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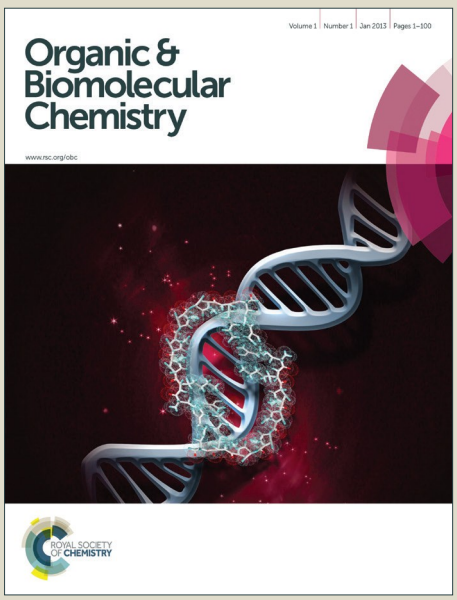

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N-Heterocyclic Carbene-Catalyzed [3+2] Annulation of Bromoenals with 3-Aminooxindoles: Highly Enantioselective Synthesis of Spirocyclic Oxindolo-γ-Lactams

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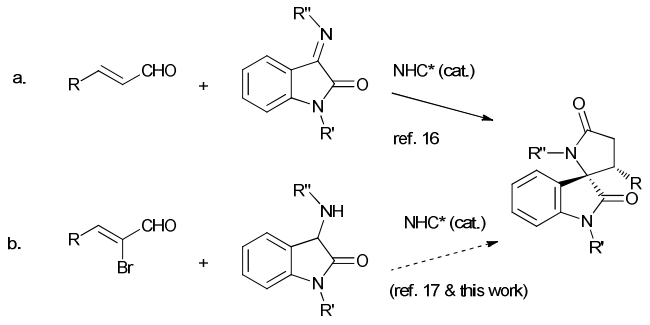
Kun-Quan Chen,[a,b] Yao Li,[a,b] Chun-Lin Zhang,[a] De-Qun Sun*[b] and Song Ye*[a]

The chiral N-heterocyclic carbene-catalyzed [3+2] annulation of α-bromoenals and 3-aminooxindoles was developed, giving the corresponding spirocyclic oxindolo-γ-lactams in good yields with high diastereoselectivities and enantioselectivities.

Introduction

Functionalized spirocyclic oxindolopyrrolidine and its derivatives are privileged structural building blocks in many natural and unnatural products with various bioactivities.[1] Thus, the synthesis of this motif has been pursued via several approaches,[2] including the typical multi-component reaction of isatin, amine and *α,β*-unsaturated ketones.[2f-h] However, the enantioselective syntheses of spirocyclic oxindolopyrrolidine are very rare but highly desired.[2d,3]

In the last decades, N-heterocyclic carbene (NHC) has been developed as one of the most powerful organocatalysts[4] for a wide variety reactions of aldehydes,[5] ketenes,[6] esters,[7] acids[8] and Michael acceptors,[9] Among these reactions, the *α,β*-unsaturated acyl azolium intermediate, catalytically generated *in situ* from enals,[10] ynals,[11] *α*-bromoenals,[12] acyl halides,[13] acids,[8a-c] and esters,[14] usually acts as biselectrophiles and goes [3+n] annulation with many bisnucleophiles to afford carbo- and heterocycles.[15] In 2012, the NHC-catalzyed [3+2] annulation of enals with oxindole-derived imines to give spirocyclic oxindolo-*γ*-lactams was developed by Jiao and Ye et al. and Chi et al.[16] (Scheme 1, reaction a). Following our previous report on NHC-catalyzed [3+3] annulation of bromoenals with 1,3-bisnucleophiles and the [3+2] annulation with α-amino ketones to give *γ*-lactams,[8a] we are interested in developing the reaction with 3-aminooxindoles for the synthesis of spirocyclic oxindolo-*γ*-lactams (Scheme 1, reaction b). During the preparation of this manuscript, Lu and Du et al. published a related paper majorly focusing on the non-asymmetric reaction.[17] In this paper, we report our enantioselective reaction, which showed the scope and limitation of 3-aminooxindoles and bromoenals.



Scheme1. NHC-catalyzed Enantioselective synthesis of spirocyclic oxindolo-γ-lactams

Results and discssion

Initially, the model reaction of 3-aminooxindole **1a** and *α*-bromoenal **2a** was investigated under NHC catalysis (Table

[a] *Beijing National Laboratory for Molecular Sciences, CAS Key Laboratory of Molecular Recognition and Function, Institute of Chemistry, Chinese Academy of Sciences, Beijing 100190, China. E-mail: songye@iccas.ac.cn*

[b] *Marine College, Shandong University at Weihai, 180 Wenhua West Road, Weihai 264209, China.. E-mail: dequn.sun@sdu.edu.cn*

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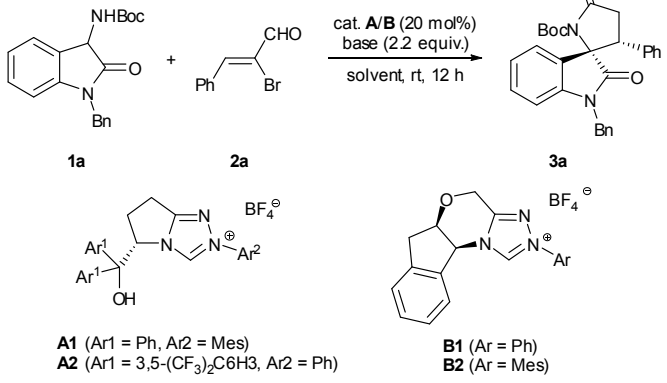
1). We were encouraged to find that the reaction catalyzed by the preNHC **A1** or **A2**,[18] derived from *L*-pyroglutamic acid, gave the desired spirocyclic oxindolo-γ-lactam **3a** in moderate yields with high enantioselectivities and diastereoselectivities (entries 1 and 2). Then the tetracyclic preNHC catalysts **B1**[19] and **B2**,[20] derived from aminoindanol, were employed, which resulted in improved yields and better enantioseletivities (entries 3 & 4). Screening of the bases revealed that the reaction using inorganic bases, such as Cs_2CO_3, K_2CO_3 and Na_2CO_3 gave product in low yields but with high diastereo- and enantioselectivities (entries 5-7), while organic bases, such as Et_3N, DIPEA and DMAP, resulted in good to high yields but much low diastereo- and/or enantioselectivities (entries 8-10). Considering the two roles of the base for generation of free NHC from triazolium salts and removal of the generated hydrobromide, we then examined the mixed base of DABCO and Cs_2CO_3, which gave the balanced results for yield and selectivies (entry 11). Solvent screening revealed that reactions went well in toluene, THF, ether and dichloromethane (entries 11-14). Lowering the catalyst loading to 15 mol% gave comparable results (entry 15), but the yields were decreased gradually when 10 and 5 mol% catalyst were used (entries 16 & 17). Further experiments to clarify the roles of two bases were carried out by using the free NHC as the catalyst, which was prepared with KH as the base.[21] It were found that the reaction gave only product in moderate yield using DABCO as the base, while only trace of product **3a** was observed when Cs_2CO_3 was used (entries 18 & 19)

