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Organocatalytic Allylic Amination of Morita–Baylis–Hillman Carbonates

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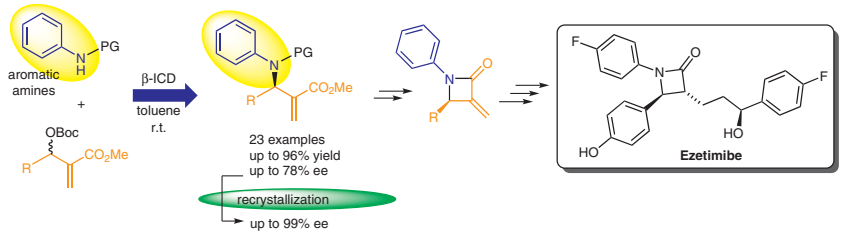
Dedicated to Prof. Bäckvall to his 70th anniversary.



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Abstract An organocatalytic asymmetric allylic amination of Morita–Baylis–Hillman carbonates with aromatic amines in the presence of β-isocupreidine is described. Chiral allylic amines were obtained in almost quantitative yields (90–96%) with moderate enantioselectivity. Recrystallization afforded products in good yields (45–73%) and high optical purity (82–99% ee). This method provides a facile and efficient route to obtain optically active β-lactams, including the building block of the cholesterol-lowering drug Ezetimibe.

Key words alkaloids, allylic amination, asymmetric synthesis, Ezetimibe, Morita–Baylis–Hillman carbonates, organocatalysis

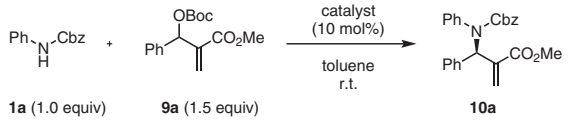
Optically active allylic amines have been recognized as valuable synthetic target molecules because of their wide-ranging occurrence in natural products and because of their remarkable biological properties.[1] Moreover, they can be utilized as building blocks for the synthesis of more complex molecules.[2] Therefore, a lot of attention has been paid to the development of asymmetric methodologies leading to the synthesis of such compounds. Among others, an asymmetric allylic amination (AAA) of Morita–Baylis–Hillman (MBH) adducts is a powerful approach that can be utilized for the synthesis of allylic amines.[3] In this area, not only transition-metal-catalyzed AAA methods have been developed, but also alternative organocatalytic approaches have become popular.[4] In the realm of transition-metal-catalyzed amination reactions of MBH adducts, catalytic systems based on Pd complexes have been successfully employed.[5] Furthermore, organocatalysis as an alternative methodology can also provide easy access to optically active allylic amines from MBH adducts. Over the last decade, chiral amine-catalyzed methods have played the most significant role in this area.[6] Recently, considerable progress has been made in allylic amination of MBH adducts using chiral phosphines.[7] To our knowledge, no attention has so far focused on enantioselective organocatalytic amination reactions of MBH adducts using primary aromatic amines, such as aniline derivatives, probably because of the challenging stereocontrol and reduced nucleophilicity. In this area, only a single allylation method using anilines based on Pd-catalyzed AAA has been disclosed to date.[5d–e] With the considerations noted above and given our interest in enantioselective allylic amination reactions,[6p] we wish to report the organocatalytic AAA of MBH carbonates with aniline derivatives and the subsequent application of this methodology to the synthesis of optically pure β-lactams.

Given that carbamates can act as suitable N-nucleophiles,[8] we started to test the reactivity of Cbz protected aniline **1a** towards conventional MBH carbonate **9a** in toluene at room temperature in the presence of β-isocupreidine (β-ICD). To our delight, we observed full conversion of **1a** after two days, and the corresponding product **10a** was isolated in almost quantitative yield (96%) with a moderate degree of enantioselectivity (52% *ee*, Table 1, entry 2).

Encouraged by this result, we focused on different catalytic systems to provide the target product **10a** with improved yield and enantiopurity. Performing the reaction in the presence of quinine as a catalyst led to unsatisfactory results (Table 1, entry 3). Other catalysts including bifunctional Takemoto catalyst as well as the phosphine(thio)urea catalysts developed previously in our group (see the Supporting Information) failed. Sterically demanding Sharpless bases were also tested in the model reaction between **1a** and **9a**; however, the reaction was significantly slowed down even when elevated temperature or an increased concentration was used (entries 4–7). The model reaction catalyzed with $(DNQD)_2AQN$ afforded allylic amine **10a** with lower yields (48–89%) with only a slightly higher degree of enantioselectivity (55–66% *ee*).

Therefore, we selected β-ICD as an appropriate catalyst for subsequent studies, which revealed low enantiocontrol dependence on catalyst loading and significant efficiency dependence on the ratio of **1a**/**9a**. The same level of enantioselectivity was observed when 5 mol% and 2 mol% of β-ICD was used. However, the yield of the product of allylic amination **10a** dropped to 90% and 58%, respectively. Additionally, the use of 1.5 equivalent of MBH-carbonate was required for full conversion of **1a**; the yield of **10a** did not exceed 60% when a lower excess (1.2 equiv) of **9a** was subjected to the reaction with **1a** (Table 1, entry 8). Next, we examined the role of the solvent on AAA between MBH carbonate **9a** with aniline **1a**.

Table 1 Screening of the Chiral Catalyst and Optimization Studies



1a (1.0 equiv) **9a** (1.5 equiv) **10a**

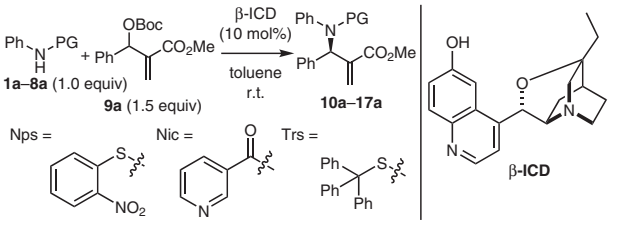
Entry	Catalyst	Solvent	Time [d]	Yield [%][a]	ee [%][b]
1	none	toluene	12	n.r.	n.d.
2	β-ICD	toluene	2	96	52
3	quinine	toluene	12	17	21
4	$(DHQD)_2PHAL$	toluene	10	53	10
5	$(DHQD)_2AQN$	toluene	10	63	66
6[c]	$(DHQD)_2AQN$	toluene	6	48	55
7[d]	$(DHQD)_2AQN$	toluene	7	89	57
8[e]	β-ICD	toluene	2	60	52
9	β-ICD	*p*-xylene	3	96	52
10	β-ICD	benzene	2	78	51
11	β-ICD	CH_2Cl_2	2	96	28
12	β-ICD	$CHCl_3$	2	88	34
13	β-ICD	Et_2O	2	96	49
14	β-ICD	THF	2	84	42
15	β-ICD	DMSO	12	trace	n.d.

[a] Isolated yield after column chromatography.
[b] Determined by HPLC analysis of the purified product **10a**.
[c] Performed at 40 °C.
[d] An increased concentration (0.5 M).
[e] The reaction with ratio **1a**/**9a** = 1:1.2.

According to our observations (Table 1), the reaction tolerates a wide range of nonpolar solvents, such as aromatic, chlorinated and ethereal solvents. Employing chlorinated solvents and ethers rendered product **10a** with slightly lowered yields and enantioselectivities (entries 11–14), whereas the use of polar aprotic DMSO provided only trace amounts of the corresponding product even after prolonged reaction time (entry 15). Based on the screening results (see the Supporting Information), toluene was chosen as the most suitable solvent; under these conditions, **10a** was obtained in excellent yield (96%) and with moderate enantioselectivity (52% *ee*) within two days (entry 2).

We then turned our attention to study the effect of N-protecting group in aniline derivatives **1a–7a** on the stereochemical outcome of the AAA. In comparison to Cbz derivative **1a**, the use of *N*-Boc aniline derivative **2a** in reaction with MBH carbonate **9a** provided allylic amine **11a** with higher enantioselectivity (58% *ee*) but in only 46% yield (Table 2, entry 2). The use of sterically less demanding carbamate **3a**, led to the formation of the corresponding allylic amine **12a** in good yield and with moderate enantioselectivity (entry 3). Employing nicotinyl (Nic) or tritylsulfenyl (Trs) group as protecting groups of aniline rendered only trace amounts of products **15a** and **16a**, respectively (entries 6 and 7). Interestingly, aniline with a 2-nitrophenylsulfenyl (Nps) group readily reacted with MBH carbonate **9a**, affording the desired product **14a** in almost quantitative yield (96%) with a good level of enantioselectivity (62% *ee*, entry 5). The use of Nps group as a readily introducible and removable N-protecting group is known from peptide and nucleoside chemistry.[9] Moreover, the Nps group was recently used as an activation group in organocatalyzed Friedel–Crafts and Pictet–Spengler reactions.[10] Apart from N-protected anilines, we tested free aniline **8a** in AAA with **9a**, but the desired allylic amine **17a** was obtained in reduced yield and selectivity (entry 8).

Table 2 Screening Results for the AAA of MBH Carbonate **9a** with N-Protected Anilines



Entry	PG	Time [d]	Product	Yield [%][a]	ee [%][b]
1	Cbz (**1a**)	2	**10a**	96	52
2	Boc (**2a**)	2	**11a**	46	58
3	Alloc (**3a**)	2	**12a**	76	50
4	Ts (**4a**)	2	**13a**	96	31
5	Nps (**5a**)	2	**14a**	96	62
6	Nic (**6a**)	7	**15a**	trace	n.d.
7	Trs (**7a**)	7	**16a**	trace	n.d.
8	H (**8a**)	2	**17a**	76	43

[a] Isolated yield after column chromatography.
[b] Determined by HPLC analysis of the purified products.

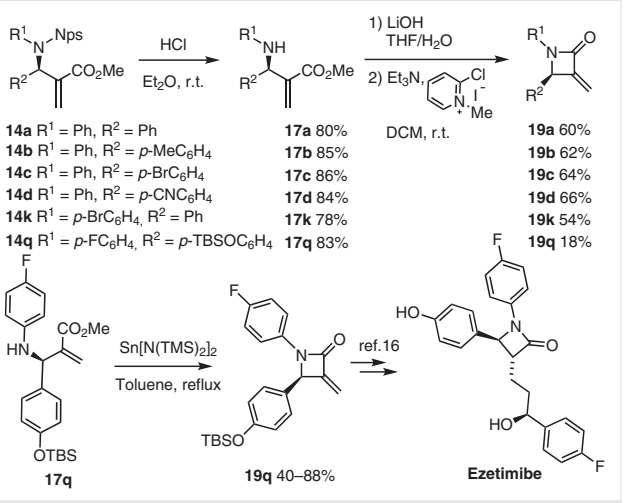
With the optimized conditions in hand, we started to explore the scope of the AAA between 2-nitrophenylsulfenyl anilines **5** and various MBH carbonates **9** (Table 3). The

corresponding allylic amines **14b–e**, which derive from MBH carbonates bearing both electron-withdrawing and electron-donating groups in the *para* position of the aromatic ring, were obtained in excellent yields (90–96%) with moderate enantioselectivity (61–78% *ee*, entries 2–5).

The effect of substitution in the *ortho*- and *meta*-position on the aromatic ring of MBH carbonates was also tested. Whereas product **14f**, bearing a bromine atom in the *ortho*-position, was obtained in excellent yield with significantly decreased enantioselectivity, allylic amine **14g** was prepared with reduced yield and with moderate enantioselectivity (63% *ee*). This behavior has already been addressed in other work focused on the substitution of MBH adducts.[6l,6p,7f,11]

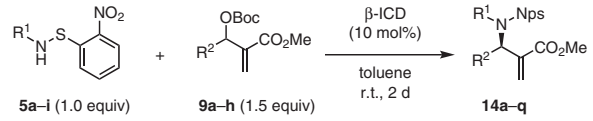
Next, AAA between **9a** and diverse anilines **5** afforded the corresponding allylic amines **14h–o** in excellent yields with significant differences in enantioselectivity. When aniline substituted in the *ortho*-position or aniline bearing an electron-donating group was used, the enantioselectivity of the reaction dropped (entries 12 and 14). Notably, the enantiomeric purity of products **14** could be readily increased by recrystallization from propan-2-ol, which makes this protocol of practical use. Selected results obtained after recrystallization are shown in Table 3; products **14a–d** were obtained in good yields (45–72%) with excellent enantiomeric excess (82–99% *ee*, entries 1–4).

