$ | 1:2 | reflux | 0.5 | **2f** (96) |
| 12 | **1g** : $R^1 = OMe$, $R^2 = R^3 = R^4 = H$ | 1:2.5 | reflux | 1 | **2g** (88) |
| 13 | **1h** : $R^1 = Cl$, $R^2 = R^3 = R^4 = H$ | 1:2.5 | reflux | 0.5 | **2h** (93) |
| 14 | **1i** : $R^1 = R^2 = Me$, $R^3 = R^4 = H$ | 1:2.5 | reflux | 1 | **2i** (95) |
| 15 | **1j** : $R^1 = R^3 = H$, $R^2 = R^4 = Me$ | 1:2.5 | reflux | 1 | **2j** (88) |

[a] The reaction of the carboxamide **1** (0.5 mmol) was carried out in AcOH (15 mL).

[b] Molar ratio.

[c] Isolated yield.

**Oxidation of 2-Oxocyclohexane-1-carboxamides 1a-j**

The general procedure for the reactions of the 2-oxocyclohexane-1-carboxamides **1a-j** with $Mn(OAc)_3•2H_2O$ was as follows. To a cyclohexanecarboxamide **1** (0.5 mmol) dissolved in glacial AcOH (15 mL) was added $Mn(OAc)_3•2H_2O$ (1 mmol), and the mixture was quickly heated under reflux using a pre-heated oil bath at 140 °C until the brown color of Mn(III) turned transparent. After the Mn(III) oxidant was completely consumed, if needed the existence of the Mn(III) could be monitored by iodine-starch paper, the solvent was removed under reduced pressure. Each reaction time is listed in Table 1. The residue was triturated with 2M HCl (15 mL) and the aqueous mixture was extracted three times with $CHCl_3$ (20 mL × 3). The combined extracts were washed with a saturated aqueous solution of $NaHCO_3$ and water, dried over anhydrous $MgSO_4$, then concentrated to dryness. The obtained residue was separated by silica gel column chromatography eluting with EtOAc–hexane (3:7 v/v), giving the desired spiro[cyclohexane-1,3'-indoline]-2,2'-diones **2a-j** (Table 1).

**1'-Methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2a)** [17] Yield 69%; $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.31-7.28 (2H, m, arom H), 7.09 (1H, dt, *J* = 7.6, 1.0 Hz, arom H), 6.84 (1H, dd, *J* = 8.0, 0.8 Hz, arom H), 3.18 (3H, s, =N-Me), 3.05 (1H, ddd, *J* = 14.3, 10.4, 5.6 Hz, *H*-CH), 2.59 (1H, dt, *J* = 14.3, 5.6 Hz, *H*-CH), 2.45-2.37 (1H, m, *H*-CH), 2.26-2.21 (1H, m, *H*-CH), 2.20-2.13 (1H, m, *H*-CH), 2.09 (1H, ddd, *J* = 14.1, 10.3, 4.1 Hz, *H*-CH), 2.02-1.94 (1H, m, *H*-CH), 1.89-1.82 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): $\delta$ 204.9 (C=O), 174.0 (-N-C=O), 143.0 (C-7'a), 129.2 (C-3'a), 128.4, 124.3, 122.4, 108.2 (arom CH), 63.4 (C-1), 39.5, 37.0, 26.7 ($CH_2$), 26.2 (=N-Me), 20.1 ($CH_2$).

**1',5'-Dimethylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2b)** Yield 84%; Colorless microcrystals (from EtOH-hexane): mp 125-127 °C; IR: ν = 1690 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.12-7.10 (2H, m, arom H), 6.73 (1H, d, *J* = 8.0 Hz, arom H), 3.18 (3H, s, =N-Me), 3.07 (1H, ddd, *J* = 16.0, 11.0, 6.0 Hz, *H*-CH), 2.59 (1H, dt, *J* = 14.0, 5.0 Hz, *H*-CH), 2.44-2.40 (1H, m, *H*-CH), 2.36 (3H, s, Me), 2.25-2.27 (2H, m, *H*-CH), 2.08 (1H, ddd, *J* = 13.5, 10.5, 4.0 Hz, *H*-CH), 2.01-1.93 (1H, m, *H*-CH), 1.89-1.82 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): $\delta$ 205.3 (C=O), 174.1 (-N-C=O), 140.8 (C-7'a), 132.1 (C-5'), 129.4 (C-3'a), 128.9, 125.4, 108.1 (arom CH), 63.7 (C-1), 39.8, 37.3, 26.9 ($CH_2$), 26.4 (=N-Me), 21.2 (Me), 20.3 ($CH_2$). FAB HRMS (acetone-NBA) calcd for $C_{15}H_{18}NO_2$: 244.1338 (M+H). Found: 244.1321.

