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Enantioselective Synthesis of Functionalized Nitrocyclopropanes by Organocatalytic Conjugate Addition of Bromonitroalkanes to α,β-Unsaturated Enones

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Abstract: A general enantioselective synthesis of functionalized nitrocyclopropanes by organocatalytic conjugate addition of a variety of bromonitroalkanes to α,β-unsaturated enone systems is presented. The process, efficiently catalyzed by the salts of 9-amino-9-deoxyepiquinine **1d** serves as a powerful approach to the preparation of synthetically and biologically important cyclopropanes with high levels of enantio- and diastereoselectivities. Since only 0.6 equivalents of bromonitromethane are used as a reagent, (*S*)-**2e** is obtained enantiomerically pure by employing chiral **1d** as a highly efficient catalyst for its kinetic resolution (97% *ee* at 51% conversion, selectivity $s = 120$).

Keywords: asymmetric catalysis · enones · Michael addition · nitrocyclopropanes · organocatalysis

Introduction

With representation in more than 4000 natural isolates[1] and 100 biologically active agents, the cyclopropane framework has long been established as an attractive target for medicinal chemistry. In this regard, the development of effective asymmetric entries to cyclopropane architecture constitutes an important research field. The current available methods for the synthesis of cyclopropanes include intensively studied organometallic-based catalysis[2–4] and asymmetric versions of the Simmons–Smith reaction.[5] Notably, recently Gaunt pioneered the use of ammonium ylides in enantioselective intermolecular[6] and intramolecular[7] cyclopropanation by using cinchona alkaloids as organocatalysts. Moreover, Kojima and Ohkata have used cinchonidine as a chiral Brønsted base for the asymmetric cyclopropanation reaction between chloromethyl ketones and β-substituted methylidenemalononitriles.[8] Furthermore, the advent in the most recent years of enantioselective cyclopropanation of α,β-unsaturated aldehydes catalyzed by chiral imidazolidinones, pioneered by MacMillan et al.,[9] and improved by Arvidsson,[10] Córdova,[11] and Wang,[12] allowed us to obtain impressive degrees of enantioselectivity by using a very simple procedure.

In particular, the recent confirmation of the first biologically active natural product structure to contain a chiral nitrocyclopropane moiety[13] prompted us to undertake the development of a convenient, organocatalytic Michael-based route to functionalized nitrocyclopropanes of high potential synthetic utility. For example, a diastereoselective nitrocyclopropanation has been reported by Ballini et al.[14] Notably, Ley and co-workers reported the first organocatalytic nitrocyclopropanation of cyclohexenone by using their proline tetrazole catalyst with modest yields and enantioselectivities,[15] and Arai and co-workers reported an asymmetric cyclopropane reaction of α-bromocyclopentenone with nitromethane by using quaternary ammonium salts as the phase-transfer catalysts.[16] Moreover, Connon and co-works have used cinchona alkaloids derivatives as catalysts for the asymmetric cyclopropanation of nitroalkenes with modest enantioselectivities.[17]

Herein, we report the highly enantioselective catalytic asymmetric reaction between bromonitroalkanes and α,β-unsaturated enones that gives the corresponding nitrocyclopropanes in high yields and with excellent asymmetric induction (up to >99% *ee*). In particular, the successful application of new primary amine salts as iminium catalysts for enone substrates has rarely been explored.[18]

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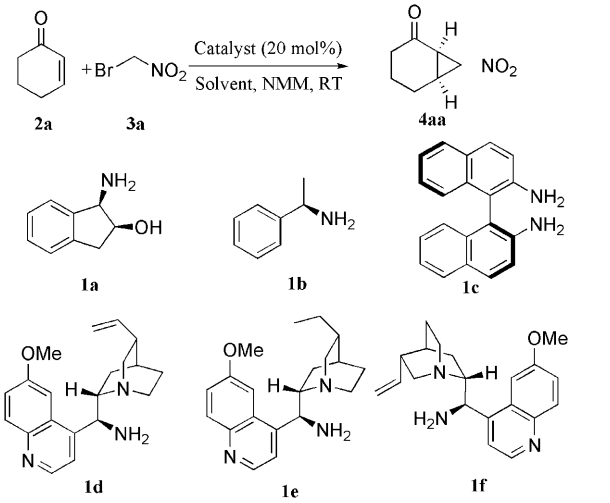
Results and Discussion

The proposed organocatalytic nitrocyclopropanation strategy was first examined by reacting cyclohexenone **2a** with bromonitromethane (**3a**) in the presence of a series of chiral amines as the catalysts (Table 1). We found that the addition of one equivalent of NMM was crucial to obtain high yields. Interesting, secondary amines, such as proline (Table 1, entry 1), afforded poor results. As the relative bulkiness of secondary amines might be unfavorable for the formation of iminium ions with α,β-unsaturated ketones, we questioned whether primary amines, owing to their reduced steric requirements, might be suitable for enone activation.[19]

Preliminary studies confirmed that the primary amines **1a–c** were able to promote the reaction with moderate catalytic efficiency and enantioselectivity (Table 1, entries 2–4).

Table 1. Catalyst screen for the reaction between **2a** and **3a**.[a]



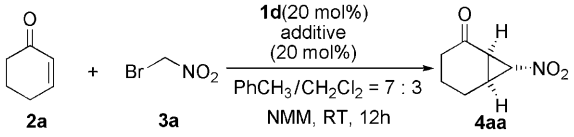
Entry	Catalyst	Solvent	*t* [h]	Yield [%][b]	*ee* [%][c]
1	proline	CH_2Cl_2	24	40	–35
2	**1a**	CH_2Cl_2	14	52	66
3	**1b**	CH_2Cl_2	12	55	31
4	**1c**	CH_2Cl_2	24	49	75
5	**1d**	CH_2Cl_2	12	82	90
6	**1e**	CH_2Cl_2	12	80	89
7	**1f**	CH_2Cl_2	12	83	–88
8	**1d**	CH_3CN	48	–	–
9	**1d**	THF	15	70	81
10	**1d**	$PhCH_3$	12	85	91
11	**1d**	CH_3OH	5	90	65
12	**1d**	H_2O	6	70	8
13	**1d**	DMSO	48	–	–
14	**1d**	Et_2O	18	60	46
15	**1d**	nBu_2O	16	54	73
16	**1d**	$PhCH_3/CH_2Cl_2$[d]	12	90	94
17[e]	**1d**	$PhCH_3/CH_2Cl_2$[d]	24	60	84
18[f]	**1d**	$PhCH_3/CH_2Cl_2$[d]	12	95	95

[a] Reaction conditions: unless otherwise noted, **2a** (0.3 mmol), **3a** (0.25 mmol), NMM (0.25 mmol), and catalyst (20 mol%) in the solvent (0.5 mL) were stirred at room temperature for the time given. [b] Yield of isolated product. [c] Determined by HPLC analysis. [d] $PhCH_3/CH_2Cl_2$ (v/v, 7:3). [e] The reaction was performed at 0°C. [f] PhCOOH (20 mol%) as acid additive.

