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Chemoselective C(sp^3)–H Bond Activation for the Preparation of Condensed N-Heterocycles

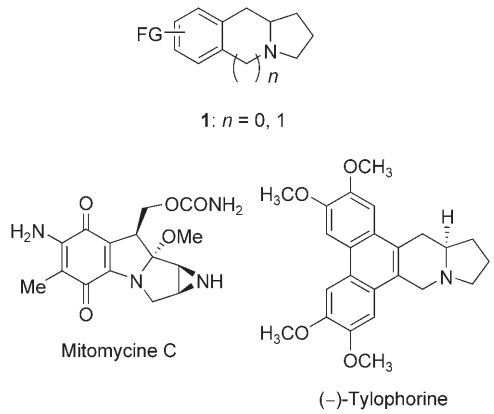
Hongjun Ren, Zhuo Li, and Paul Knochel*[a]

Abstract: Condensed N-heterocycles were prepared by using C–H activation reactions catalyzed by $Pd(OAc)_2$ (5 mol%) and $(p\text{-tolyl})_3P$ (10 mol%). The key step of these ring closures is chemoselective intramolecular C–H activation of the methyl group at position 2 of the pyrrole ring. Functionalized 9*H*-pyrrolo[1,2-a]indoles and pyrrolo[1,2-f]phenanthridine derivatives were prepared in good yields. The preparation of some complex N-heterocycles by using successive reactions is also described.

Keywords: C–H activation · N-heterocycles · palladium · pyrroles · successive reactions

Introduction

Polycyclic heterocycles of type **1** are found in various alkaloids such as mytomicine C and (−)-tylophorine (Scheme 1). The mytomicine family is a group of metabolites from *Streptomyces* that has attracted much attention owing to their potent antitumoral and antibacterial activity.[1] (−)-Tylophorine and its analogues are phenanthroindolizidine alkaloids, many of which have been isolated from plants of the family Asclepiadaceae, including members of the genus *Tylophora*, which are found in India and Southeast Asia.[2] These types of polycyclic heterocycles, because of their reported antitumor activity, have been the targets of total synthesis, structural modification, and antitumor evaluation.[3]



Scheme 1. Structure of mitomycine C and (−)-tylophorine. FG = functional group.

The preparation of complex polycyclic heterocycles is an important synthetic goal owing to the use of these molecules as potential pharmaceuticals.[4] One of the most efficient approaches for preparing polycyclic molecules is the use of domino reactions.[5] Especially attractive are reaction sequences that involve C–H activation reactions,[6] as such reactions tolerate the presence of additional functionalities in the substrate. A range of Ru-,[7] Rh-,[8] Pt-,[9] and Pd-catalyzed[10] C–H activations of arenes for the preparation of heterocycles was recently described. An excellent synthesis of biaryl structural units involving intramolecular arylations with unactivated arenes was achieved (Scheme 2, Equation (1)),[11] but few cases have been reported that involve catalytic activation of C(sp^3)–H bonds for the preparation of polyheterocycles, owing to the high activation energy of the C(sp^3)–H bond.[12] Herein, we report a new method of constructing polycyclic ring systems of types **4** and **5** by using chemoselective benzylic C(sp^3)–H bond activation of pyrroles of types **2** and **3** (Scheme 2, Equation (2)).

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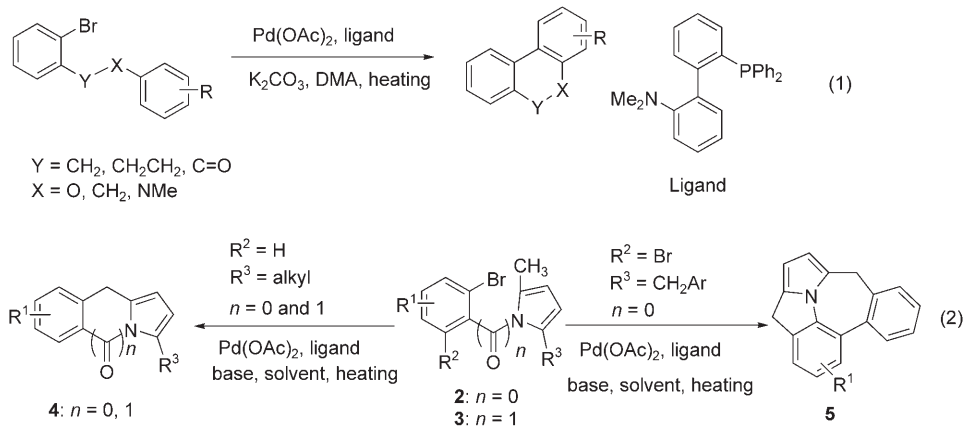
Results and Discussion

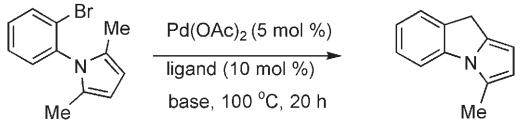
The first experiments were performed with *N*-(2-bromophenyl)-2,5-dimethylpyrrole (**6a**), which is readily available by the condensation of 2-bromoaniline with hexane-2,5-dione in the presence of catalytic amounts of $TsOH\cdot H_2O$



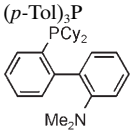
Scheme 2. Routes to tricyclic biaryl compounds and condensed N-heterocycles by C–H activation reactions. DMA = *N*,*N*-dimethylacetamide.

(Ts = *p*-toluenesulfonyl). Heating of **6a** with $Pd(OAc)_2$ (5 mol%) and various ligands in toluene in the presence of a base was performed to trap the HBr produced (100°C, 20 h; Table 1).[13] Preliminary experiments showed that polar solvents such as *N*,*N*-dimethylformamide (DMF) led to complex reaction mixtures, but apolar solvents such as toluene gave much better results. Strongly chelating ligands such as dppe or dppp did not lead to defined products. However, PPh_3 (10 mol%) furnished the desired 9*H*-pyrrolo[1,2-a]indole **7a** with 45% conversion at 100°C after 20 h of reaction time (Table 1, entries 1–3). By replacing K_2CO_3 with Cs_2CO_3 (1.2 equiv), the conversion increased to 73% (Table 1, entry 4). Sterically hindered ligands such as (*o*-Tol)$_3$P or (2-furyl)$_3$P led to low conversion (Table 1, entries 5 and 6), but (*m*-Tol)$_3$P afforded 27% conversion in the presence of K_2CO_3 and 100% conversion by using Cs_2CO_3. The best result was obtained with (*p*-Tol)$_3$P, which in the presence of Cs_2CO_3 gave 100% conversion at 110°C within 12 h (compare Table 1, entries 7–10). Interestingly, by using the hindered phosphine 2-dicyclohexylphosphino-2′-(*N*,*N*-dimethylamino)biphenyl,[14] only 67% conversion was observed (Table 1, entry 11).

Table 1. Pd-catalyzed cyclization of pyrrole derivative **6a** leading to tricyclic heterocycle **7a**.



6a **7a**

Entry	Ligand	Base	Conversion [%][a]
1	dppe	Cs_2CO_3	0
2	dppp	Cs_2CO_3	0
3	PPh_3	K_2CO_3	45
4	PPh_3	Cs_2CO_3	73
5	(*o*-Tol)$_3$P	Cs_2CO_3	0
6	(2-furyl)$_3$P	Cs_2CO_3	8
7	(*m*-Tol)$_3$P	K_2CO_3	27
8	(*m*-Tol)$_3$P	Cs_2CO_3	100
9	(*p*-Tol)$_3$P	K_2CO_3	15
10	(*p*-Tol)$_3$P	Cs_2CO_3	100[b]
11		Cs_2CO_3	67

[a] Determined by GC analysis of hydrolyzed reaction aliquots. [b] Conversion at 110°C after 12 h. Cy = cyclohexyl, dppe = 1,2-bis(diphenylphosphanyl)ethane, dppp = 1,3-bis(diphenylphosphanyl)propane, Tol = tolyl.