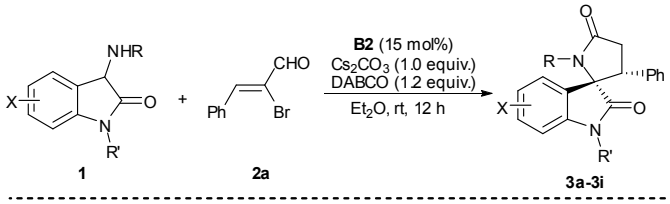
Table 1. Optimization of reaction conditions

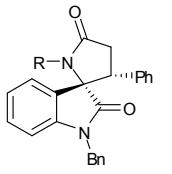


entry	cat.	base	solvent	yield (%)[a]	ee (%)[b]	d.r.[c]
1	**A1**	DABCO	toluene	24	-89	>20:1
2	**A2**	DABCO	toluene	48	-92	10:1
3	**B1**	DABCO	toluene	51	95	12:1
4	**B2**	DABCO	toluene	50	95	15:1
5	**B2**	Cs_2CO_3	toluene	39	96	>20:1
6	**B2**	K_2CO_3	toluene	30	97	>20:1
7	**B2**	Na_2CO_3	toluene	32	92	17:1
8	**B2**	Et_3N	toluene	75	92/73	3:1
9	**B2**	DIPEA	toluene	68	83/65	5:1
10	**B2**	DMAP	toluene	85	67/72	3:1
11	**B2**	DABCO/Cs_2CO_3[d]	toluene	52	97	>20:1
12	**B2**	DABCO/Cs_2CO_3[d]	THF	45	90	12:1
13	**B2**	DABCO/Cs_2CO_3[d]	DCM	57	94/45	6:1
14	**B2**	DABCO/Cs_2CO_3[d]	Et_2O	67	98	17:1
15	**B2**[e]	DABCO/Cs_2CO_3[d]	Et_2O	70	98	16:1
16	**B2**[f]	DABCO/Cs_2CO_3[d]	Et_2O	60	98	17:1
17	**B2**[g]	DABCO/Cs_2CO_3[d]	Et_2O	45	98	16:1
18	**B2**	DABCO/KH[h]	Et_2O	44	95	>20:1
19	**B2**	Cs_2CO_3/KH[h]	Et_2O	trace	/	/

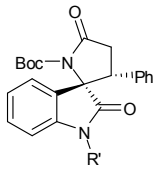
[a] Isolated yields. [b] Enantiomerical excess of the major isomer, and followed by minor isomer for entries 8, 9, 10 and 13. [c] Determined by ^{1}H NMR (300 MHz) of the raw products. [d] The mix base of DABCO (1.0 equiv.) and Cs_2CO_3 (1.2 equiv.) was used. [e] 15 mol% of preNHC **B2.** [f] 10 mol% of preNHC **B2.** [g] 5 mol% of of preNHC **B2**. [h] The free NHC was prepared using KH as the base and used immediately

Table 2. Variation of 3-aminooxindoles.

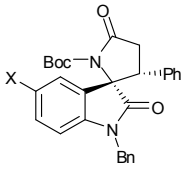




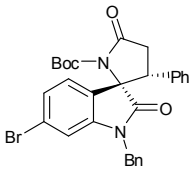
3a (R = Boc), 70%, 98% ee, 16:1 dr
3a' (R = Ac), trace
3a" (R = Bz), trace



3b (R' = H), 52%, 99% ee, >20:1 dr
3c (R' = Me), 69%, 91% ee, >20:1 dr
3d (R' = *n*-Pr), 67%, 99% ee, >20:1 dr



3e (X = F), 68%, 98% ee, 12:1 dr
3f (X = Cl), 66%, 98% ee, 15:1 dr
3g (X = Me), 76%, 98% ee, 17:1 dr
3h (X = MeO), 69%, 97% ee, 17:1 dr



3i, 65%, 99% ee, 15:1 dr

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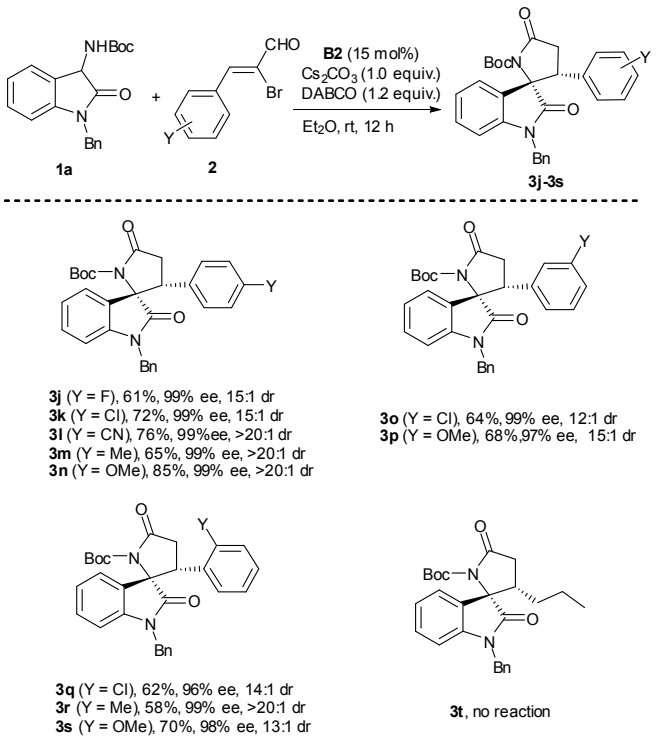
Table 3. Variation of bromoenals.