Subsequently, we found that 9-amino-9-deoxyepiquinine **1d** exhibited much higher catalytic activity, and the product **4aa** was obtained in 82% yield with 90% *ee* after 12 h at room temperature (Table 1, entry 5). Compounds **1e** and **1f** furnished comparable yields and enantioselectivities (Table 1, entries 6 and 7). A variety of solvents were screened; however, inferior results to that with **1d** were observed (Table 1, entries 8–15). The product **4aa** was formed with the best yield and enantioselectivity when the reaction was conducted in the solvent system $PhCH_3/CH_2Cl_2$ (v/v, 7:3) at room temperature (Table 1, entry 16). The yield and enantioselectivity of this reaction was decreased at 0°C (Table 1, entry 17). Notably, the use of the benzoic acid salt of the easily available 9-amino-9-deoxyepiquinine **1d**, which was very recently described as an effective catalyst for enone activation,[20] afforded a promising yield and stereoinduction. With this consideration in mind, a survey of various salts of the chiral primary amine **1d** were performed (Table 1, entry 17).

An extensive screening of the acidic additives revealed that the use of *N*-Boc phenylalanine gave the product **4aa** with a high yield (96–98%; Table 2, entries 5–7) and high enantiomeric excess (97% *ee*, Table 2, entries 5–7). Surprisingly, employing the racemic or enantiomeric counterion formed the same enantiomeric product **4aa** with very similar selectivity; thus, we didn't consider that the chiral anion of the amine salt of **1d** might influence asymmetric induction.

Table 2. Acid Additive screen for the reaction between **2a** and **3a**.[a]



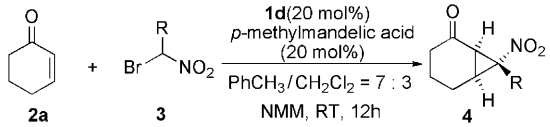
Entry	Additive	Yield [%][b]	*ee* [%][c]
1	AcOH	80	99
2	TFA[d]	86	92
3	TsOH[d]	87	89
4	PhCOOH	95	95
5	BocHN(L)COOH, Bn	96	97
6	BocHN(D)COOH, Bn	98	97
7	BocHN(RAC)COOH, Bn; PGO COOH, R	96	97
8	R = CH_3, PG = H[d]	87	92
9	R = Ph, PG = H[d]	96	97
10	R = 3-Cl-Ph, PG = H[d]	92	93
11	R = 3,5-F_2-Ph, PG = H[d]	93	95
12	R = 4-Br-Ph, PG = H[d]	94	92
13	R = 4-CH_3, PG = H[d]	99	98
14	R = Ph, PG = Ac[d]	95	96

[a] Reaction conditions: **2a** (0.3 mmol), **3a** (0.25 mmol), NMM (0.25 mmol), **1d** (20 mol%), and acid additive (20 mol%) in $PhCH_3/CH_2Cl_2$ (7:3) were stirred at room temperature for 12 h. [b] Yield of isolated product. [c] Determined by HPLC analysis. [d] PG = protecting group; TFA = trifluoroacetic acid; Ts = tosyl.

Next, we evaluated the efficiency of catalytic salts derived from the combination of **1d** with a series of (*rac*)-mandelic acids (Table 2, entries 9–14). Variation in the electronic contribution of substituents on the phenyl ring reveals that the electron-donating methyl group engenders higher yields (99%) and enantioselectivities (98% *ee*). The presence of a protecting group in the hydroxy acid had a little deleterious effect on the catalytic activity (Table 2, entry 14). On the basis of these studies, (*rac*)-4-methyl mandelic acid was chosen for further investigations as it proved to be superior with regard to enantioselectivity and catalytic efficiency.

Next, we examined the nitrocyclopropanation of a range of bromonitro compounds **3** to cyclohexenone **2a** under the optimized conditions. Alkyl groups tested were suitable substrates for the reaction and gave excellent enantioselectivities (Table 3, entries 1 and 2, ≥97%). However, phenyl group compound **3c** did not react with **2a**, presumably owing to the electronic effect.

Table 3. Nitrocyclopropanation of various bromonitroalkanes to cyclohexenone.[a]



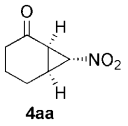
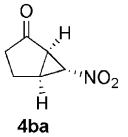
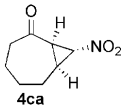
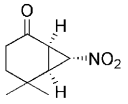
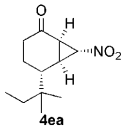
Entry	R	Product	*t* [h]	Yield [%][b]	*ee* [%][c]
1	H	**4aa**	12	99	98
2[d]	CH_3	**4ab**[d]	48	54	97
3	Ph	–	72	–	–

[a] Reaction conditions: **2a** (0.3 mmol), **3** (0.25 mmol), NMM (0.25 mmol), **1d** (20 mol%), and *p*-methyl mandelic acid (20 mol%) in $PhCH_3/CH_2Cl_2$ (7:3) were stirred at room temperature. [b] Yield of isolated product. [c] Determined by HPLC analysis. [d] Structure deduced from ^1H NMR spectroscopic analysis (NOE).

Next, the scope of organocatalytic cyclic enone substituent nitrocyclopropanation was explored by using the standard reaction conditions and is reported in Table 4. It appears from these results that the enantioselectivity is dependent on the ring size. For cyclopentenone **2b**, the reaction proceeds well giving a 94% yield of **4ba**; however, the enantiomeric excess of the product was only 83% *ee* (Table 4, entry 2). It is notable that increasing the ring size to seven-membered rings led to an improvement in the enantioselectivity up to 99% (Table 4, entry 3). For the six-membered ring systems, it was pleasing to find that as well as the known compound **2a**, other substituted 2-cyclohexenones were also formed with similarly high enantioselectivity (Table 4, entries 4 and 5). Interestingly, the racemic enone **2e** only gave one isomer and higher enantioselectivity (up to >99% *ee*). 4-Alkyl-substituted 2-cyclohexenones may provide high selectivity in the kinetic resolution of these compounds.