Preparation of Functionalized 9*H*-pyrrolo[1,2-a]indoles by Using C–H Activation

A broad range of 9*H*-pyrrolo[1,2-a]indoles of type **7** can be prepared from the corresponding bromo-*N*-arylpyrrole derivatives under optimized reaction conditions (Table 2). The 2-iodo- and 2-bromo-*N*-arylpyrrole derivatives **6b** and **6c** underwent the desired ring closure smoothly to provide the tricyclic product **7b** in 81% and 83% yield, respectively, thus showing that the use of aryl iodides or bromides leads to similar results (Table 2, entries 1 and 2). The ester functionality was well-tolerated in this ring closure. The cyano-substituted iodide **6d** and bromide **6e** also furnished the expected product **7c** in 70% and 60% yield, respectively, under the standard conditions (Table 2, entries 3 and 4). Trifluoromethyl-substituted substrates, which may be of importance in the preparation of pharmaceutically relevant heterocycles, reacted readily and led to the tricyclic products

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Paul Knochel *was born in 1955 in Strasbourg, France. After his PhD at the ETH Zürich with Prof. D. Seebach, he spent four years at the CNRS, Univ. Pierre & Marie Curie with Prof. J.-F. Normant followed by a year-long postdoctorate at Princeton Univ. with Prof. M. F. Semmelhack. He then became Assist. Prof. (1987) and Full Prof. (1991) at the Univ. of Michigan at Ann Arbor. In 1992, he moved to Philipps Univ. as C4 Prof. in Organic Chemistry. He took up his current position at Ludwig-Maximilians-Univ. in 1999. His research interests are in the development of new synthetic methods for organic and heterocyclic chemistry and new reagents for asymmetric catalysis.*

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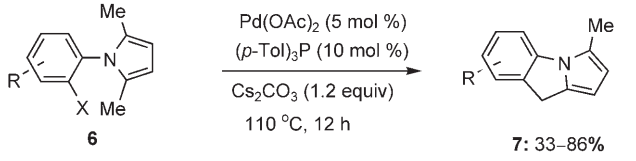
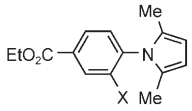
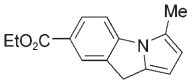
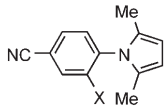
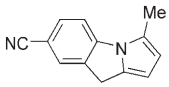
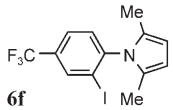
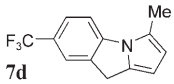
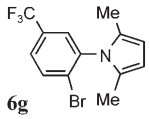
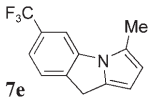
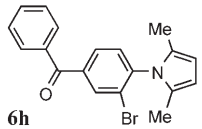
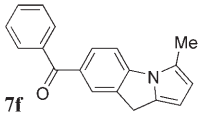
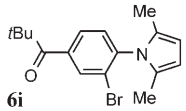
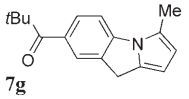
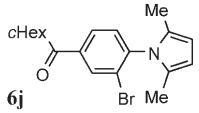
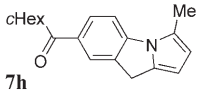
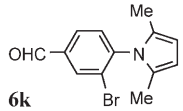
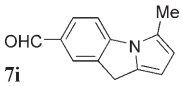
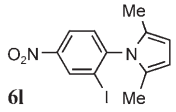
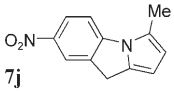
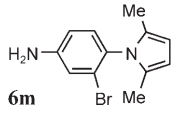
Table 2. Preparation of 9*H*-pyrrolo[1,2-a]indoles of type **7** from *N*-arylpyrroles of type **6**.



Entry	Pyrrole of type **6**	Product of type **7**	Yield [%][a]
			
1	**6b**: X = I	**7b**	86
2	**6c**: X = Br	**7b**	83
			
3	**6d**: X = I	**7c**	70
4	**6e**: X = Br	**7c**	60
5	 **6f**	 **7d**	77
6	 **6g**	 **7e**	65
7	 **6h**	 **7f**	61
8	 **6i**	 **7g**	66
9	 **6j**	 **7h**	69
10	 **6k**	 **7i**	55
11	 **6l**	 **7j**	33
12	 **6m**		0

[a] Yield of isolated analytically pure products.

7d (77%) and **7e** (65%) (Table 2, entries 5 and 6). Ketone and aldehyde functionalities were also well-tolerated. For example, the ketone derivatives **6h–j** were converted into the tricyclic products **7f–h** in 55–61% yields (Table 2, entries 7–9). Even the aldehyde functionality was tolerated in this ring-closure process. Hence, heating of aldehyde **6k** in the presence of $Pd(OAc)_2$ afforded the tricyclic compound **7i** in 55% yield. Only the nitro substituent complicated the C–H activation reaction and furnished the 9*H*-pyrrolo[1,2-a]indole **7j** in just 33% yield (Table 2, entry 11). With a strong electron donor such as NH_2 as substituent, no intermolecular amination and intramolecular ring closure was observed (Table 2, entry 12).

Regioselectivity in the Preparation of Functionalized 9*H*-pyrrolo[1,2-a]indoles

Regioselective C–H activations have hardly been studied.[15] Remarkably, when an unsymmetrically 2,5-substituted substrate such as 2-ethyl-5-methyl arylpyrrole **8a** was treated with $Pd(OAc)_2$, only the activation of the methyl group was observed, and the tricyclic compound **9a** was obtained in 75% yield (Table 3, entry 1). This may be a consequence of steric hindrance. When a 2,5-diethylpyrrole derivative was used, no C–H activation was observed. Multisubstituted pyrroles also led to excellent selectivities. With an ester-substituted pyrrole ring, selective C–H activation provided the polyfunctionalized tricyclic compounds **9b** and **9c** in 80–81% yield (Table 3, entries 2 and 3). Tetracyclic compounds can also be prepared by this C–H activation method. Thus, 2-methyl-4,5,6,7-tetrahydro-1*H*-indole derivative **8d** and 2-methyl-1,4,5,6-tetrahydrocyclopenta[b]pyrrole derivative **8e** underwent selective C–H activation to provide the tetracyclic compounds **9d** (64%) and **9e** (60%) under the standard conditions (Table 3, entries 4 and 5). Even for the substrate **8f**, which bears two benzylic hydrogen atoms, selective C–H activation of the methyl group resulted in the formation of the product **9f** in 57% yield (Table 3, entry 6). Substitution on the *N*-arylpyrrole also affects the regioselectivity of the ring closure. For example, a **9g**/**9g′** ratio of 2:1 was obtained in the reaction of the 2,5-dimethyl-3-ethoxycarbonyl phenylpyrrole derivative **8g** (Table 3, entry 7). This might have resulted from acidification of the proximal methyl group. The structure of **9g** was determined by H-H NOESY NMR spectroscopic analysis (see Experimental Section).

Preparation of Pyrrolo[1,2-f]phenanthridine Derivatives

In the case of 2-phenyl-5-methyl arylpyrrole derivatives, the activation of the $C(sp^2)$–H bond of the phenyl group was found to be much faster than that of the methyl group and leads to the pyrrolo[1,2-f]phenanthridine ring system. Thus, the *N*-arylpyrrole derivative **10a** preferentially underwent chemoselective activation of the phenyl ring over the methyl substituent, resulting in the pyrrolo[1,2-f]phenanthridine derivative **11a** in 93% yield (Table 4, entry 1). The ester functionality was well-tolerated in this ring closure. The ester substituent on both arene and pyrrole groups gave good yields (83–86%; Table 4, entries 2, 5, 6, and 7). Moreover, the trifluoromethyl-substituted bromides **10c** and **10f** furnished the expected products **11c** and **11f** in 85% and 86% yield, respectively (Table 4, entries 3 and 6). Ketones **10d**

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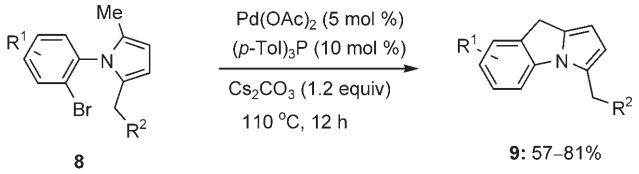
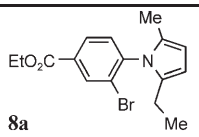
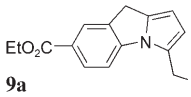
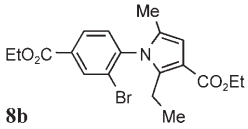
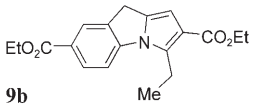
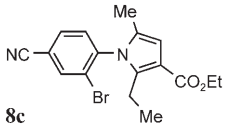
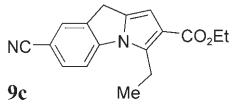
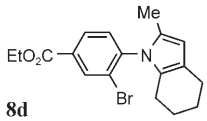
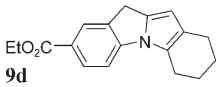
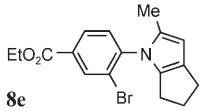
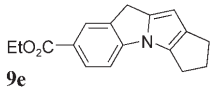
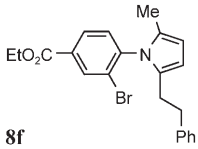
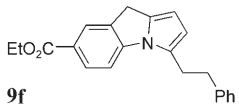
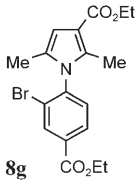
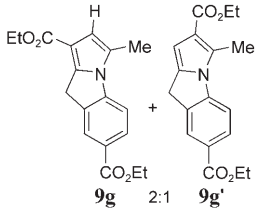
Table 3. Chemoselective preparation of 9*H*-pyrrolo[1,2-a]indoles of type **9** from pyrroles of type **8**.

