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Brønsted Acid Catalyzed Asymmetric Diels–Alder Reactions: Stereoselective Construction of Spiro[tetrahydrocarbazole-3,3′-oxindole] Framework

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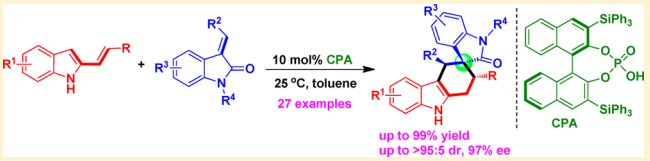
Supporting Information

ABSTRACT: The chiral phosphoric acid catalyzed asymmetric Diels–Alder reactions of 2-vinylindoles with methyleneindolinones have been established, which efficiently construct the spiro[tetrahydrocarbazole-3,3′-oxindole] architecture with one quaternary and three contiguous stereogenic centers in high yields (up to 99%) and excellent stereoselectivities (up to >95:5 *dr*, 97% *ee*). This reaction not only provides an efficient strategy to access enantioenriched spiro[tetrahydrocarbazole-3,3′-oxindoles] based on hydrogen-bonding activation mode but also supplies successful examples of catalytic asymmetric Diels–Alder reactions for constructing complex spiro-frameworks with optical purity.



INTRODUCTION

Chiral tetrahydrocarbazole and spirooxindole are privileged structural motifs, which constitute the core structures of many natural products and pharmacologically active compounds (Figure 1).[1] For example, (*R*)-ramatroban is a promising drug

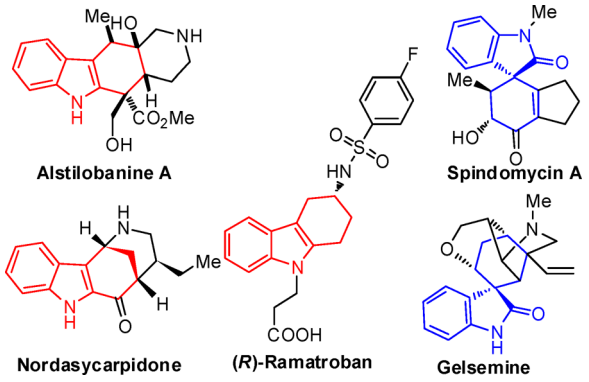
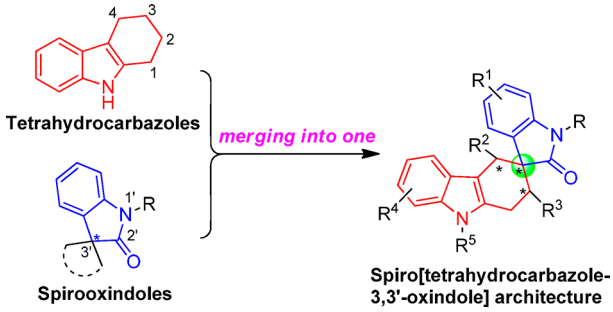


Figure 1. Selected compounds containing chiral tetrahydrocarbazole and spirooxindole cores.

for the treatment of coronary artery disease.[1b] Besides, chiral spirooxindoles showed versatile bioactivities such as antitumoral,[1e] anti-HIV,[1f] antimalarial,[1g] and antidiabetic[1h] activities. The medicinal relevance of these two frameworks has incurred the rapid development of the catalytic asymmetric approaches to construct such enantioenriched scaffolds.[2,3]

In medicinal chemistry, it is reported that the incorporation of two bioactive moieties into another unique and complex structure may provide good opportunities for obtaining improved or new bioactivities.[4] Besides, structure-based design and diversity-oriented synthesis have proven to be powerful tools to access structurally complex and diverse molecules with potential bioactivity.[3j] Therefore, these two intriguing frameworks of tetrahydrocarbazole and spirooxindole inspired us to integrate them into a complex spiro[tetrahydrocarbazole-3,3′-oxindole] scaffold bearing multiple substituents (Scheme 1),

Scheme 1. Design of Chiral Spiro[tetrahydrocarbazole-3,3′-oxindole] Architecture



which would provide a collection of promising compounds with structural diversity for bioassay. Although elegant developments have been achieved in the catalytic asymmetric transformations leading to enantioselective spirooxindoles,[3] the construction of this type of complex spiro-framework with multiple stereogenic centers has rarely been reported.[5]

Survey of the literature revealed that Melchiorre and coworkers established a chiral amine-catalyzed asymmetric Diels–Alder reaction of methyleneindolinones with heterocyclic *ortho*-quinodimethanes (*o*QDMs) in situ generated from *α,β*-

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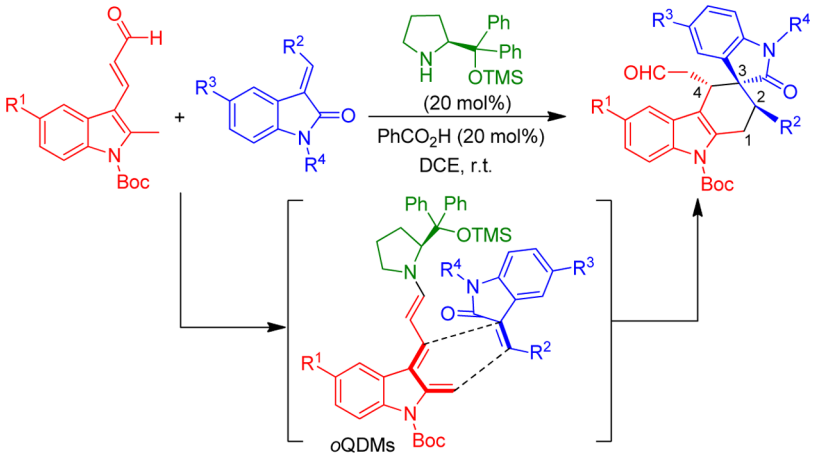
Scheme 2. Previous Work on Catalytic Asymmetric Construction of Spiro[tetrahydrocarbazole-3,3′-oxindole] Framework

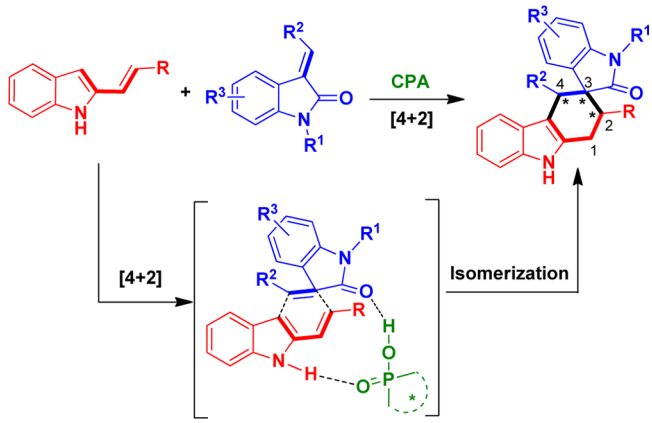


unsaturated aldehydes, which constructed a chiral spiro-[tetrahydrocarbazole-3,3′-oxindole] scaffold in a highly stereoselective fashion (Scheme 2).[5a] In this work, *o*QDMs were utilized as reactive diene species under aminocatalysis. In spite of this creative work, the construction of an optically pure spiro[tetrahydrocarbazole-3,3′-oxindole] architecture is still rather limited. Therefore, it is highly desirable to develop more strategies to construct this fascinating structure based on different activation and disconnection modes.

Chiral phosphoric acids (CPAs) belong to a class of privileged organocatalysts, which have enabled a variety of enantioselective transformations.[6] Moreover, 2-vinylindoles have recently been utilized as dienes to participate in a number of catalytic asymmetric Diels–Alder reactions or formal [4 + 2] cycloadditions.[7] However, this diene species has never been employed to the Diels–Alder reactions with methyleneindolinones[8] to construct a spiro[tetrahydrocarbazole-3,3′-oxindole] motif. On the basis of our previous works on CPA-catalyzed enantioselective reactions,[9] we envisioned that 2-vinylindoles and methyleneindolinones could be simultaneously activated by CPA via dual hydrogen-bonding activation to undergo stereoselective Diels–Alder reaction/isomerization, thus constructing the desired enantioenriched spiro[tetrahydrocarbazole-3,3′-oxindole] framework in a single transformation (Scheme 3).

Herein, we report the CPA-catalyzed asymmetric Diels–Alder reactions of 2-vinylindoles with methyleneindolinones, which efficiently construct the chiral spiro[tetrahydrocarbazole-3,3′-oxindole] architecture with three contiguous stereogenic centers in excellent stereoselectivities (up to >95:5 *dr*, 97% *ee*).