Under the optimized reaction conditions, the scope of 3-aminooxindole were then briefly investigated (**Table 2**). Different substituents on the 3-amino of the oxindoles were examined, and it was found that although the amine with *N*-Boc worked well for the reaction (**3a)**, *N*-acyl and *N*-benzoyl did not (**3a′** & **3a″**). Then, the protecting groups on the nitrogen of the oxindole ring were tested. Interestingly, the oxindole without protecting group resulted in only slight loss of the yield but with excellent diastereo- and enantioselectivity (**3b**), and the ones with *N*-methyl, *N*-propyl substituents (**3c** & **3d)** worked as well as the *N*-benzyl (**3a**). Further variation of the substituent on the phenyl ring of the oxindole revealed that both electron-withdrawing (5-FC_6H_4, 5-ClC_6H_4) and electron-donating groups (5-MeC_6H_4, 5-$MeOC_6H_4$) were well tolerated (**3e-3h**), and the one with 6-substituent (6-BrC_6H_4) afforded the product **3i** in 65% yield with 99% ee and 15:1 dr.

The reaction scope of bromoenals was also investigated (Table 3). It was found that all the α-bromocinnamic aldehdyes with *para*-electron-withdrawing (4-FC_6H_4, 4-ClC_6H_4, 4-CNC_6H_4) and electron-donating substituent (4-MeC_6H_4, 4-$MeOC_6H_4$) worked well to give the desired products (**3j-3n**) in good yield with excellent enantioselectivities and high diastereoselectivities. The ones with *meta*-substituent (3-ClC_6H_4, 3-$MeOC_6H_4$) and *ortho*-substituent (2-ClC_6H_4, 2-MeC_6H_4, 2-$MeOC_6H_4$) were also tolerated (**3o-3s**). Unfortunately, alkyl bromoenals did not work under current reaction condition.

The configuration of the compounds **3a-c** was assigned by the comparison of its optical rotation with those reported in the literature.[16a]

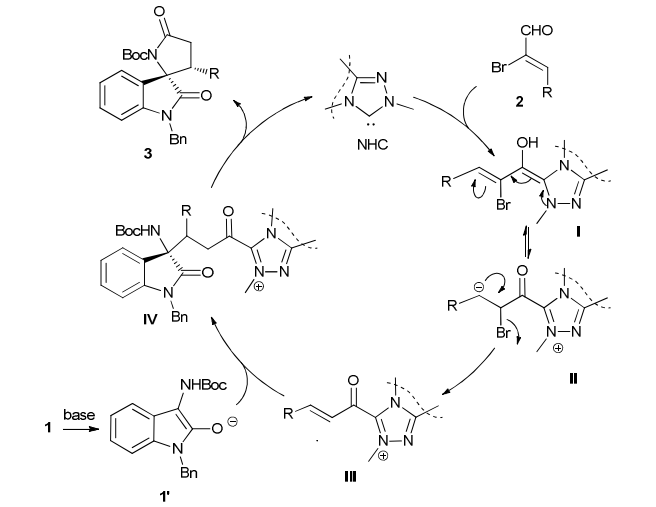


Fig. 1 Plausible catalytic cycle.

The plausible catalytic cycle of the NHC-catalyzed reaction is depicted in Figure 1. The addition of an NHC catalyst to bromoenal **2** generates the Breslow intermediate **I**, which is tautomerized to α-bromoacyl azolium anion **II**. The leaving of the bromide gives the corresponding unsaturated acyl azolium intermediate **III**. Michael addition of 3-aminooxindole **1** via its enolate **1′** to the α,β-unsaturated acyl azolium **III** gives adduct **IV**, which then undergoes lactamization to afford the final cycloadduct **3** and regenerates the NHC catalyst.

Conclusions

In summary, the NHC-catalyzed [3+2] annulation of α-bromoenals and 3-aminooxindoles was developed. The mix base of inorganic and organic bases benefits the reaction. A variety of α-bromoenals and 3-amniooxindoles worked well, giving the corresponding spirocyclic oxindolo-γ-lactams in good yields with excellent enantioselectivities and high diastereoselectivities. Other related NHC-catalyzed reactions are underway in our laboratory.

Acknowledgements

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Experimental section

General information

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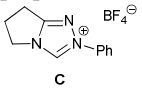
Unless otherwise indicated, all reactions were carried out with N_2/Ar protection with magnetic stirring. Anhydrous THF and toluene were distilled from sodium and benzophenone. Anhydrous CH_2Cl_2 was distilled from CaH_2. Chiral triazolium salts **A1-A2**, **B1-B2** and 3-aminooxindoles[22] were synthesized according to literatures. Column chromatograph was performed on silica gel 200~300 mesh. All ^{1}H NMR (400 MHz) or (500 MHz), ^{13}C NMR (101 or 125 MHz) spectra were recorded on a Bruker-DMX 400 or 500 pectrometer in $CDCl_3$, with tetramethylsilane as an internal standard and reported in parts per million (ppm, δ). ^{1}H NMR Spectroscopy splitting patterns were designated as singlet (s), doublet (d), triplet (t), quartet (q). Splitting patterns that could not be interpreted or easily visualized were designated as multiplet (m) or broad (br). Infrared spectra were recorded on a Nicolet 6700 spectrophotometer and reported as wave number (cm^{-1}). Optical rotations were measured on Rudolph-Autop VI digital polarimeter operating at the sodium D line with a 100 mm path cell, and are reported as follows: $[\alpha]_D^T$ (concentration (g/100 mL), solvent).

[3+2] Annulation of bromoenals with 3-aminooxindoles (Table 2 & 3)

Typical procedure: To the a dry Schlenk, aminooxindole **1a** (47.8 mg, 0.2 mmol), bromoenal **2a** (84.4 mg, 0.4 mmol), NHC precursor **B2** (12.5 mg，0.03 mmol), Cs_2CO_3 (65 mg, 0.2 mmol) and DABCO (27 mg, 0.24 mmol) were added in toluene (2.0 mL), at room temperature. The reaction mixture was stirred at room temperature until the full consumption of the aminooxindole (typically, 12 h). The reaction mixture was concentrated under reduced pressure, and the diastereomerical ratio of the raw product was determined by the ^{1}H NMR (300 MHz). The residue was purified by column chromatography on silica gel (petroleumether/EtOAc as the eluent, typically 7:1-5:1) to give **3a**.