Encouraged by these results, we proceeded with the synthesis of enantiomerically enriched β-lactams. First, selected allylic amines **14** were subjected to deprotection reaction by following the procedure of Zervas.[9b] To our delight, the treatment of **14** with HCl in diethyl ether led to the rapid formation of the corresponding β-aminoesters **17** in high yields (78–86%), with preserved optical purity and no effect on other functional groups present in the compounds (Scheme 1). Next, we focused on cyclization leading to α-alkylidene-β-lactams based on reported one-step protocols.[12] The use of strong bases, such as lithium diisopropylamide (LDA) or lithium hexamethyldisilazane (LiHMDS), as well as procedures using *t*BuOK or Bu_2SnO did not lead to the formation of β-lactams.[13] Therefore, we have turned our attention to cyclizations of β-amino acids using less sensitive non-metallic reagents. β-Amino acids **18** were prepared in almost quantitative yield from **17** with LiOH in THF–water mixture. Conventional peptide coupling reagents, such as *N*,*N*-dicyclohexylcarbodiimide (DCC) and (benzotriazol-1-yloxy)tris(dimethylamino)phosphonium hexafluorophosphate (BOP),[14] did not provide satisfactory results in β-lactamization of **18a** (see the Supporting Information). Gratifyingly, the cyclization reaction in the presence of Mukaiyama reagent proceeded smoothly.[15] Desired β-lactams **19a–q** were prepared from the corresponding β-aminoesters **17** by using the one-pot hydrolysis/lactamization procedure in good yields and without loss of enantiomeric purity (Scheme 1).



Scheme 1 Synthesis of enantiomerically enriched α-alkylidene-β-lactams

Table 3 Reaction Scope of AAA between Anilines **5** and MBH Carbonates **9**



Entry	R^1	R^2	Product	Yield [%][a]	ee [%][b]
1	Ph	Ph	**14a**	96 (72)[c]	62 (82)[c]
2	Ph	*p*-MeC_6H_4	**14b**	96 (45)[c]	61 (92)[c]
3	Ph	*p*-BrC_6H_4	**14c**	96 (60)[c]	78 (99)[c]
4	Ph	*p*-NCC_6H_4	**14d**	96 (63)[c]	78 (97)[c]
5	Ph	*p*-$NO_2C_6H_4$	**14e**	90	62[d]
6	Ph	*o*-BrC_6H_4	**14f**	96	30
7	Ph	*m*-BrC_6H_4	**14g**	60	63
8	p-$NO_2C_6H_4$	Ph	**14h**	96	52
9	*p*-$CO_2EtC_6H_4$	Ph	**14i**	96	52
10	3-pyridyl	Ph	**14j**	96	53
11	*p*-BrC_6H_4	Ph	**14k**	96	56[d]
12	*o*-BrC_6H_4	Ph	**14l**	96	16
13	*m*-BrC_6H_4	Ph	**14m**	96	52
14	*p*-$CH_3C_6H_4$	Ph	**14n**	96	32
15	*p*-FC_6H_4	Ph	**14o**	96	59
16	Ph	*p*-$TBSOC_6H_4$	**14p**	96	57
17	*p*-FC_6H_4	*p*-$TBSOC_6H_4$	**14q**	96	57[d]

[a] Isolated yield after column chromatography.
[b] Determined by HPLC analysis of the purified product **14**.
[c] Crystallization from *i*PrOH.
[d] The *ee* was unchanged after crystallization.

Unfortunately, the one-pot hydrolysis/lactamization protocol starting from an allylic amine **17q**, bearing a TBSO group, afforded β-lactam **19q** with low efficiency. Partial decomposition of **17q** during hydrolysis was observed. Thus, β-lactam **19q** was prepared from **17q** using $Sn[N(TMS)_2]_2$ reagent as reported by Roskamp.[16]

Enantiomerically enriched α-methylidene-β-lactams **19** reported herein are useful synthetic intermediates. For example, lactam **19q** could be easily transformed in four steps into Ezetimibe,[17] which is a strong cholesterol absorption inhibitor reducing LDL concentration (Scheme 1).[18]

To ascertain the absolute configuration of allylic amines **14** and the corresponding α-methylidene-β-lactams **19**, single-crystal X-ray diffraction analysis of compound **14c** was performed;[19] the crystals were obtained by crystallization from propan-2-ol. As shown in Figure 1, the stereogenic center (C4) appears to have (*R*)-absolute configuration and this observation is consistent with the generally accepted successive S_N2'/S_N2' mechanism for organocatalytic AAA using MBH carbonates.[6b]

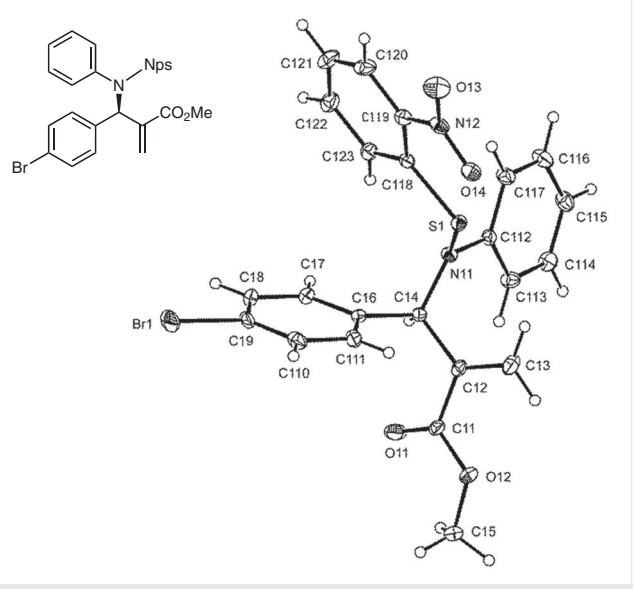


Figure 1 View of one of symmetrically independent molecule of **14c**, with displacement ellipsoids at 30% probability level.

In summary, we have developed the asymmetric allylic amination of Morita–Baylis–Hillman carbonates with 2-nitrophenylsulfenyl anilines catalyzed by β-ICD. The corresponding allylic amines were afforded in almost quantitative yields with a moderate degree of enantiomeric purity. Products with high optical purity (82–99% *ee*) and good yields (45–73%) can be easily obtained after recrystallization. Enantiomerically enriched amines can be used for the synthesis of valuable β-lactams by simple deprotection followed by one-pot saponification/lactamization reaction.

Chemicals and solvents were either purchased (puriss p.A.) from commercial suppliers or purified by using standard techniques. For thin-layer chromatography (TLC), silica gel or neutral alumina plates Merck 60 F254 were used, and compounds were visualized by irradiation with UV light and/or by treatment with a solution of phosphomolybdenic acid (25 g), $Ce(SO_4)_2{\cdot}H_2O$ (10 g), conc. H_2SO_4 (60 mL) and H_2O (940 mL) followed by heating or treatment with a solution of vanillin (15 g) in EtOH (250 mL) and conc. sulfuric acid (2.5 mL) followed by heating. Flash chromatography was performed by using silica gel Merck 60 (particle size 0.040–0.063 mm) or alumina (neutral, grade II-III).

^1H, ^{13}C, ^{19}F NMR spectra were measured with FT-NMR spectrometers Bruker AVANCE III 600 MHz or Varian UNITY INOVA 300. Chemical shifts are given in ppm relative to tetramethylsilane and coupling constants *J* are given in Hz. The spectra were recorded in $CDCl_3$ or DMSO-d_6 as solvent at 25 °C and served as internal standard (δ_{CDCl3} = 7.26 ppm, $\delta_{DMSO\text{-}d6}$ = 2.50 ppm) for ^1H NMR and (δ_{CDCl3} = 77.0 ppm, $\delta_{DMSO\text{-}d6}$ = 39.5 ppm) for ^{13}C NMR, trifluoroacetic acid was used as external standard for ^{19}F NMR. IR DRIFT spectra were recorded with a Nicolet AVATAR 370 FT-IR in cm^{-1}. Melting points were measured with a Büchi Melting Point B-545 apparatus. All melting points were measured in open glass capillary and values are uncorrected. Chiral HPLC was carried out with a LC20AD Shimadzu liquid chromatograph with a SPD-M20A diode array detector with columns Daicel Chiralpak® IA, IB, IC, AD or Daicel Chiralcel® OD-H. High-resolution mass spectroscopic data were obtained at the Laboratory of Mass Spectrometry, Faculty of Science, Department of Chemistry, Charles University.

N-Benzyloxycarbonylaniline (**1a**),[20], *N*-*tert*-butyloxycarbonylaniline (**2a**),[21] *N*-allyloxycarbonyl-aniline (**3a**),[22] *N*-tosylaniline (**4a**),[23] and *N*-phenyl nicotinamide (**6a**),[24] were prepared according to reported procedures.

Preparation of Protected Anilines 5; General Procedure GP1

By following a reported procedure,[25] in a round-bottom flask, 2-nitrophenylsulfenylchloride (190 mg, 1.0 mmol) was dissolved in anhydrous CH_2Cl_2 (2.5 mL) and a solution of the corresponding aniline derivative (3.0 mmol) in anhydrous CH_2Cl_2 (3.8 mL) was added under argon. After 2 h stirring at r.t., the precipitated hydrochloride was filtered over a plug of alumina, washed with CH_2Cl_2 (20 mL) and the solvent was evaporated under vacuum. The crude product was purified by flash column chromatography (FC) on silica gel to afford the desired product.

S-(2-Nitrophenyl)-*N*-phenylthiohydroxylamine (5a)

By following GP1, the reaction was carried out with aniline (279 mg, 3.0 mmol). FC (hexanes/EtOAc, 7:1) furnished **5a**.

Yield: 214 mg (87%); orange solid; mp 96 °C (EtOAc/hexane).

^1H NMR (600 MHz, $CDCl_3$): δ = 8.33 (dd, *J* = 8.3, 1.4 Hz, 1 H), 7.63 (dd, *J* = 8.2, 1.3 Hz, 1 H), 7.54 (ddd, *J* = 8.3, 7.1, 1.4 Hz, 1 H), 7.29 (ddd, *J* = 8.4, 7.1, 1.3 Hz, 1 H), 7.26–7.23 (m, 2 H), 6.99 (m, 2 H), 6.95–6.90 (m, 1 H), 5.16 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 145.3, 144.5, 143.01, 134.2, 129.5 (2C), 125.9, 125.3, 124.3, 121.0, 114.6 (2C).

IR (KBr): 3361, 3083, 1599, 1508, 1494, 1337, 1304, 1227, 902, 732 cm^{-1}.

HRMS (EI): *m*/*z* $[M]^+$ calcd for $C_{12}H_{10}N_2O_2S^+$: 246.0463; found: 246.0461.

***S*-(2-Nitrophenyl)-*N*-(4-nitrophenyl)thiohydroxylamine (5b)**

By following GP1, the reaction was carried out with *p*-nitroaniline (414 mg, 3.0 mmol). FC (hexanes/EtOAc, 3:1) furnished **5b**.

Yield: 102 mg (35%); yellow crystals; mp 152 °C (benzene).

^{1}H NMR (600 MHz, DMSO-d_6): δ = 9.13 (s, 1 H), 8.37 (d, *J* = 8.3 Hz, 1 H), 8.12 (d, *J* = 9.2 Hz, 2 H), 7.79–7.75 (m, 1 H), 7.49–7.44 (m, 1 H), 7.41 (d, *J* = 8.3 Hz, 1 H), 7.14 (d, *J* = 9.2 Hz, 2 H).

^{13}C NMR (151 MHz, DMSO-d_6): δ = 153.3, 142.7, 141.9, 140.0, 135.2, 126.3, 126.3, 125.9 (2C), 123.8, 114.3 (2C).

IR (KBr): 3366, 3309, 1589, 1509, 1449, 1293, 1251, 1186, 1111, 896 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{12}H_9N_3NaO_4S^+$: 314.0206; found: 314.0206.