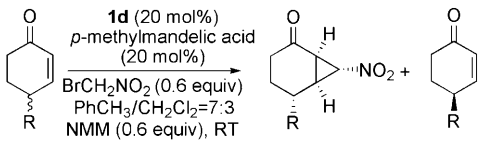
To check the viability of the approach, we tested **1d** in the kinetic resolution of racemic 4-substituted 2-cyclohexenones **2e–h** under the conditions typical for the asymmetric

Table 4. Scope of the organocatalytic cyclic enones nitropropanation.[a]

Entry	Product	*t* [h]	Yield [%][b]	*ee* [%][c]
1	 **4aa**	12	99	98
2	 **4ba**	24	94	83
3	 **4ca**	16	85	99
4	 **4da**	12	94	>99
5[d,e]	 **4ea**	48	83	>99

[a] Reaction conditions: **2a** (0.3 mmol), **3a** (0.25 mmol), NMM (0.25 mmol), **1d** (20 mol%), and *p*-methyl mandelic acid (20 mol%) in $PhCH_3/CH_2Cl_2$ (7:3) were stirred at room temperature. [b] Yield of isolated product. [c] Determined by HPLC analysis. [d] Structure deduced from ^1H NMR spectroscopic analysis (NOE). [e] Reaction condition: **2e** (0.3 mmol), **3a** (0.18 mmol), NMM (0.18 mmol), **1d** (20 mol%), and *p*-methyl mandelic acid (20 mol%) in $PhCH_3/CH_2Cl_2$ (7:3) were stirred at room temperature.

nitrocyclopropanation as shown in Scheme 1. By using the salt of **1d** (20 mol%) and bromonitromethane (0.6 equiv) in $PhCH_3/CH_2Cl_2$ (v/v, 7:3) at room temperature for the resolution of (±)-4-*tert*-amyl-2-cyclohexenone (**2e**) on an 1 mmol scale, an *ee* of 97% was reached at 51% conversion, which indicated a selectivity (*s*) of 120 (Table 5, entry 1). A bulky *tert*-butyl group (**2f**) led to a slight decrease in the selectivity (*s* = 61, Table 5, entry 2), and substrate **2g** containing a phenyl group at the 4-position also gave a lower selectivity (*s* = 7, Table 5, entry 3) than **2e**. Unfortunately, substrate **2h** containing a relatively small methyl group at the 4-position produced no selectivity.



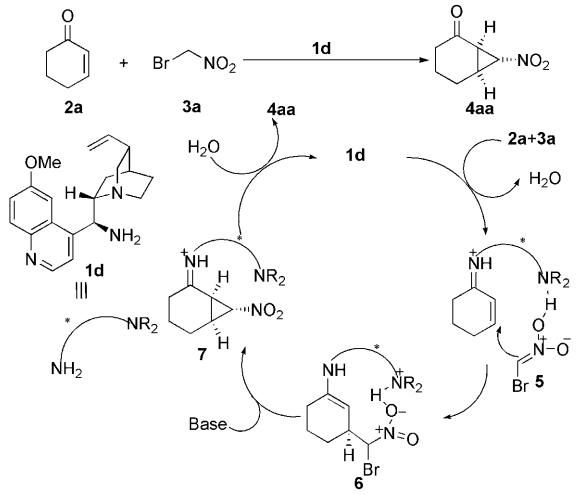
Scheme 1. Kinetic resolution of racemic 4-substituted 2-cyclohexenones **2e–h** under conditions typical for asymmetric nitrocyclopropanation. NMM = *N*-methyl morpholine.

Table 5. Kinetic resolution of 4-substituted 2-cyclohexenones **2e–h** according to Scheme 1.

Entry	Enone	*t* [h]	Conv. [%][a]	*ee* [%][b]	*s*	Conf.[c]
1	**2e**	24	51	97	120	*S*
2	**2f**	24	54	99	61	*S*
3	**2g**	24	58	76	8	*S*
4	**2h**	12	60	–	–	–

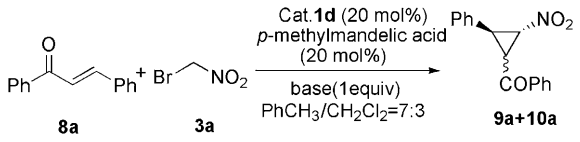
[a] Yield of isolated product. [b] Determined by HPLC analysis. [c] Configuration of the unconverted enone.

Based on the absolute and relative configuration of nitrocyclopropane derivatives **4**, we propose the following mechanism to account for the organocatalytic nitrocyclopropanation reaction of enones **2** (Scheme 2). We propose that a cinchona alkaloid derivative, such as **1d**, could render the nucleophilic addition of the bromomethane **3a** to the iminium intermediate **5** enantioselective. Presumably, owing to steric crash and multipoint binding interactions between the chiral enamine intermediate **6** and the covalently linked cinchona alkaloid, the rotational freedom of the chiral enamine should be hampered. Next, the generated chiral enamine intermediate undergoes intramolecular 3-*exo*-*tert* nucleophilic attack to form the cyclopropane ring **7**. Hydrolysis of iminium intermediate **7** releases the catalyst and gives the nitrocyclopropane **4aa**.



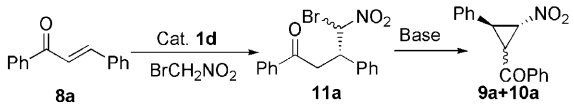
Scheme 2. A proposed catalytic cycle for the reaction of **2a** and **3a** with cinchona alkaloid **1d**.

The addition of **3a** to chalcone **8a** promoted by the salt of organocatalyst **1d** and Brønsted-base additives was then attempted (Scheme 3). These experiments exposed route A as unsatisfactory from an asymmetric catalysis standpoint: of the additives tested DBU furnished **1d** in racemic form, whereas substoichiometric amounts of NMM as the base resulted in a good enantioselectivity (95% *ee*), but diminished yield (8%). Compound **1d** was not involved catalytically in this reaction.



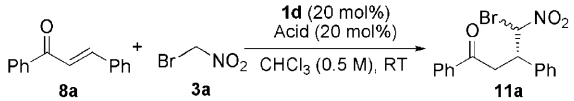
Scheme 3. Route A. Base = none: no reaction; morpholine: 30% yield, 0% *ee*; NMM: 8% yield, 95% *ee*; DBU: 95% yield, 0% *ee*.

To circumvent these difficulties, route B was examined (Scheme 4). The initial Michael addition of bromonitromethane **3a** to **8a** was promoted by chiral catalysts, with a subsequent amine-promoted ring-closure (Scheme 4). First, the proposed organocatalytic Michael addition reaction was examined by reacting chalcone **8a** with bromonitromethane **3a** in the presence of **1d** as the catalyst. The results of these experiments are outlined in Table 6. We were pleased to find that 9-amino-9-deoxyepiquinine **1d** in combination with TFA (20 mol%) exhibited high bifunctional catalytic activity[21] for asymmetric Michael addition of **3a** to chalcone **8a** in $CHCl_3$ at room temperature (Table 6, entry 4). The enantioselectivity was decreased in the presence of other acidic additives (Table 6, entries 2 and 5–8). Under the optimized conditions, **1f** furnished a comparable yield and enantioselectivity (Table 6, entry 9). Moreover, it was necessary to use two equivalents of chalcone **8a** to obtain a good yield of product (Table 6, entries 4 and 10).