Racemic samples for the chiral phase HPLC analysis were prepared using NHC precursor **C** under the same conditions.



C

(*2'S,3'R*)-*tert*-butyl 1-benzyl-2,5'-dioxo-3'-phenylspiro [indoline-3,2'-pyrrolidine]-1'- carboxylate (3a).[16a]
Yield: 58 mg (70%), white solid mp 180-182°C, $[\alpha]_D^{25}$ +31.1 (*c* 1.0, CH_2Cl_2); HPLC analysis: 98% ee [Daicel CHIRALPAK OD-H, 70:30 hexanes/*i*-PrOH, 1.0 ml/min, 9.2min (minor), 22.8min (major)], ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43 (d, J = 7.1 Hz, 1H), 7.30 (t, J = 7.4 Hz, 1H), 7.20 -7.14 (m 5H), 7.08 (t, J = 7.5 Hz, 2H), 6.93 (d, J = 7.6 Hz, 2H), 6.40 (t, J = 6.9 Hz, 3H), 5.02 (d, J = 15.9 Hz, 1H), 4.10 (d, J = 15.9 Hz, 1H), 3.84 (dd, J = 13.9, 7.5 Hz, 1H), 3.70 (dd, J = 16.2, 14.2 Hz, 1H), 2.80 (dd, J = 16.4, 7.5 Hz, 1H), 1.09 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.0, 173.6, 148.1, 143.5, 134.7, 132.7, 129.9, 128.8, 128.7, 128.6, 128.5, 127.4, 126.6, 123.3, 122.2, 109.7, 83.8, 71.7, 49.0, 44.1, 35.1, 27.7, 27.6. IR (KBr) *v* 3061, 2980, 1723, 1490, 1104 cm^{-1}. HRMS (ESI) [M+Na] calcd for $C_{29}H_{28}O_4N_2Na$ 491.1932, found 491.1941.

(*2'S,3'R*)-*tert*-butyl 2,5'-dioxo-3'-phenylspiro[indoline-3,2'-pyrrolidine]-1'-carboxylate (3b).[16a]
Yield: 39.3 mg (52%), white solid, mp 178-179°C, R_f= 0.1 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +25 (*c* 0.5 CH_2Cl_2); HPLC analysis: 99% ee [Daicel CHIRALPAK AD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 12.8 min (minor), 30.4 min (major)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (t, *J* = 6.9 Hz, 1H), 7.30 – 7.21 (m, 5H), 6.87 (d, *J* = 8.1 Hz, 2H), 6.66 (d, *J* = 7.7 Hz, 1H). 3.74 (dd, *J* = 13.8, 7.5 Hz, 1H), 3.74 (dd, *J* = 13.8, 7.5 Hz, 1H), 3.63 – 3.51 (m, 1H), 2.76 (dd, *J* = 16.4, 7.4 Hz, 1H), 1.15 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 175.3, 173.5, 148.2, 141.0, 132.5, 129.9, 129.0, 128.5, 128.4, 128.2, 123.3, 122.5, 110.1, 84.2, 72.0, 49.1, 34.9, 27.5. IR (KBr) *v* 3304, 2918, 1785, 1384, 1297 cm^{-1}.HRMS (ESI) *m/z*: [M+Na]Calc. for $C_{24}H_{15}Cl_2O_3Na$, 401.1465, Found 401.1472.

(*2'S,3'R*)-*tert*-butyl 1-methyl-2,5'-dioxo-3'-phenylspiro [indoline-3,2'-pyrrolidine]-1'- carboxylate (3c).[16a]
Yield: 53 mg (69%). white solid mp 188-190°C, $[\alpha]_D^{25}$ -23.5 (c 1.0, CH_2Cl_2); HPLC analysis: 91% ee [Daicel CHIRALPAK OD-H, 90:10 hexanes/i-PrOH, 1.0 ml/min, 8.5 min(minor), 19.8 min (major)]; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39 (d, J = 7.3 Hz, 1H), 7.32 (d, J = 7.6 Hz, 1H), 7.19-7.10 (M Hz, 4H), 6.82 (d, J = 7.5 Hz, 2H), 6.60 (d, J = 7.8 Hz, 1H), δ 3.71 (dd, J = 13.9, 7.1 Hz, 1H), 3.65 – 3.59 (m, 1H), δ 2.76 (dd, J = 16.1, 7.1 Hz, 1H), 2.72 (s, 3H), 1.09 (s, 9H). ^{13}C NMR (126 MHz, CDCl3) δ 173.7, 148.1, 143.8, 132.5, 129.9, 128.7, 128.4, 128.2, 128.1, 128.0, 123.2, 121.9, 108.2, 83.8, 72.1, 49.2, 34.8, 27.5, 25.7. IR (KBr) *v* 3312, 2908, 1790, 1307, 1152 cm^{-1}.HRMS (ESI) m/z: [M+Na] Calc. for $C_{23}H_{24}O_4N_2Na$, 415.1621, Found 415.1628.

(*2'S,3'R*)-*tert*-butyl 2,5'-dioxo-3'-phenyl-1-propylspiro [indoline-3,2'-pyrrolidine]-1'- carboxylate (3d).
Yield: 56 mg (67%), white solid, mp 175-176°C, R_f = 0.35 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ -55.5 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK AD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 85:15, 1.0 mL/min, 250 nm, 7.3 min (minor), 15.8 min (major)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, J = 7.3 Hz, 1H), 7.32 (td, J = 7.8, 1.0 Hz, 1H), 7.19 – 7.10 (m, 4H), 6.83 (d, J = 7.3 Hz, 2H), 6.62 (d, J = 7.8 Hz, 1H), 3.77 – 3.61 (m, 2H), 3.52 (ddd, J = 14.4, 9.0, 5.8 Hz, 1H), 2.96 – 2.90 (m, 1H), 2.77 (dd, J = 15.8, 6.9 Hz, 1H), 1.08 (s, 9H), 1.06 – 0.86 (m, 2H), 0.56 (t, J = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 173.8, 173.5, 148.0, 143.8, 132.5, 129.78, 128.75, 128.4, 128.3, 128.2, 123.0, 122.1, 108.5, 83.8, 71.7, 49.0, 41.6, 34.8, 27.5, 20.6, 11.4. IR (KBr) *v* 3421, 1791, 1384, 1100cm^{-1}.HRMS (ESI) *m/z*: [M+Na]Calc. for $C_{25}H_{28}O_4N_2Na$, 443.1936, Found 443.1941.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-5-fluoro-2,5'-dioxo-3'-phenylspiro[indoline-3,2'-pyrrolidine] -1'- carboxylate (3e).