Scheme 3. Design of CPA-Catalyzed Reaction to Construct Chiral Spiro[tetrahydrocarbazole-3,3′-oxindole] Architecture



RESULTS AND DISCUSSION

Initially, the reaction of 2-vinylindole **1a** and methyleneindolinone **2a** catalyzed by 10 mol % of CPA **4a** in toluene at 50 °C was employed to testify our hypothesis (Table 1, entry 1), which smoothly underwent the Diels–Alder reaction to afford the desired spiro[tetrahydrocarbazole-3,3′-oxindole] **3aa** in a high yield of 80% and a considerable stereoselectivity of >95:5 *dr* and 72% *ee*. Then, this reaction was utilized as a model reaction to screen a variety of CPAs **4a**–**4g**, which revealed that catalysts **4e** and **4g** with bulky 3,3′-substituents on the BINOL backbone delivered the highest enantioselectivity of 94% *ee* (entries 5 and 7). Considering the higher yield of CPA **4g** catalyzed reaction, this catalyst was selected as the optimal one for further condition optimization. The screening of solvents disclosed that no other types of solvents were better than toluene in terms of enantioselective control (entries 8–14 vs 7). Then, variation of the reaction temperature (entries 15–17) found that 25 °C was the most suitable condition, which delivered the spiro-product **3aa** in the highest yield of 96% and the best stereoselectivity of >95:5 *dr* and 97% *ee* (entry 16). Notably, when the catalyst loading was reduced to 5 mol %, the reaction could also proceed in an efficient mode with a high yield and excellent stereoselectivity (entry 18).

With the optimal conditions in hand, we investigated the substrate scope of 2-vinylindoles **1** by the reactions with methyleneindolinone **2a** (Table 2). As shown in entries 1–7, a variety of (*E*)-2-vinylindoles **1** linked with different aryl groups were applicable to the designed Diels–Alder reactions, which generated the spiro[tetrahydrocarbazole-3,3′-oxindoles] **3** bearing three contiguous stereogenic centers in high yields (87–96%) and excellent stereoselectivities (all >95:5 *dr*, 90–97% *ee*) without exception. It seemed that the position of the substituents linked to the phenyl ring imposed some effect on the enantioselectivity since *para*-methyl substituted substrate **1g** offered higher enantioselectivity than *meta*- and *ortho*-methyl

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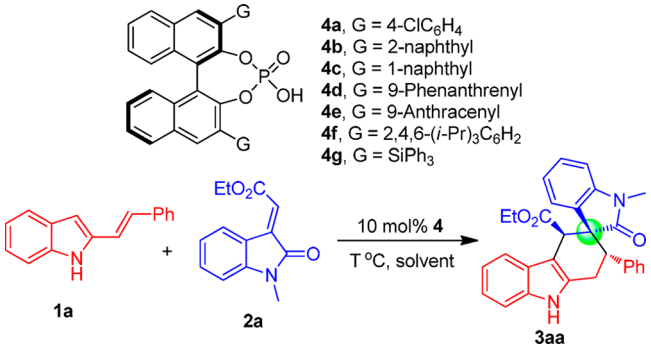
Table 1. Screening of Catalysts and Optimization of Reaction Conditions[a]



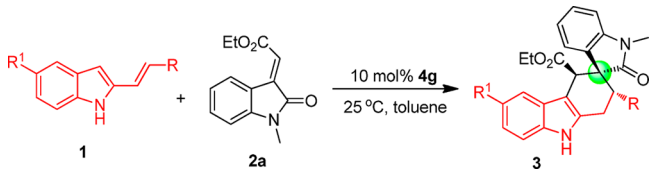
entry	cat.	solvent	T (°C)	yield (%)[b]	dr[c]	ee (%)[d]
1	**4a**	toluene	50	80	>95:5	72
2	**4b**	toluene	50	68	>95:5	76
3	**4c**	toluene	50	80	>95:5	83
4	**4d**	toluene	50	77	>95:5	90
5	**4e**	toluene	50	75	>95:5	94
6	**4f**	toluene	50	52	>95:5	88
7	**4g**	toluene	50	90	>95:5	94
8	**4g**	*o*-xylene	50	82	>95:5	92
9	**4g**	*m*-xylene	50	81	>95:5	92
10	**4g**	*p*-xylene	50	82	>95:5	92
11	**4g**	$ClCH_2CH_2Cl$	50	53	>95:5	89
12	**4g**	EtOAc	50	88	>95:5	80
13	**4g**	CH_3CN	50	82	19:1	30
14	**4g**	1,4-dioxane	50	85	12:1	49
15	**4g**	toluene	70	82	>95:5	92
16	**4g**	**toluene**	**25**	**96**	**>95:5**	**97**
17	**4g**	toluene	0	91	>95:5	92
18[e]	**4g**	toluene	25	87	>95:5	94

[a]Unless otherwise indicated, the reaction was carried out at the 0.05 mmol scale and catalyzed by 10 mol % **4g** in a solvent (0.2 mL) at T °C for 15 h. The molar ratio of **1a**:**2a** was 1:1.5. [b]Isolated yield. [c]The dr value was determined by ^{1}H NMR and HPLC. [d]The ee value was determined by HPLC. [e]5 mol % **4g** was used.

substituted counterparts **1e** and **1c** (entry 7 vs 5 and 3). In most cases, there was no obvious difference between electron-donating and electron-withdrawing groups in terms of stereoselectivity, because electronically different substituents at the same position delivered the reactions in similar diastereo- and enantioselectivities (entry 4 vs 5, entry 6 vs 7). However, in some cases, a strong electron-withdrawing group afforded higher enantioselectivity than an electron-donating group (entry 2 vs 3). Notably, 2-vinylindole **1h** linked with an aliphatic methyl group could also be accommodated to the Diels–Alder reaction, offering spiro[tetrahydrocarbazole-3,3′-oxindole] **3ha** in a good yield of 82% and high enantioselectivity of 90% *ee*, albeit with a decreased diastereoselectivity of 80:20 *dr* (entry 8). However, the two diastereomers could be easily separated by column chromatography. Besides, substituted 2-vinylindoles as exemplified by 5-fluoro-substituted substrate **1i**, which could be synthesized from commercially available starting materials, smoothly participated in the Diels–Alder reaction in a high yield of 87% and an excellent stereoselectivity of 92% *ee* and >95:5 *dr* (entry 9).

Next, the generality of the Diels–Alder reaction for methyleneindolinones **2** was studied by the reactions with 2-vinylindoles **1**. As illustrated in Table 3, this protocol was amenable to a wide scope of methyleneindolinones **2** bearing various R/R^1/R^2 substituents at different positions of the moiety, giving structurally diverse spiro[tetrahydrocarbazole-3,3′-oxindoles] **3** with one quaternary and three contiguous stereogenic centers in generally high yields (65–99%) and excellent diastereo- and enantioselectivities (all >95:5 *dr*, 81–97% *ee*). First, the influence of *N*-substituents of the indolinone motif was investigated by using substrates **2a**–**2e** with *N*-alkyl, *N*-benzyl, *N*-benzoyl, and *N*-H groups (entries 1–5), which revealed that both *N*-protected and *N*-unprotected methyleneindolinones **2** could successfully take part in the Diels–Alder reactions to afford the chiral spiro-products. Although *N*-benzoyl substituted and *N*-unsubstituted substrates **2d**–**2e** were inferior to *N*-alkyl and *N*-benzyl substituted analogues **2a**–**2c** with regard to the reactivity and the enantioselectivity (entries 4–5 vs 1–3), the successful utilization of these different types of substrates greatly demonstrated the wide

Table 2. Substrate Scope of 2-Vinylindoles 1[a]



entry	**3**	R/R^1 (**1**)	yield (%)[b]	dr[c]	ee (%)[d]
1	**3aa**	C_6H_5/H (**1a**)	96 (87[e])	>95:5 (>95:5[e])	97 (94[e])
2	**3ba**	*o*-FC_6H_4/H (**1b**)	93	>95:5	96
3	**3ca**	*o*-MeC_6H_4/H (**1c**)	89	>95:5	90
4	**3da**	*m*-ClC_6H_4/H (**1d**)	87	>95:5	92
5	**3ea**	*m*-MeC_6H_4/H (**1e**)	90	>95:5	92
6	**3fa**	*p*-BrC_6H_4/H (**1f**)	94	>95:5	96
7	**3ga**	*p*-MeC_6H_4/H (**1g**)	90	>95:5	95
8	**3ha**	Me/H (**1h**)[f]	82	80:20	90
9	**3ia**	C_6H_5/F (**1i**)	87	>95:5	92

[a]Unless otherwise indicated, the reaction was carried out at the 0.05 mmol scale and catalyzed by 10 mol % **4g** in toluene (0.2 mL) at 25 °C for 15 h. The molar ratio of **1**:**2a** was 1:1.5. [b]Isolated yield. [c]The *dr* value was determined by ^{1}H NMR. [d]The *ee* value was determined by HPLC. [e]In the presence of 5 mol % **4g**. [f]The mixture of *E*/*Z* isomers (*E*/*Z* = 10:1) was employed to the reaction.