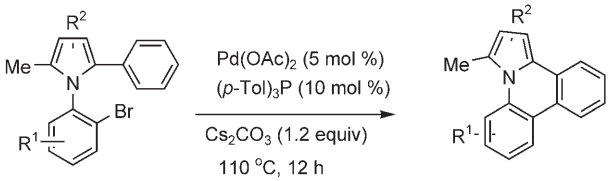


8 **9:** 57–81%

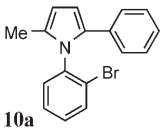
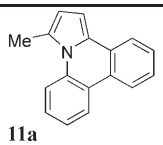
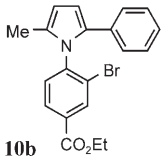
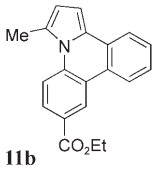
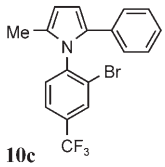
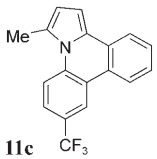
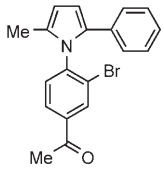
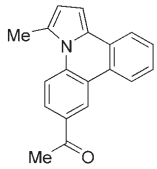
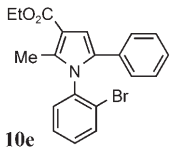
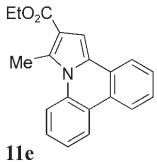
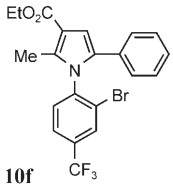
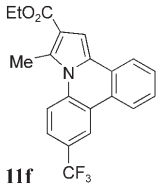
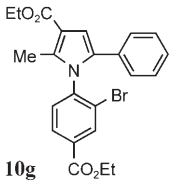
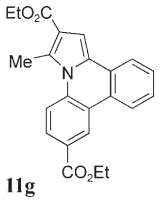
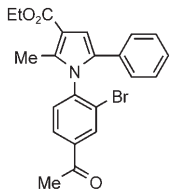
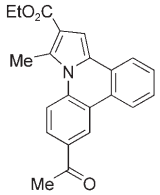
Entry	Pyrrole of type **8**	Product of type **9**	Yield [%][a]
1	 **8a**	 **9a**	75
2	 **8b**	 **9b**	80
3	 **8c**	 **9c**	81
4	 **8d**	 **9d**	64
5	 **8e**	 **9e**	60
6	 **8f**	 **9f**	57
7	 **8g**	 **9g** 2:1 **9g'**	80

[a] Yield of isolated analytically pure products.

Table 4. Preparation of pyrrolo[1,2-f]phenanthridines of type **9** from pyrroles of type **8**.



10 **11**: 46–93%

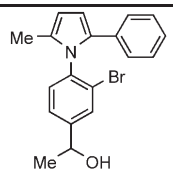
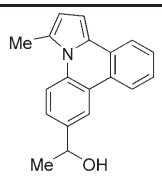
Entry	Aniline	Product	Yield [%][a]
1	 **10a**	 **11a**	93
2	 **10b**	 **11b**	85
3	 **10c**	 **11c**	85
4	 **10d**	 **11d**	61
5	 **10e**	 **11e**	83
6	 **10f**	 **11f**	86
7	 **10g**	 **11g**	84
8	 **10h**	 **11h**	46

and **10h** led to the tetracyclic products **11d** and **11h** in 46–61% yield (Table 4, entries 4 and 8). Pyrrole **10i**, which bears a hydroxy group in the benzylic position, also gave the desired product **11i** in 53% yield (Table 4, entry 9).

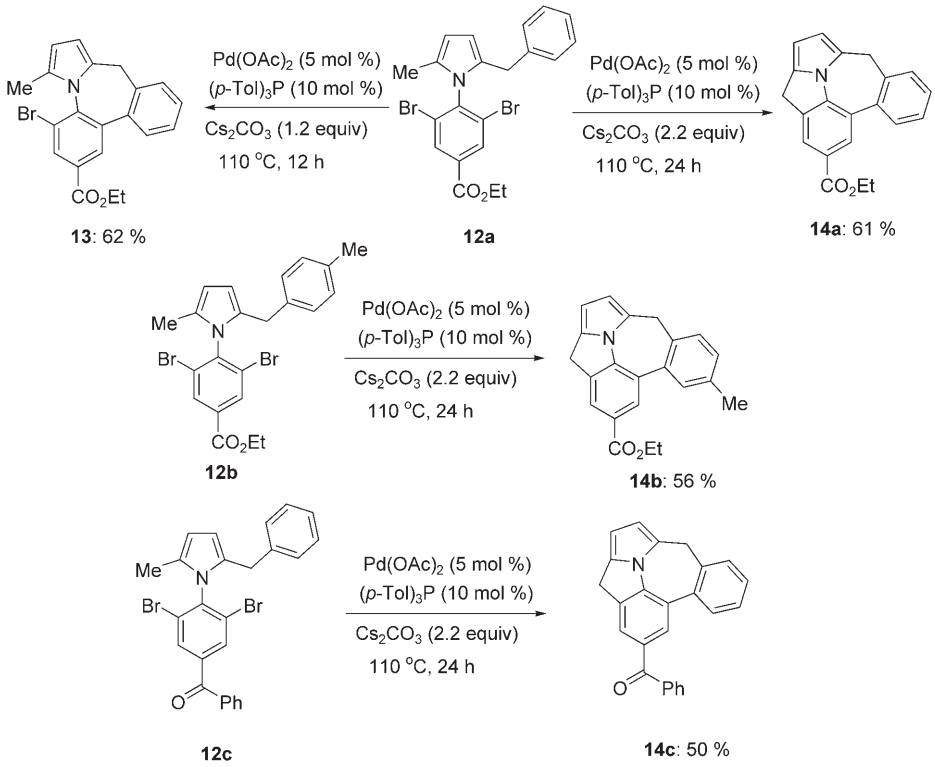
Preparation of Condensed Heterocyclic Compounds by Successive C–H Activation

In the case of the unsymmetrically 2,5-substituted dibromo derivative **12a**, an interesting selectivity was observed. Only the benzylic substituent was activated, leading to the seven-membered ring **13** in 62% yield (Scheme 3). Forcing reaction conditions (110 °C, 24 h) led to a second cyclization

Table 4. (Continued)

Entry	Aniline	Product	Yield [%][a]
9	 **10i**	 **11i**	53

[a] Yield of isolated analytically pure products.



Scheme 3. Preparation of condensed pentaheterocyclic compounds by successive C–H activation reactions.

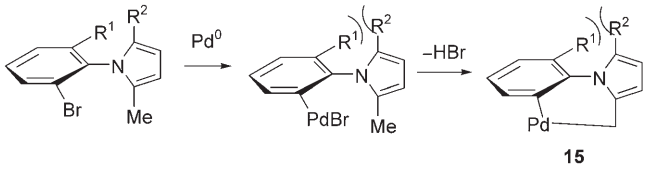
with the formation of the pentacyclic compound **14a** in 61% yield. Under the same conditions, the pentaheterocyclic compounds **14b** and **14c** were obtained from the corresponding dibromopyrroles **12b** and **12c** in 50–56% yield. These condensed heterocyclic compounds are difficult to prepare by conventional cross-coupling methods.