**5'-Methoxy-1'-methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2c)** Yield 86%; Colorless microcrystals (from EtOH-hexane): mp 111-113 °C; IR: ν = 1684 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 6.89 (1H, d, *J* = 2.4 Hz, arom H), 6.83 (1H, dd, *J* = 8.5, 2.4 Hz, arom H), 6.74 (1H, d, *J* = 8.5 Hz, arom H), 3.80 (3H, s, MeO), 3.17 (3H, s, =N-Me), 3.08 (1H, ddd, *J* = 16.0, 11.0, 6.0 Hz, *H*-CH), 2.57 (1H, dt, *J* = 14.0, 5.0 Hz, *H*-CH), 2.49-2.40 (1H, m, *H*-CH), 2.25-2.17 (2H, m, $CH_2$), 2.08 (1H, ddd, *J* = 14.5, 11.0, 4.0 Hz, *H*-CH), 2.01-1.92 (1H, m, *H*-CH), 1.87-1.81 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): $\delta$ 205.1 (C=O), 173.8 (-N-C=O), 155.9 (C-5'), 136.7 (C-7'a), 130.6 (C-3'a), 112.6, 112.3, 108.6 (arom CH), 64.0 (C-1), 55.8 (MeO), 39.7, 37.5, 26.9 ($CH_2$), 26.5 (=N-Me), 20.3 ($CH_2$). FAB HRMS (acetone-NBA) calcd for $C_{15}H_{18}NO_3$: 260.1287 (M+H). Found: 260.1296.

**5'-Chloro-1'-methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2d)** Yield 75%; Colorless microcrystals (from EtOH-hexane): mp 89-91 °C; IR: ν = 1694 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.29 (1H, dd, *J* = 8.3, 2.0 Hz, arom H), 7.25 (1H, d, *J* = 2.0 Hz, arom H), 6.76 (1H, d, *J* = 8.3 Hz, arom H), 3.18 (3H, s, =N-Me), 3.10 (1H, ddd, *J* = 16.5, 11.5, 6.0 Hz, *H*-CH), 2.57 (1H, dt, *J* = 14.0, 5.0 Hz, *H*-CH), 2.50-2.42 (1H, m, *H*-CH), 2.25-2.19 (2H, m, $CH_2$), 2.08 (1H, ddd, *J* = 15.0, 11.5, 4.0 Hz, *H*-CH), 2.00-1.91 (1H, m, *H*-CH), 1.86-1.80 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): $\delta$ 204.4 (C=O), 173.6 (-N-C=O), 141.7 (C-7'a), 130.9 (C-3'a), 128.5 (arom CH), 128.0 (C-5'), 125.2, 109.2 (arom CH), 63.7 (C-1), 39.6, 37.5, 26.9 ($CH_2$), 26.6 (=N-Me), 20.1 ($CH_2$). FAB HRMS (acetone-NBA) calcd for $C_{14}H_{15}ClNO_2$: 264.0791 (M+H). Found: 264.0784.