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Yield: 62 mg (68%) with 18:1 dr, white solid, mp 159-163°C, R_f= 0.3 (petroleum ether/ethyl acetate, 5:1).$[\alpha]_D^{25}$ +24 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 80:20, 1.0 mL/min, 250 nm, 13.4 min (minor) , 27.3 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 (t, J = 7.3 Hz, 1H), 7.26-7.15 (m, 4H), 7.09 (t, J = 7.5 Hz, 2H), 6.97 – 6.88 (m, 3H), 6.38 (d, J = 7.5 Hz, 2H), 6.31 (dd, J = 8.5, 3.9 Hz, 1H), 4.99 (d, J = 15.9 Hz, 1H), 4.11 (d, J = 15.9 Hz, 1H), 3.79 (dd, J = 13.9, 7.3 Hz, 1H), δ 3.79 (dd, *J* = 13.9, 7.3 Hz, 1H), 3.72 – 3.66 (m, 1H), 2.81 (dd, J = 16.2, 7.3 Hz, 1H), 1.16 (s, 9H). ^{13}C NMR (126 MHz, CDCl3) δ 173.9, 173.2, δ 159.53 (d, $J_{C,F}$ = 243.0 Hz 1C), 148.1, 139.4 139.4, 134.5, 132.4, 130.29 (d, $J_{C,F}$ = 7.7 Hz 1C), 128.9, 128.8, 128.7, 128.6, δ 127.5, 126.6, 116.1 (d, $J_{C,F}$ = 23.3 Hz 1C), 110.37 (t, $J_{C,F}$ = 16.2 Hz), 84.2, 71.8, 49.1, 44.3, 35.2, 27.8, 27.7. IR (KBr) *v* 3344, 1793, 1492, 1154cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$Calc. for $C_{29}H_{27}O_4N_2NaF$, 509.1838, Found 509.1847.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-5-chloro-2,5'-dioxo-3'-phenylspiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3f).

Yield: 65 mg (66%) with 16:1 dr, white solid mp 165-169°C, R_f= 0.22 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +35 (*c* 1.0, CH_2Cl_2), HPLC analysis: 98% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 14.5 min (minor) , 26.6 min (major)]. ^{1}H NMR (500 MHz, CDCl3) δ 7.43 (d, J = 2.0 Hz, 1H), 7.33 (t, J = 7.4 Hz, 1H), 7.21 (t, J = 7.7 Hz, 2H), 7.19 – 7.15 (m, 2H), 7.09 (t, J = 7.5 Hz, 2H), 6.97 (d, J = 7.6 Hz, 2H), 6.39 (t, J = 7.8 Hz, 2H), 6.31 (d, J = 8.3 Hz, 1H), 4.98 (d, J = 15.9 Hz, 1H), 4.11 (d, J = 16.0 Hz, 1H), 3.80 (dd, J = 13.9, 7.5 Hz, 1H), 3.68 (dd, J = 16.3, 14.0 Hz, 1H), 2.81 (dd, J = 16.4, 7.5 Hz, 1H), 1.16 (s, 9H). ^{13}C NMR (126 MHz, CDCl3) δ 173.7, 173.1, 148.1, 142.0, 134.3, 132.3, 130.4, 129.8, 128.9, 128.8, 128.74, 128.72, 128.6, 127.6, 126.6, 122.6, 110.7, 84.3, 71.6, 49.0, 44.2, 35.2, 27.7. IR (KBr) *v* 3304, 1791, 1384, 1150 cm^{-1}.HRMS (ESI) *m/z*: [M+Na] Calc. for $C_{29}H_{27}O_4N_2ClNa$, 525.1545, Found 525.1552.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-5-methyl-2,5'-dioxo-3'-phenylspiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3g).

Yield: 73 mg (76%), white solid mp 173-175°C, R_f= 0.22 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +47 (*c* 1.0, CH_2Cl_2), HPLC analysis: 98% ee [Daicel CHIRALPAK AD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 85:15, 1.0 mL/min, 250 nm, 15.8 min (minor), 32.9 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.23 (t, *J* = 7.4 Hz, 1H), 7.19 (d, *J* = 4.4 Hz, 1H), 7.12-7.05 (m, 3H), 7.00 (t, *J* = 7.5 Hz, 2H), 6.89 (dd, *J* = 20.2, 7.8 Hz, 3H), 6.30 (d, *J* = 7.5 Hz, 2H), 6.21 (d, *J* = 7.9 Hz, 1H), 4.93 (d, *J* = 15.9 Hz, 1H), 4.00 (d, *J* = 15.9 Hz, 1H), 3.75 (dd, *J* = 13.9, 7.5 Hz, 1H), 3.65 – 3.59 (m, 1H), 2.72 (dd, *J* = 16.3, 7.5 Hz, 1H), 2.30 (s, 3H), 1.02 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.0, 173.6, 148.1, 141.1, 134.9, 132.9, 132.8, 130.1, 128.71, 128.66, 128.6, 128.54, 128.46, 127.3, 126.6, 122.8, 109.4, 83.8, 71.8, 48.9, 44.1, 35.2, 27.5, 21.2. IR (KBr) *v* 3459, 1635, 1384, 1088 cm^{-1}.HRMS (ESI) *m/z*: [M+Na] Calc. for $C_{30}H_{30}O_4N_2Na$, 505.2089, Found 505.2098.

(*2'S, 3'R*)-*tert*-butyl 1-benzyl-5-methoxy-2,5'-dioxo-3'-phenylspiro[indoline-3,2'-pyrrolidine]-1'- carboxylate (3h).