Mechanistic Investigations

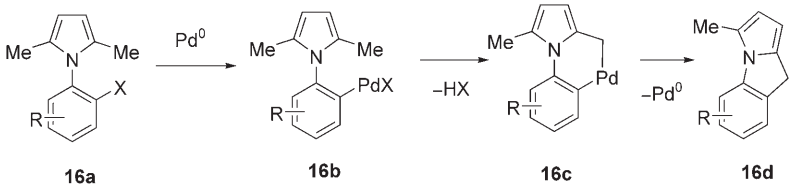
Several mechanistic pathways have been proposed for direct arylation reactions, including an electrophilic palladation pathway,[16] a carbopalladation (Heck-type) pathway,[17] and a direct C–H activation pathway.[18] All of these processes involve the formation of palladacycles. In our case, the two rings (the aryl ring and the pyrrole) are not co-planar; a rotation has to take place, leading to increased repulsion between the substituents R^1 and R^2 (Scheme 4). Hence, the formation of palladacycles **15** is greatly affected by the nature of R^1 and R^2.

Our results show that the activation of a methyl substituent is not an easy process and that the reaction is hampered by steric hindrance. These considerations led us to propose the following tentative mechanism for the cyclization reaction. The *N*-(2-haloaryl)pyrrole derivative **16a** first undergoes an oxidative addition of Pd^0 generated in situ to give the Pd^{II} species **16b** (Scheme 5). Concomitant C–H activation and HX elimination provides the palladacycle **16c**, which, after reductive elimination, yields the 9*H*-pyrrolo[1,2-a]indole **16d**.

On this basis, we suggest a plausible reaction mechanism for the preparation of pentaheterocyclic compounds **14a–c** by successive C–H activation (Scheme 6). The process is most likely initiated by an oxidative addition of dibromoarylpyrrole **12a** to Pd^0, resulting in the Pd^{II} species **17a**. The formation of the carbon–carbon bond may proceed by electrophilic aromatic substitution to give the eight-membered palladacycle **17c**, which then undergoes reductive elimination to afford the product **13** and regenerate the active Pd^0 species. Pd^0 insertion into the C–Br bond of aryl



Scheme 4. Formation of palladacycles **15** by C–H activation.



Scheme 5. Tentative mechanistic pathway for the ring closure.

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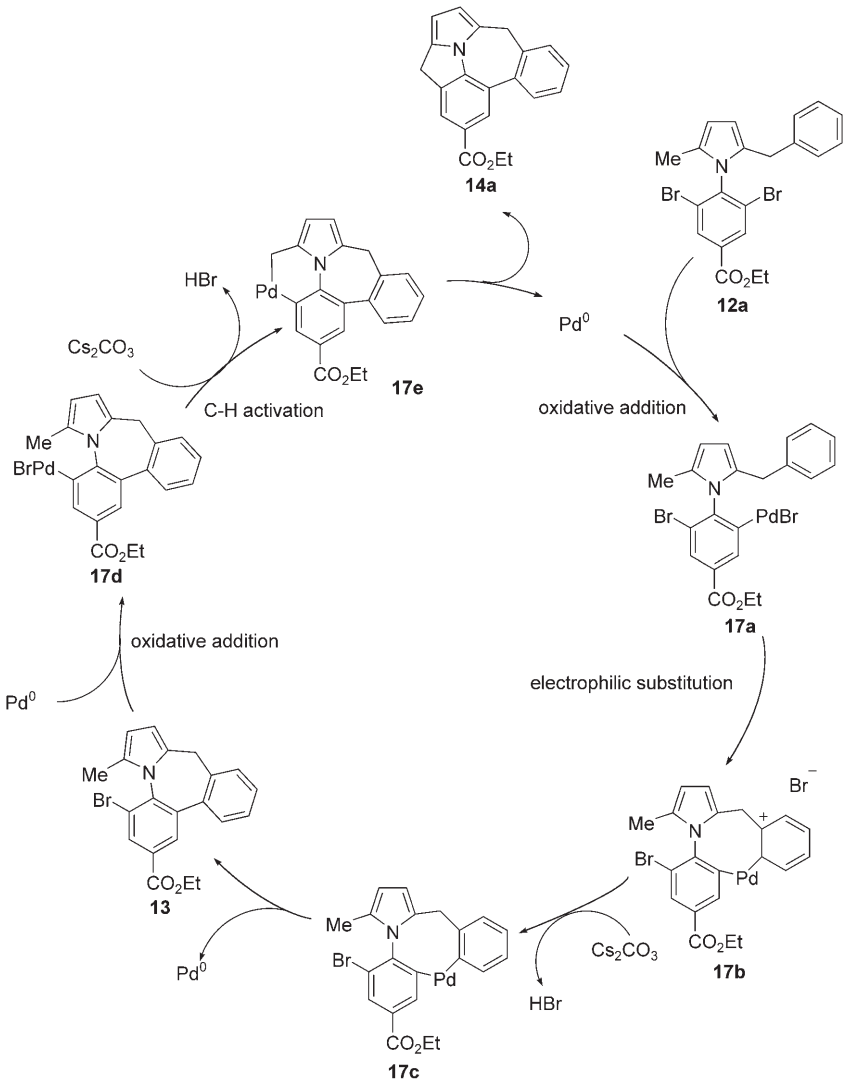


Scheme 6. Plausible reaction mechanism for the preparation of pentacyclic compound **14a** by successive C–H activation starting from dibromide **12a**.

bromide **13** results in the formation of the Pd^{II} species **17d**. Concomitant C–H activation and HX elimination provides palladacycle **17e**, which leads to the pentacyclic compound **14a** after reductive elimination.

Extending the C–H Activation Reaction

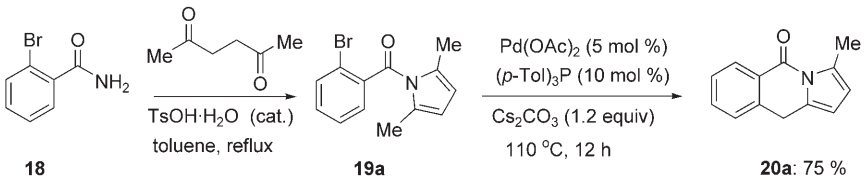
We next focused our attention on the formation of six-membered-ring systems. The reaction of 2-bromobenzamide (**18**) with hexane-2,5-dione (120 °C, 4 h) afforded *N*-arylpyrrole **19a**, which provided, under our standard conditions, the tricyclic product **20a** in 75% yield (Scheme 7).

To investigate the scope of this reaction, several *N*-acyl-2,5-pyrrole derivatives **19b–d** were prepared from the corresponding methyl esters **21a–c** and the lithium amide of 2,5-dimethyl-1*H*-pyrrole (Scheme 8). Thus, treatment of 2-bromo-5-methoxybenzoic acid methyl ester (**21a**) and 2-bromo-3,4,5-trimethoxybenzoic acid methyl ester (**21b**) with the lithium amide of 2,5-dimethyl-1*H*-pyrrole (obtained by the reaction of 2,5-dimethyl-1*H*-pyrrole with *n*BuLi) provided *N*-arylpyrroles **19b** and **19c** in 72–84% yield. Cycloalkenyl derivative **19d** was obtained by this method starting from 1-bromo-3,4-2*H*-naphthalene-2-carboxylic acid methyl ester (**21c**),[19] which was obtained from α-tetralone in three steps.

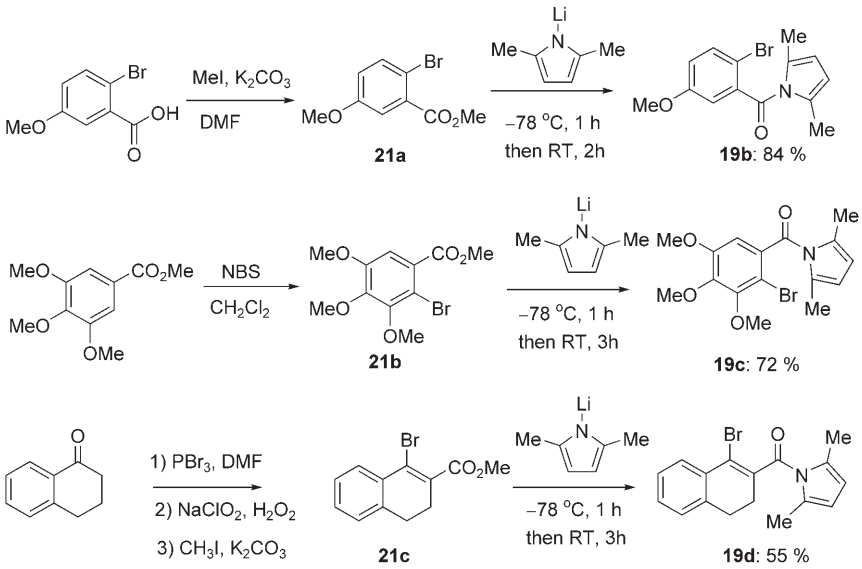
Remarkably, under the standard conditions, the readily available amides **19b** and **19c** were both converted into pyrrolo[1,2-b]isoquinolines **20b** and **20c** in 75–81% yield (Scheme 9). For substrate **19d**, milder conditions can be used. Thus, amide **19d** was heated in the presence of $Pd(OAc)_2$ (5 mmol%) at 80 °C for 6 h to afford heterocycle **20d** in 79% yield. The oxidized naphthyl derivative **20f** was also present in the crude reaction mixture (<5% as shown by ^1H NMR spectroscopic analysis).