Ethyl 4-(((2-Nitrophenyl)thio)amino)benzoate (5c)

By following GP1, the reaction was carried out with ethyl 4-aminobenzoate (496 mg, 3.0 mmol). FC (hexane/EtOAc, 7:1) furnished **5c**.

Yield: 255 mg (80%); yellow solid; mp 155 °C (EtOAc/hexanes).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.35 (dd, *J* = 8.3, 1.1 Hz, 1 H), 7.94 (d, *J* = 8.8 Hz, 2 H), 7.58–7.48 (m, 2 H), 7.32 (ddd, *J* = 8.3, 6.9, 1.5 Hz, 1 H), 7.01 (d, *J* = 8.8 Hz, 2 H), 5.46 (s, 1 H), 4.33 (q, *J* = 7.1 Hz, 2 H), 1.36 (t, *J* = 7.1 Hz, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.3, 149.6, 143.2, 143.1, 134.3, 131.5 (2C), 126.1, 125.6, 124.0, 123.2, 114.0 (2C), 60.6, 14.4.

IR (KBr): 3288, 2982, 1688, 1604, 1508, 1295, 1250, 1176, 905, 734 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{15}H_{14}N_2O_4S^+$: 318.0674; found: 318.0673.

***S*-(2-Nitrophenyl)-*N*-(pyridin-3-yl)thiohydroxylamine (5d)**

By following GP1, the reaction was carried out with pyridin-3-amine (282 mg, 3.0 mmol). FC (hexanes/EtOAc, 1:1) furnished **5d**.

Yield: 89 mg (36%); yellow solid; mp 170 °C (EtOAc/hexane).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.66 (s, 1 H), 8.33 (d, *J* = 8.0 Hz, 1 H), 8.14 (d, *J* = 4.3 Hz, 1 H), 7.59–7.56 (m, 2 H), 7.53–7.51 (m, 1 H), 7.34–7.29 (m, 2 H), 6.63 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 143.9, 143.1, 142.6, 138.6, 135.4, 134.5, 126.1, 125.8, 125.0, 123.9, 123.4.

IR (KBr): 3443, 3111, 2851, 1586, 1509, 1398, 1335, 1311, 1263, 1096, 902 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{11}H_9N_3O_2S^+$: 247.0415; found: 247.0417.

***N*-(4-Bromophenyl)-*S*-(2-nitrophenyl)thiohydroxylamine (5e)**

By following GP1, the reaction was carried out with 4-bromoaniline (516 mg, 3.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **5e**.

Yield: 176 mg (54%); yellow solid; mp 150 °C (toluene/hexane).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.34–8.31 (m, 1 H), 7.56–7.55 (m, 2 H), 7.34–7.29 (m, 3 H), 6.88–6.86 (m, 2 H), 5.21 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 144.6, 143.7, 143.0, 134.3, 132.3 (2C), 126.0, 125.5, 124.0, 116.3 (2C), 113.1.

IR (KBr): 3363, 3106, 1589, 1509, 1482, 1329, 1237, 1180, 997, 893 cm^{-1}.

HRMS (APCI): *m*/*z* [M + H]$^+$ calcd for $C_{12}H_{10}BrN_2O_2S^+$: 324.9641; found: 324.9642.

***N*-(2-Bromophenyl)-*S*-(2-nitrophenyl)thiohydroxylamine (5f)**

By following GP1, the reaction was carried out with 2-bromoaniline (516 mg, 3.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **5f**.

Yield: 169 mg (52%); yellow needles; mp 120 °C (EtOAc/hexane).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.34 (dd, *J* = 8.3, 1.4 Hz, 1 H), 7.59–7.55 (m, 1 H), 7.52–7.48 (m, 2 H), 7.33–7.29 (m, 1 H), 7.20–7.13 (m, 2 H), 6.81–6.77 (m, 1 H), 5.85 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 143.4, 143.0, 142.4, 134.4, 132.6, 128.8, 126.0, 125.5, 124.0, 121.8, 114.5, 111.0.

IR (KBr): 3366, 3097, 1586, 1503, 1332, 1308, 1284, 1174, 1042, 911 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{12}H_9BrN_2O_2S^+$: 323.9568; found: 323.9561.

***N*-(3-Bromophenyl)-*S*-(2-nitrophenyl)thiohydroxylamine (5g)**

By following GP1, the reaction was carried out with 3-bromoaniline (516 mg, 3.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **5g**.

Yield: 221 mg (52%); yellow powder; mp 132 °C (EtOAc/hexane).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.34–8.32 (m, 1 H), 7.60–7.55 (m, 2 H), 7.34–7.30 (m, 1 H), 7.15–7.02 (m, 3 H), 6.92–6.90 (m, 1 H), 5.24 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 146.9, 143.6, 142.9, 134.4, 130.8, 126.0, 125.6, 123.97, 123.96, 123.3, 117.4, 113.3.

IR (KBr): 3354, 3076, 1592, 1512, 1332, 1305, 1234, 1099, 1039, 988 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{12}H_9BrN_2O_2S^+$: 323.9568; found: 323.9559.

***S*-(2-Nitrophenyl)-*N*-(*p*-tolyl)thiohydroxylamine (5h)**

By following GP1, the reaction was carried out with *p*-toluidine (322 mg, 3.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **5h**.

Yield: 187 mg (72%); orange crystals; mp 122 °C (benzene).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.33 (d, *J* = 8.3 Hz, 1 H), 7.56–7.52 (m, 2 H), 7.29 (ddd, *J* = 8.3, 5.6, 2.8 Hz, 1 H), 7.15 (d, *J* = 7.3 Hz, 1 H), 7.12–7.06 (m, 2 H), 6.85 (td, *J* = 7.3, 1.5 Hz, 1 H), 5.10 (s, 1 H), 2.35 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 144.4, 143.2, 143.0, 134.2, 130.6, 127.5, 125.9, 125.2, 124.2, 123.4, 120.6, 112.8, 17.4.

IR (KBr): 3373, 3092, 1587, 1504, 1492, 1332, 1307, 1244, 901, 737 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{13}H_{12}N_2O_2S^+$: 260.0619; found: 260.0618.

***N*-(4-Fluorophenyl)-*S*-(2-nitrophenyl)thiohydroxylamine (5i)**

By following GP1, the reaction was carried out with 4-fluoroaniline (322 mg, 3.0 mmol). FC (hexanes/EtOAc, 7:1) furnished **5i**.

Yield: 103 mg (39%); yellow crystals; mp 136 °C (benzene).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.33 (d, *J* = 8.3 Hz, 1 H), 7.61 (m, 1 H), 7.56 (t, *J* = 8.1 Hz, 1 H), 7.30 (t, *J* = 7.6 Hz, 1 H), 6.98–6.88 (m, 4 H), 5.11 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 157.7 (d, *J* = 239.0 Hz, 1C), 144.2, 143.0, 141.4 (d, *J* = 1.5 Hz, 1C), 134.2, 126.0, 125.4, 124.1, 116.0 (d, *J* = 22.8 Hz, 2C), 115.6 (d, *J* = 7.7 Hz, 2C).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –123.60 to –123.67 (m, 1F).

IR (KBr): 3352, 3101, 1849, 1591, 1503, 1335, 1311, 1217, 815, 744 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{12}H_9FN_2O_2S^+$: 264.0369; found: 264.0372.

N-Phenyl-*S*-tritylthiohydroxylamine (7a)

Prepared by following a reported procedure,[26] to a stirred solution of triphenylmethanethiol (335 mg, 1.21 mmol) in anhydrous Et_2O (4 mL) and anhydrous toluene (1 mL), SO_2Cl_2 (0.20 mL, 2.48 mmol) was added dropwise at 0 °C under argon atmosphere. The solution was stirred for 1 h at 0 °C before being transferred to a separating funnel with toluene (5 mL) and washed with H_2O (3 × 5 mL), sat. $NaHCO_3$ (5 mL) and brine (5 mL). The organic phase was dried over $MgSO_4$ and the solvent was removed under vacuum. The crude solid (297 mg, 1.21 mmol) was dissolved at 0 °C in anhydrous CH_2Cl_2 (4 mL). This solution was added dropwise at 0 °C to a stirred solution of aniline (0.20 mL, 2.19 mmol) in CH_2Cl_2 (2.5 mL). The resulting solution was stirred for 15 min at 0 °C and then at r.t. for 1 h. The reaction mixture was filtered over a plug of silica gel, washed with CH_2Cl_2 and the solvent was evaporated. The crude product was subsequently subjected to FC (hexanes/toluene, 5:1). Recrystallization from hot MeOH yielded **7a**.

Yield: 135 mg (37%); white crystals; mp 148 °C (MeOH).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.38–7.21 (m, 15 H), 6.93–6.90 (m, 2 H), 6.58–6.55 (m, 1 H), 6.37–6.36 (m, 2 H), 5.01 (br s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 146.2, 145.4 (3C), 129.2 (6C), 128.2 (2C), 127.9 (6C), 126.8 (3C), 117.3, 116.1 (2C), 71.4.

IR (KBr): 3108, 2952, 1720, 1584, 1514, 1336, 1254, 1114, 1060, 736 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{25}H_{21}NS^+$: 367.1395; found: 367.1396.

Preparation of MBH Alcohols 9′; General Procedure GP2

By following a reported procedure,[27] to a stirred solution of arylaldehyde (2.0 mmol) in MeOH (48 mg, 1.5 mmol) was added methyl acrylate (258 mg, 3.0 mmol) and then 1,4-diaza-bicyclo[2.2.2]octane (DABCO) (112 mg, 1.0 mmol). The solution was stirred at r.t. for 48–120 h. After full conversion (TLC) the reaction mixture was evaporated under vacuum. The crude product was purified by flash column chromatography (FC) on silica gel to afford the desired product.

The following MBH alcohols were prepared by using GP2 and their spectral data correspond with published data: Methyl 2-(hydroxy(phenyl)methyl)acrylate (**9′a**),[28] methyl 2-(hydroxy(4-tolyl)methyl)acrylate (**9′b**),[28] methyl 2-((4-bromophenyl)(hydroxy)methyl)acrylate (**9′c**),[28] methyl 2-((4-cyanophenyl)(hydroxy)methyl)acrylate (**9′d**),[29] methyl 2-((2-bromophenyl)(hydroxy)methyl)acrylate (**9′f**),[28] methyl 2-((3-bromophenyl)(hydroxy)methyl)acrylate (**9′g**),[28] benzyl 2-(hydroxy(phenyl)methyl)acrylate (**9′i**),[29] and *tert*-butyl 2-(hydroxy(phenyl)methyl)acrylate (**9′j**).[29]

Methyl 2-(Hydroxy(4-nitrophenyl)methyl)acrylate (9′e)

By following GP2, the reaction was carried out with 4-nitrobenzaldehyde (302 mg, 2.0 mmol). FC (hexanes/EtOAc, 7:1) furnished **9′e**.

Yield: 152 mg (32%); yellow powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.20 (d, *J* = 8.8 Hz, 2 H), 7.57 (d, *J* = 8.8 Hz, 2 H), 6.40 (s, 1 H), 5.87 (s, 1 H), 5.63 (s, 1 H), 3.75 (s, 3 H), 3.28 (s, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.4, 148.5, 147.5, 140.9, 127.3 (3C overlapped), 123.6 (2C), 72.8, 52.2.

IR (KBr): 3511, 3106, 2959, 1698, 1518, 1349, 1196, 1146, 1044, 984 cm^{-1}.

HRMS (EI): *m*/*z* [M]$^+$ calcd for $C_{11}H_{11}NO_5^+$: 237.0637; found: 237.0638.

Methyl 2-((4-((*tert*-Butyldimethylsilyl)oxy)phenyl)(hydroxy)methyl)acrylate (9′h)

By following GP2, the reaction was carried out with 4-((*tert*-butyldimethylsilyl)oxy)benzaldehyde (473 mg, 2.0 mmol) and DABCO (224 mg, 2.0 mmol, 1 equiv) without MeOH. FC (hexanes/EtOAc, 10:1) furnished **9′h**.