Yield: 69 mg (69%),white solid mp 183-186°C, R_f= 0.22 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +47 (*c* 1.0, CH_2Cl_2), HPLC analysis: 97% ee [Daicel CHIRALPAK OD-H column, 20°C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 15.1 min (minor) , 31.0 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (t, *J* = 7.3 Hz, 1H), 7.20-7.13 (m, 3H), 7.09 – 7.05 (m, 3H), 6.96 (d, *J* = 7.6 Hz, 2H), 6.71 (dd, *J* = 8.5, 2.2 Hz, 1H), 6.38 (d, *J* = 7.4 Hz, 2H), 6.30 (d, *J* = 8.5 Hz, 1H), 4.99 (d, *J* = 15.9 Hz, 1H), 4.07 (d, *J* = 15.9 Hz, 1H), 1H NMR (500 MHz, $CDCl_3$) δ 3.80 (s, 3H) 3.82 – 3.67 (m, 2H), 2.79 (dd, *J* = 16.2, 7.3 Hz, 1H), 1.13 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.8, 173.5, 156.6, 148.1, 136.8, 134.8, 132.7, 129.8, 128.8, 128.71, 128.66, 128.6, 128.5, 126.6, 114.4, 110.2, 109.1, 83.9, 72.0, 56.0, 49.1, 44.1, 35.2, 27.6. IR (KBr) *v* 3329, 1795, 1484, 1288 cm^{-1}.HRMS (ESI) *m/z*: Calc. [M+Na]for $C_{30}H_{30}N_2NaO_5$, 521.2040 Found 521.2044.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-6-bromo-2,5'-dioxo-3'-phenylspiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3i).

Yield: 77 mg (65%), white solid, mp 156-158°C, R_f = 0.30 (petroleum ether/ethyl acetate, 20:1). $[\alpha]_D^{25}$ +47 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20°C, 250 nm hexane/*i*-PrOH = 90:10, 1.0 mL/min, 250 nm, 10.9min (minor), 29.7min (major),]. ^{1}H NMR (500 MHz, CDCl3) δ 7.43 (d, *J* = 7.2 Hz, 1H), 7.30 (t, *J* = 7.4 Hz, 1H), 7.21 – 7.13 (m, 4H), 7.08 (t, *J* = 7.5 Hz, 2H), 6.93 (d, *J* = 7.7 Hz, 2H), 6.40 (t, *J* = 6.4 Hz, 3H), 5.02 (d, *J* = 15.9 Hz, 1H), 4.10 (d, *J* = 15.9 Hz, 1H), 3.83 (dd, *J* = 13.9, 7.5 Hz, 1H), 3.73 – 3.67 (m, 1H), 2.81 (dd, *J* = 16.4, 7.5 Hz, 1H), 1.09 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.1, 173.6, 148.1, 143.5, 134.8, 132.7, 129.9, 128.8, 128.7, 128.64, 128.57, 128.5, 127.4, 126.7, 123.3, 122.2, 109.7, 83.9, 71.7, 49.0, 44.1, 35.2, 27.6. IR (KBr) *v* 3343, 1790, 1467, 1276cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$Calc. for $C_{29}H_{28}O_4N_2Na$, 491.1932, Found 491.1941.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(4-fluorophenyl)-2,5'-dioxospiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3j).

Yield: 59 mg (61%), white solid, mp 149-150°C, R_f= 0.31 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +25 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 80:20, 1.0 mL/min, 250 nm, 11.2 min (minor) 36.7 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.42 (d, J = 7.3 Hz, 1H), 7.26 – 7.12 (m, 4H), 6.85 (dq, J = 17.2, 8.7 Hz, 3H), 6.48 (d, J = 7.0 Hz, 2H), 5.03 (d, J = 15.8 Hz, 1H), 4.12 (d, J = 15.8 Hz, 1H), 3.80 (dd, J = 13.9, 7.6 Hz, 1H), 3.66 – 3.60 (m, 1H), 2.80 (dd, J = 16.4, 7.6 Hz, 1H), 1.10 (s, 9H). ^{13}C NMR (126 MHz, CDCl3) δ 173.9, 173.2, 163.0 (d, $J_{C,F}$ = 245.1 Hz, 1C) 148.1, 143.5, 134.8, 130.3, 130.2, 130.1, 128.5 (d, $J_{C,F}$ = 7.8 Hz, 1C), 128.4, 127.7, 126.7, 123.4, 122.2, δ 115.72 (d, $J_{C,F}$ = 21.4 Hz, 1C), 109.7, 84.0, 71.6, 48.3, 44.1, 35.3, 27.6. IR (KBr) *v* 3389, 1791, 1383, 1152 cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$Calc. for $C_{29}H_{27}O_4N_2NaF$, 509.1844, Found 509.1847.