Cycloalkenyl *N*-acylpyrroles also undergo the desired ring closure. The starting materials were prepared as shown in Scheme 10 from cyclic ketones **21**. Thus, 2-bromocyclohex-1-enecarboxylic acid amide (**22b**) was obtained in four steps according to the literature.[20] Treatment of **22b** with hexane-2,5-dione in the presence of $TsOH{\cdot}H_2O$ (2 mol%) provided *N*-acylpyrrolamide **23b** in 79% yield. *N*-acylpyrrolamides **23a** and **23c** were prepared by the same procedure in 40–81% yield.

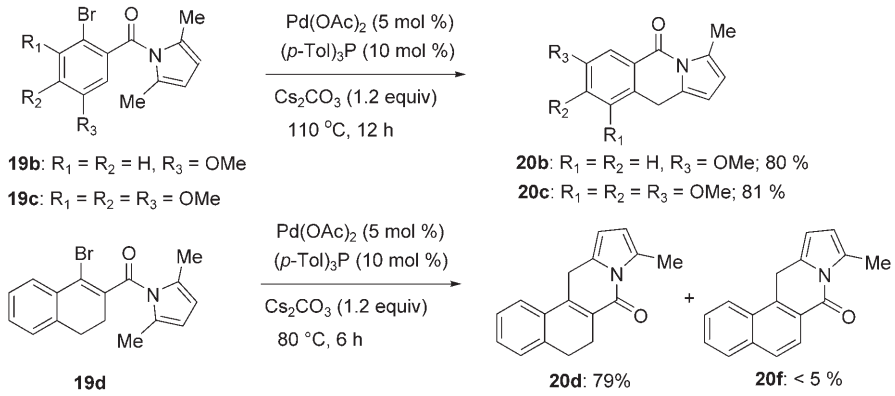
N-acylpyrrolamides **23a–c** were all converted into the tricyclic compounds **24a–c** under the usual conditions in 74–85% yield (Scheme 11).



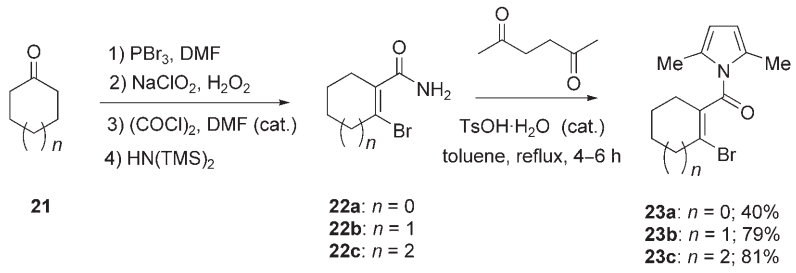
Scheme 7. Formation of six-membered ring by using Pd-catalyzed C–H activation.



Scheme 8. Preparation of *N*-acyl-2,5-pyrrole derivatives. NBS = *N*-bromosuccinimide.



Scheme 9. Preparation of pyrrolo[1,2-b]isoquinolines.



Scheme 10. Preparation of nonaromatic *N*-acylpyrroles. TMS = trimethylsilyl.

Successive Reactions that Involve Suzuki Cross-Coupling and C–H activation

We also investigated the performance of C–H activation reactions in conjunction with Suzuki cross-coupling. Dibromoarylpyrrole **25**, when treated with $Pd(OAc)_2$ in toluene, did not give the desired C–H activation product **26** (Scheme 12). However, the reaction of **25** with phenylboronic acid (1.1 equiv) in the presence of $Pd(OAc)_2$ (10 mol %) and $(p\text{-Tol})_3P$ (20 mol %) led to successive Suzuki cross-coupling and C–H activation, resulting in the product **27a** in 65 % yield (after recrystallization) (Scheme 13). The amount of phenylboronic acid used is crucial for the success of the reaction. When an excess of phenylboronic acid (2.0 equiv) was used, the double Suzuki cross-coupling product was formed instead of **27a**. When 0.9 equivalents were used, the mono Suzuki cross-coupling compound at position 4 and starting material **25** were obtained without any trace of **27a**. When 3-methyloxylbenzeneboronic acid was used, the cross-coupling and C–H activation compound **27b** was obtained in 89 % yield. Interestingly, when the dibromo substrate **28** was treated with 3-methyloxylbenzeneboronic acid under these conditions, the desired product **29** was formed in 59 % yield (Scheme 13).

Conclusions

We have established a new type of C–H activation reaction catalyzed by $Pd(OAc)_2$ and $(p\text{-Tol})_3P$ for the construction of complex condensed N-heterocycles. The key step of these ring closures is chemoselective intramolecular C–H activation of the methyl group at position 2 of the pyrrole ring. We also extended this reaction to successive reactions, thus allowing the one-pot preparation of some complex N-heterocycles.

CHEMISTRY
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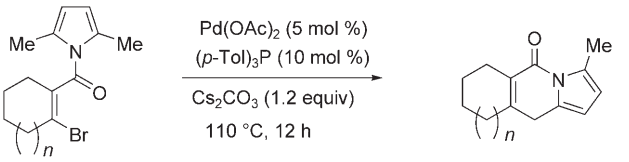
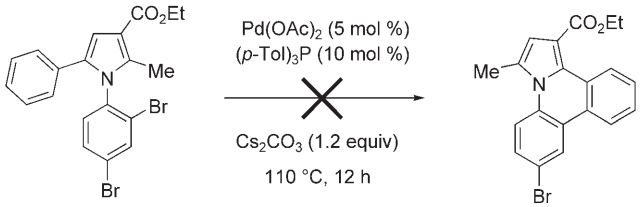


23a: $n = 0$
23b: $n = 1$
23c: $n = 2$

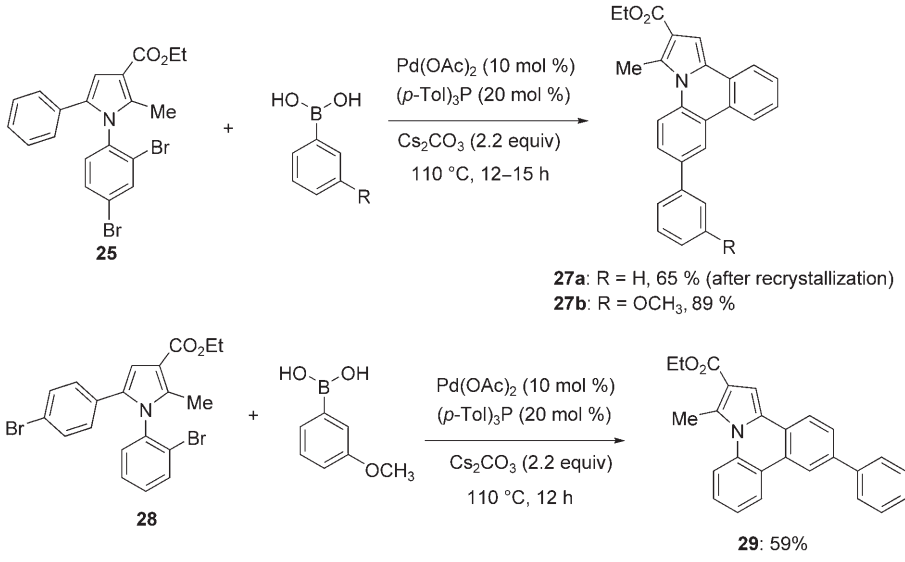
24a: $n = 0$; 80%
24b: $n = 1$; 85%
24c: $n = 2$; 74%

Scheme 11. Preparation of tricyclic heterocycles starting from nonaromatic *N*-acylpyrroles.