**5'-Fluoro-1'-methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2e)** Yield 90%; Colorless microcrystals (from EtOH-hexane): mp 76-78 °C; IR: ν = 1697 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.04-6.99 (2H, m, arom H), 6.77-6.75 (1H, m, arom H), 3.18 (3H, s, =N-Me), 3.12 (1H, ddd, *J* = 17.0, 11.5, 5.5 Hz, *H*-CH), 2.56 (1H, dt, *J* = 13.5, 4.5 Hz, *H*-CH), 2.52-2.43 (1H, m, *H*-CH), 2.25-2.19 (2H, m, $CH_2$), 2.08 (1H, ddd, *J* = 15.5, 11.5, 4.0 Hz, *H*-CH), 2.00-1.91 (1H, m, *H*-CH), 1.85-1.79 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): $\delta$ 204.5 (C=O), 173.7 (-N-C=O), 159.0 (d, *J* = 239 Hz, C-5'), 139.0 (d, *J* = 3 Hz, C-7'a), 130.7 (d, *J* = 9 Hz, C-3'a), 114.7 (d, *J* = 23 Hz, C-6'), 112.8 (d, *J* = 23 Hz, C-4'), 108.6 (d, *J* = 9 Hz, C-7'), 63.8 (d, *J* = 1 Hz, C-1), 39.5, 37.5, 26.9 ($CH_2$), 26.5 (=N-Me), 20.0 ($CH_2$). FAB HRMS (acetone-NBA) calcd for $C_{14}H_{15}FNO_2$: 248.1087 (M+H). Found: 248.1091.

**1',7'-Dimethylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2f)** Yield 96%; Colorless microcrystals (from EtOH-hexane): mp 128-130 °C; IR: ν = 1684 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): $\delta$ 7.09 (1H, d, *J* = 7.2 Hz arom H), 7.03 (1H, d, *J* = 7.6 Hz, arom H), 6.99 (1H, t, *J* = 7.6 Hz, arom H), 3.47 (3H, s, =N-Me), 3.08 (1H, ddd, *J* = 16.5, 11.5, 5.5 Hz, *H*-CH), 2.59-2.57 (1H, m, *H*-CH), 2.56 (3H, s, Me), 2.48-2.41 (1H, m, *H*-CH), 2.21-2.18 (2H, m, $CH_2$), 2.07 (1H,

ddd, *J* = 14.0, 10.5, 4.0 Hz, *H*-CH), 1.99-1.90 (1H, m, *H*-CH), 1.86-1.81 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): *δ* 205.4 (C=O), 174.8 (-N-C=O), 140.9 (C-7'a), 132.3 (arom CH), 130.0 (C-3'a), 122.5 (2C, arom CH), 119.9 (C-7'), 63.0 (C-1), 39.7, 37.7 ($CH_2$), 29.8 (=N-Me), 26.9, 20.3 ($CH_2$), 19.1 (Me). FAB HRMS (acetone-NBA) calcd for $C_{15}H_{18}NO_2$: 244.1338 (M+H). Found: 244.1326.

**7'-Methoxy-1'-methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2g)** Yield 88%; Colorless microcrystals (from EtOH-hexane): mp 94-96 °C; IR: ν = 1684 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): *δ* 7.04 (1H, t, *J* = 7.9 Hz, arom H), 6.88 (1H, s, arom H), 6.88 (1H, d, *J* = 8.0 Hz, arom H), 3.84 (3H, s, MeO), 3.46 (3H, s, =N-Me), 3.10 (1H, ddd, *J* = 16.5, 11.0, 6.0 Hz, *H*-CH), 2.56 (1H, dt, *J* = 13.5, 4.8 Hz, *H*-CH), 2.50-2.41 (1H, m, *H*-CH), 2.23-2.19 (2H, m, $CH_2$), 2.07 (1H, ddd, *J* = 14.0, 10.0, 4.0 Hz, *H*-CH), 1.98-1.89 (1H, m, *H*-CH), 1.85-1.80 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): *δ* 205.4 (C=O), 174.2 (-N-C=O), 145.3 (C-7'a), 131.1 (C-3'a), 130.9 (C-7'), 123.1, 117.2, 112.4 (arom CH), 63.6 (C-1), 55.9 (MeO), 39.6, 37.6 ($CH_2$), 29.7 (=N-Me), 26.8, 20.1 ($CH_2$). FAB HRMS (acetone-NBA) calcd for $C_{15}H_{18}NO_3$: 260.1287 (M+H). Found: 260.1277.