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(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(4-chlorophenyl)-2,5'-dioxospiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3k). Yield: 72 mg (72%), white solid, mp 156-158°C, R_f= 0.27 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +51 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK AD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 85:15, 1.0 mL/min, 250 nm, 13.2 min (minor), 45.4 min (major)] ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41 (d, J = 7.3 Hz, 1H), 7.26-7.12 (m, 7H), 6.84 (d, J = 8.4 Hz, 2H), 6.47 (d, J = 7.2 Hz, 3H), 5.07 (d, J = 15.8 Hz, 1H), 4.11 (d, J = 15.8 Hz, 1H), 3.79 (dd, J = 13.9, 7.6 Hz, 1H), 3.63 – 3.60 (m, 1H), 2.79 (dd, J = 16.4, 7.6 Hz, 1H), 1.10 (s, 9H). ^{13}C NMR (126 MHz, CDCl3) δ 173.9, 173.1, 148.0, 143.5, 134.7, 134.6, 131.3, 130.1, 130.0, 129.0, 128.8, 128.3, 127.7, 126.7, 123.4, 122.2, 109.7, 84.0, 71.5, 48.4, 44.2, 35.1, 27.6. IR (KBr) *v* 3400, 1790, 1384, 1089 cm^{-1}. HRMS (ESI) *m/z*: [M-H]$^+$Calc. for $C_{29}H_{27}O_4N_2ClNa$, 525.1544, Found 525.1552.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(4-cyanophenyl)-2,5'-dioxospiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3l). Yield: 75 mg (76%), white solid, mp 143-145°C, R_f= 0.15 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ -1.59 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH =70:30, 1.0 mL/min, 250 nm, 12.6 min (minor), 46,5 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 (d, *J* = 7.3 Hz, 1H), 7.37 (d, *J* = 8.3 Hz, 2H), 7.30 – 7.25 (m, 2H), 7.21 – 7.17 (m, 3H), 6.98 (d, *J* = 8.3 Hz, 2H), 6.57 (dd, *J* = 12.7, 7.7 Hz, 3H), 4.94 (d, *J* = 15.6 Hz, 1H), 4.15 (d, *J* = 15.6 Hz, 1H), 3.84 (dd, *J* = 13.8, 7.6 Hz, 1H), 3.64 (dd, *J* = 16.4, 13.8 Hz, 1H), 2.82 (dd, *J* = 16.4, 7.6 Hz, 1H), 1.11 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 173.6, 172.5, 147.9, 143.4, 138.2, 134.7, 132.3, 130.4, 129.3, 128.8, 128.0, 127.9, 127.0, 123.6, 122.3, 118.4, 112.6, 109.7, 84.3, 71.2, 48.7, 44.2, 34.7, 27.6. IR (KBr) *v* 3314, 1791, 1311, 1028 cm^{-1}. HRMS (ESI) *m/z*: [M+Na] Calc. for $C_{30}H_{27}N_3NaO_4Na$, 516.1888 , Found 516.1894.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-2,5'-dioxo-3'-(p-tolyl)spiro [indoline-3,2'-pyrrolidine]-1'- carboxylate (3m). Yield: 63 mg (65%), white solid, mp 81-83°C, R_f= 0.35 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +53 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 80:20, 1.0 mL/min, 250 nm, 16.5 min (minor), 49.9 min (major)]. ^{1}H NMR (400 MHz, CDCl3) δ 7.41 (d, J = 7.0 Hz, 1H), 7.26 – 7.12 (m, 3H), 7.07 (t, J = 7.4 Hz, 2H), 6.98 (d, J = 7.7 Hz, 2H), 6.82 (d, J = 7.8 Hz, 2H), 6.42 (dd, J = 14.1, 7.5 Hz, 3H), 5.08 (d, J = 15.9 Hz, 1H), 4.10 (d, J = 15.9 Hz, 1H), 3.80 (dd, J = 13.9, 7.3 Hz, 1H), 3.75 – 3.53 (m, 1H), 2.78 (dd, J = 16.2, 7.3 Hz, 1H), 2.33 (s, 3H), 1.09 (s, 9H). ^{13}C NMR (101 MHz, CDCl3) δ 174.1, 173.7, 148.1, 143.5, 138.2, 134.8, 129.8, 129.7, 129.4, 128.7, 128.53, 128.50, 127.3, 126.8, 123.2, 122.2, 109.6, 83.8, 71.7, 48.7, 44.1, 35.3, 29.8, 27.6, 21.4. IR (KBr) *v* 3466, 1634, 1384, 1088 cm^{-1}HRMS (ESI) *m/z*: [M-H] Calc. for $C_{30}H_{30}O_4N_2Na$, 505.2103 Found 505.2089.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(4-methoxyphenyl)-2,5'-dioxospiro[indoline-3,2'-pyrrolidine]-1'-carboxylate(3n). Yield: 85 mg (85%), white solid, mp 181-183°C, R_f= 0.20 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +86 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 10.4 min (minor) , 24.1 min (major)]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, *J* = 7.0 Hz, 1H), 7.22 – 7.07 (m, 5H), 6.84 (d, *J* = 8.6 Hz, 2H), 6.69 (d, *J* = 8.7 Hz, 2H), 6.49 – 6.05 (m, 3H), 5.10 (d, *J* = 15.9 Hz, 1H), 4.10 (d, *J* = 15.9 Hz, 1H), 3.7550 (s, 9H), 3.82 – 3.60 (m, 4H), 2.78 (dd, *J* = 16.3, 7.4 Hz, 1H), 1.09 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 174.1, 173.6, 159.8, 148.1, 143.5, 134.7, 129.8, 129.7, 128.7, 128.5, 127.4, 126.7, 124.5, 123.2, 122.1, 114.1, 109.6, 83.8, 71.8, 55.2, 48.3, 44.0, 35.4, 27.6. IR (KBr) *v* 3420, 1791, 1467, 1153 cm^{-1}HRMS (ESI) *m/z*: [M-H] Calc. for $C_{30}H_{30}N_2NaO_5Na$, 521.2051 Found 5212054.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(3-chlorophenyl)-2,5'-dioxospiro[indoline-3,2'-pyrrolidine] -1'-carboxylate (3o). Yield: 64 mg (64%) with 22:1 dr, white solid, mp 179-181°C, R_f= 0.32 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +12 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK AD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 80:20, 1.0 mL/min, 250 nm, 12.1 min (minor), 57.9 min major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41 (d, J = 7.2 Hz, 1H), 7.23 (dd, J = 7.8, 0.8 Hz, 2H), 7.20 – 7.12 (m, 4H), 7.06 (t, J = 7.9 Hz, 1H), 6.83 (s, 1H), 6.81 (d, J = 7.9 Hz, 1H), 6.52 (dd, J = 17.0, 7.5 Hz, 3H), 4.14 (d, J = 15.8 Hz, 1H), 3.78 (dd, J = 13.9, 7.5 Hz, 1H), 3.64 (dd, J = 16.3, 13.9 Hz, 1H), 2.80 (dd, J = 16.3, 7.5 Hz, 1H), 1.10 (s, 9H). ^{13}C NMR (126 MHz, CDCl3) δ 173.8, 173.0, 148.0, 143.5, 134.9, 134.8, 134.6, 130.2, 129.9, 128.8, 128.7, 128.2, 127.6, 126.8, 126.6, 123.5, 122.1 109.7, 84.1, 71.4, 48.5, 44.2, 34.9, 27.6. IR (KBr) *v* 3420, 1635, 1384, 1088 cm^{-1}. HRMS (ESI) *m/z*: [M+Na] Calc. for $C_{29}H_{27}O_4N_2ClNa$, 525.1544 Found 525.1552.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(3-methoxyphenyl)-2,5'-dioxospiro[indoline-3,2'- pyrrolidine]-1'-carboxylate (3p). Yield: 68 mg (68%), white solid, mp 153-155°C, R_f= 0.20 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +54 (*c* 1.0, CH_2Cl_2), HPLC analysis: 97% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 7.1 min (minor), 10.2 min (major)]. ^{1}H NMR (500 MHz, CDCl3) δ 7.48 (d, J = 7.3 Hz, 1H), 7.28 – 7.26 (m, 2H), 7.20 -7. 09 (m, 6H), 6.67 (dd, J = 8.8, 2.9 Hz, 1H), 6.58 (d, J = 7.5 Hz, 2H), 6.46 (d, J = 7.8 Hz, 1H), 5.15 (d, J = 15.9 Hz, 1H), 4.55 (dd, J = 13.5, 8.2 Hz, 1H), 4.20 (d, J = 16.0 Hz, 1H), 3.60 (s, 3H), δ 3.41 (dd, J = 16.8, 13.6 Hz, 1H), 2.89 (dd, J = 16.9, 8.2 Hz, 1H), 1.10 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.7, 172.9, 159.1, 147.9, 143.2, 135.0, 133.9, 133.7, 130.0, 128.8, 127.6, 127.5, 126.5, 124.2, 123.1, 116.7, 116.4, 115.0, 109.4, 84.0, 71.8, 55.6, 45.6, 44.1, 37.7, 27.6. IR (KBr) *v* 2925, 1796, 1455, 1035 cm^{-1}. HRMS (ESI) *m/z*: [M+Na] Calc. for$C_{30}H_{30}N_2NaO_5$, 521.2043 Found 521.2039.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(2-chlorophenyl)-2,5'-dioxospiro[indoline-3,2'- pyrrolidine]-1'-carboxylate (3q). Yield: 62 mg (62%), white solid, mp 140-143°C, R_f= 0.15 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +44 (*c* 1.0,