25 **26**

Scheme 12. Treatment of dibromoarylpyrrole **25** with $Pd(OAc)_2$.



25

28

Scheme 13. Successive reactions involving Suzuki cross-coupling and C–H activation.

Experimental Section

General

All reactions were carried out under nitrogen with standard Schlenk techniques. Melting points are uncorrected. ^1H and ^{13}C NMR spectra were recorded on a Bruker AMX 300 or AMX 600 or Varian VXR 400 S instrument. Chemical shifts (δ) are given in ppm relative to the residual solvent peaks ([D]chloroform: 7.24, 77.0 ppm; [D_6]benzene: 7.16, 128.0 ppm). IR spectra were recorded on a Perkin–Elmer 1420 IR spectrometer. Mass spectra were recorded on a FINNIGAN MAT 95 Q spectrometer. Column chromatography was performed on Merck silica gel 60 (230–400 mesh ASTM). THF and toluene were dried with sodium/benzophenone and distilled. Elemental analysis was performed on an Elementar Vario EL and with a Metrohm Titroprocessor 686 instrument.

*Preparation of Bromo- or Iodo-*N*-arylpyrrole Derivatives*

Procedure A (**6a–g, 6l, 8a–g, 10a–h, 12a**, **12b, 19a, 23a–c, 25**, and **28**): The mixture of bromo- or iodoaniline (1.0 equiv), 1,4-dione (1.2 equiv), and catalytic amounts of $TsOH{\cdot}H_2O$ (1.0 or 2.0 mol%) in toluene was heated in a flask equipped with a Dean–Stark apparatus for 2–5 h. After cooling, the dark-brown reaction mixture was concentrated in vacuo. Purification by flash chromatography provided the desired bromo- or iodo-*N*-arylpyrrole derivatives.

Procedure B (**6h–k** and **12c**): *i*PrMgCl·LiCl (5.50 mmol, 3.5 mL, 1.55 M in THF) was slowly added to a solution of 1-(2-bromo-4-iodophenyl)-2,5-dimethyl-1*H*-pyrrole (1.88 g, 5.0 mmol) in THF (10 mL) at −30 °C. After 2 h, THF (5 mL) and CuCN·2LiCl (5.0 mmol, 5.0 mL, 1.0 M in THF) was added at this temperature, and the mixture was stirred for 15 min. The acid chloride (7.5 mmol) was added, and the reaction mixture was stirred at −30 °C for 1 h, then warmed to room temperature and stirred for 1 h. Aqueous NH_3 (5 mL) and water (10 mL) were added, and the aqueous phase was extracted with diethyl ether (3×25 mL). The organic fractions were washed with brine (10 mL), dried over Na_2SO_4, and concentrated in vacuo. Purification by flash chromatography provided the desired arylpyrrole derivatives.

*Synthesis of 9*H*-pyrrolo[1,2-*a*]indoles*

Procedure C (**7a–j, 9a–g, 11a–i, 14a–c, 20a–d**, and **24a–c**): The reaction was performed in a sealed tube with a mixture of bromo- or iodo-*N*-arylpyrrole derivative (1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), $(p\text{-Tol})_3P$ (30 mg, 10 mol%), and Cs_2CO_3 (391 mg, 1.2 mmol) at 110 °C with toluene (5 mL) as solvent for 12 h. After the mixture was cooled to room temperature, water (10 mL) was added. The mixture was extracted with diethyl ether (3×30 mL). The combined extracts were washed with brine, dried over Na_2SO_4, and concentrated in vacuo. Purification by flash chromatography provided the desired 9*H*-pyrrolo-[1,2-a]indoles.

6a: Prepared from 2-bromoaniline (3.440 g, 20.0 mmol), 2,5-hexanedione (2.74 g, 24.0 mmol), and $TsOH{\cdot}H_2O$ (38 mg, 1.0 mol%) according to Procedure A. Purification by flash chromatography (pentane/diethyl ether = 100:1) provided **6a** (4.25 g, 85%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2918 (s), 1588 (m), 1524 (s), 1485 (vs), 1436 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.72 (d, J = 8.0 Hz, 1H), 7.40–7.46 (m, 1H), 7.28–7.34 (m, 2H), 5.94 (s, 2H), 1.97 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 138.5, 133.3, 130.5, 129.8, 128.4, 128.1, 124.1, 105.6, 12.5 ppm; MS (EI, 70 ev): m/z (%) = 251 (91) $[M]^+$ (^{81}Br), 250 (100) $[M-H]^+$ (^{81}Br), 249 (91) $[M]^+$ (^{79}Br), 248 (100) $[M-H]^+$ (^{79}Br), 168 (25), 154 (69), 83 (26); HRMS (EI): m/z calcd for $C_{12}H_{12}BrN$: 249.0153 $[M]^+$ (^{79}Br); found: 249.0134.

6b: Prepared from 4-amino-3-iodobenzoic acid ethyl ester[21] (2.91 g, 10.0 mmol), 2,5-hexanedione (1.37 g, 12.0 mmol), and $TsOH{\cdot}H_2O$ (19 mg, 1.0 mol%) according to Procedure A. Reaction time: 4 h. Purification by flash chromatography (pentane/diethyl ether = 15:1) provided **6b** (1.48 g, 40%) as a brown solid. M.p.: 80.2–80.6 °C; IR (neat): $\tilde{\nu}$ = 2915 (w), 1723 (s), 1590 (w), 1483 (s), 1395 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.59 (d, J = 1.8 Hz, 1H), 8.13 (dd, ^1J = 8.0 Hz, ^2J = 1.8 Hz, 1H), 7.32 (d, J = 8.0 Hz, 1H), 5.93 (s, 2H), 4.41 (q, J = 7.1 Hz, 2H), 1.93 (s, 6H), 1.41 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 164.4, 146.2, 140.6, 131.9, 130.3, 129.5, 127.8, 106.3, 100.3, 61.6, 14.3, 12.8 ppm; MS (EI, 70 eV): m/z (%) = 369 (100), 340 (15), 324 (5), 296 (5), 168 (19),

154 (11); HRMS (EI): *m/z* calcd for $C_{15}H_{16}INO_2$: 369.0226 $[M]^+$; found: 369.0219.

6c: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (2.44 g, 10.0 mmol), 2,5-hexanedione (1.37 g, 12.0 mmol) and TsOH·H_2O (19 mg, 1.0 mol %) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **6c** (2.81 g, 87 %) as a brown solid. M.p.: 56.1–56.9 °C; IR (neat): $\tilde{\nu}$ = 2979 (w), 1724 (vs), 1402 (s), 1283 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.37 (d, J = 1.8 Hz, 1H), 8.80 (dd, ^1J = 8.0 Hz, ^2J = 1.8 Hz, 1H), 7.35 (d, J = 8.0 Hz, 1H), 5.93 (s, 2H), 4.41 (q, J = 7.1 Hz, 2H), 1.94 (s, 6H), 1.41 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 164.6, 142.6, 134.4, 132.1, 130.5, 129.3, 128.3, 124.5, 106.2, 61.6, 14.3, 12.5 ppm; MS (EI, 70 eV): *m/z* (%) = 323 (100) $[M]^+$ (^{81}Br), 321 (100) $[M]^+$ (^{79}Br), 294 (70) $[M]^+$ (^{81}Br), 292 (70) $[M]^+$ (^{79}Br), 198 (25), 168 (62), 154 (49); HRMS (EI): *m/z* calcd for $C_{15}H_{16}BrNO_2$: 321.0364 $[M]^+$ (^{79}Br); found: 321.0369.

6d: Prepared from 4-amino-3-iodobenzonitrile[22] (2.44 g, 10.0 mmol), 2,5-hexanedione (1.37 g, 20.0 mmol), and TsOH·H_2O (19 mg, 1.0 mol %) according to Procedure A. Reaction time: 5 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **6d** (1.54 g, 48 %) as a brown solid. M.p.: 102.3–102.8 °C; IR (neat): $\tilde{\nu}$ = 2915 (w), 2231 (w), 1481 (s), 1397 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.23 (d, J = 1.8 Hz, 1H), 7.76 (dd, ^1J = 8.1 Hz, ^2J = 1.8 Hz, 1H), 7.37 (d, J = 8.1 Hz, 1H), 5.94 (s, 2H), 1.93 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 146.7, 142.7, 132.7, 130.2, 127.7, 116.3, 113.9, 106.8, 101.0, 12.7 ppm; MS (EI, 70 eV): *m/z* (%) = 322 (100), 321 (81), 307 (3), 193 (8), 179 (12), 127 (11); HRMS (EI): *m/z* calcd for $C_{13}H_{11}IN_2$: 321.9967 $[M]^+$; found: 321.9977.