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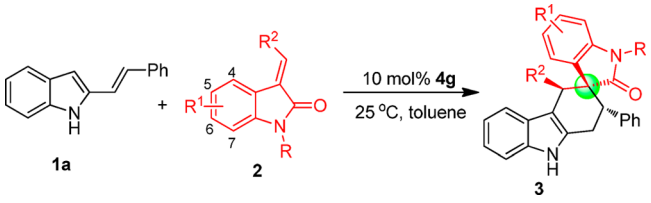
Table 3. Substrate Scope of Methyleneindolinones 2[a]



Entry	3	R/R^1/R^2 (2)	yield (%)[b]	dr[c]	ee (%)[d]
1	3aa	Me/H/CO_2Et (2a)	96	>95:5	97
2	3ab	Et/H/CO_2Et (2b)	95	>95:5	90
3	3ac	Bn/H/CO_2Et (2c)	93	>95:5	92
4	3ad	Bz/H/CO_2Et (2d)	65	>95:5	80
5	3ae	H/H/CO_2Et (2e)	88	>95:5	82
6	3af	Me/5-F/CO_2Et (2f)	83	>95:5	96
7	3ag	Me/5-Cl/CO_2Et (2g)	95	>95:5	95
8	3ah	Me/5-Br/CO_2Et (2h)	93	>95:5	96
9	3ai	Me/5-Me/CO_2Et (2i)	96	>95:5	96
10	3aj	Me/5-OMe/CO_2Et (2j)	86	>95:5	96
11	3ak	Me/6-Cl/CO_2Et (2k)	92	>95:5	94
12	3al	Me/6-OMe/CO_2Et (2l)	71	>95:5	92
13	3am	Me/7-F/CO_2Et (2m)	99	>95:5	92
14	3an	Me/7-Cl/CO_2Et (2n)	90	>95:5	96
15	3ao	Me/7-Br/CO_2Et (2o)	88	>95:5	92
16	3ap	Me/7-CF_3/CO_2Et (2p)	90	>95:5	92
17	3aq	Me/7-Me/CO_2Et (2q)	89	>95:5	94
18[e]	3ar	Me/H/COPh (2r)	93	>95:5	92
19	3as	Me/H/CN (2s)	79	>95:5	84

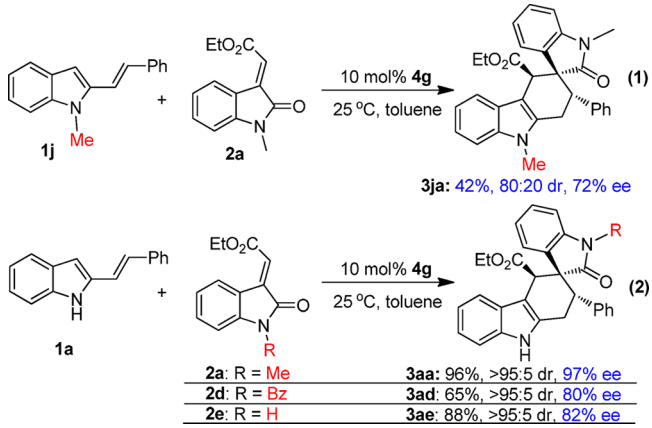
[a]Unless otherwise indicated, the reaction was carried out at the 0.05 mmol scale and catalyzed by 10 mol % **4g** in toluene (0.2 mL) at 25 °C for 15 h. The molar ratio of **1a**:**2** was 1:1.5. [b]Isolated yield. [c]The *dr* value was determined by ^{1}H NMR. [d]The *ee* value was determined by HPLC. [e]In the presence of 20 mol % **4g**.

applicability of this method. Second, the impact of the substituents R^1 on the reaction was examined by employing a wide range of substrates **2f**–**2q** bearing electronically distinct substituents at different positions of the indolinone scaffold (entries 6–17). The results disclosed that the electronic nature and the position of the substituents at C5–C7 had no obvious effect on the stereoselectivity, because all of these substrates uniformly afforded the spiro[tetrahydrocarbazole-3,3′-oxindoles] **3** with structural diversity in excellent diastereo- and enantioselectivities (entries 6–17, all >95:5 *dr*, 92–96% *ee*). Finally, the R^2 group of methyleneindolinones **2** could be altered from an ester group to a ketone group, which also successfully underwent the desired Diels–Alder reaction to form the corresponding spiro-product **3ar** in a high yield of 93% and excellent stereoselectivity of >95:5 *dr* and 92% *ee* (entry 18). Besides, the R^2 group could also be changed to a cyano group, and this substrate **2s** smoothly participated in the reaction in a considerable diastereo- and enantioselectivity (entry 19).

The absolute configuration of spiro[tetrahydrocarbazole-3,3′-oxindole] **3ao** (>99% *ee* after recrystallization) was unambiguously determined to be (2*S*,3*R*,4*R*) by single-crystal X-ray diffraction analysis.[10] The absolute configuration of other spiro-products **3** were assigned by analogy.

In order to gain some insight into the activation mode of the reaction, some control experiments were carried out under the optimal conditions (Scheme 4). As shown in eq 1, *N*-methyl

Scheme 4. Control Experiments To Investigate the Activation Mode



protected 2-vinylindole **1j** was utilized as a substrate instead of *N*-unprotected substrate **1a**, which could also afford the corresponding spiro-product **3ja** but in an obviously diminished yield and stereoselectivity. This result demonstrated that the N-H group of 2-vinylindoles was very important for both the reactivity and the stereoselectivity of the Diels–Alder reaction by forming a hydrogen bond with the P═O group of catalyst **4g**. Furthermore, as mentioned above (Table 3, entries 1 and 4–5), changing the *N*-methyl group of substrates **2** to an *N*-benzoyl or N-H group led to decreased enantioselectivities (eq 2). This phenomenon indicated that the *N*-benzoyl group of **2d** might compete with the amide group of the indolinone moiety to form a hydrogen bond with CPA, and the N-H group of **2e** might also disturb the hydrogen-bonding interaction between the N-H group of **1a** and the catalyst, thus resulting in the reduced enantioselectivities of spiro-products **3ad** and **3ae**.

On the basis of the experimental results, a possible transition state illustrating the activation mode of the reaction was suggested to explain the stereochemistry of this chiral phosphoric acid catalyzed asymmetric Diels–Alder reaction. As exemplified by the generation of spiro-product **3aa** (Scheme 5), CPA **4g** acted as a Brønsted acid/Lewis base bifunctional catalyst to simultaneously activate both the amide group of methyleneindolinone and the N-H group of 2-vinylindole via dual hydrogen-bonding interaction,[11] which facilitated the designed Diels–Alder reaction. The (*R*)-BINOL backbone of the catalyst and the steric hindrance of its 3,3′-substitutents created a chiral environment, which contributed greatly to the excellent enantioselectivity obtained. Besides, the terminal phenyl group of (*E*)-2-vinylindole was oriented to the opposite

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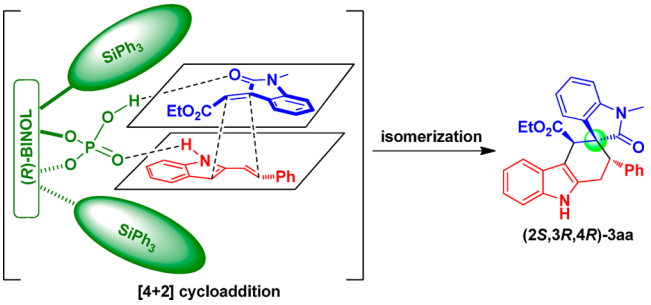
Scheme 5. Suggested Transition State of the Diels–Alder Reaction



side of the benzene ring of the indolinone moiety, thus avoiding the steric repulsion between them and leading to the perfect diastereoselectivity experimentally observed. Therefore, an efficient and stereoselective Diels–Alder reaction occurred under the catalysis of CPA **4g** to afford the spiro-product **3aa** with (2*S*,3*R*,4*R*)-configuration.

Moreover, some preliminary derivations of the spiro-products could be carried out. For example, the ester group of product **3aa** was easily transformed into an alcohol hydroxyl functionality with retained diastereo- and enantioselectivity in a high yield (eq 3).

CONCLUSIONS

In summary, we have established the chiral phosphoric acid catalyzed asymmetric Diels–Alder reactions of 2-vinylindoles with methyleneindolinones, which efficiently construct the chiral spiro[tetrahydrocarbazole-3,3′-oxindole] architecture with one quaternary and three contiguous stereogenic centers in high yields (up to 99%) and excellent stereoselectivities (up to >95:5 *dr*, 97% *ee*). This approach integrated biologically important tetrahydrocarbazole and spirooxindole frameworks into a new type of structurally complex spirooxindoles, which would offer a collection of promising compounds with structural diversity for bioassay. This reaction not only provided an efficient strategy to access enantioenriched spiro[tetrahydrocarbazole-3,3′-oxindoles] based on hydrogen-bonding activation mode but also supplied successful examples of catalytic asymmetric Diels–Alder reactions for constructing complex spiro-frameworks with optical purity.