Yield: 355 mg (55%); colorless oil.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.22 (d, *J* = 8.6 Hz, 2 H), 6.81 (d, *J* = 8.6 Hz, 2 H), 6.31 (s, 1 H), 5.81–5.78 (m, 1 H), 5.52 (d, *J* = 5.2 Hz, 1 H), 3.72 (s, 3 H), 2.86 (d, *J* = 5.2 Hz, 1 H), 0.97 (s, 9 H), 0.19 (s, 6 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.9, 155.3, 142.2, 133.9, 127.8 (2C), 125.8, 120.0 (2C), 72.9, 52.0, 25.7, 18.2 (3C), –4.4 (2C).

IR (KBr): 3482, 2950, 2857, 1718, 1610, 1509, 1437, 1254, 1147, 1036, 917 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{17}H_{26}NaO_4Si^+$: 345.1493; found: 345.1493.

Preparation of MBH Carbonates 9; General Procedure GP3

By following a reported procedure,[20] to a solution of MBH alcohol **9′** (1 mmol) in CH_2Cl_2 (1.7 mL) was added Boc_2O (240 mg, 1.1 mmol) and 4-dimethylaminopyridine (DMAP) (12 mg, 0.1 mmol). The reaction was stirred at r.t. and monitored by TLC analysis. After full conversion (ca. 3 h) the solvent was evaporated under vacuum. The crude product was purified by flash column chromatography (FC) on silica gel to afford the desired product.

The following MBH-alcohols were prepared by using GP3 and their spectral data correspond with published data: Methyl 2-(((*tert*-butoxycarbonyl)oxy)(phenyl)methyl)acrylate (**9a**), [30] methyl 2-((4-bromophenyl)((*tert*-butoxycarbonyl)oxy)methyl)acrylate (**9c**),[31] methyl 2-(((*tert*-butoxycarbonyl)oxy)(4-nitrophenyl)methyl)acrylate (**9e**),[30] methyl 2-((2-bromophenyl)((*tert*-butoxycarbonyl)oxy)methyl)acrylate (**9g**),[31] methyl 2-((3-bromophenyl)((*tert*-butoxycarbonyl)oxy)methyl)acrylate (**9g**),[30] and *tert*-butyl 2-(((*tert*-butoxycarbonyl)oxy)(phenyl)methyl)acrylate (**9j**).[30]

Methyl 2-(((*tert*-butoxycarbonyl)oxy)(*p*-tolyl)methyl)acrylate (9b)

By following GP3, the reaction was carried out with **9′b** (206 mg, 1.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **9b**.

Yield: 291 mg (95%); white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.29–7.27 (m, 2 H), 7.15–7.14 (m, 2 H), 6.45 (s, 1 H), 6.39 (m, 1 H), 5.91 (m, 1 H), 3.70 (s, 3 H), 2.33 (s, 3 H), 1.46 (s, 9 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 165.4, 152.4, 139.7, 138.2, 134.5, 129.1 (2C), 127.6 (2C), 125.6, 82.5, 75.7, 52.0, 27.8 (3C), 21.2.

IR (KBr): 2975, 2952, 1918, 1741, 1515, 1288, 1148, 1088, 974, 820 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{17}H_{22}NaO_5^+$: 329.1359; found: 329.1360.

Methyl 2-(((*tert*-butoxycarbonyl)oxy)(4-cyanophenyl)methyl)acrylate (9d)

By following GP3, the reaction was carried out with **9′d** (217 mg, 1.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **9b**.

Yield: 178 mg (56%); white semi-solid.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.64 (d, *J* = 8.2 Hz, 2 H), 7.52 (d, *J* = 8.2 Hz, 2 H), 6.47 (s, 1 H), 6.44 (m, 1 H), 5.99 (m, 1 H), 3.72 (s, 3 H), 1.46 (s, 9 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 165.0, 152.1, 143.0, 138.7, 132.3 (2C), 128.2 (2C), 126.7, 118.5, 112.3, 83.3, 74.8, 52.2, 27.7 (3C).

IR (KBr): 3004, 2983, 2229, 1748, 1368, 1248, 1159, 1093, 967, 896 cm^{-1}.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{17}H_{19}NNaO_5^+$: 340.1155; found: 340.1157.

Methyl 2-(((*tert*-Butoxycarbonyl)oxy)(4-((*tert*-butyldimethylsilyl)oxy)phenyl)methyl)acrylate (9h)

By following GP3, the reaction was carried out with **9'h** (322 mg, 1.0 mmol). FC (hexanes/EtOAc, 12:1) furnished **9h**.

Yield: 334 mg (79%); white wax.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.25–7.23 (m, 2 H), 6.80–6.77 (m, 2 H), 6.42 (s, 1 H), 6.38 (m, 1 H), 5.90 (m, 1 H), 3.70 (s, 3 H), 1.46 (s, 9 H), 0.97 (s, 9 H), 0.18 (s, 6 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 165.4, 155.8, 152.4, 139.8, 130.0, 129.1 (2C), 125.2, 119.9 (2C), 82.5, 75.6, 51.9, 27.8 (3C), 27.4, 25.6 (3C), –4.4 (2C).

IR (KBr): 2953, 2859, 1917, 1747, 1509, 1253, 1151, 1089, 976, 845 cm^{-1}.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{22}H_{34}O_6NaSi^+$: 445.2017; found: 445.2017.

Benzyl 2-(((*tert*-Butoxycarbonyl)oxy)(phenyl)methyl)acrylate (9i)

By following GP3, the reaction was carried out with **9'i** (268 mg, 1.0 mmol). FC (hexanes/EtOAc, 10:1) furnished **9i**.

Yield: 96 mg (26%); white powder.

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.38–7.37 (m, 2 H), 7.34–7.30 (m, 6 H), 7.24–7.23 (m, 2 H), 6.50 (s, 1 H), 6.46 (m, 1 H), 5.94 (m, 1 H), 5.17 (d, *J* = 12.5 Hz, 1 H), 5.11 (d, *J* = 12.5 Hz, 1 H), 1.45 (s, 9 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 164.7, 152.4, 139.5, 137.4, 135.5, 128.5 (2C), 128.4 (4C), 128.2, 128.1, 127.7 (2C), 126.2, 82.6, 75.9, 66.7, 27.7 (3C).

IR (KBr): 3034, 2980, 1744, 1497, 1277, 1253, 1156, 1085, 968, 882 cm^{-1}.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{22}H_{24}NaO_5^+$: 391.1516; found: 391.1516.

Catalytic Amination of MBH Carbonates; General Procedure GP4

To a stirred homogenous solution of β-ICD (3.1 mg, 0.01 mmol) and MBH carbonate **9** (0.15 mmol) in toluene (1 mL) was added appropriate N-protected aniline derivative **1**–**8** (0.10 mmol) at r.t. in one portion. After full conversion (TLC monitoring) the solvent was evaporated under vacuum. The crude product was purified by flash column chromatography (FC) on silica gel to afford the desired product.

Methyl (*R*)-2-((((Benzyloxy)carbonyl)(phenyl)amino)(phenyl)methyl)acrylate (10a)

By following GP4, the reaction was carried out with **9a** (28.8 mg, 0.15 mmol) and **1a** (22.7 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **10a**.

Yield: 38.5 mg (96%); white foam; 52% *ee* (IC, heptane/*i*-PrOH, 90:10; t_R = 16.3 (minor), 21.4 (major) min); $[\alpha]_D$ = +8.9° (*c* 0.96; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.29–7.15 (m, 13 H), 7.09–7.07 (m, 2 H), 6.37 (m, 1 H), 6.26 (s, 1 H), 5.56 (dd, *J* = 1.7, 0.6 Hz, 1 H), 5.12 (m, 2 H), 3.67 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.6, 155.3, 140.8, 140.0, 138.0, 136.6, 128.8 (2C), 128.7 (2C), 128.4 (2C), 128.3 (5C), 128.2, 127.7, 127.5, 127.5, 127.0, 67.2, 64.1, 52.0.

IR (KBr): 3087, 2950, 2848, 1724, 1601, 1491, 1317, 1296, 1195, 917 cm^{-1}.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{25}H_{23}O_4NNa^+$: 424.1519; found: 424.1519.

Methyl (*R*)-2,2-(((*tert*-Butoxycarbonyl)(phenyl)amino)(phenyl)methyl)acrylate (11a)

By following GP4, the reaction was carried out with **9a** (28.8 mg, 0.15 mmol) and **2a** (19.3 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **11a**.

Yield: 16.9 mg (46%); colorless foam; 58% *ee* (IC, heptane/*i*-PrOH, 95:5; t_R = 10.0 (minor), 13.2 (major) min); $[\alpha]_D$ = –38.9° (*c* 0.36; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.29–7.19 (m, 7 H), 7.14–7.11 (m, 1 H), 7.09–7.07 (m, 2 H), 6.37 (dd, *J* = 1.4, 0.9 Hz, 1 H), 6.17 (m, 1 H), 5.57 (dd, *J* = 1.8, 0.8 Hz, 1 H), 3.70 (s, 3 H), 1.34 (s, 9 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.8, 154.7, 141.6, 140.7, 138.7, 128.7 (2C), 128.6 (2C), 128.3 (2C), 128.2 (2C), 127.4, 127.3, 126.4, 80.7, 64.0, 52.0, 28.1 (3C).

IR (KBr): 3058, 2950, 1718, 1637, 1589, 1494, 1329, 1296, 1189, 925 cm^{-1}.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{22}H_{25}O_4NNa^+$: 390.1677; found: 390.1676.

Methyl (*R*)-2-(((Allyloxycarbonyl)(phenyl)amino)(phenyl)methyl)acrylate (12a)

By following GP4, the reaction was carried out with **9a** (28.8 mg, 0.15 mmol) and **3a** (17.7 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **12a**.

Yield: 26.7 mg (76%); colorless foam; 50% *ee* (IC, heptane/*i*-PrOH, 90:10; t_R = 14.6 (minor), 21.2 (major) min); $[\alpha]_D$ = +4.2° (*c* 1.08; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.28–7.15 (m, 8 H), 7.09–7.07 (m, 2 H), 6.40 (m, 1 H), 6.26 (s, 1 H), 5.83–5.77 (m, 1 H), 5.61 (d, *J* = 1.2 Hz, 1 H), 5.13–5.07 (m, 2 H), 4.56 (dt, *J* = 5.2, 1.5 Hz, 2 H), 3.70 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.7, 155.2, 140.7, 140.0, 138.0, 132.6, 128.8 (2C), 128.7 (2C), 128.4 (2C), 128.2 (2C), 128.1, 127.5, 127.0, 116.9, 66.1, 64.1, 52.0.

IR (KBr): 3087, 2950, 2848, 1724, 1595, 1497, 1317, 1299, 1195, 937 cm^{-1}.

HRMS (EI): *m*/*z* $[M]^+$ calcd for $C_{21}H_{21}O_4N^+$: 351.1471; found: 351.1470.

Methyl (*R*)-2-(((4-Methyl-*N*-phenylphenyl)sulfonamido)(phenyl)methyl)acrylate (13a)

By following GP4, the reaction was carried out with **9a** (28.8 mg, 0.15 mmol) and **4a** (24.7 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **13a**.

Yield: 40.4 mg (96%); colorless foam; 31% *ee* (AD, heptane/*i*-PrOH, 90:10; t_R = 18.1 (minor), 22.1 (major) min); $[\alpha]_D$ = –10.4° (*c* 0.97; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.50–7.48 (m, 2 H), 7.21–7.07 (m, 10 H), 6.83–6.81 (m, 2 H), 6.51 (m, 1 H), 6.42 (s, 1 H), 6.09–6.08 (m, 1 H), 3.61 (s, 3 H), 2.41 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.3, 143.2, 140.0, 137.7, 137.3, 137.2, 132.3 (2C), 129.3 (2C), 129.1 (2C), 128.7, 128.4 (2C), 128.1 (3C), 127.8 (3C), 65.1, 51.9, 21.5.

IR (KBr): 2953, 1730, 1595, 1491, 1449, 1302, 1272, 1186, 1141, 982 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{24}H_{23}O_4NNaS^+$: 444.1240; found: 444.1240.

Methyl (*R*)-2-((((2-Nitrophenyl)thio)(phenyl)amino)(phenyl)methyl)acrylate (14a)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **14a**.