6e: Prepared from 4-amino-3-bromobenzonitrile (1.97 g, 10.0 mmol), 2,5-hexanedione (1.37 g, 12.0 mmol), and TsOH·H_2O (19 mg, 1.0 mol %) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **6e** (2.60 g, 94 %) as a brown solid. M.p.: 94.7–95.2 °C; IR (neat): $\tilde{\nu}$ = 2915 (w), 2232 (m), 1487 (vs), 1400 (vs), 1380 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.00 (d, J = 1.8 Hz, 1H), 7.72 (dd, ^1J = 8.0 Hz, ^2J = 1.8 Hz, 1H), 7.39 (d, J = 8.0 Hz, 1H), 5.94 (s, 2H), 1.94 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): 143.2, 136.7, 131.9, 131.4, 128.2, 125.5, 116.6, 114.0, 106.7, 12.5 ppm; MS (EI, 70 eV): *m/z* (%) = 276 (72) $[M]^+$ (^{81}Br), 275 (100) $[M-H]^+$ (^{81}Br), 274 (75) $[M]^+$ (^{79}Br), 273 (100) $[M-H]^+$ (^{79}Br), 261 (5), 193 (11), 179 (55); HRMS (EI): *m/z* calcd for $C_{13}H_{11}BrN_2$: 274.0106 $[M]^+$ (^{79}Br); found: 274.0080.

6f: Prepared from 2-iodo-4-trifluoromethylphenylamine (2.87 g, 10.0 mmol), 2,5-hexanedione (1.37 g, 12.0 mmol), and TsOH·H_2O (19 mg, 1.0 mol %) according to Procedure A. Reaction time: 5 h. Purification by flash chromatography (pentane/diethyl ether = 100:1) provided **6f** (1.83 g, 50 %) as a brown solid. M.p.: 80.6–81.2 °C; IR (neat): $\tilde{\nu}$ = 2921 (m), 1599 (m), 1523 (w), 1491 (m), 1322 (s), 1312 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.20 (s, 1H), 7.75 (d, J = 8.1 Hz, 1H), 7.38 (d, J = 8.1 Hz, 1H), 5.94 (s, 2H), 1.94 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 145.7, 136.5 (q, J_{C-F} = 3.5 Hz), 131.9 (q, J_{C-F} = 33.5 Hz), 130.0, 127.9, 126.2 (q, J_{C-F} = 3.5 Hz), 122.6 (q, J_{C-F} = 273.0 Hz), 106.5, 100.7, 12.8 ppm; MS (EI, 70 eV): *m/z* (%) = 365 (100) $[M]^+$, 236 (14), 222 (16), 168 (6); HRMS (EI): *m/z* calcd for $C_{13}H_{11}BrF_3NI$: 364.9888 $[M]^+$; found: 364.9887.

6g: Prepared from 2-bromo-4-trifluoromethylphenylamine (1.50 g, 6.3 mmol), 2,5-hexanedione (0.86 g, 7.5 mmol), and TsOH·H_2O (12 mg, 1.0 mol %) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 100:1) provided **6g** (1.63 g, 82 %) as a brown solid. M.p.: 74.5–75.3 °C; IR (neat): $\tilde{\nu}$ = 2920 (w), 1483 (s), 1433 (vs), 1338 (vs), 1174 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.86 (d, J = 8.8 Hz, 1H), 7.50–7.60 (m, 2H), 5.94 (s, 2H), 1.95 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 139.5, 134.1, 131.0 (q, J_{C-F} = 33.3 Hz), 128.8, 128.4, 127.5 (q, J_{C-F} = 3.5 Hz), 126.5 (q, J_{C-F} = 3.5 Hz), 123.2 (q, J_{C-F} = 273.2 Hz), 106.4, 12.5 ppm; MS (EI, 70 eV): *m/z* (%) = 319 (82) $[M]^+$ (^{81}Br), 318 (100) $[M-H]^+$ (^{81}Br), 317 (80) $[M]^+$ (^{79}Br), 316 (95) $[M-H]^+$ (^{79}Br), 236 (9), 222 (23), 168 (15); HRMS (EI): *m/z* calcd for $C_{13}H_{11}BrF_3N$: 317.0027 $[M]^+$ (^{79}Br); found: 317.0005.

1-(2-bromo-4-iodophenyl)-2,5-dimethyl-1*H*-pyrrole (**6aa**): Prepared from 2-bromo-4-iodophenylamine (1.79 g, 6.0 mmol), 2,5-hexanedione (0.82 g, 7.2 mmol), and TsOH·H_2O (12 mg, 1.0 mol %) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 100:1) provided **6aa** (1.83 g, 81 %) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2915 (w), 1483 (vs), 1499 (s), 1399(m), 993 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.06 (d, J = 1.8 Hz, 1H), 7.74 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.01 (d, J = 7.9 Hz, 1H), 5.92 (s, 2H), 1.95 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 141.4, 138.4, 137.5, 131.9, 128.3, 125.5, 106.0, 94.0, 12.6 ppm; MS (EI, 70 eV): *m/z* (%) = 377 (100) $[M]^+$ (^{81}Br), 375 (100) $[M]^+$ (^{79}Br), 249 (20), 167 (45), 154 (39), 83 (23); HRMS (EI): *m/z* calcd for $C_{12}H_{11}BrIN$: 374.9120 $[M]^+$ (^{79}Br); found: 374.9075.

6h: Prepared from **6aa** (1.88 g, 5.0 mmol), *i*PrMgCl·LiCl (3.8 mL, 1.55 M in THF), and benzoyl chloride (7.5 mmol) according to Procedure B. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided pure **6h** (1.45 g, 82 %) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2918 (w), 1698 (m), 1661 (s), 1594 (m), 1489 (m), 1401 (m), 1282 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.17 (d, J = 1.9 Hz, 1H), 7.81–7.88 (m, 3H), 7.61–7.68 (m, 1H), 7.51–7.56 (m, 2H), 7.41 (d, J = 1.9 Hz, 1H), 5.96 (s, 2H), 2.01 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75.0 MHz): δ = 194.1, 142.0, 138.8, 136.4, 134.5, 132.9, 130.3, 129.8, 129.6, 128.4, 128.2, 124.6, 106.1, 12.5 ppm; MS (EI, 70 eV): *m/z* (%) = 355 (100) $[M]^+$ (^{81}Br), 353 (98) $[M]^+$ (^{79}Br), 258 (10), 168 (25), 105 (51); HRMS (EI): *m/z* calcd for $C_{19}H_{16}BrNO$: 353.0415 $[M]^+$ (^{79}Br); found: 353.0403.

6i: Prepared from **6aa** (1.88 g, 5.0 mmol), *i*PrMgCl·LiCl (3.8 mL, 1.55 M in THF), and 2,2-dimethylpropionyl chloride (7.5 mmol) according to Procedure B. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided pure **6i** (1.34 g, 82 %) as a white solid. M.p.: 125.1–126.2 °C; IR (neat): $\tilde{\nu}$ = 2963 (w), 1669 (s), 1592 (vs), 1494 (m), 1473 (vs), 1396 (s), 1179 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.99 (d, J = 1.8 Hz, 1H), 7.72 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.31 (d, J = 7.9 Hz, 1H), 5.92 (s, 2H), 1.95 (s, 6H), 1.37 ppm (s, 9H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 207.0, 140.7, 139.8, 132.8, 130.1, 128.4, 127.5, 124.5, 106.1, 44.4, 27.9, 12.6 ppm; MS (EI, 70 eV): *m/z* (%) = 335 (75) $[M]^+$ (^{81}Br), 333 (74) $[M]^+$ (^{79}Br), 276 (24), 248 (100), 167 (47), 154 (35); HRMS (EI): *m/z* calcd for $C_{17}H_{20}BrNO$: 333.0728 $[M]^+$ (^{79}Br); found: 333.0715.