EXPERIMENTAL SECTION

General Information. ^{1}H and ^{13}C NMR spectra were measured at 400 and 100 MHz, respectively. The solvent used for NMR spectroscopy was $CDCl_3$, using tetramethylsilane as the internal reference. HRMS (ESI) was determined by a HRMS/MS instrument. Enantiomeric excesses (*ee*) were determined by chiral high-performance liquid chromatography (chiral HPLC). The chiral columns used for the determination of enantiomeric excesses by chiral HPLC were Chiralpak IC, OD-H and IA columns. Optical rotation values were measured with instruments operating at λ = 589 nm, corresponding to the sodium D line at the temperatures indicated. Analytic grade solvents for the chromatography and commercially available reagents were used as received. Substrates **1** and **2** were synthesized according to the literature methods.[7d,8b] Catalyst **4g** was prepared according to the procedures reported in the literature.[12]

Typical Procedure for Chiral Phosphoric Acid Catalyzed Asymmetric Diels–Alder Reactions. Toluene (0.2 mL) was added to the mixture of 2-vinylindoles **1** (0.05 mmol), methyleneindolinones **2** (0.075 mol), and the catalyst **4g** (0.005 mmol). After being stirred at 25 °C for 15 h, the reaction mixture was concentrated under the reduced pressure to give the residue, which was purified through preparative thin layer chromatography to afford pure products **3**.

(2*S*,3*R*,4*R*)-Ethyl 1′-Methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3aa). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 96% (21.7 mg); >95:5 *dr*; white solid; mp 215–216 °C; $[\alpha]_D^{20}$ = +56.5 (*c* 0.45, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.43–7.40 (m, 1H), 7.36–7.30 (m, 2H), 7.13–7.01 (m, 8H), 6.94–7.89 (m, 1H), 6.56 (d, *J* = 8.0 Hz, 1H), 4.55–4.53 (m, 1H), 4.17–4.10 (m, 1H), 4.11–4.01 (m, 2H), 3.81 (dd, *J* = 16.1, 11.3 Hz, 1H), 3.15 (dd, *J* = 16.5, 5.6 Hz, 1H), 3.06 (s, 3H), 1.16 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (400 MHz, $CDCl_3$) δ 176.5, 172.4, 143.3, 140.1, 136.2, 135.6, 129.3, 128.6, 128.2, 127.7, 126.8, 126.8, 125.2, 121.8, 121.4, 119.5, 117.8, 110.7, 107.6, 104.7, 60.8, 52.1, 45.5, 43.0, 27.2, 25.9, 14.2; IR (KBr): 3647, 3056, 2963, 2925, 1706, 1710, 1493, 1458, 1261, 1030, 798, 746, 700 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{26}N_2O_3 - H)^-$ requires *m*/*z* 449.1860, found *m*/*z* 449.1857; Enantiomeric excess: 97%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, *T* = 30 °C, 254 nm): t_R = 10.48 min (major), t_R = 8.00 min (minor).

(2*R*,3*R*,4*R*)-Ethyl 2-(2-Fluorophenyl)-1′-methyl-2′-oxo-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ba). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 93% (21.9 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +90.5 (*c* 0.42, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.11 (s, 1H), 7.44–7.36 (m, 2H), 7.31–7.26 (m, 1H), 7.18–7.09 (m, 3H), 7.08–6.99 (m, 2H), 6.94–6.82 (m, 2H), 6.78 (t, *J* = 9.2 Hz, 1H), 6.60 (d, *J* = 7.8 Hz, 1H), 5.00 (s, 1H), 4.18–3.99 (m, 3H), 3.68–3.62 (m, 1H), 3.16–3.05 (m, 4H), 1.13 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 172.0, 143.2, 136.3, 135.1, 129.1, 128.4, 128.4, 127.7, 127.6, 126.8, 125.1, 125.0, 123.8, 123.7, 122.1, 121.5, 119.5, 118.1, 115.0, 114.8, 110.8, 107.5, 104.9, 60.8, 52.1, 45.5, 33.5, 26.7, 26.0, 14.1; IR (KBr): 3677, 3649, 3630, 1670, 1522, 1288, 1262, 1177, 1093, 1029, 817 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}FN_2O_3 - H)^-$ requires *m*/*z* 467.1765, found *m*/*z* 467.1773; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, *T* = 30 °C, 254 nm): t_R = 15.16 min (major), t_R = 13.85 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Methyl-2′-oxo-2-(o-tolyl)-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ca). Preparative thin layer chromatography: Toluene/ethyl acetate = 8/1; Reaction time = 15 h; yield: 89% (20.9 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +109.0 (*c* 0.50, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.43 (d, *J* = 8.0 Hz, 1H), 7.33 (d, *J* = 7.0 Hz, 1H), 7.29–7.27 (m, 1H), 7.15–7.09 (m, 3H), 7.07–7.02 (m, 1H), 6.98–6.90 (m, 3H), 6.89–6.82 (m, 1H), 6.63 (d, *J* = 8.0 Hz, 1H), 5.06–5.02 (m, 1H), 4.19–4.12 (m, 1H), 4.11–4.01 (m, 2H), 3.64 (dd, *J* = 16.5, 10.9 Hz, 1H), 3.16 (s, 3H), 3.05 (dd, *J* = 16.6, 5.6 Hz, 1H), 2.39 (s, 3H), 1.17 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.0, 172.6, 143.3, 139.4, 136.2, 136.2, 135.9, 130.2, 129.6, 128.3, 126.8, 126.5, 125.8, 125.6, 124.3, 121.8, 121.4, 119.5, 117.9, 110.8, 107.7, 104.7, 60.8, 52.1, 45.9, 37.2, 27.9, 26.1, 20.3, 14.2; IR (KBr): 3650, 1734, 1717, 1672, 1648, 1542, 1508, 1364, 1339, 1262, 807 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires *m*/*z* 463.2016, found *m*/*z* 463.2016; Enantiomeric excess: 90%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, *T* = 30 °C, 254 nm): t_R = 16.69 min (major), t_R = 13.91 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 2-(3-Chlorophenyl)-1′-methyl-2′-oxo-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3da). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 87% (21.2 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +21.0 (*c* 0.38, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (s, 1H), 7.41 (d, *J* = 8.0 Hz, 1H), 7.32 (d, *J* = 8.0 Hz, 2H), 7.16–7.04 (m, 4H), 7.02–6.91 (m, 4H), 6.59 (d, *J* = 8.0 Hz, 1H), 4.59–4.52 (m, 1H), 4.20–4.13 (m, 1H), 4.10–4.01 (m, 2H), 3.77 (dd, *J* = 16.4, 11.2 Hz, 1H), 3.16–3.06 (m, 4H), 1.16 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.2, 172.4, 143.2, 142.3, 136.2, 135.1, 133.6, 129.0, 128.9, 128.6, 128.5, 127.0, 126.9, 126.8, 125.2, 122.1, 121.5, 119.6, 117.9, 110.8, 107.9, 104.7, 60.9, 51.9, 45.5, 42.8, 27.1, 25.9, 14.2; IR