Scheme 4. Route B.

Table 6. Enantioselective Michael addition reaction with **1d.**[a]



Entry	Acid	Yield [%][b]	d.r.[c]	*ee* [%][d,e]
1	-	50	1.7	85
2	*p*-methylmandelic acid	85	1.6	98
3[f]	*p*-methylmandelic acid	82	1.6	95
4	TFA	87	1.4	99
5	AcOH	78	1.5	93
6	PhCOOH	85	1.5	97
7	*N*-Boc-benzyl L-glycine[g]	80	1.6	98
8	(*R*)-mandelic acid	84	1.6	98
9[h]	TFA	85	1.2	−97
10[i]	TFA	99	1.2	>99

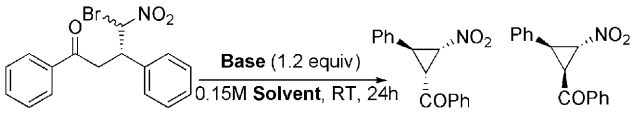
[a] Unless noted, reactions were carried out with **8a** (0.15 mmol) and **3a** (0.125 mmol) in 0.5 mL of $CHCl_3$ for 48 h. [b] Yield of isolated product. [c] Determined by NMR analysis. [d] Determined by HPLC analysis. [e] Enantiomeric excess for major isomer. [f] $PhCH_3$:CH_2Cl_2 (v/v = 7:3) as solvent. [g] Boc = *tert*-butoxycarbonyl. [h] **1f** as an organocatalyst. [i] Reaction was carried out with **8a** (0.25 mmol) and **3a** (0.125 mmol) in 0.5 mL of $CHCl_3$ for 24 h.

After considerable experimentation, it was found that the variation of the bases had a substantial impact on diastereoselectivity, but a minimal impact on enantioselectivity (Table 7). The diastereoselectivity of the reaction was also sensitive to the choice of organic base (Table 7, entries 1–7). For example, when the reaction was performed in CH_2Cl_2 by using *trans*-dimethylpiperazine as the base, a slower but cleaner reaction resulted, leading to the formation of the desired product in a 94:6 diastereomeric ratio (d.r.) (Table 7, entry 7). On closer examination of the reaction solvent, CH_2Cl_2 was found to be the optimal solvent in terms of both yield and distereoselection. However, the diastereoselectivity decreased in $CHCl_3$, THF, $PhCH_3$, and CH_3OH (Table 7, entries 8–11).

To investigate the scope of the present nitrocyclopropane transformations, the reaction of **3a** with a series of aromatic (*E*)-α,β-unsaturated enones was explored under the optimized reaction conditions (Table 8). It was pleasing to find that these also worked very well and the nitrocyclopropane adducts were all formed in high yields and with generally excellent enantioselectivities. Electron-withdrawing (Cl, CF_3; Table 8, entries 13 and 15) substituents can be introduced on the aromatic ring of R^1 with a loss in diastereoselectivity; however, a recrystallization takes the 60:40 d.r. up to 96:4 (Table 8, entry 15). Moreover, we were encouraged to develop a one-pot cyclopropanation involving the controlled **1d**-catalyzed addition of bromonitromethane to (*E*)-α,β-unsaturated enones, followed by *trans*-dimethylpiperazine-mediated cyclization. However, enantioselectivity and diastereoselectivity were decreased.

Work is now underway to explore the scope of the reaction for the other substrates. Preliminary indications suggest that for the β-methyl with alternative groups, the Michael addition product was easily formed in high yield and with excellent enantioselectivity (98% *ee*); however, few nitrocyclopropane adducts were obtained with *trans*-2,5-dimethylpiperazine as the base. Unfortunately, oct-3-en-2-one as a Michael acceptor did not react with **3a**. These results suggest that further optimization and catalyst development will be necessary to discover a general nitrocyclopropanation procedure.

Table 7. Effect of base and solvent on nitrocyclopropane stereochemistry.[a]



11a 9a 10a

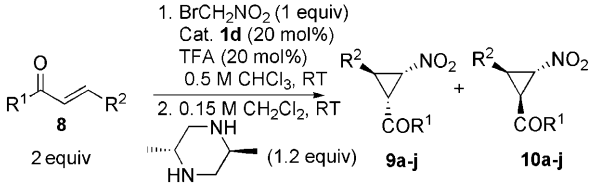
Entry	Solvent	Base	Yield [%][b]	d.r. **9a**/**10a**[c]
1	CH_2Cl_2	morpholine	25	68:32
2	CH_2Cl_2	NMM	8	80:20
3	CH_2Cl_2	pyridine	80	78:22
4	CH_2Cl_2	DBU[d]	95	38:62
5	CH_2Cl_2	Et_3N	50	86:14
6	CH_2Cl_2	nPr_2NH	75	84:16
7	CH_2Cl_2	*trans*-2,5-dimethylpiperazine	71	94:6
8	$CHCl_3$	*trans*-2,5-dimethylpiperazine	65	90:10
9	THF	*trans*-2,5-dimethylpiperazine	75	84:16
10	$PhCH_3$	*trans*-2,5-dimethylpiperazine	72	86:14
11	CH_3OH	*trans*-2,5-dimethylpiperazine	80	32:68

[a] NMR spectroscopic data of **9a** and **10a** are consistent with the reference reported.[22] [b] Yield of isolated product. [c] Determined by NMR spectroscopic analysis. [d] DBU = 1,8-diazabicyclo[5.4.0]undec-7-ene.

Conclusion

In summary, a general enantioselective synthesis of functionalized nitrocyclopropanes by organocatalytic conjugate addi-

Table 8. Organocatalytic asymmetric Michael ring-closure reactions of **5a–j** and **3a**.