Yield: 40.3 mg (96%); yellow crystalline solid; 62% *ee* (IC, heptane/*i*-PrOH, 95:5; t_R = 7.4 (minor), 8.3 (major) min); $[\alpha]_D$ = +28.3° (*c* 0.53; $CHCl_3$); after crystallization from hot *i*PrOH: yield: 72%; 82% *ee*; $[\alpha]_D$ = +51.5° (*c* 0.99; $CHCl_3$); mp 114 °C.

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:0.8) = 8.29 (d, *J* = 8.2 Hz, 1 H), 8.01 (d, *J* = 8.2 Hz, 1 H), 7.48–7.47 (m, 2 H), 7.37–7.36 (m, 2 H), 7.30–7.25 (m, 10 H), 7.20–7.18 (m, 6 H), 7.11–7.08 (m, 1 H), 6.98–6.96 (m, 5 H), 6.69 (s, 1 H), 6.52 (s, 1 H), 6.37 (s, 1 H), 6.30 (s, 1 H), 5.88 (s, 1 H), 5.53 (s, 1 H), 3.68 (s, 3 H), 3.54 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:0.8) = 167.2, 166.5, 148.7, 148.5, 144.2, 143.0, 142.7, 142.6, 139.5, 138.6, 137.5, 135.5, 134.1, 133.5, 133.0, 130.9 (2C), 129.3 (2C), 129.2 (2C), 128.8 (2C), 128.1 (2C), 127.5 (2C), 127.3 (2C), 126.1, 126.1, 125.9, 125.8, 125.3, 125.1, 125.0, 121.1, 121.0, 117.0 (2C), 116.1 (2C), 66.2, 63.9, 52.11, 52.05.

IR (KBr): 3060, 2953, 2851, 1715, 1589, 1512, 1341, 1236, 1144, 917 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{20}O_4N_2NaS^+$: 443.1036; found: 443.1036.

Methyl (*R*)-2-((((2-Nitrophenyl)thio)(phenyl)amino)(*p*-tolyl)methyl)acrylate (14b)

By following GP4, the reaction was carried out with **9b** (45.9 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **14b**.

Yield: 41.7 mg (96%); yellow crystalline solid; 61% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 10.5 (major), 12.5 (minor) min); $[\alpha]_D$ = +42.8° (*c* 0.35; $CHCl_3$); after crystallization from hot *i*PrOH, yield: 45%; 92% *ee*; $[\alpha]_D$ = +47.4° (*c* 1.08; $CHCl_3$); mp 152 °C.

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.8:1) = 8.29 (d, *J* = 8.2 Hz, 1 H), 8.01 (d, *J* = 8.2 Hz, 1 H), 7.50–7.46 (m, 2 H), 7.29–7.25 (m, 6 H), 7.20–7.09 (m, 15 H), 6.96 (t, *J* = 7.2 Hz, 1 H), 6.91–6.90 (m, 1 H), 6.77 (s, 1 H), 6.75 (s, 1 H), 6.65 (s, 1 H), 6.49 (s, 1 H), 6.36 (s, 1 H), 3.68 (s, 3 H), 3.53 (s, 3 H), 2.34 (s, 3 H), 2.10 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.8:1) = 167.3, 166.6, 148.7, 148.5, 144.3, 143.2, 142.7 (2C overlapped), 139.6, 137.9, 137.7, 137.1, 135.5, 133.9, 133.5, 132.9, 132.5, 130.7 (2C), 129.4 (2C), 129.3 (2C), 129.2 (2C), 128.0 (2C), 127.4 (2C), 126.3, 126.0, 125.8, 125.6, 125.2, 125.0, 124.8, 121.0, 120.8, 117.0 (2C), 116.0 (2C), 65.9, 63.7, 52.1, 52.0, 21.0, 20.9.

IR (KBr): 3026, 2946, 2851, 1713, 1591, 1511, 1339, 1240, 1145, 736 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{24}H_{22}N_2NaO_4S^+$: 457.1193; found: 457.1194.

Methyl (*R*)-2-((4-Bromophenyl)(((2-nitrophenyl)thio)(phenyl)amino)methyl)acrylate (14c)

By following GP4, the reaction was carried out with **9c** (55.7 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14c**.

Yield: 47.9 mg (96%); yellow crystalline solid; 78% *ee* (IC, heptane/*i*-PrOH, 98:2; t_R = 9.0 (major), 11.6 (minor) min); $[\alpha]_D$ = +23.9° (*c* 0.59; $CHCl_3$); after crystallization from hot *i*PrOH, yield: 60%; 99% *ee*; $[\alpha]_D$ = +52.7° (*c* 0.46; $CHCl_3$); mp 161 °C.

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.8:1) = 8.29 (d, *J* = 8.1 Hz, 1 H), 8.08 (d, *J* = 8.1 Hz, 1 H), 7.49–7.46 (m, 4 H), 7.32–7.10 (m, 18 H), 6.98 (t, *J* = 7.2 Hz, 1 H), 6.93 (t, *J* = 6.7 Hz, 1 H), 6.63 (s, 1 H), 6.53 (s, 1 H), 6.37 (s, 1 H), 6.25 (s, 1 H), 5.88 (s, 1 H), 5.54 (s, 1 H), 3.69 (s, 3 H), 3.54 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.8:1) = 167.0, 166.3, 148.4, 148.2, 143.8, 142.7, 142.6, 139.1, 137.8, 137.1, 134.8, 134.1, 133.5, 133.1, 132.3 (2C), 131.9 (2C), 130.5 (2C), 129.4 (2C), 129.29 (2C), 129.25 (2C), 126.4, 125.9 (2C), 125.8, 125.4 (2C), 125.3, 125.2, 122.4, 121.4, 121.3, 121.2, 116.9 (2C), 116.0 (2C), 65.6, 63.5, 52.2, 52.1.

IR (KBr): 2947, 2848, 1718, 1592, 1437, 1335, 1239, 1141, 1072, 854 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}O_4N_2BrNaS^+$: 521.0141; found: 521.0142.

Methyl (*R*)-2-((4-Cyanophenyl)(((2-nitrophenyl)thio)(phenyl)amino)methyl)acrylate (14d)

By following GP4, the reaction was carried out with **9d** (47.6 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **14d**.

Yield: 42.7 mg (96%); amber crystalline solid; 78% *ee* (IC, heptane/*i*-PrOH, 80:20; t_R = 14.9 (major), 20.9 (minor) min); $[\alpha]_D$ = +25.0° (*c* 0.78; $CHCl_3$); after crystallization from hot *i*PrOH, yield: 63%; 98% *ee*; $[\alpha]_D$ = +43.9° (*c* 0.49; $CHCl_3$); mp 176 °C.

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.9:1) = 8.29 (d, *J* = 7.9 Hz, 1 H), 8.07 (d, *J* = 7.9 Hz, 1 H), 7.67–7.66 (m, 2 H), 7.52–7.38 (m, 6 H), 7.35–7.27 (m, 5 H), 7.24–7.15 (m, 9 H), 7.01–6.99 (m, 1 H), 6.96–6.94 (m, 1 H), 6.73 (s, 1 H), 6.61 (s, 1 H), 6.39 (s, 1 H), 6.33 (s, 1 H), 5.95 (s, 1 H), 5.49 (s, 1 H), 3.69 (s, 3 H), 3.56 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.9:1) = 166.8, 166.1, 148.2, 148.0, 144.4, 143.3, 142.8, 142.6, 142.1, 141.0, 138.7, 136.3, 134.3, 133.6, 133.2, 132.6 (2C), 131.3 (2C), 131.1 (2C), 129.5 (3C), 128.4 (2C), 127.3, 125.9, 125.8, 125.7 (2C), 125.6 (2C), 125.4, 121.6, 121.5, 118.4, 118.2, 116.8 (2C), 116.0 (2C), 111.9, 111.6, 65.8, 63.8, 52.3.

IR (KBr): 3070, 2952, 2852, 1715, 1591, 1511, 1339, 1237, 1146, 1058 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{24}H_{19}N_3NaO_4S^+$: 468.0989; found: 468.0989.

Methyl (*R*)-2-((4-Nitrophenyl)(((2-nitrophenyl)thio)(phenyl)amino)methyl)acrylate (14e)

By following GP4, the reaction was carried out with **9e** (50.6 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 5:1) furnished **14e**.

Yield: 41.9 mg (90%); yellow-green foam; 62% *ee* (IC, heptane/*i*-PrOH, 80:20; t_R = 12.9 (major), 16.7 (minor) min); $[\alpha]_D$ = +12.9° (*c* 0.52; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 8.30 (d, *J* = 7.7 Hz, 1 H), 8.23 (d, *J* = 7.4 Hz, 2 H), 8.04 (d, *J* = 8.7 Hz, 1 H), 7.86 (d, *J* = 7.9 Hz, 2 H), 7.50–7.45 (m, 6 H), 7.35–7.27 (m, 5 H), 7.24–7.12 (m, 7 H), 7.02–6.99 (m, 1 H), 6.96–6.94 (m, 1 H), 6.77 (s, 1 H), 6.63 (s, 1 H), 6.41 (s, 1 H), 6.39 (s, 1 H), 5.97 (s, 1 H), 5.51 (s, 1 H), 3.69 (s, 3 H), 3.57 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 166.8, 166.0, 148.1, 147.9, 147.4, 146.6, 143.3, 143.0, 142.8, 142.6, 142.0, 138.7, 136.3, 134.4, 133.6, 133.3, 131.5 (2C), 129.5 (4C), 128.5 (2C), 127.5, 125.9, 125.77, 125.76, 125.7, 125.6, 125.5, 125.4, 124.0 (2C), 122.5 (2C), 121.7, 121.6, 116.9 (2C), 116.0 (2C), 65.4, 63.7, 52.32 (2C overlapped).

IR (KBr): 3069, 2952, 2853, 1716, 1592, 1518, 1344, 1235, 1147, 857 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}N_3NaO_6S^+$: 488.0887; found: 488.0886.

Methyl (*R*)-2-((2-Bromophenyl)(((2-nitrophenyl)thio)(phenyl)amino)methyl)acrylate (14f)

By following GP4, the reaction was carried out with **9f** (55.7 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14f**.

Yield: 47.9 mg (96%); yellowish oil; 30% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 11.6 (minor), 13.9 (major) min); $[\alpha]_D$ = +22.3° (c 0.47; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.6:1) = 8.30 (d, *J* = 7.9 Hz, 1 H), 7.99 (dd, *J* = 8.3, 1.4 Hz, 1 H), 7.62 (d, *J* = 7.9 Hz, 1 H), 7.54–7.48 (m, 4 H), 7.41–7.39 (m, 1 H), 7.37–7.28 (m, 6 H), 7.25–7.17 (m, 5 H), 7.11–7.08 (m, 3 H), 7.00–6.95 (m, 2 H), 6.90 (t, *J* = 7.3 Hz, 1 H), 6.82–6.79 (m, 3 H), 6.58 (d, *J* = 1.6 Hz, 1 H), 6.36 (s, 1 H), 5.90 (d, *J* = 1.9 Hz, 1 H), 5.40 (s, 1 H), 3.66 (s, 3 H), 3.51 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.6:1) = 166.4, 166.3, 148.6, 147.9, 143.8, 142.7, 142.5, 142.4, 138.3, 137.4, 137.2, 135.7, 133.7, 133.62, 133.60, 133.1, 132.3, 132.0, 129.5, 129.4 (2C), 129.28, 129.26 (2C), 128.4, 127.9, 126.9, 126.5, 126.33, 126.28, 126.2, 125.8, 125.4, 125.2, 124.9, 123.4, 121.2, 121.1, 116.8 (2C), 115.8 (2C), 64.6, 64.4, 52.2, 52.0.

IR (KBr): 3091, 2950, 2842, 1709, 1592, 1511, 1339, 1235, 1150, 757 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}O_4N_2BrNaS^+$: 521.0141; found: 521.0142.

Methyl (*R*)-2-((3-Bromophenyl)(((2-nitrophenyl)thio)(phenyl)amino)methyl)acrylate (14g)

By following GP4, the reaction was carried out with **9g** (55.7 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14g**.