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(KBr): 3691, 3677, 3650, 1801, 1718, 1700, 1508, 1458, 1262, 795 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}ClN_2O_3 - H)^-$ requires m/z 483.1470, found m/z 483.1469; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 10.46 min (major), t_R = 7.85 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Methyl-2′-oxo-2-(*m*-tolyl)-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ea). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 90% (20.9 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +56.2 (*c* 0.42, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.41 (d, J = 8.0 Hz, 1H), 7.31 (dd, J = 15.0, 8.0 Hz, 2H), 7.12−7.02 (m, 3H), 6.94−6.80 (m, 5H), 6.56 (d, J = 8.0 Hz, 1H), 4.54−4.50 (m, 1H), 4.16−4.13 (m, 1H), 4.11−4.00 (m, 2H), 3.80 (dd, J = 16.5, 11.2 Hz, 1H), 3.18−3.07 (m, 1H), 3.07 (s, 3H), 2.14 (s, 3H), 1.16 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 172.5, 143.3, 140.0, 137.3, 136.2, 135.7, 129.5, 129.3, 128.2, 127.6, 127.5, 126.9, 125.6, 125.3, 121.8, 121.3, 119.4, 117.8, 110.8, 107.6, 104.7, 60.8, 52.1, 45.6, 43.0, 27.2, 25.9, 21.3, 14.2; IR (KBr): 3677, 3650, 1734, 1685, 1654, 1508, 1318, 1265, 1156, 1090, 1029, 744 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires m/z 463.2016, found m/z 463.2014; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 9.77 min (major), t_R = 7.20 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 2-(4-Bromophenyl)-1′-methyl-2′-oxo-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3fa). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 94% (24.8 mg); >95:5 *dr*; yellow sticky oil; $[\alpha]_D^{20}$ = +12.8 (*c* 0.47, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 (s, 1H), 7.41 (d, J = 8.0 Hz, 1H), 7.32 (d, J = 8.0 Hz, 2H), 7.19−7.11 (m, 4H), 7.08−7.02 (m, 1H), 6.98−6.90 (m, 3H), 6.61 (d, J = 8.0 Hz, 1H), 4.55−4.51 (m, 1H), 4.16−4.14 (m, 1H), 4.07−3.99 (m, 2H), 3.75 (dd, J = 16.5, 11.0 Hz, 1H), 3.17−3.10 (m, 1H), 3.08 (s, 3H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 172.4, 143.2, 139.3, 136.2, 135.1, 130.9, 130.3, 129.0, 128.5, 126.8, 125.1, 122.0, 121.6, 120.7, 119.6, 117.9, 110.8, 108.0, 104.7, 60.8, 52.0, 45.5, 42.4, 27.2, 26.0, 14.2; IR (KBr): 3677, 3649, 3628, 1799, 1728, 1687, 1524, 1163, 1109, 745 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}BrN_2O_3 - H)^-$ requires m/z 527.0965, found m/z 527.0969; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 12.22 min (major), t_R = 9.36 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Methyl-2′-oxo-2-(*p*-tolyl)-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ga). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 90% (21.0 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +102.1 (*c* 0.28, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.41 (d, J = 8.0 Hz, 1H), 7.33 (d, J = 7.6 Hz, 1H), 7.30−7.27 (m, 1H), 7.13−7.09 (m, 2H), 7.07−7.03 (m, 1H), 6.98−6.89 (m, 3H), 6.90−6.83 (m, 2H), 6.59 (d, J = 8.0 Hz, 1H), 4.50−4.46 (m, 1H), 4.20−4.10 (m, 1H), 4.10−3.99 (m, 2H), 3.76 (dd, J = 16.5, 10.9 Hz, 1H), 3.16−3.02 (m, 4H), 2.17 (s, 3H), 1.15 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 172.5, 143.3, 137.1, 136.3, 136.2, 135.7, 129.5, 128.5, 128.4, 128.1, 126.9, 125.2, 121.8, 121.4, 119.4, 117.9, 110.8, 107.7, 104.7, 60.8, 52.2, 45.6, 42.6, 27.5, 25.9, 20.9, 14.2; IR (KBr): 3677, 3650, 3630, 1733, 1670, 1648, 1569, 1261, 1236, 1091, 1029, 802, 743 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires m/z 463.2016, found m/z 463.2016; Enantiomeric excess: 95%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 10.88 min (major), t_R = 7.75 min (minor).

(2*R*,3*R*,4*R*)-Ethyl 1′,2-Dimethyl-2′-oxo-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ha). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 82% (16.1 mg); 80:20 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +19.1 (*c* 0.88, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.37 (d, J = 8.0 Hz, 1H), 7.32−7.28 (m, 2H), 7.22 (d, J = 7.6 Hz, 1H), 7.10−7.06 (m, 1H), 7.05−6.95 (m, 2H), 6.87 (d, J = 8.0 Hz, 1H), 4.17 (s, 1H), 3.97−3.92 (m, 2H), 3.21 (s, 3H), 3.07−2.84 (m, 3H), 1.00 (t, J = 7.2 Hz, 3H), 0.92−0.89 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.2, 171.9, 143.9, 136.2, 134.6, 130.3, 128.4, 127.0, 124.8, 122.2, 121.3, 119.4, 118.4, 110.7, 107.9, 104.7, 60.6, 52.5, 44.4, 32.1, 28.2, 26.2, 16.0, 14.0; IR (KBr): 3677, 3650, 3079, 3050, 2930, 1734, 1699, 1647, 1457, 1094, 1023, 800, 746 cm^{-1}; ESI FTMS exact mass calcd for $(C_{24}H_{24}N_2O_3 - H)^-$ requires m/z 387.1703, found m/z 387.1713; Enantiomeric excess: 90%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 9.85 min (major), t_R = 7.73 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 6-Fluoro-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ia). Preparative thin layer chromatography: petroleum ether/ethyl acetate = 3/1; Reaction time = 15 h; yield: 87% (20.5 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +56.9 (*c* 0.43, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (s, 1H), 7.34 (d, J = 7.6 Hz, 1H), 7.17−6.97 (m, 8H), 6.94−6.84 (m, 1H), 6.82−6.77 (m, 1H), 6.56 (d, J = 8.0 Hz, 1H), 4.57−4.53 (m, 1H), 4.23−4.06 (m, 2H), 4.01 (s, 1H), 3.80 (dd, J = 16.4, 11.2 Hz, 1H), 3.17−3.02 (m, 4H), 1.17 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 172.4, 143.2, 139.9, 137.6, 132.6, 129.1, 128.6, 128.3, 127.8, 126.9, 125.3, 122.0, 111.4, 109.4, 109.2, 107.8, 104.8, 103.1, 60.9, 52.1, 45.4, 42.9, 27.3, 26.0, 14.2; IR (KBr): 3675 3651, 3309, 3100, 1763, 1652, 1311, 1099, 1011, 749, 677 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}FN_2O_3 - H)^-$ requires m/z 467.1766, found m/z 467.1768; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak IC, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 7.69 min (major), t_R = 4.33 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Ethyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ab). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 95% (22.2 mg); >95:5 *dr*; white solid; mp 200−202 °C; $[\alpha]_D^{20}$ = +92.7 (*c* 0.42, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (s, 1H), 7.42 (d, J = 8.0 Hz, 1H), 7.35 (d, J = 7.6 Hz, 1H), 7.29−7.27 (m, 1H), 7.22−6.99 (m, 8H), 6.96−6.87 (m, 1H), 6.59 (d, J = 8.0 Hz, 1H), 4.55−4.51 (m, 1H), 4.17−4.11 (m, 1H), 4.09−3.98 (m, 2H), 3.77−3.68 (m, 2H), 3.57−3.50 (m, 1H), 3.12 (dd, J = 16.6, 5.8 Hz, 1H), 1.19−1.11 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.2, 172.5, 142.4, 140.1, 136.2, 135.7, 129.5, 128.9, 128.1, 127.8, 126.8, 126.8, 125.5, 121.6, 121.4, 119.4, 117.8, 110.8, 107.8, 104.6, 60.8, 52.0, 45.7, 42.9, 34.4, 27.2, 14.2, 12.2; IR (KBr): 3650, 3057, 2964, 2929, 1734, 1717, 1647, 1430, 1262, 801, 745, 702 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires m/z 463.2016, found m/z 463.2015; Enantiomeric excess: 90%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 9.41 min (major), t_R = 6.78 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Benzyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ac). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 93% (24.6 mg); >95:5 *dr*; yellow sticky oil; $[\alpha]_D^{20}$ = +48.3 (*c* 0.59, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (s, 1H), 7.46−7.34 (m, 3H), 7.29−7.27 (m, 2H), 7.20−6.96 (m, 11H), 6.92−6.88 (m, 1H), 6.54 (d, J = 8.0 Hz, 1H), 4.87 (d, J = 15.6 Hz, 1H), 4.73 (d, J = 15.6 Hz, 1H), 4.62−4.58 (m, 1H), 4.22−4.10 (m, 2H), 4.07−3.98 (m, 1H), 3.83 (dd, J = 16.4, 11.0 Hz, 1H), 3.13 (dd, J = 16.6, 5.8 Hz, 1H), 1.14 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 172.4, 142.6, 140.1, 136.2, 135.7, 135.7, 129.3, 128.9, 128.6, 128.2, 128.0, 127.6, 127.5, 126.8, 125.5, 121.9, 121.4, 119.5, 117.9, 110.9, 108.8, 104.5, 60.9, 52.3, 46.2, 43.7, 42.7, 27.3, 14.2; IR (KBr): 3650, 3057, 3032, 2963, 2917, 2849, 1732, 1700, 1686, 1019, 801, 748, 701 cm^{-1}; ESI FTMS exact mass calcd for $(C_{35}H_{30}N_2O_3 - H)^-$ requires m/z 525.2173, found m/z 525.2183; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 10.07 min (major), t_R = 13.74 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Benzoyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ad). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 65% (17.7 mg); >95:5 *dr*; pale yellow sticky oil; $[\alpha]_D^{20}$ = +57.9 (*c* 0.44, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.66 (d, J = 7.6 Hz, 2H), 7.57 (d, J = 8.0 Hz, 1H), 7.52−7.48 (m, 1H), 7.46−7.35 (m, 4H), 7.28−7.26 (m, 1H), 7.23−7.18 (m, 2H),

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7.17−7.06 (m, 7H), 4.51−4.47 (m, 1H), 4.34−4.32 (m, 1H), 4.19−4.10 (m, 1H), 4.08−3.92 (m, 1H), 3.64−3.59 (m, 1H), 3.19 (dd, J = 16.8, 6.0 Hz, 1H), 1.12 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.8, 171.7, 169.4, 139.8, 139.7, 136.2, 135.2, 134.3, 132.8, 129.2, 129.0, 128.7, 128.6, 128.3, 128.2, 127.4, 126.7, 125.4, 124.2, 121.6, 119.6, 117.9, 114.6, 110.9, 104.3, 61.1, 53.1, 46.6, 43.3, 27.2, 14.1; IR (KBr): 3650, 2962, 2901, 1717, 1654, 1262, 1024, 801, 743, 669 cm^{-1}; ESI FTMS exact mass calcd for $(C_{35}H_{28}N_2O_4 - H)^-$ requires m/z 539.1965, found m/z 539.1977; Enantiomeric excess: 80%, determined by HPLC (Daicel Chirapak IC, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 5.13 min (minor), t_R = 6.08 min (major).