Entry	R^1	R^2	Yield [%][a]	Major product	d.r.[b] **9**/**10**	*ee* [%][c,d]
1	Ph	Ph	70	**9a**	94:6	>99
2[e]			75		90:10	95
3	Ph	4-Cl-C_6H_4	66	**9b**	95:5	98
4[e]			70		85:15	96
5	Ph	3-Cl-C_6H_4	75	**9c**	96:4	99
6[e]			76		90:10	95
7	Ph	4-Me-C_6H_4	63	**9d**	90:10	99
8[e]			67		87:13	90
9	Ph	4-NO_2-C_6H_4	73	**9e**	99:1	93
10[e]			70		95:5	88
11	Ph	3-furyl	60	**9f**	92:8	98
12[e]			61		86:14	91
13	4-Cl-C_6H_4	Ph	77	**9g**	69:31 (99:1)[g]	97 (>99)[f]
14[e]			80		85:15	82
15	4-CF_3-C_6H_4	Ph	85	**9h**	60:40 (96:4)[g]	>99 (>99)[f]
16[e]			82		78:22	90
17[g]	4-MeO-C_6H_4	Ph	80	**9i**	95:5	98
18[e,g]			71		85:15	90
19	2-naphthyl	Ph	76	**9j**	87:13	96
20[e]			72		81:19	71

[a] Yield of isolated product. [b] Determined by NMR spectroscopic analysis. [c] Determined by HPLC analysis. [d] Enantiomeric excess for major isomer. [e] The one-pot reaction was carried out with **1a** (0.13 mmol), **2a** (0.125 mmol), **1d** (20 mol%), and TFA (20 mol%). *trans*-Dimethylpiperazine (1.2 equiv) was added to the mixture after 72 h. [f] After recrystallization. [g] *trans*-Dimethylpiperazine (2 equiv).

tion of a variety of bromonitroalkanes to α,β-unsaturated enone systems has been developed. The reaction is efficiently catalyzed by the salt of cinchona alkaloid **1d**. Cyclic and aromatic enones can be used and the reaction with bromonitromethane **3a** provides the nitrocyclopropane products in high yields with good to excellent stereoselectivities. Since only 0.6 equivalents of bromomethane are used as a reagent, (*S*)-**2e** is obtained enantiomerically pure by employing chiral **1d** as a highly efficient catalyst for their kinetic resolution (97% *ee* at 51% conversion, selectivity $s=120$).

Experimental Section

General: Commercial reagents were used as received, unless otherwise stated. Catalysts **1d**, **1e**, and **1f** were synthesized according to literature procedures.[21a] ^{1}H and ^{13}C NMR spectra were recorded on either a Bruker-DPX 300 or AV-400 sepectrometer. Chemical shifts are reported in ppm from tetramethylsilane with the solvent resonance as the internal standard. Accurate mass data were obtained on VG ZAB-HS by EI. Optical rotations were measured on a Perkin–Elmer 341 Polarimeter at 20°C. HPLC analysis was performed on Shimadzu CTO-10AS by using a Chiralpak AD-H and OD-H column purchased from Daicel Chemical Industries.

General procedure for the nitrocyclopropanation of bromonitromethane to cyclic enones: (*rac*)-4-Methyl-mandelic acid (20 mol%) was added to a stirred solution of catalyst (20 mol%) in $PhCH_3/CH_2Cl_2$ (v/v, 7:3, 0.5 mL) and the solution was stirred for 5 min at room temperature. After addition of enone (1.2 equiv), the mixture was stirred at the indicated temperature for 10 min. The bromonitromethane (1 equiv) and NMM (1 equiv) were added, separately, the tube was closed with a rubber stopper, and stirring was continued for the indicated time. Then, the crude reaction mixture was loaded onto a silica-gel column for purification (EtOAc/hexane 1:5) to afford the nitrocyclopropanation product.

(1*R*,6*S*,7*R*)-7-Nitrobicyclo[4.1.0]heptan-2-one (4aa): The title compound was obtained according to the general procedure. White solid; yield: 99%; $[\alpha]_D^{20}=-57.1$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (300 MHz, $CDCl_3$, 25°C, TMS): $\delta=4.71$ (t, ^3J(H,H) = 2.9 Hz, 1H), 2.81 (dd, ^3J(H,H) = 2.5, 9.6 Hz, 1H), 2.69–2.66 (m, 1H), 2.35 (td, ^3J(H,H) = 4.53, 4.53, 17.94 Hz, 1H), 2.22–2.13 (m, 2H), 2.06–1.99 (m, 1H), 1.91–1.83 (m, 1H), 1.63–1.52 ppm (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$, 25°C, TMS): $\delta=201.2$, 60.7, 37.3, 35.3, 26.9, 19.70, 18.3 ppm; MS (EI): *m*/*z*: 155 $[M]^+$; HRMS-EI: *m*/*z*: calcd for $C_7H_9NO_3$: 155.05824 $[M]^+$; found: 155.05768; HPLC (Chiralpak AD-H, hexane/*i*PrOH 95:5, flow rate = 0.6 mL min^{-1}): t_R(minor) = 35.5, t_R(major) = 38.5 min.

(1*R*,5*S*,6*R*)-6-Nitrobicyclo[3.1.0]hexan-2-one (4ba): The title compound was obtained according to the general procedure. White solid; yield: 95%; $[\alpha]_D^{20}=+11.8$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (300 MHz, $CDCl_3$, 25°C, TMS): $\delta=4.41$ (t, ^3J(H,H) = 1.5 Hz, 1H), 3.01–2.98 (m, 1H), 2.82 (d, ^3J(H,H) = 6.6 Hz, 1H), 2.40–2.20 (m, 3H), 2.04–1.95 ppm (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$, 25°C, TMS): $\delta=208.3$, 62.4, 37.5, 32.7, 31.0, 22.4 ppm; MS (EI): *m*/*z*: 141 $[M]^+$; HRMS-EI: *m*/*z*: calcd for $C_6H_7NO_3$: 141.04259 $[M]^+$; found: 141.04217; HPLC (Chiralpak AD-H, hexane/*i*PrOH 95:5, flow rate = 0.6 mL min^{-1}): t_R(minor) = 39.2, t_R(major) = 40.4 min.

(1*R*,7*S*,8*R*)-8-Nitrobicyclo[5.1.0]octan-2-one (4ca): The title compound was obtained according to the general procedure. White solid; yield: 85%; $[\alpha]_D^{20}=-20.1$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (300 MHz, $CDCl_3$, 25°C, TMS): $\delta=4.65$ (t, ^3J(H,H) = 2.9 Hz, 1H), 2.70–2.80 (m, 2H), 2.37–2.44 (m, 1H), 2.22–2.31 (m, 1H), 2.11–2.02 (m, 1H), 1.85–1.93 (m, 2H), 1.78 (s, 3H), 1.59–1.65 ppm (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$, 25°C, TMS): $\delta=203.3$, 62.9, 43.1, 39.9, 27.3, 26.9, 25.6, 24.4 ppm; MS (EI): *m*/*z*: 169 $[M]^+$; HRMS-EI: *m*/*z*: calcd for $C_8H_{11}NO_3$: 169.07389 $[M]^+$; found: 169.07328; HPLC (Chiralpak AD-H, hexane/*i*PrOH 98:2, flow rate = 0.5 mL min^{-1}): t_R(minor) = 21.1, t_R(major) = 22.3 min.