Yield: 29.9 mg (60%); yellow foam; 63% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 10.9 (major), 12.4 (minor) min); $[\alpha]_D$ = +76.8° (*c* 0.63; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.7:1) = 8.29 (d, *J* = 8.1 Hz, 1 H), 8.04 (d, *J* = 8.1 Hz, 1 H), 7.50–7.38 (m, 6 H), 7.33–7.28 (m, 4 H), 7.24–7.14 (m, 10 H), 7.08 (d, *J* = 8.3 Hz, 1 H), 6.98 (t, *J* = 7.2 Hz, 1 H), 6.93 (t, *J* = 6.7 Hz, 1 H), 6.86 (t, *J* = 7.8 Hz, 1 H), 6.66 (s, 1 H), 6.57 (s, 1 H), 6.39 (s, 1 H), 6.25 (s, 1 H), 5.90 (s, 1 H), 5.56 (s, 1 H), 3.71 (s, 3 H), 3.55 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.7:1) = 167.0, 166.2, 148.33, 148.28, 143.8, 142.7, 142.6, 142.4, 141.3, 139.0, 137.8, 136.6, 134.4, 134.0, 133.5, 133.0, 131.0, 130.7, 130.6, 130.3, 129.4 (2C), 129.3 (2C), 129.0, 128.7, 126.7, 126.0, 125.93, 125.90, 125.8, 125.5, 125.4, 125.0, 122.9, 121.3, 121.3, 121.2, 116.9 (2C), 115.9 (2C), 65.6, 63.4, 52.2, 52.1.

IR (KBr): 3061, 2951, 2852, 1717, 1592, 1512, 1338, 1238, 1145, 735 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}O_4N_2BrNaS^+$: 521.0141; found: 521.0141.

Methyl (*R*)-2-(((4-Nitrophenyl)((2-nitrophenyl)thio)amino)(phenyl)methyl)acrylate (14h)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5b** (29.1 mg, 0.10 mmol). FC (hexanes/EtOAc, 5:1) furnished **14h**.

Yield: 44.6 mg (96%); yellow-green foam; 52% *ee* (IA, heptane/*i*-PrOH, 80:20; t_R = 8.5 (minor), 16.5 (major) min); $[\alpha]_D$ = –5.7° (*c* 0.44; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 8.36–8.33 (m, 1 H), 8.20–8.17 (m, 2 H), 8.12–8.09 (m, 2 H), 8.07–8.04 (m, 1 H), 7.55–7.51 (m, 1 H), 7.42–7.12 (m, 16 H), 7.04–6.98 (m, 3 H), 6.77 (m, 1 H), 6.56 (m, 1 H), 6.45 (m, 1 H), 6.37 (m, 1 H), 5.83 (m, 1 H), 5.59 (m, 1 H), 3.72 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 167.0, 166.1, 154.3, 154.0, 142.8, 142.70, 141.41, 141.39, 141.37, 140.5, 138.7, 137.2, 136.9, 135.1, 134.2, 133.9, 133.4, 130.9 (2C), 129.1 (2C), 128.7, 128.0, 127.5 (2C), 127.2 (2C), 126.1, 126.0, 125.9, 125.8, 125.6 (2C), 125.50 (2C), 125.48 (2C), 125.3, 116.3 (2C), 115.7 (2C), 66.7, 64.1, 52.4, 52.2.

IR (KBr): 3075, 2952, 2842, 1720, 1584, 1514, 1336, 1254, 1114, 1060 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}N_3NaO_6S^+$: 488.0887; found: 488.0887.

Ethyl (*R*)-2–4-((2-(Methoxycarbonyl)-1-phenylallyl)((2-nitrophenyl)thio)amino)benzoate (14i)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5c** (31.8 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **14h**.

Yield: 47.2 mg (96%); yellow-green foam; 52% *ee* (IA, heptane/*i*-PrOH, 80:20; t_R = 7.9 (minor), 10.6 (major) min); $[\alpha]_D$ = +26.9° (*c* 0.97; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.9:1) = 8.31 (d, *J* = 8.2 Hz, 1 H), 8.01 (d, *J* = 8.2 Hz, 1 H), 7.97 (d, *J* = 9.0 Hz, 2 H), 7.89 (d, *J* = 9.0 Hz, 2 H), 7.48 (t, *J* = 7.6 Hz, 1 H), 7.38–7.35 (m, 3 H), 7.32–7.28 (m, 3 H), 7.25–7.17 (m, 9 H), 7.13 (t, *J* = 7.6 Hz, 1 H), 6.99–6.95 (m, 3 H), 6.74 (s, 1 H), 6.52 (s, 1 H), 6.40 (s, 1 H), 6.35 (s, 1 H), 5.82 (s, 1 H), 5.54 (s, 1 H), 4.37–4.28 (m, 4 H), 3.69 (s, 3 H), 3.51 (s, 3 H), 1.36 (t, *J* = 7.1 Hz, 3 H), 1.33 (t, *J* = 7.1 Hz, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.9:1) = 167.0, 166.3, 166.2 (2C overlapped), 152.5, 152.3, 142.8, 142.69, 142.65, 141.7, 139.1, 137.9, 137.2, 134.8, 134.6, 133.7, 133.1, 131.2 (2C), 131.1 (2C), 130.9 (2C), 128.9 (2C), 128.4, 127.7, 127.4 (2C), 127.3 (2C), 125.92, 125.88 (2C overlapped), 125.8, 125.6, 125.4, 125.1, 123.0, 116.1 (2C), 115.4 (2C), 66.4, 63.9, 60.6, 60.5, 52.2, 52.1, 14.4, 14.3.

IR (KBr): 3061, 2986, 2848, 1712, 1601, 1506, 1337, 1281, 1245, 1182, 1108 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{26}H_{24}N_2NaO_6S^+$: 515.1247; found: 515.1249.

Methyl (*R*)-2-((((2-Nitrophenyl)thio)(pyridin-3-yl)amino)(phenyl)methyl)acrylate (14j)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5d** (24.7 mg, 0.10 mmol). FC (hexanes/EtOAc, 5:1) furnished **14j**.

Yield: 40.4 mg (96%); yellow foam; 53% *ee* (IA, heptane/*i*-PrOH, 70:30; t_R = 10.6 (minor), 21.3 (major) min); $[\alpha]_D$ = +11.3° (*c* 0.62; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.9:1) = 8.53 (s, 1 H), 8.52 (s, 1 H), 8.31 (d, *J* = 8.0 Hz, 1 H), 8.23 (d, *J* = 3.9 Hz, 1 H), 8.17 (d, *J* = 3.9 Hz, 1 H), 8.04 (d, *J* = 8.0 Hz, 1 H), 7.52–7.49 (m, 3 H), 7.41–7.13 (m, 16 H), 7.00 (m, 3 H), 6.64 (s, 1 H), 6.54 (s, 1 H), 6.42 (s, 1 H), 6.28 (s, 1 H), 5.84 (s, 1 H), 5.55 (s, 1 H), 3.68 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.9:1) = 167.0, 166.1, 145.2, 144.8, 142.8, 142.6, 142.5, 141.64, 141.59, 141.4, 138.8, 138.3, 137.7, 137.5, 137.0, 134.7, 133.8, 133.3, 130.8 (2C), 129.0 (2C), 128.50, 127.90, 127.47 (2C), 127.31 (2C), 126.06 (2C), 125.79, 125.54, 125.47 (2C), 125.30, 124.47, 123.76 (2C), 123.55, 66.20, 63.89, 52.24, 52.16.

IR (KBr): 3061, 2951, 2851, 1716, 1567, 1511, 1338, 1254, 1146, 1059 cm^{-1}.

HRMS (ESI): *m*/*z* [M + H]$^+$ calcd for $C_{22}H_{20}N_3O_4S^+$: 422.1169; found: 422.1170.

Methyl (*R*)-2-(((4-Bromophenyl)((2-nitrophenyl)thio)amino)(phenyl)methyl)acrylate (14k)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5e** (32.5 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14k**.

Yield: 47.9 mg (96%); yellow-green wax; 56% *ee* (IA, heptane/*i*-PrOH, 98:2; t_R = 13.6 (minor), 15.0 (major) min); $[\alpha]_D$ = +22.8° (*c* 0.58; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 8.29 (d, *J* = 8.3 Hz, 1 H), 8.01 (d, *J* = 8.3 Hz, 1 H), 7.49 (t, *J* = 7.6 Hz, 1 H), 7.41–7.20 (m, 15 H), 7.13–7.11 (m, 1 H), 7.08–7.05 (m, 4 H), 6.98 (m, 3 H), 6.61 (s, 1 H), 6.51 (s, 1 H), 6.37 (s, 1 H), 6.23 (s, 1 H), 5.83 (s, 1 H), 5.52 (s, 1 H), 3.68 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 167.2, 166.4, 147.9, 147.6, 143.4, 142.8, 142.6, 142.3, 139.3, 138.1, 137.3, 135.1, 134.3, 133.6, 133.1, 132.1 (2C), 132.0 (2C), 130.8 (2C), 128.9 (2C), 128.3, 127.7, 127.4 (4C overlapped), 125.9 (2C), 125.8 (2C), 125.5, 125.3, 125.2, 118.7 (2C), 117.8 (2C), 113.6, 113.4, 66.4, 64.0, 52.2, 52.1.

IR (KBr): 3058, 2981, 2848, 1712, 1604, 1501, 1338, 1284, 1241, 1180, 1112 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}BrN_2NaO_4S^+$: 521.0141; found: 521.0142.

Methyl (*R*)-2-(((2-Bromophenyl)((2-nitrophenyl)thio)amino)(phenyl)methyl)acrylate (14l)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5f** (32.5 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14l**.

Yield: 47.9 mg (96%); yellow wax; 16% *ee* (IB, heptane/*i*-PrOH, 90:10; t_R = 6.5 (minor), 7.2 (major) min); $[\alpha]_D$ = +0.0° (*c* 1.49; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.20 (d, *J* = 8.2 Hz, 1 H), 8.14 (d, *J* = 7.1 Hz, 1 H), 7.60 (dd, *J* = 8.0, 1.4 Hz, 1 H), 7.57–7.53 (m, 2 H), 7.42 (br. s, 2 H), 7.25–7.16 (m, 5 H), 7.00–6.95 (m, 1 H), 6.51 (s, 1 H), 6.31–5.77 (m, 2 H), 3.56 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.6, 148.4, 143.3, 142.0, 138.9, 137.0, 134.2, 133.6, 129.1 (3C overlapped), 128.1, 128.0 (3C), 127.8, 126.7, 126.3, 125.5, 124.8, 120.3, 52.0 (signal of C4 is missing).

IR (KBr): 3064, 2950, 1718, 1592, 1509, 1437, 1335, 1302, 1150, 1036 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}BrN_2NaO_4S^+$: 521.0141; found: 521.0142.

Methyl (*R*)-2-(((3-Bromophenyl)((2-nitrophenyl)thio)amino)(phenyl)methyl)acrylate (14m)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5g** (32.5 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14m**.

Yield: 47.9 mg (96%); yellow foam; 52% *ee* (IB, heptane/*i*-PrOH, 95:5; t_R = 7.8 (minor), 8.5 (major) min); $[\alpha]_D$ = +21.8° (*c* 0.71; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 8.31 (d, *J* = 8.2 Hz, 1 H), 8.01 (d, *J* = 8.1 Hz, 1 H), 7.53–7.49 (m, 1 H), 7.41–7.19 (m, 13 H), 7.16–7.02 (m, 7 H), 6.99–6.95 (m, 3 H), 6.63 (s, 1 H), 6.53 (s, 1 H), 6.37 (s, 1 H), 6.24 (s, 1 H), 5.84 (s, 1 H), 5.53 (s, 1 H), 3.68 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 167.1, 166.3, 150.1, 149.9, 143.2, 142.7, 142.5, 142.0, 139.1, 137.9, 137.0, 135.0, 134.5, 133.7, 133.2, 130.8 (2C), 130.5, 130.4, 128.9 (2C), 128.3, 127.7, 127.3 (4C overlapped), 126.0, 125.95, 125.8, 125.7, 125.6, 125.3, 125.1, 124.1, 124.0, 123.4, 123.2, 119.8, 118.9, 115.5, 114.6, 66.2, 63.8, 52.2, 52.1.