**7'-Chloro-1'-methylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2h)** Yield 93%; Yellow oil; IR: ν = 1699 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): *δ* 7.23 (1H, dd, *J* = 8.2, 1.1 Hz, arom H), 7.12 (1H, dd, *J* = 7.4, 1.1 Hz, arom H), 7.01 (1H, t, *J* = 7.5 Hz, arom H), 3.56 (3H, s, =N-Me), 3.13 (1H, ddd, *J* = 18.0, 12.5, 6.0 Hz, *H*-CH), 2.55 (1H, dt, *J* = 13.5, 4.3 Hz, *H*-CH), 2.52-2.45 (1H, m, *H*-CH), 2.25-2.18 (2H, m, $CH_2$), 2.08 (1H, ddd, *J* = 15.5, 11.5, 4.0 Hz, *H*-CH), 1.97-1.88 (1H, m, *H*-CH), 1.84-1.78 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): *δ* 204.5 (C=O), 174.1 (-N-C=O), 139.0 (C-7'a), 131.9 (C-3'a), 130.8, 123.4, 123.2 (arom CH), 115.5 (C-7'), 63.2 (C-1), 39.5, 37.9 ($CH_2$), 29.8 (=N-Me), 26.9, 20.0 ($CH_2$). FAB HRMS (acetone-NBA) calcd for $C_{14}H_{15}ClNO_2$: 264.0791 (M+H). Found: 264.0777.

**1',6',7'-Trimethylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2i)** Yield 95%; Colorless microcrystals (from EtOH-hexane): mp 132-134 °C; IR: ν = 1684 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): *δ* 6.99 (1H, d, *J* = 7.5 Hz, arom H), 6.92 (1H, d, *J* = 7.5 Hz, arom H), 3.49 (3H, s, =N-Me), 3.07 (1H, ddd, *J* = 16.5, 11.0, 5.5 Hz, *H*-CH), 2.56 (1H, dt, *J* = 14.5, 5.0 Hz, *H*-CH), 2.47 (3H, s, Me-C-7'), 2.45-2.38 (1H, m, *H*-CH), 2.30 (3H, s, Me-C-6'), 2.21-2.17 (2H, m, $CH_2$), 2.11-2.02 (1H, m, *H*-CH), 1.98-1.89 (1H, m, *H*-CH), 1.86-1.79 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): *δ* 205.5 (C=O), 175.2 (-N-C=O), 141.2 (C-7'a), 138.4 (C-6'), 127.9 (C-3'a), 124.2, 121.7 (arom C), 119.1 (C-7'), 62.7 (C-1), 39.6, 37.6 ($CH_2$), 30.6 (=N-Me), 26.8 ($CH_2$), 20.8 (Me-C-7'a), 20.3 ($CH_2$), 14.1 (Me-C-6'a). FAB HRMS (acetone-NBA) calcd for $C_{16}H_{20}NO_2$: 258.1494 (M+H). Found: 258.1505.

**1',4',6'-Trimethylspiro[cyclohexane-1,3'-indoline]-2,2'-dione (2j)** Yield 88%; Colorless microcrystals (from EtOH-hexane): mp 164-166 °C; IR: ν = 1686 (-N-C=O); $^1$H NMR (500 MHz, $CDCl_3$): *δ* 6.72 (1H, s, arom H), 6.49 (1H, s, arom H), 3.19-3.15 (1H, m, *H*-CH), 3.13 (3H, s, =N-Me), 2.64-2.54 (2H, m, $CH_2$), 2.38 (1H, dt, *J* = 13.8, 4.5 Hz, *H*-CH), 2.33 (3H, s, Me-C-6'), 2.27-2.22 (1H, m, *H*-CH), 2.17 (3H, s, Me-C-4'), 2.05-2.01 (1H, m, *H*-CH), 1.87-1.79 (1H, m, *H*-CH), 1.78-1.74 (1H, m, *H*-CH); $^{13}$C NMR (125 MHz, $CDCl_3$): *δ* 204.6 (C=O), 173.8 (-N-C=O), 143.4 (C-7'a), 138.6 (C-6'), 134.6 (C-4'), 125.9 (arom C), 124.7 (C-3'a), 125.9 (arom C), 63.3 (C-1), 40.3, 34.8, 26.4 ($CH_2$), 26.3 (=N-Me), 21.5 (Me-C-6'), 20.0 ($CH_2$), 19.0 (Me-C-4'). FAB HRMS (acetone-NBA) calcd for $C_{16}H_{19}NO_2Na$: 280.1313 (M+Na). Found: 280.1315.

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