(1*R*,6*S*,7*R*)-7-Nitro-5,5-dimethylbicyclo[4.1.0]heptan-2-one (4da): The title compound was obtained according to the general procedure. White solid; yield: 94%; $[\alpha]_D^{20}=-134.6$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): $\delta=4.65$ (t, ^3J(H,H) = 2.8 Hz, 1H), 2.82 (dd, ^3J(H,H) = 1.9, 9.6 Hz, 1H), 2.40 (d, ^3J(H,H) = 9.5 Hz, 1H), 2.26 (dd, ^3J(H,H) = 4.6, 9.2 Hz, 2H), 1.41–1.53 (m, 2H), 1.12 (s, 3H), 1.19 ppm (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): $\delta=208.8$, 54.6, 36.4, 32.9, 28.9, 26.8, 25.5, 24.2 ppm; MS (EI): *m*/*z*: 183 $[M]^+$; HRMS-EI: *m*/*z*: calcd for $C_7H_9NO_3$: 183.08954; found: 183.08913 $[M]^+$; HPLC (Chiralpak AD-H, hexane/*i*PrOH 97:3, flow rate = 0.6 mL min^{-1}): t_R(minor) = 23.6, t_R(major) = 25.5 min.

(1*R*,5*R*,6*S*,7*R*)-7-Nitro-5-tert-amylbicyclo[4.1.0]heptan-2-one (4ea): The title compound was obtained according to the general procedure. White solid; yield: 83%; $[\alpha]_D^{20}=+26.9$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): $\delta=4.51$ (t, ^3J(H,H) = 3.2 Hz, 1H), 2.71 (d, ^3J(H,H) = 2.7 Hz, 1H), 2.56–2.60 (dt, ^3J(H,H) = 3.2, 10.1 Hz, 1H), 2.41 (d, ^3J(H,H) = 16.2 Hz, 1H), 1.84–2.02 (m, 2H), 2.02–2.11 (m, 2H), 1.35–1.41 (m, 2H), 0.96 (s, 3H), 0.95 (s, 3H), 0.87 ppm (t, ^3J(H,H) = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): $\delta=208.3$, 62.0, 42.8, 38.7, 36.3, 34.4, 32.8, 32.6, 31.4, 24.3, 24.1, 7.8 ppm; MS (EI): *m*/*z*: 225 $[M]^+$; HRMS-EI: *m*/*z*: calcd for $C_7H_9NO_3$: 225.13649 $[M]^+$; found: 225.13605; HPLC (Chiralpak AD-H, hexane/*i*PrOH 98:2, flow rate = 0.5 mL min^{-1}): t_R(minor) = 24.0, t_R(major) = 35.8 min.

(1*R*,6*S*,7*R*)-7-Nitro-7-mehthylbicyclo[4.1.0]heptan-2-one (4ab): The title compound was obtained according to the general procedure. White solid; yield: 54%; $[\alpha]_D^{20}=-40.1$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): $\delta=2.70$–2.80 (m, 2H), 2.37–2.44 (m, 1H), 2.22–2.31 (m, 1H), 2.11–2.02 (m, 1H), 1.85–1.93 (m, 2H), 1.78 (s, 3H), 1.59–1.65 ppm (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$, 25°C, TMS): $\delta=203.2$, 69.8, 39.0, 35.6, 23.6, 18.0, 12.8 ppm; MS (EI): *m*/*z*: 169 $[M]^+$; HRMS-EI: *m*/*z*: calcd for $C_8H_{11}NO_3$: 169.07389 $[M]^+$; found: 169.07336; HPLC (Chiralpak AD-H, hexane/*i*PrOH 98:2, flow rate = 0.5 mL min^{-1}): t_R(minor) = 43.9, t_R(major) = 46.6 min.

General procedure for the nitrocyclopropanation of bromonitromethane to aromatic (*E*)-α,β-unsaturated enones: CF_3COOH (20 mol%) was added to a stirred solution of catalyst (20 mol%) in $CHCl_3$ (0.5 mL), and the solution was stirred for 5 min at room temperature. After addition of enone (2 equiv), the mixture was stirred for 10 min. The bromonitromethane (1 equiv) was added, the tube was closed with a rubber stopper, and stirring was continued for the indicated time. Then, the crude reaction mixture was loaded onto a silica-gel column for purification (EtOAc/hexane 1:10) to afford the Michael adduct as a white solid. The resulting solid was dissolved in CH_2Cl_2 (0.15 M). *trans*-Dimethylpiperazine as a base was added, the tube was closed with a rubber stopper, and stirring was continued for 24 h. The crude reaction mixture was loaded onto a silica-gel column for purification (EtOAc/hexane 1:10) to afford the nitrocyclopropanation product.

General procedure for the one-pot nitrocyclopropanation of bromonitromethane to aromatic (*E*)-α,β-unsaturated enones: CF_3COOH (20 mol%) was added to a stirred solution of catalyst (20 mol%) in $CHCl_3$ (0.5 mL), and the solution was stirred for 5 min at room temperature. After addition of enone (2 equiv), the mixture was stirred for 10 min. The bromonitromethane (1 equiv) was added, the tube was closed with a rubber stopper, and stirring was continued for 72 h. Then, *trans*-dimethylpiperazine as a base was added and stirring was continued for 24 h. The crude reaction mixture was loaded onto a silica-gel column for purification (EtOAc/hexane 1:10) to afford the nitrocyclopropanation product.

1-(2-Nitro-3-phenylcyclopropyl)-1′-phenylmethanone (mixture of 9a and 10a): The title compound was obtained according to the general procedure. White solid; yield: 70%; $[\alpha]_D^{20}=-3.0$ ($c=0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9a** peaks reported: $\delta=$ 8.13 (d, ^3J(H,H) = 8.2 Hz, 2H), 7.69 (t, ^3J(H,H) = 7.7 Hz, 1H), 7.58 (t, ^3J(H,H) = 7.6 Hz, 2H), 7.36 (s, 5H), 5.10 (dd, ^3J(H,H) = 3.2, 8.8 Hz, 1H), 4.40 (dd, ^3J(H,H) = 3.2, 7.5 Hz, 1H), 3.50 ppm (t, ^3J(H,H) = 8.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9a** peaks reported: $\delta=193.6$, 136.1, 134.3, 134.0, 130.9, 128.8, 128.5, 128.4, 66.5, 36.2, 30.8 ppm; d.r.: **9a**/**10a** 94:6; MS (ESI): *m*/*z*: 268 $[M+H]^+$; HRMS-EI: *m*/*z*: calcd for $C_{16}H_{13}NO_3$: 267.08954 (parent ion not found); found:

235.11315 $[M-NO_2]^+$; the *ee* of major diastereomer **9a** was determined to be >99% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9a** minor) = 12.2, t_R(**9a** major) = 14.9 min.