IR (KBr): 3061, 2947, 2845, 1718, 1583, 1515, 1338, 1237, 1147, 1057 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}BrN_2NaO_4S^+$: 521.0141; found: 521.0146.

Methyl (*R*)-2-((((2-Nitrophenyl)thio)(*p*-tolyl)amino)(phenyl)methyl)acrylate (14n)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5h** (26.0 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14n**.

Yield: 41.7 mg (96%); yellowish oil; 32% *ee* (AD, heptane/*i*-PrOH, 99:1; t_R = 10.2 (minor), 12.4 (major) min); $[\alpha]_D$ = +16.3° (*c* 0.86; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.14 (d, *J* = 8.1 Hz, 1 H), 7.91 (d, *J* = 7.7 Hz, 1 H), 7.54 (d, *J* = 8.1 Hz, 1 H), 7.50 (t, *J* = 7.5 Hz, 1 H), 7.37 (d, *J* = 6.9 Hz, 2 H), 7.25–7.21 (m, 3 H), 7.17–7.15 (m, 2 H), 7.09 (t, *J* = 7.2 Hz, 1 H), 7.00 (t, *J* = 7.4 Hz, 1 H), 6.39 (s, 1 H), 6.00 (br s, 1 H), 5.89 (br s, 1 H), 3.57 (s, 3 H), 2.55 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 167.0, 148.6, 144.9, 142.3, 139.6, 138.0, 133.3, 133.2, 132.0, 129.0 (3C overlapped), 128.2 (2C), 128.0, 126.4 (2C), 125.8, 125.6, 125.1, 124.7, 52.0, 19.7 (signal of C4 is missing).

IR (KBr): 3062, 2951, 2853, 1720, 1591, 1511, 1337, 1305, 1140, 1039 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{24}H_{22}N_2NaO_4S^+$: 457.1193; found: 457.1194.

Methyl (*R*)-2-(((4-Fluorophenyl)((2-nitrophenyl)thio)amino)(phenyl)methyl)acrylate (14o)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **5i** (26.4 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14o**.

Yield: 42.0 mg (96%); yellow foam; 59% *ee* (AD, heptane/*i*-PrOH, 99:1; t_R = 17.8 (minor), 23.5 (major) min); $[\alpha]_D$ = +20.1° (*c* 0.40; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 8.29 (d, *J* = 7.9 Hz, 1 H), 8.02 (d, *J* = 7.3 Hz, 1 H), 7.50 (m, 2 H), 7.37–7.26 (m, 10 H), 7.15–7.12 (m, 6 H), 7.00–6.95 (m, 4 H), 6.90–6.87 (m, 2 H), 6.60 (s, 1 H), 6.52 (s, 1 H), 6.37 (s, 1 H), 6.24 (s, 1 H), 5.87 (s, 1 H), 5.53 (s, 1 H), 3.68 (s, 3 H), 3.55 (s, 3 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = 167.2, 166.4, 158.5, 158.4, 157.0, 156.9, 145.0, 144.7, 144.0, 142.8, 142.7, 142.5, 139.4, 138.4, 137.5, 135.4, 134.0, 133.5, 133.0, 130.7 (2C), 128.8 (2C), 128.2, 127.6, 127.4 (2C), 127. (2C), 125.89, 125.85, 125.8 (4C), 125.4, 125.2, 125.1, 118.5, 117.3, 115.8, 115.7, 115.6, 115.6, 66.7, 64.6, 52.1 (2C).

^{19}F NMR (282 MHz, $CDCl_3$): δ (mixture of rotamers, 1:1) = –123.43 (m, 1F), –123.76 (m, 1F).

IR (KBr): 3055, 2953, 2848, 1718, 1589, 1503, 1335, 1224, 1144, 917 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{19}O_4N_2FNaS^+$: 461.0942; found: 461.0942.

Methyl (*R*)-2-((4-((*tert*-Butyldimethylsilyl)oxy)phenyl)(((2-nitrophenyl)thio)(phenyl) amino)methyl)acrylate (14p)

By following GP4, the reaction was carried out with **9h** (42.2 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14p**.

Yield: 52.8 mg (96%); yellow wax; 57% *ee* (AD, heptane/*i*-PrOH, 99:1; t_R = 10.2 (major), 11.7 (minor) min); $[\alpha]_D$ = +42.7° (*c* 0.75; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.4:1) = 8.28 (d, *J* = 8.1 Hz, 1 H), 8.05 (d, *J* = 8.2 Hz, 1 H), 7.48 (s, 1 H), 7.32–7.08 (m, *J* = 7.7 Hz, 19 H), 6.96 (t, *J* = 7.2 Hz, 1 H), 6.82 (d, *J* = 8.1 Hz, 1 H), 6.60 (s, 1 H), 6.47 (s, 1 H), 6.44 (d, *J* = 8.3 Hz, 2 H), 6.35 (s, 1 H), 6.25 (s, 1 H), 5.83 (s, 1 H), 5.56 (s, 1 H), 3.67 (s, 3 H), 3.52 (s, 3 H), 0.98 (s, 9 H), 0.86 (s, 9 H), 0.20 (s, 6 H), –0.03 (s, 6 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.4:1) = 167.3, 166.6, 155.5, 154.9, 148.8, 148.4, 144.3, 143.3, 142.7, 142.4, 139.7, 137.9, 133.8, 133.5, 132.9, 132.1 (2C), 130.9, 129.3 (2C), 129.2, 129.1 (2C), 128.6 (2C), 128.3, 126.1, 125.8, 125.3, 125.2, 125.1, 125.0, 121.0, 120.9, 120.2 (2C), 119.0 (2C), 117.0 (2C), 116.0 (2C), 65.6, 63.5, 52.1, 52.0, 25.63 (3C), 25.56 (3C), 18.2, 18.1, –4.4 (2C), –4.6 (2C).

IR (KBr): 3058, 2956, 1724, 1565, 1473, 1308, 1192, 1171, 1096, 917 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{29}H_{34}O_5N_2NaSSi^+$: 573.1850; found: 573.1850.

Methyl (*R*)-2-((4-((*tert*-Butyldimethylsilyl)oxy)phenyl)((4-fluorophenyl)((2-nitrophenyl) thio)amino)methyl)acrylate (14q)

By following GP4, the reaction was carried out with **9h** (42.2 mg, 0.15 mmol) and **5i** (26.4 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14q**.

Yield: 54.5 mg (96%); yellow wax; 57% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 7.5 (minor), 8.8 (major) min); $[\alpha]_D$ = +32.9° (*c* 0.70; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = (mixture of rotamers, 1:2) = 8.28 (d, *J* = 6.7 Hz, 1 H), 8.06 (d, *J* = 7.8 Hz, 1 H), 7.48 (s, 1 H), 7.34–7.32 (m, 1 H), 7.26 (m, 2 H), 7.14–7.09 (m, 10 H), 6.97–6.95 (m, 3 H), 6.90–6.87 (m, 1 H), 6.83–6.82 (m, 1 H), 6.49–6.44 (m, 5 H), 6.35 (s, 1 H), 6.17 (s, 1 H), 5.82 (s, 1 H), 5.55 (s, 1 H), 3.67 (s, 3 H), 3.53 (s, 3 H), 0.98 (s, 9 H), 0.85 (s, 9 H), 0.20 (s, 6 H), –0.03 (s, 6 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:2) = 167.3, 166.5, 158.6, 158.4, 157.0, 156.8, 155.6, 155.1, 145.1, 144.6, 144.1, 143.1, 142.7, 142.4, 139.6, 137.9, 133.6, 133.5, 133.0 (2C), 132.0 (2C), 130.7, 128.6, 128.3, 125.8 (2C), 125.3 (2C), 125.1 (2C), 120.2, 119.1 (2C), 118.6, 117.3, 117.2 (2C), 115.8, 115.7 (2C), 115.5, 66.1, 64.3, 52.1, 52.0, 25.6 (6C), 18.2, 18.1, –4.4 (2C), –4.6 (2C).

^{19}F NMR (282 MHz, $CDCl_3$): δ (mixture of rotamers, 1:2) = –123.53 (m, 1F), –123.98 (m, 1F).

IR (KBr): 2953, 2854, 1721, 1589, 1506, 1437, 1341, 1227, 1144, 917 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{29}H_{33}O_5N_2FNaSSi^+$: 591.1756; found: 591.1756.

Benzyl (*R*)-2-((((2-Nitrophenyl)thio)(phenyl)amino)(phenyl)methyl)acrylate (14r)

By following GP4, the reaction was carried out with **9i** (55.2 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14r**.

Yield: 47.6 mg (96%); yellow foam; 57% *ee* (AD, heptane/*i*-PrOH, 90:10; t_R = 9.7 (minor), 10.9 (major) min); $[\alpha]_D$ = +9.9° (*c* 0.46; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 0.8:1) = 8.24 (d, *J* = 8.1 Hz, 1 H), 8.01 (d, *J* = 8.2 Hz, 1 H), 7.45 (d, *J* = 8.2 Hz, 1 H), 7.36 (t, *J* = 7.4 Hz, 2 H), 7.32–7.25 (m, 15 H), 7.23–7.08 (m, 13 H), 7.00–6.91 (m, 5 H), 6.74 (s, 1 H), 6.59 (s, 1 H), 6.43 (s, 1 H), 6.31 (s, 1 H), 5.88 (m, 1 H), 5.60 (s, 1 H), 5.16 (d, *J* = 12.5 Hz, 1 H), 5.09 (d, *J* = 12.4 Hz, 1 H), 5.05 (d, *J* = 12.5 Hz, 1 H), 4.91 (d, *J* = 12.4 Hz, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 0.8:1) = 166.5, 165.9, 148.8, 148.5, 144.1, 143.0, 142.61, 142.55, 139.4, 138.6, 137.5, 135.6, 135.5, 135.3, 134.4, 133.6, 133.0, 130.9 (2C), 129.3 (2C), 129.2 (2C), 128.7 (2C), 128.5, 128.4, 128.3, 128.1 (2C), 128.0, 127.8 (2C), 127.5 (3C), 127.3 (2C), 126.4, 126.1, 125.9, 125.69, 125.67, 125.3, 125.03 (2C), 124.99, 121.1, 121.0, 117.0 (2C), 116.0 (2C), 66.74, 66.70, 66.3, 63.7.

IR (KBr): 3060, 2926, 1715, 1589, 1509, 1401, 1335, 1236, 1144, 970 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{29}H_{24}O_4N_2NaS^+$: 519.1349; found: 519.1349.

***tert*-Butyl (*R*)-2-((((2-Nitrophenyl)thio)(phenyl)amino)(phenyl)methyl)acrylate (14s)**

By following GP4, the reaction was carried out with **9j** (50.1 mg, 0.15 mmol) and **5a** (24.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **14s**.

Yield: 44.3 mg (96%); yellow foam; 60% *ee* (AD, heptane/*i*-PrOH, 99:1; t_R = 8.9 (minor), 10.6 (major) min); $[\alpha]_D$ = –70.7° (*c* 0.24; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ (mixture of rotamers, 1:2) = 8.29 (d, *J* = 8.2 Hz, 1 H), 8.01 (d, *J* = 8.1 Hz, 1 H), 7.55 (d, *J* = 8.1 Hz, 1 H), 7.46 (t, *J* = 7.5 Hz, 1 H), 7.36–7.24 (m, 9 H), 7.21–7.19 (m, 6 H), 7.08 (dt, *J* = 16.1, 4.6 Hz, 1 H), 7.00–6.94 (m, 6 H), 6.90 (s, 1 H), 6.68 (s, 1 H), 6.44 (s, 1 H), 6.37 (s, 1 H), 6.20 (s, 1 H), 5.71 (s, 1 H), 5.59 (s, 1 H), 1.36 (s, 9 H), 1.27 (s, 9 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ (mixture of rotamers, 1:2) = 165.8, 165.3, 148.8, 144.2, 143.0, 142.6, 142.5, 140.6, 139.4, 139.1, 136.2, 134.1, 133.9, 132.9, 130.8 (2C), 129.3 (2C), 129.1 (2C), 128.6, 127.9 (2C), 127.5, 127.21, 127.18 (2C), 126.1 (2C), 125.9, 125.8, 125.7, 125.0 (2C), 124.9 (2C), 121.0, 120.9, 117.0 (2C), 116.0 (2C), 81.4, 81.2, 66.6, 63.2, 28.0 (3C), 27.7 (3C).