(2*S*,3*R*,4*R*)-Ethyl 2′-Oxo-2-phenyl-1,2,4,9-tetrahydrospiro-[carbazole-3,3′-indoline]-4-carboxylate (3ae). Preparative thin layer chromatography: Toluene/ethyl acetate = 8/1; Reaction time = 15 h; yield: 88% (19.3 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +63.0 (c 0.42, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (s, 1H), 7.86−7.79 (m, 1H), 7.42 (d, J = 7.6 Hz, 1H), 7.31−7.28 (m, 2H), 7.25−6.94 (m, 8H), 6.89−6.85 (m, 1H), 6.51 (d, J = 8.0 Hz, 1H), 4.52−4.47 (m, 1H), 4.19−4.08 (m, 2H), 4.08−3.98 (m, 1H), 3.78−3.72 (m, 1H), 3.15 (dd, J = 16.6, 5.6 Hz, 1H), 1.12 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.6, 172.3, 140.2, 136.2, 135.4, 129.8, 128.7, 128.2, 128.0, 126.9, 126.9, 125.7, 121.8, 121.5, 119.5, 118.0, 110.9, 109.4, 104.6, 60.8, 52.7, 45.6, 43.0, 27.3, 14.1; IR (KBr): 3647, 3031, 2961, 2920, 1721, 1715, 1688, 1605, 1207, 1117, 803, 745, 702 cm^{-1}; ESI FTMS exact mass calcd for $(C_{28}H_{24}N_2O_3 - H)^-$ requires m/z 435.1703, found m/z 435.1712; Enantiomeric excess: 82%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 25.17 min (major), t_R = 16.55 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 5′-Fluoro-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3af). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 83% (19.6 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +72.2 (c 0.47, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.42 (d, J = 8.0 Hz, 1H), 7.32 (d, J = 8.0 Hz, 1H), 7.20−6.96 (m, 8H), 6.88−6.75 (m, 1H), 6.46 (dd, J = 8.4, 4.2 Hz, 1H), 4.57−4.53 (m, 1H), 4.23−4.04 (m, 3H), 3.81−3.77 (m, 1H), 3.14 (dd, J = 16.6, 5.8 Hz, 1H), 3.08−2.98 (m, 3H), 1.19 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.0, 172.3, 139.7, 139.3, 136.2, 135.5, 128.6, 127.9, 127.0, 126.7, 121.5, 119.6, 117.9, 114.5, 114.3, 113.7, 113.4, 110.8, 108.1, 104.4, 61.0, 52.6, 45.5, 43.0, 27.2, 26.0, 14.2; IR (KBr): 3651, 3049, 2971, 2963, 1665, 1272, 1015, 804, 749, 700 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}FN_2O_3 - H)^-$ requires m/z 467.1765, found m/z 467.1765; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 11.58 min (major), t_R = 8.40 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 5′-Chloro-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ag). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 95% (23.0 mg); >95:5 *dr*; white solid; mp 296−298 °C; $[\alpha]_D^{20}$ = +112.7 (c 0.43, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.42−7.38 (m, 1H), 7.36−7.33 (m, 1H), 7.31 (d, J = 8.0 Hz, 1H), 7.17−6.99 (m, 8H), 6.47 (d, J = 8.4 Hz, 1H), 4.55−4.48 (m, 1H), 4.25−4.12 (m, 2H), 4.06 (s, 1H), 3.82−3.75 (m, 1H), 3.14 (dd, J = 16.6, 5.8 Hz, 1H), 3.04 (s, 3H), 1.20 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.0, 172.3, 141.9, 139.6, 136.2, 135.5, 131.0, 128.6, 128.1, 128.0, 127.4, 127.0, 126.7, 125.7, 121.5, 119.6, 117.8, 110.8, 108.6, 104.3, 61.1, 52.4, 45.4, 43.0, 27.1, 26.0, 14.2; IR (KBr): 3649, 3599, 2962, 1685, 1647, 1261, 1151, 1095, 1019, 799, 741, 705 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}ClN_2O_3 - H)^-$ requires m/z 483.1470, found m/z 483.1474; Enantiomeric excess: 95%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 12.01 min (major), t_R = 8.78 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 5′-Bromo-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ah). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 93% (24.7 mg); >95:5 *dr*; pale yellow solid; mp 285−286 °C; $[\alpha]_D^{20}$ = +99.3 (c 0.43, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.49−7.46 (m, 1H), 7.40 (d, J = 8.0 Hz, 1H), 7.30 (d, J = 8.0 Hz, 1H), 7.25−7.20 (m, 1H), 7.16−7.03 (m, 7H), 6.42 (d, J = 8.4 Hz, 1H), 4.53−4.48 (m, 1H), 4.20−4.12 (m, 2H), 4.06 (s, 1H), 3.79 (dd, J = 16.4, 11.0 Hz, 1H), 3.13 (dd, J = 16.4, 5.8 Hz, 1H), 3.03 (s, 3H), 1.21 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.9, 172.3, 142.3, 139.6, 136.2, 135.5, 131.4, 131.0, 128.6, 128.4, 128.0, 127.0, 126.7, 121.5, 119.6, 117.7, 114.6, 110.9, 109.1, 104.3, 61.1, 52.4, 45.4, 43.0, 27.1, 26.0, 14.3; IR (KBr): 3691, 3651, 2963, 1699, 1686, 1340, 1263, 1098, 1022, 806, 743, 703 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}BrN_2O_3 - H)^-$ requires m/z 527.0965, found m/z 527.0967; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 12.08 min (major), t_R = 8.45 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′,5′-Dimethyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ai). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 96% (22.4 mg); >95:5 *dr*; white solid; mp 289−291 °C; $[\alpha]_D^{20}$ = +112.7 (c 0.44, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.11 (s, 1H), 7.41 (d, J = 7.6 Hz, 1H), 7.28 (d, J = 7.2 Hz, 1H), 7.12−7.02 (m, 8H), 6.90 (d, J = 8.0 Hz, 1H), 6.45 (d, J = 8.0 Hz, 1H), 4.52−4.44 (m, 1H), 4.22−4.01 (m, 3H), 3.79−3.73 (m, 1H), 3.11 (dd, J = 16.4, 5.6 Hz, 1H), 3.05 (s, 3H), 2.26 (s, 3H), 1.16 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 172.6, 140.9, 140.3, 136.2, 135.6, 131.2, 129.3, 128.6, 128.4, 127.8, 126.9, 126.8, 126.0, 121.4, 119.4, 117.8, 110.8, 107.4, 104.7, 60.7, 52.2, 45.6, 43.1, 27.3, 26.0, 21.2, 14.2; IR (KBr): 3691, 3677, 3651, 2962, 1685, 1559, 1263, 1176, 1024, 817, 753, 709 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires m/z 463.2016, found m/z 463.2009; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 9.33 min (major), t_R = 7.11 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 5′-Methoxy-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3aj). Preparative thin layer chromatography: petroleum ether/ethyl acetate = 3/1; Reaction time = 15 h; yield: 86% (20.6 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +96.9 (c 0.29, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.42 (d, J = 8.0 Hz, 1H), 7.31−7.27 (m, 1H), 7.14−6.97 (m, 8H), 6.67−6.60 (m, 1H), 6.45 (d, J = 8.4 Hz, 1H), 4.55−4.50 (m, 1H), 4.24−4.13 (m, 1H), 4.10−3.92 (m, 2H), 3.80 (dd, J = 16.4, 11.2 Hz, 1H), 3.74 (s, 3H), 3.11 (dd, J = 16.4, 6.0 Hz, 1H), 3.04 (s, 3H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 172.5, 155.5, 140.2, 137.0, 136.2, 135.6, 130.6, 128.6, 127.8, 126.8, 121.4, 119.4, 117.8, 112.9, 112.8, 110.8, 107.9, 104.6, 60.8, 56.0, 52.5, 45.7, 43.0, 27.4, 26.0, 14.2; IR (KBr): 3648, 3566, 3347, 2963, 1730, 1700, 1654, 1625, 1497, 1458, 1261, 1031, 809, 737, 705 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_4 - H)^-$ requires m/z 479.1965 found m/z 479.1972; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak IC, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 24.65 min (major), t_R = 6.30 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 6′-Chloro-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ak). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 92% (22.4 mg); >95:5 *dr*; white solid; mp 281−283 °C; $[\alpha]_D^{20}$ = +73.9 (c 0.36, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.44−7.39 (m, 1H), 7.29−7.27 (m, 1H), 7.14−7.02 (m, 8H), 6.92−6.86 (m, 1H), 6.58−6.54 (m, 1H), 4.58−4.50 (m, 1H), 4.22−4.16 (m, 1H), 4.08−4.00 (m, 2H), 3.80−3.72 (m, 1H), 3.12 (dd, J = 16.8, 6.0 Hz, 1H), 3.04 (s, 3H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 172.4, 144.6, 139.8, 136.2, 135.5, 134.0, 128.5, 128.0, 127.8, 127.3, 127.1, 126.7, 126.4, 123.4, 121.7, 121.5, 121.3, 119.6, 117.8, 114.7, 112.4, 110.8, 108.5, 104.3, 61.0, 52.0, 45.5, 42.9, 27.2, 26.0, 14.2; IR (KBr): 3650, 3630, 2963, 1717, 1685, 1543, 1374, 1262, 1076, 1019, 800, 745, 697 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}ClN_2O_3 - H)^-$ requires m/z 483.1470, found m/z 483.1470; Enantiomeric excess: 94%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow

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rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 11.02 min (major), t_R = 8.41 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 6′-Methoxy-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3al). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 71% (17.1 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +68.1 (*c* 0.43, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.42 (d, J = 8.0 Hz, 1H), 7.30−7.27 (m, 1H), 7.22 (d, J = 8.4 Hz, 1H), 7.15−7.00 (m, 7H), 6.43−6.38 (m, 1H), 6.18−6.10 (m, 1H), 4.55−4.47 (m, 1H), 4.21−4.13 (m, 1H), 4.10−4.00 (m, 2H), 3.83−3.70 (m, 4H), 3.11 (dd, J = 16.4, 5.6 Hz, 1H), 3.04 (s, 3H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.1, 172.6, 160.0, 144.6, 140.3, 136.2, 135.6, 128.6, 127.8, 126.8, 126.8, 126.0, 121.4, 121.2, 119.4, 117.9, 110.8, 105.8, 104.8, 95.5, 60.8, 55.3, 51.8, 45.8, 43.2, 27.3, 25.9, 14.3; IR (KBr): 3691, 3650, 3630, 1718, 1685, 1489, 1265, 1093, 1019, 743, 701 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_4 - H)^-$ requires m/z 479.1965, found m/z 479.1967; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 12.37 min (major), t_R = 9.92 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 7′-Fluoro-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3am). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 99% (23.1 mg); >95:5 *dr*; white solid; mp 241−243 °C; $[\alpha]_D^{20}$ = +100.9 (*c* 0.33, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.44−7.38 (m, 1H), 7.30−7.27 (m, 1H), 7.17−7.02 (m, 8H), 6.87−6.80 (m, 2H), 4.56−4.48 (m, 1H), 4.20−4.14 (m, 1H), 4.09−3.98 (m, 2H), 3.78 (dd, J = 16.4, 11.2 Hz, 1H), 3.31−3.28 (m, 3H), 3.12 (dd, J = 16.4, 6.0 Hz, 1H), 1.17 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.2, 172.3, 148.5, 146.1, 139.8, 136.2, 135.5, 132.2, 130.2, 130.1, 128.5, 127.9, 127.3, 127.1, 126.7, 123.4, 122.3, 122.2, 121.5, 121.3, 121.2, 121.1, 119.5, 117.8, 116.3, 116.1, 114.7, 112.4, 110.8, 104.3, 60.9, 52.5, 45.7, 43.1, 28.4, 28.4, 27.2, 14.2; IR (KBr): 3649, 3619, 1685, 1558, 1240, 1176, 1017, 802, 744, 703, 669 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}FN_2O_3 - H)^-$ requires m/z 467.1765, found m/z 467.1767; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 7.96 min (major), t_R = 6.32 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 7′-Chloro-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3an). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 90% (21.7 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +72.8 (*c* 0.55, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (s, 1H), 7.40 (d, J = 8.0 Hz, 1H), 7.30−7.27 (m, 1H), 7.25−7.22 (m, 1H), 7.17−7.00 (m, 8H), 6.82 (t, J = 8.0 Hz, 1H), 4.54−4.42 (m, 1H), 4.19−4.13 (m, 1H), 4.09−3.99 (m, 2H), 3.76 (dd, J = 16.4, 11.2 Hz, 1H), 3.47 (s, 3H), 3.12 (dd, J = 16.4, 6.0 Hz, 1H), 1.16 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 172.3, 139.8, 139.3, 136.2, 135.5, 132.1, 130.6, 128.5, 128.0, 127.1, 126.7, 123.8, 122.5, 121.5, 119.5, 117.8, 115.1, 110.9, 104.4, 60.9, 51.9, 45.9, 43.1, 29.4, 27.4, 14.2; IR (KBr): 3676, 3650, 1717, 1639, 1508, 1155, 1094, 837, 744, 672 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}ClN_2O_3 - H)^-$ requires m/z 483.1470, found m/z 483.1462; Enantiomeric excess: 96%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 8.07 min (major), t_R = 6.78 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 7′-Bromo-1′-methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ao). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 88% (23.4 mg); >95:5 *dr*; white solid; mp 226−228 °C; $[\alpha]_D^{20}$ = +67.4 (*c* 0.47, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.40 (d, J = 8.0 Hz, 1H), 7.31−7.27 (m, 2H), 7.24−7.20 (m, 1H), 7.15−7.03 (m, 7H), 6.75 (t, J = 8.0 Hz, 1H), 4.51−4.43 (m, 1H), 4.16−4.11 (m, 1H), 4.09−3.98 (m, 2H), 3.75−3.71 (m, 1H), 3.48 (s, 3H), 3.13 (dd, J = 16.4, 6.0 Hz, 1H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.0, 172.3, 140.7, 139.8, 136.2, 135.4, 134.0, 132.4, 128.5, 128.0, 127.1, 126.7, 124.3, 122.9, 121.5, 119.6, 117.8, 110.9, 104.4, 102.0, 60.9, 51.9, 45.9, 43.1, 27.5, 14.2; IR (KBr): 3691, 3650, 3057, 3032, 1717, 1686, 1458, 1339, 1264, 1019, 744, 689 cm^{-1}; ESI FTMS exact mass calcd for $(C_{29}H_{25}BrN_2O_3 - H)^-$ requires m/z 527.0965, found m/z 527.0975; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 8.37 min (major), t_R = 7.15 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′-Methyl-2′-oxo-2-phenyl-7′-(trifluoromethyl)-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ap). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 90% (23.2 mg); >95:5 *dr*; pale yellow sticky oil; $[\alpha]_D^{20}$ = +110.9 (*c* 0.37, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (s, 1H), 7.55 (d, J = 7.6 Hz, 1H), 7.41 (d, J = 8.0 Hz, 2H), 7.30 (d, J = 8.0 Hz, 1H), 7.17−7.10 (m, 1H), 7.09−6.95 (m, 7H), 4.52−4.44 (m, 1H), 4.19−4.12 (m, 1H), 4.11−3.98 (m, 2H), 3.76−3.70 (m, 1H), 3.33−3.28 (m, 3H), 3.15 (dd, J = 16.8, 6.0 Hz, 1H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.2, 172.3, 141.4, 139.5, 136.2, 135.3, 131.9, 128.6, 128.4, 128.0, 127.2, 126.7, 126.3, 126.2, 124.8, 122.1, 121.6, 121.1, 119.6, 117.8, 112.1, 111.8, 110.9, 104.4, 61.0, 50.6, 45.6, 43.4, 28.7, 28.6, 27.2, 14.2; IR (KBr): 3677, 3650, 3032, 1717, 1672, 1437, 1339, 1175, 1023 745 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{25}F_3N_2O_3 - H)^-$ requires m/z 517.1734, found m/z 517.1747; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 12.45 min (major), t_R = 16.45 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′,7′-Dimethyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3aq). Preparative thin layer chromatography: petroleum ether/ethyl acetate = 3/1; Reaction time = 15 h; yield: 89% (20.8 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +88.7 (*c* 0.44, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (s, 1H), 7.39 (d, J = 8.0 Hz, 1H), 7.27−7.24 (m, 1H), 7.20−7.16 (m, 1H), 7.13−7.01 (m, 7H), 6.85−6.76 (m, 2H), 4.52−4.42 (m, 1H), 4.25−4.11 (m, 1H), 4.10−3.95 (m, 2H), 3.79−3.72 (m, 1H), 3.37 (s, 3H), 3.11 (dd, J = 16.4, 6.0 Hz, 1H), 2.38 (s, 3H), 1.15 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.4, 172.5, 141.1, 140.4, 136.2, 135.6, 132.0, 129.8, 128.7, 127.8, 126.8, 126.8, 123.0, 121.7, 121.3, 119.4, 119.1, 117.7, 110.8, 104.8, 60.8, 51.4, 46.0, 43.1, 27.5, 19.1, 14.2; IR (KBr): 3677, 3650, 3032, 1734, 1718, 1658, 1339, 1175, 1023, 745 719 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires m/z 463.2016, found m/z 463.2015; Enantiomeric excess: 94%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 11.14 min (major), t_R = 8.44 min (minor).