1-(2-(4-Chlorophenyl)-3-nitrocyclopropyl)-1′-phenylmethanone (mixture of 9b and 10b): The title compound was obtained according to the general procedure. White solid; yield: 66%; $[\alpha]_D^{20} = -13.9$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9b** peaks reported: $\delta = 8.11$ (d, ^3J(H,H) = 8.1 Hz, 2H), 7.70 (t, ^3J(H,H) = 6.9 Hz, 1H), 7.58 (t, ^3J(H,H) = 7.7 Hz, 2H), 7.34 (d, ^3J(H,H) = 8.4 Hz, 2H), 7.29 (d, ^3J(H,H) = 8.6 Hz, 2H), 5.07 (dd, ^3J(H,H) = 3.0, 8.8 Hz, 1H), 4.35 (dd, ^3J(H,H) = 3.3, 7.6 Hz, 1H), 3.46 ppm (t, ^3J(H,H) = 8.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9b** peaks reported: δ = 193.3, 135.9, 134.6, 134.5, 130.2, 129.4, 129.2, 129.1, 128.5, 66.4, 35.3, 30.7 ppm; d.r.: **9b/10b** 95:5; MS (ESI): *m/z*: 302 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{16}H_{12}ClNO_3$: 301.05057 (parent ion not found); found: 255.05894 $[M-NO_2]^+$; the *ee* of major diastereomer **9a** was determined to be 98% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9b** minor) = 16.9, t_R(**9b** major) = 18.7 min.

1-(2-(3-Chlorophenyl)-3-nitrocyclopropyl)-1′-phenylmethanone (mixture of 9c and 9c): The title compound was obtained according to the general procedure. White solid; yield: 75%; $[\alpha]_D^{20} = -23.1$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **6c** peaks reported: $\delta = 8.11$ (d, ^3J(H,H) = 7.6 Hz, 2H), 7.70 (t, ^3J(H,H) = 7.3 Hz, 1H), 7.58 (t, ^3J(H,H) = 7.7 Hz, 2H), 7.34–7.22 (m, 4H), 5.05 (dd, ^3J(H,H) = 3.3, 8.8 Hz, 1H), 4.36 (dd, ^3J(H,H) = 3.3, 7.5 Hz, 1H), 3.47 ppm (t, ^3J(H,H) = 8.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9c** peaks reported: δ = 193.5, 136.1, 134.9, 134.8, 133.0, 130.3, 129.4, 129.3, 129.1, 128.7, 127.2, 66.5, 35.5, 30.8 ppm; d.r.: **9c/10c** 96: 4; MS (ESI): *m/z*: 302 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{16}H_{12}ClNO_3$: 301.05057 (parent ion not found); found: 255.05894 $[M-NO_2]^+$; the *ee* of major diastereomer **9c** was determined to be 99% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9c** minor) = 12.8, t_R(**9c** major) = 15.8 min.

1-(2-Nitro-3-*p*-tolylcyclopropyl)-1′-phenylmethanone (mixture of 9d and 10d): The title compound was obtained according to the general procedure. White solid; yield: 63%; $[\alpha]_D^{20} = -15.1$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9d** peaks reported: δ = 8.12 (d, ^3J(H,H) = 7.6 Hz, 2H), 7.68 (t, ^3J(H,H) = 7.4 Hz, 1H), 7.57 (t, ^3J(H,H) = 7.8 Hz, 2H), 7.24 (d, ^3J(H,H) = 8.0 Hz, 2H), 7.17 (d, ^3J(H,H) = 7.8 Hz, 2H), 5.08 (dd, ^3J(H,H) = 3.2, 8.7 Hz, 1H), 4.37 (dd, ^3J(H,H) = 3.2, 7.5 Hz, 1H), 3.46 ppm (t, ^3J(H,H) = 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9d** peaks reported: δ = 194.1, 138.6, 136.3, 134.5, 131.2, 129.7, 129.3, 128.8, 127.9, 66.9, 36.4, 31.0, 21.4 ppm; d.r.: **9d/10d** 90:10; MS (ESI): *m/z*: 282 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{17}H_{15}NO_3$: 281.10519 (parent ion not found); found: 235.11315 $[M-NO_2]^+$; the *ee* of major diastereomer **9d** was determined to be 99% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9d** minor) = 13.5, t_R(**9d** major) = 15.8 min.

1-(2-Nitro-3-(4-nitophenylcyclopropyl)-1′-phenylmethanone (mixture of 9e and 10e): The title compound was obtained according to the general procedure. White solid; yield: 73%; $[\alpha]_D^{20} = -5.0$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9e** peaks reported: $\delta = 8.11$ (d, ^3J(H,H) = 7.6 Hz, 2H), 7.70 (t, ^3J(H,H) = 7.3 Hz, 1H), 7.58 (t, ^3J(H,H) = 7.7 Hz, 2H), 7.34–7.22 (m, 4H), 5.05 (dd, ^3J(H,H) = 3.3, 8.8 Hz, 1H), 4.36 (dd, ^3J(H,H) = 3.3, 7.5 Hz, 1H), 3.47 ppm (t, ^3J(H,H) = 8.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9e** peaks reported: δ = 193.5, 136.1, 134.9, 134.8, 133.0, 130.3, 129.4, 129.3, 129.1, 128.7, 127.2, 66.5, 35.5, 30.8 ppm; d.r.: **9e/10e** 99:1; MS (ESI): *m/z*: 313 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{16}H_{12}N_2O_5$: 312.07462 (parent ion not found); found: 266.08126 $[M-NO_2]^+$; the *ee* of major diastereomer **9e** was determined to be 93% by chiral HPLC analysis (Chiralpak OD-H, hexanes/*i*PrOH 90:10, flow rate = 1 mL min^{-1}): t_R(**9e** minor) = 62.5, t_R(**9e** major) = 67.7 min.