IR (KBr): 2977, 2926, 1724, 1589, 1509, 1398, 1338, 1239, 1144, 949 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{26}H_{26}O_4N_2NaS^+$: 485.1506; found: 485.1506.

Methyl (*R*)-2-(Phenyl(phenylamino)methyl)acrylate (17a)

By following GP4, the reaction was carried out with **9a** (43.8 mg, 0.15 mmol) and **8a** (9.3 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **17a**.

Yield: 20.3 mg (76%); colorless oil; 43% *ee* (IB, heptane/*i*-PrOH, 98:2; t_R = 6.7 (major), 7.1 (minor) min); $[\alpha]_D$ = –60.7° (*c* 0.23; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[30]

Deprotection of 2-Nitrophenylsulfenyl Group; General Procedure GP5

By following the modified procedure,[9b] to a stirred solution of adduct **14** (0.10 mmol) in anhydrous Et_2O (1.2 mL, 0.08 M), HCl in Et_2O (ca 6 M, 0.1 mL, 0.6 mmol) was added at 0 °C. The solution was stirred at r.t. for 1 h. The stirred mixture was diluted with H_2O (equal volume as Et_2O) and the reaction was quenched with NH_4OH solution (25% w/w, 0.2 mL, 1.2 mmol). The aqueous phase was extracted with EtOAc (3 × 2 mL), the combined organic layers were washed with brine, dried over $MgSO_4$ and the solvent was evaporated under vacuum. The crude product was purified by flash column chromatography (FC) on silica gel to afford the desired product.

Methyl (*R*)-2-((Phenylamino)(*p*-tolyl)methyl)acrylate (17b)

By following GP5, the reaction was carried out with **14b** (43.4 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **17b**.

Yield: 23.9 mg (85%); yellow wax; 62% *ee* (IA, heptane/*i*-PrOH, 98:2; t_R = 8.6 (minor), 9.4 (major) min); $[\alpha]_D$ = –63.3° (*c* 0.89; $CHCl_3$); 92% *ee*; $[\alpha]_D$ = –142.1° (*c* 0.29; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[28]

Methyl (*R*)-2-((4-Bromophenyl)(phenylamino)methyl)acrylate (17c)

By following GP5, the reaction was carried out with **14c** (49.9 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **17c**.

Yield: 29.8 mg (86%); yellow wax; 78% *ee* (IA, heptane/*i*-PrOH, 98:2; t_R = 10.5 (minor), 11.3 (major) min); $[\alpha]_D$ = –99.0° (*c* 0.53; $CHCl_3$); 99% *ee*; $[\alpha]_D$ = –114.3° (*c* 0.50; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[28]

Methyl (*R*)-2-((4-Cyanophenyl)(phenylamino)methyl)acrylate (17d)

By following GP5, the reaction was carried out with **14d** (44.5 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **17d**.

Yield: 24.5 mg (84%); yellowish wax; 78% *ee* (OD-H, heptane/*i*-PrOH, 98:2; t_R = 31.9 (major), 37.7 (minor) min); $[\alpha]_D$ = –51.3° (*c* 0.96; $CHCl_3$); 98% *ee*; $[\alpha]_D$ = –71.8° (*c* 0.43; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[32]

Methyl (*R*)-2-((4-Nitrophenyl)(phenylamino)methyl)acrylate (17e)

By following GP5, the reaction was carried out with **14e** (46.5 mg, 0.10 mmol). FC (hexanes/EtOAc, 8:1) furnished **17e**.

Yield: 25.6 mg (82%); yellow wax; 61% *ee* (IA, heptane/*i*-PrOH, 95:5; t_R = 17.4 (major), 18.3 (minor) min); $[\alpha]_D$ = –51.6° (*c* 0.61; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[33]

Methyl (*R*)-2-(((4-Bromophenyl)amino)(phenyl)methyl)acrylate (17k)

By following GP5, the reaction was carried out with **14k** (49.9 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **17k**.

Yield: 27.0 mg (78%); yellow wax; 55% *ee* (IB, heptane/*i*-PrOH, 98:2; t_R = 7.0 (minor), 7.8 (major) min); $[\alpha]_D$ = –68.3° (*c* 0.30; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[28]

Methyl (*R*)-2-((4-((*tert*-Butyldimethylsilyl)oxy)phenyl)((4-fluorophenyl)amino)methyl)acrylate (17q)

By following GP5, the reaction was carried out with **14q** (56.9 mg, 0.10 mmol). FC (hexanes/EtOAc, 12:1) furnished **17q**.

Yield: 34.5 mg (83%); yellowish oil; 58% *ee* (AD, heptane/*i*-PrOH, 99:1; t_R = 6.7 (minor), 7.8 (major) min); $[\alpha]_D$ = –70.7° (*c* 0.24; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.21 (d, *J* = 8.5 Hz, 2 H), 6.86 (t, *J* = 8.7 Hz, 2 H), 6.80 (d, *J* = 8.5 Hz, 2 H), 6.50–6.48 (m, 2 H), 6.35 (s, 1 H), 5.90 (s, 1 H), 5.27 (s, 1 H), 4.01 (bs, 1 H), 3.71 (s, 3 H), 0.98 (s, 9 H), 0.20 (s, 6 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 166.7, 156.7, 155.3, 155.2, 143.1, 140.2, 133.0, 128.6 (2C), 125.7, 120.2 (2C), 115.6, 115.5, 114.3, 114.20, 58.9, 51.9, 25.6 (3C), 18.2, –4.4 (2C).

^{19}F NMR (282 MHz, $CDCl_3$): δ = –127.56 to –127.65 (m).

IR (KBr): 3063, 3031, 2956, 2890, 1718, 1631, 1601, 1506, 1467, 1437, 1404, 1263, 1224, 1195, 1171, 1159, 1111, 1078, 1012, 914 cm^{-1}.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{23}H_{30}O_3NFNaSi$: 438.1871; found: 438.1871.

Synthesis of β-Lactams; General Procedure GP6

Method A: By following the slightly modified procedure,[15] to a stirred solution of β-aminoester **17** (0.10 mmol) in THF/water (1:1, v/v, 0.6 mL), $LiOH{\cdot}H_2O$ (21.0 mg, 0.50 mmol) was added. The reaction mixture was stirred at r.t. for 24 h. Solvents were evaporated under vacuum and the crude product **18**[34] was used directly in the next step. The crude material was suspended in CH_2Cl_2 (5 mL), 2-chloro-1-methylpyridinium iodide (28.1 mg, 0.11 mmol) and subsequently Et_3N (31 µL, 0.22 mmol) was added. The reaction mixture was stirred at r.t. until full conversion (ca. 2 h, TLC monitoring). The solvent was evaporated under vacuum. The crude product was purified by flash column chromatography (FC) on silica gel to afford the desired product.

Method B: By following the procedure,[16] in a flame-dried Schlenk flask β-aminoester **17** (0.10 mmol, 1.0 equiv) was dissolved in anhydrous toluene (1.5 mL, 0.07 M). To the stirred solution, $Sn[N(TMS)_2]_2$ (0.12 mmol, 1.2 equiv) was added under argon atmosphere. The mixture was heated at gentle reflux for 3 h before being cooled and concentrated under vacuum. The crude product was directly purified by flash column chromatography (FC) on silica gel to afford the desired product.

(*R*)-3-Methylene-1,4-diphenylazetidin-2-one (19a)

By following GP6, the reaction was carried out with **17a** (26.7 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **19a** as a white solid.

Yield: 14.1 mg (60%; *Method A*); 0–17.6 mg (0–75%; *Method B*);[35] mp 170 °C; 43% *ee* (ODH, heptane/*i*-PrOH, 95:5; t_R = 6.7 (major), 8.3 (minor) min); $[\alpha]_D$ = –54.4° (*c* 0.52; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with previously reported values.[5d]

(*R*)-3-Methylene-1-phenyl-4-(*p*-tolyl)azetidin-2-one (19b)

By following GP6, the reaction was carried out with **17b** (28.1 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **19b** as a white solid.

Yield: 15.4 mg (62%; *Method A*); 0–8.5 mg (0–34%; *Method B*);[35] mp 99 °C; 62% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 29.8 (minor), 32.4 (major) min); $[\alpha]_D$ = –67.0° (*c* 0.56; $CHCl_3$); 93% *ee* $[\alpha]_D$ = –84.7° (*c* 0.36; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with previously reported values.[15]

(*R*)-4-(4-Bromophenyl)-3-methylene-1-phenylazetidin-2-one (19c)

By following GP6, the reaction was carried out with **17c** (34.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **19c** as a yellowish solid.

Yield: 20.1 mg (64%; *Method A*); 0–3.1 mg (0–10%; *Method B*);[35] mp 120 °C; 78% *ee* (IC, heptane/*i*-PrOH, 98:2; t_R = 16.9 (minor), 18.0 (major) min); $[\alpha]_D$ = –77.1° (*c* 0.42; $CHCl_3$); 99% *ee*; $[\alpha]_D$ = –94.7° (*c* 0.48; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[15]

(*R*)-4-(3-Methylene-4-oxo-1-phenylazetidin-2-yl)benzonitrile (19d)

By following GP6, the reaction was carried out with **17d** (29.2 mg, 0.10 mmol). FC (hexanes/EtOAc, 7:1) furnished **19d** as a white solid.

Yield: 17.2 mg (66%; *Method A*); mp 110 °C; 78% *ee* (IB, heptane/*i*-PrOH, 80:20; t_R = 8.5 (major), 9.4 (minor) min); $[\alpha]_D$ = –93.7° (*c* 0.32; $CHCl_3$); 98% *ee*; $[\alpha]_D$ = –144.4° (*c* 0.45; $CHCl_3$).

^{1}H NMR (600 MHz, $CDCl_3$): δ = 7.70–7.68 (m, 2 H), 7.52–7.50 (m, 2 H), 7.29–7.27 (m, 4 H), 7.11–7.08 (m, 1 H), 5.89–5.87 (m, 1 H), 5.45 (m, 1 H), 5.19 (dd, *J* = 2.3, 1.2 Hz, 1 H).

^{13}C NMR (151 MHz, $CDCl_3$): δ = 160.20, 148.84, 141.90, 137.07, 133.00 (2C), 129.34 (2C), 127.19 (2C), 124.61, 118.21, 116.95 (2C), 112.82, 111.76, 62.60.

IR (KBr): 3062, 2883, 2257, 1739, 1607, 1509, 1374, 1266, 1126, 911 cm^{-1}.

HRMS (EI): *m*/*z* $[M]^+$ calcd for $C_{17}H_{12}N_2O$: 260.0950; found: 260.0948.

(*R*)-1-(4-Bromophenyl)-3-methylene-4-phenylazetidin-2-one (19k)

By following GP6, the reaction was carried out with **17k** (34.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **19k** as a yellowish solid.

Yield: 17.0 mg (54%; *Method A*); mp 130 °C; 55% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 19.2 (major), 22.3 (minor) min); $[\alpha]_D$ = –62.5° (*c* 0.40; $CHCl_3$). The recorded ^{1}H NMR and MS spectral data were consistent with reported values.[15]

(*R*)-4-(4-((*tert*-Butyldimethylsilyl)oxy)phenyl)-1-(4-fluorophenyl)-3-methyleneazetidin-2-one (19q)

By following GP6, the reaction was carried out with **17q** (41.6 mg, 0.10 mmol). FC (hexanes/EtOAc, 10:1) furnished **19q** as a white solid.

Yield: 6.9 mg (18%; *Method A*); 15.4–33.8 mg (40–88%; *Method B*);[35] mp 93 °C; 58% *ee* (IC, heptane/*i*-PrOH, 99:1; t_R = 14.1 (major), 15.3 (minor) min); $[\alpha]_D$ = –90.3° (*c* 0.42; $CHCl_3$). The recorded ^{1}H, ^{19}F NMR and MS spectral data were consistent with previously reported values.[15]

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Supporting Information

Supporting information for this article is available online at https://doi.org/10.1055/s-0037-1611229.

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