(2*S*,3*R*,4*R*)-4-Benzoyl-1′-methyl-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indolin]-2′-one (3ar). Preparative thin layer chromatography: pure dichloromethane; Reaction time = 15 h; yield: 93% (22.5 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = −58.0 (*c* 0.47, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (s, 1H), 7.68−7.61 (m, 2H), 7.52−7.44 (m, 1H), 7.36−7.30 (m, 2H), 7.27−7.24 (m, 1H), 7.12−7.07 (m, 2H), 7.04−7.00 (m, 5H), 6.97−6.90 (m, 1H), 6.85−6.78 (m, 2H), 6.66−6.59 (m, 1H), 6.51 (d, J = 8.0 Hz, 1H), 5.21 (s, 1H), 4.64−4.56 (m, 1H), 3.87 (dd, J = 16.4, 11.2 Hz, 1H), 3.19 (dd, J = 16.4, 6.0 Hz, 1H), 3.11 (s, 3H); ^{13}C NMR (100 MHz, cdcl$_3$) δ 201.5, 177.0, 143.0, 140.0, 138.6, 136.1, 135.9, 132.9, 128.7, 128.5, 128.3, 127.9, 127.7, 126.8, 126.5, 126.2, 121.8, 121.2, 119.2, 117.5, 110.8, 107.5, 105.8, 52.8, 44.6, 43.3, 27.2, 26.0; IR (KBr): 3676, 3650, 3055, 1717, 1699, 1686, 1263, 1207, 1088, 1014, 746 cm^{-1}; ESI FTMS exact mass calcd for $(C_{33}H_{26}N_2O_2 - H)^-$ requires m/z 481.1911, found m/z 481.1912; Enantiomeric excess: 92%, determined by HPLC (Daicel Chirapak OD-H, hexane/isopropanol = 85/15, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 31.95 min (major), t_R = 14.02 min (minor).

(2*S*,3*R*,4*R*)-1′-Methyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carbonitrile (3as). Preparative thin layer chromatography: petroleum ether/ethyl acetate = 2/1; Reaction time = 15 h; yield: 79% (16.0 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = +44.8 (*c* 0.19, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (s, 1H), 7.66 (d, J = 7.6 Hz, 1H), 7.54 (d, J = 8.0 Hz, 1H), 7.36 (d, J = 8.0 Hz, 1H), 7.25−7.19 (m, 2H), 7.18−7.14 (m, 1H), 7.11−7.02 (m, 6H), 6.64 (d, J = 8.0 Hz, 1H), 4.32 (s, 1H), 3.88−3.86 (m, 1H), 3.85−3.70 (m, 1H), 3.18 (dd, J = 16.4, 5.6 Hz, 1H), 3.11 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175., 143.0, 138.9, 136.2, 135.0, 129.0, 128.2,

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128.1, 128.0, 127.4, 125.9, 125.9, 122.5, 122.3, 120.3, 118.4, 117.6, 111.0, 108.0, 101.4, 51.0, 45.0, 32.3, 27.2, 26.2; IR (KBr): 3650, 3301, 3123, 2197, 2015, 1711, 1642, 1333, 1143, 1013, 983 cm^{-1}; ESI FTMS exact mass calcd for $(C_{27}H_{21}N_3O - H)^-$ requires m/z 402.1602, found m/z 402.1611; Enantiomeric excess: 84%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 22.14 min (major), t_R = 13.11 min (minor).

(2*S*,3*R*,4*R*)-Ethyl 1′,9-Dimethyl-2′-oxo-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indoline]-4-carboxylate (3ja). Preparative thin layer chromatography: petroleum ether/ethyl acetate = 3/1; Reaction time = 15 h; yield: 42% (9.9 mg); 80:20 *dr*; pale yellow sticky oil; $[\alpha]_D^{20}$ = +91.8 (*c* 0.16, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (d, J = 8.0 Hz, 1H), 7.35 (d, J = 7.2 Hz, 1H), 7.30 (d, J = 8.0 Hz, 1H), 7.20−7.13 (m, 1H), 7.13−6.98 (m, 7H), 6.94−6.88 (m, 1H), 6.56 (d, J = 8.0 Hz, 1H), 4.62−4.56 (m, 1H), 4.24−4.15 (m, 1H), 4.11−3.98 (m, 2H), 3.83−3.67 (m, 4H), 3.25−3.15 (m, 1H), 3.06 (s, 3H), 1.17 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 172.7, 143.3, 140.3, 137.4, 137.1, 129.3, 128.6, 128.2, 127.8, 126.8, 126.4, 125.3, 121.9, 120.8, 119.0, 117.8, 108.9, 107.7, 103.4, 65.9, 60.8, 52.0, 45.7, 43.0, 26.6, 25.9, 15.3, 14.2; IR (KBr): 3652, 3321, 3027, 1715, 1655, 1321, 1109, 1011, 745 cm^{-1}; ESI FTMS exact mass calcd for $(C_{30}H_{28}N_2O_3 - H)^-$ requires m/z 463.2016, found m/z 463.2018; Enantiomeric excess: 72%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 95/5, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 20.89 min (major), t_R = 13.18 min (minor).

Procedure and Characterization Data for the Synthesis of Product 5. $LiAlH_4$ (0.15 mmol) was added to the solution of compound **3aa** (0.1 mmol) in THF (1.5 mL) at room temperature. Then, this reaction mixture was refluxed at 80 °C overnight. After the completion of the reaction indicated by TLC, NaOH aqueous (1 M) was added to the reaction mixture, which was further extracted by AcOEt to give the organic layer. Then, the organic layer was dried by anhydrous Na_2SO_4 and was concentrated under the reduced pressure to give the residue, which was purified through flash column chromatography to afford pure product **5**.

(2*S*,3*R*,4*R*)-4-(Hydroxymethyl)-1′-methyl-2-phenyl-1,2,4,9-tetrahydrospiro[carbazole-3,3′-indolin]-2′-one (5). Flash column chromatography eluent, petroleum ether/ethyl acetate = 5/1; Reaction time = 15 h; yield: 92% (37.4 mg); >95:5 *dr*; white sticky oil; $[\alpha]_D^{20}$ = −12.5 (*c* 0.61, Acetone); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.66 (d, J = 8.0 Hz, 1H), 7.36 (d, J = 8.0 Hz, 1H), 7.25−7.23 (m, 3H), 7.22−7.16 (m, 3H), 7.16−7.12 (m, 2H), 7.11−7.06 (m, 1H), 6.63 (t, J = 7.6 Hz, 1H), 6.50 (d, J = 7.6 Hz, 1H), 4.26−4.20 (m, 1H), 4.09−3.93 (m, 1H), 3.89−3.77 (m, 1H), 3.55−3.48 (m, 1H), 3.28−3.22 (m, 1H), 3.06 (dd, J = 17.2, 7.6 Hz, 1H), 2.71 (s, 3H), 2.28−2.24 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.9, 142.2, 136.7, 134.7, 132.6, 129.7, 128.2, 127.4, 126.7, 125.9, 121.6, 119.6, 119.2, 118.0, 110.8, 109.2, 108.1, 64.1, 63.7, 51.8, 44.9, 43.8, 35.9, 28.2; IR (KBr): 3673, 3651, 3542, 3317, 3234, 2928, 1647, 1628, 1435, 1175, 1016, 749, 699 cm^{-1}; ESI FTMS exact mass calcd for $(C_{27}H_{24}N_2O_2 - H)^-$ requires m/z 407.1754, found m/z 407.1762; Enantiomeric excess: 94%, determined by HPLC (Daicel Chirapak IA, hexane/isopropanol = 70/30, flow rate 1.0 mL/min, T = 30 °C, 254 nm): t_R = 8.66 min (major), t_R = 8.08 min (minor).

■ ASSOCIATED CONTENT

Supporting Information

Characterization data (including ^{1}H, ^{13}C NMR and HPLC spectra) for all products, single-crystal data of product **3ao**. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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