1-(2-(Furan-3-yl)3-nitrocyclopropyl)-1′-phenylmethanone (mixture of 9f and 10f): The title compound was obtained according to the general procedure. White solid; yield: 60%; $[\alpha]_D^{20} = +28.3$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9f** peaks reported: $\delta = 8.06$ (d, ^3J(H,H) = 7.5 Hz, 2H), 7.67 (t, ^3J(H,H) = 7.4 Hz, 1H), 7.55 (t, ^3J(H,H) = 7.7 Hz, 2H), 7.51 (s, 1H), 7.40 (s, 1H), 6.42 (s, 1H), 5.01 (dd, ^3J(H,H) = 3.6, 8.6 Hz, 1H), 4.17 (dd, ^3J(H,H) = 3.6, 7.4 Hz, 1H), 3.19 ppm (t, ^3J(H,H) = 8.03 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9f** peaks reported: δ = 193.6, 143.7, 141.9, 136.1, 134.6, 129.3, 128.9, 116.2, 111.0, 66.4, 31.7, 28.1 ppm; d.r.: **9f/10f** 92:8; MS (ESI): *m/z*: 257 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{14}H_{11}NO_4$: 257.06881 (parent ion not found); found: 211.07582 $[M-NO_2]^+$; the *ee* of major diastereomer **9f** was determined to be 98% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9f** minor) = 17.9, t_R(**9f** major) = 20.4 min.

1-(2-Nitro-3-phenylcyclopropyl)-1′-(4-chlorophenyl)methanone (mixture of 9g and 10g): The title compound was obtained according to the general procedure. White solid; yield: 77%; $[\alpha]_D^{20} = +8.5$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9g** peaks reported: $\delta = 8.06$ (d, ^3J(H,H) = 8.3 Hz, 2H), 7.55 (d, ^3J(H,H) = 8.3 Hz, 2H), 7.40–7.30 (m, 5H), 5.08 (dd, ^3J(H,H) = 3.0, 8.7 Hz, 1H), 4.32 (dd, ^3J(H,H) = 3.1, 7.3 Hz, 1H), 3.49 ppm (t, ^3J(H,H) = 8.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9g** peaks reported: δ = 192.8, 141.2, 134.5, 130.8, 130.1, 129.9, 128.9, 128.8, 128.5, 66.8, 36.7, 30.9 ppm; d.r.: **9g/10g** 69:31; MS (ESI): *m/z*: 302 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{16}H_{12}ClNO_3$: 301.05057 (parent ion not found); found: 255.05894 $[M-NO_2]^+$; the *ee* of major diastereomer **9g** was determined to be 97% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9g** minor) = 15.9, t_R(**9g** major) = 24.7 min.

1-(2-Nitro-3-phenylcyclopropyl)-1′-(4-trifluoromethylphenyl)methanone (mixture of 9h and 10h): The title compound was obtained according to the general procedure. White solid; yield: 80%; $[\alpha]_D^{20} = +8.1$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9h** peaks reported: $\delta = 8.23$ (d, ^3J(H,H) = 8.1 Hz, 2H), 7.84 (d, ^3J(H,H) = 8.1 Hz, 2H), 7.36 (s, 3H), 7.25 (d, ^3J(H,H) = 7.0 Hz, 1H), 5.12 (dd, ^3J(H,H) = 3.3, 8.8 Hz, 1H), 4.38 (dd, ^3J(H,H) = 3.3, 7.5 Hz, 1H), 3.52 ppm (t, ^3J(H,H) = 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): major rotamer **9h** peaks reported: δ = 193.3, 138.8, 135.5, 130.7, 130.6, 129.1, 129.0, 128.9, 126.4 ppm; d.r.: **9h/10h** 60:40; MS (ESI): *m/z*: 336 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{17}H_{12}F_3NO_3$: 301.05057 (parent ion not found); found: 255.05894 $[M-NO_2]^+$; the *ee* of major diastereomer **6h** was determined to be >99% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95: 5, flow rate = 1 mL min^{-1}): t_R(**6d** minor) = 11.5, t_R(**6d** major) = 17.7 min.

1-(2-Nitro-3-phenylcyclopropyl)-1′-(4-methoxyphenyl)methanone (mixture of 9i and 10i): The title compound was obtained according to the general procedure. White solid; yield: 80%; $[\alpha]_D^{20} = +2.3$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9i** peaks reported: $\delta = 8.11$ (d, ^3J(H,H) = 8.8 Hz, 2H), 7.35 (s, 5H), 7.03 (d, ^3J(H,H) = 8.8 Hz, 2H), 5.07 (dd, ^3J(H,H) = 3.4, 8.8 Hz, 1H), 4.33 (dd, ^3J(H,H) = 3.4, 7.6 Hz, 1H), 3.92 (s, 3H), 3.48 ppm (t, ^3J(H,H) = 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9i** peaks reported: δ = 192.1, 164.7, 131.3, 132.0, 131.1, 129.3, 129.0, 128.7, 114.5, 66.6, 55.9, 36.3, 30.7 ppm; d.r.: **9i/10i** 95:5; MS (ESI): *m/z*: 298 $[M+H]^+$; HRMS-EI: *m/z*: calcd for $C_{17}H_{15}NO_4$: 297.10011 (parent ion not found); found: 251.10696 $[M-NO_2]^+$; the *ee* of major diastereomer **9i** was determined to be 98% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9i** minor) = 27.9, t_R(**9i** major) = 44.9 min.

1-(2-Nitro-3-phenylcyclopropyl)-1′-(4-chlorophenyl)methanone (mixture of 9j and 10j): The title compound was obtained according to the general procedure. White solid; yield: 76%; $[\alpha]_D^{20} = +1.4$ ($c = 0.5$ in CH_2Cl_2); ^{1}H NMR (400 MHz, $CDCl_3$, 25°C, TMS): major rotamer **9j** peaks reported: $\delta = 8.68$ (s, 1H), 8.12 (d, ^3J(H,H) = 8.6 Hz, 1H), 8.06 (d, ^3J(H,H) = 8.0 Hz, 1H), 7.99 (d, ^3J(H,H) = 8.7 Hz, 1H), 7.93 (d, ^3J(H,H) = 7.8 Hz, 1H), 7.65 (m, 2H), 7.39 (s, 5H), 5.15 (dd, ^3J(H,H) = 3.0, 8.8 Hz, 1H), 4.55 (dd, ^3J(H,H) = 3.1, 7.4 Hz, 1H), 3.57 ppm (t, ^3J(H,H) = 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): major rotamer **9j** peaks reported: 193.8, 136.3, 133.6, 132.7, 131.2, 131.0, 129.5, 129.3, 129.1, 128.9, 128.2, 127.5, 123.8, 66.9, 36.5, 31.1 ppm; d.r.: **9j/10j** 87:13; MS (ESI): *m/z*: 318

$[M+H]^+$; HRMS-EI: m/z: calcd for $C_{20}H_{15}NO_3$: 317.10519 (parent ion not found); found: 271.11280 $[M-NO_2]^+$; the *ee* of major diastereomer **9j** was determined to be 96% by chiral HPLC analysis (Chiralpak AD-H, hexanes/*i*PrOH 95:5, flow rate = 1 mL min^{-1}): t_R(**9j** minor) = 18.9, t_R(**9j** major) = 20.7 min.

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