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CH_2Cl_2), HPLC analysis: 96% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 14.2 min (minor), 24.9 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.63 – 7.61 (m, 1H), 7.45 (d, *J* = 7.4 Hz, 1H), 7.20-7.15 (m, 5H), 7.10-7.07 (m, 3H), 6.50 (d, *J* = 7.6 Hz, 2H), 6.42 (d, *J* = 7.8 Hz, 1H), 5.09 (d, *J* = 15.9 Hz, 1H), 4.59 (dd, *J* = 13.5, 8.2 Hz, 1H), 4.16 (d, *J* = 15.9 Hz, 1H), 3.50 (dd, *J* = 16.8, 13.7 Hz, 1H), 2.86 (dd, *J* = 16.8, 8.2 Hz, 1H), 1.09 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.4, 173.1, 148.0, 143.0, 135.6, 134.9, 131.3, 130.1, 129.90, 129.88, 129.4, 128.8, 127.9, 127.5, 127.4, 126.7, 123.8, 123.2, 109.5, 84.0, 71.7, 44.1, 42.9, 37.1, 27.6. IR (KBr) *v* 3301, 1792, 1384, 1128 cm^{-1}. HRMS (ESI) *m/z*: [M+Na] Calc. For $C_{29}H_{27}O_4N_2ClNa$, 525.1552 Found 525.1547

(*2'S,3'R*)-*tert*-butyl 1-benzyl-2,5'-dioxo-3'-(o-tolyl)spiro [indoline-3,2'-pyrrolidine] -1'-carboxylate (3r).

Yield: 56 mg (58%), white solid, mp 164-165°C , R_f= 0.20 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ +52 (*c* 1.0, CH_2Cl_2), HPLC analysis: 99% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 70:30, 1.0 mL/min, 250 nm, 8.7 min (minor), 48.3 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (d, *J* = 7.6 Hz, 1H), 7.42 (d, *J* = 7.3 Hz, 1H), 7.19 – 7.13 (m, 4H), 7.10-7.06 (m, 3H), 7.01 (d, *J* = 7.1 Hz, 1H), 6.35 (dd, *J* = 19.0, 11.2 Hz, 3H), 5.14 (d, *J* = 15.9 Hz, 1H), 4.20 (dd, *J* = 13.6, 8.1 Hz, 1H), 4.07 (d, *J* = 16.0 Hz, 1H), 3.58 (dd, *J* = 16.9, 13.7 Hz, 1H), 2.84 (dd, *J* = 17.0, 8.1 Hz, 1H), 1.64 (s, 3H), 1.09 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.6, 173.6, 148.0, 143.3, 138.0, 134.8, 131.6, 130.8, 129.9, 129.1, 128.8, 128.5, 128.1, 127.3, 126.8, 126.6, 123.0, 122.7, 109.8, 83.9, 72.1, 44.1, 43.6, 37.6, 27.6, 19.6. IR (KBr) *v* 2925, 1606, 1454, 1028 cm^{-1}. HRMS (ESI) *m/z*: [M+Na] Calc. For $C_{30}H_{30}O_4N_2Na$, 505.2091 Found 505.2098.

(*2'S,3'R*)-*tert*-butyl 1-benzyl-3'-(2-methoxyphenyl)-2,5'-dioxospiro[indoline-3,2'- pyrrolidine]-1'-carboxylate (3s).

Yield 70 mg (70%) with 14:1 dr, white solid, mp 188-190°C , R_f= 0.20 (petroleum ether/ethyl acetate, 5:1). $[\alpha]_D^{25}$ -0.94 (*c* 1.0, CH_2Cl_2), HPLC analysis: 98% ee [Daicel CHIRALPAK OD-H column, 20 °C, 250 nm hexane/*i*-PrOH = 60:40, 1.0 mL/min, 250 nm, 5.4 min (minor), 9.4 min (major)]. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 (d, J = 2.3 Hz, 1H), 7.40 – 7.38 (m, 1H), 7.32 (dd, J = 8.7, 2.4 Hz, 1H), 7.20 – 7.08 (m, 6H), 6.62 (d, J = 7.0 Hz, 2H), 6.46 (dd, J = 7.7, 6.4 Hz, 2H), 5.11 (d, J = 15.6 Hz, 1H), 4.46 (dd, J = 13.9, 8.0 Hz, 1H), 4.10 (d, J = 15.7 Hz, 1H), 3.53 (dd, J = 16.5, 14.0 Hz, 1H), 3.10 (s, 3H), 2.73 (dd, J = 16.6, 8.0 Hz, 1H), 1.08 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 174.2, 173.4, 157.2, 148.0, 143.1, 135.2, 132.1, 131.8, 129.3, 129.0, 128.8, 127.5, 126.9, 124.2, 123.1, 122.7, 113.3, 112.4, 109.1, 83.8, 71.4, 55.2, 44.3, 39.7, 35.7, 27.6. IR (KBr) *v* 3445, 1639, 1384, 1101 cm^{-1}.HRMS (ESI) *m/z*: [M+Na] Calc. for $C_{30}H_{30}N_2O_5Na$, 521.2052, Found 521.2042

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