6j: Prepared from **6aa** (1.88 g, 5.0 mmol), *i*PrMgCl·LiCl (3.8 mL, 1.55 M in THF), and cyclohexanecarbonyl chloride (7.5 mmol) according to Procedure B. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided pure **6j** (1.46 g, 81 %) as a white solid. M.p.: 133.6–134.7 °C; IR (neat): $\tilde{\nu}$ = 2932 (m), 1676 (s), 1592 (m), 1492 (m), 1394 (s), 1200 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.24 (d, J = 1.8 Hz, 1H), 7.95 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.37 (d, J = 7.9 Hz, 1H), 5.93 (s, 2H), 3.10–3.30 (m, 1H), 1.95 (s, 6H), 1.20–1.93 ppm (m, 10H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 201.6, 142.4, 137.6, 133.2, 130.7, 128.3, 127.9, 125.1, 106.2, 45.8, 29.3, 25.8, 25.7, 12.6 ppm; MS (EI, 70 eV): *m/z* (%) = 361 (100) $[M]^+$ (^{81}Br), 359 (100) $[M]^+$ (^{79}Br), 248 (34), 167 (20), 154 (10); HRMS (EI): *m/z* calcd for $C_{19}H_{22}BrNO$: 359.0885 $[M]^+$ (^{79}Br); found: 359.0853.

6k: Prepared from **6aa** (1.88 g, 5.0 mmol), *i*PrMgCl·LiCl (3.8 mL, 1.55 M in THF), and DMF (1 mL) according to Procedure B. Purification by flash chromatography (pentane/diethyl ether = 10:1) yielded pure **6k** (1.08 g, 78 %) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2918 (w), 1697 (vs), 1594 (m), 1492 (s), 1397 (s), 1187 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 10.03 (s, 1H), 8.22 (d, J = 1.9 Hz, 1H), 7.94 (d, ^1J = 7.9 Hz, ^2J = 1.7 Hz, 1H), 7.46 (d, J = 7.9 Hz, 1H), 5.94 (s, 2H), 1.96 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 189.6, 143.8, 137.2, 134.1, 131.3, 129.1, 128.1, 125.5, 106.4, 12.5 ppm; MS (EI, 70 eV): *m/z* (%) = 279 (100) $[M]^+$ (^{81}Br), 277 (98) $[M]^+$ (^{79}Br), 182 (10), 168 (40), 154 (25), 128 (8); HRMS (EI): *m/z* calcd for $C_{13}H_{12}BrNO$: 277.0102 $[M]^+$ (^{79}Br); found: 277.0082.

6l: Prepared from 2-iodo-4-nitrophenylamine (5.28 g, 20.0 mmol), 2,5-hexanedione (2.74 g, 24.0 mmol), and TsOH·H_2O (38 mg, 1 mol %) according to Procedure A. Reaction time: 5 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **6l** (3.08 g, 45 %) as a brown solid. M.p.: 114.8–115.2 °C; IR (neat): $\tilde{\nu}$ = 2913 (w), 1594 (m), 1574 (w), 1518 (vs), 1476 (s), 1341 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.78 (d, J = 2.5 Hz, 1H), 8.32 (dd, ^1J = 8.5 Hz, ^2J = 2.5 Hz, 1H), 7.43 (d, J = 8.5 Hz, 1H), 5.95 (s, 2H), 1.95 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 148.3, 147.5, 134.5, 130.1, 127.7, 124.1, 106.9, 100.6, 12.8 ppm; MS (EI, 70 eV): *m/z* (%) = 342 (100), 341 (46), 296 (17), 168

(29), 154 (19); HRMS (EI): *m/z* calcd for $C_{12}H_{11}IN_2O_2$: 341.9865 $[M]^+$; found: 341.9877.

6m: A mixture of 1-(2-bromo-4-nitrophenyl)-2,5-dimethyl-1*H*-pyrrole (1.52 g, 5 mmol), activated carbon (0.24 g, 20 mmol), and $FeCl_3{\cdot}7H_2O$ (144 mg, 0.5 mmol) in MeOH (20 mL) was heated at reflux under nitrogen for 10 min. Hydrazine monohydrate (0.6 mL, 20 mmol) was slowly added, and the mixture was heated at reflux for 6 h. The cooled solution was diluted with CH_2Cl_2 (50 mL) and water (10 mL), and then filtered through celite. The organic layer was separated, dried over Na_2SO_4, and the solvent was removed under reduced pressure. The residue was purified by column chromatography to give **6m** (1.06 g, 80%) as a white solid. M.p.: 109.5–110.9 °C; IR (neat): $\tilde{\nu}$ = 3480 (w), 3429 (w), 3382 (w), 3357 (w), 3342 (w), 2916(w), 1617 (m), 1601 (m), 1503 (s), 1404 (m), 1243 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.02 (d, J = 8.8 Hz, 1H), 6.98 (d, J = 2.6 Hz, 1H), 6.64 (dd, ^1J = 7.9 Hz, ^2J = 2.6 Hz, 1H), 5.89 (s, 2H), 3.84 (brs, 2H), 1.96 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 147.4, 130.6, 128.9, 128.5, 124.7, 118.5, 114.2, 105.0, 12.6 ppm; MS (EI, 70 eV): *m/z* (%) = 266 (100) $[M]^+$(^{81}Br), 264 (100) $[M]^+$ (^{79}Br), 249 (17), 183 (29), 169 (39), 144 (34), 91 (34); HRMS (EI): *m/z* calcd for $C_{12}H_{13}BrN_2$: 264.0262 $[M]^+$ (^{79}Br); found: 264.0271.

8a: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (1.22 g, 5.0 mmol), heptane-2,5-dione (768 mg, 6.0 mmol), and $TsOH{\cdot}H_2O$ (5 mg, 1 mol%) according to Procedure A. Reaction time: 4 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **8a** (1.34 g, 80%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2971 (m), 1721 (vs), 1598 (m), 1495 (m), 1408 (m), 1210 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.37 (d, J = 1.8 Hz, 1H), 8.08 (d, ^1J = 8.2 Hz, ^2J = 1.8 Hz, 1H), 7.36 (d, J = 8.2 Hz, 1H), 6.00 (s, 2H), 4.42 (t, J = 7.1 Hz, 2H), 2.13–2.40 (m, 2H), 1.94 (s, 3H), 1.42 (t, J = 7.1 Hz, 3H), 1.09 ppm (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 164.6, 142.6, 134.8, 134.4, 132.0, 130.6, 129.3, 128.2, 124.6, 106.1, 104.4, 61.6, 20.1, 14.2, 13.0, 12.4 ppm; MS (EI, 70 eV): *m/z* (%) = 337 (56) $[M]^+$ (^{81}Br), 335 (56) $[M]^+$ (^{79}Br), 322 (100), 292 (43), 226 (8), 198 (11), 168 (54); HRMS (EI): *m/z* calcd for $C_{16}H_{18}BrNO_2$: 335.0521 $[M]^+$ (^{79}Br); found: 335.0511.

8b: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (0.98 g, 4.0 mmol), 3-oxo-2-(2-oxopropyl)pentanoic acid ethyl ester (0.96 g, 4.8 mmol), and $TsOH{\cdot}H_2O$ (5 mg, 1 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 6:1) provided **8b** (1.36 g, 83%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2978 (w), 1723 (s), 1698 (vs), 1532 (m), 1494 (m), 1273 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 600 MHz): δ = 8.38 (d, J = 1.9 Hz, 1H), 8.10 (dd, ^1J = 8.1 Hz, ^2J = 1.9 Hz, 1H), 7.34 (d, J = 8.1 Hz, 1H), 6.39 (s, 1H), 4.41 (q, J = 7.2 Hz, 2H), 4.25 (q, J = 7.2 Hz, 2H), 2.72–2.78 (m, 1H), 2.44–2.50 (m, 1H), 1.87 (s, 3H), 1.40 (t, J = 7.2 Hz, 3H), 1.32 (t, J = 7.2 Hz, 3H), 0.96 ppm (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 165.1, 164.4, 141.6, 141.1, 134.6, 132.7, 130.5, 129.4, 128.1, 124.2, 111.6, 108.2, 61.8, 59.3, 19.4, 14.4, 14.24, 14.22, 12.1 ppm; MS (EI, 70 eV): *m/z* (%) = 409 (73) $[M]^+$ (^{81}Br), 407 (72) $[M]^+$ (^{79}Br), 394 (60), 392 (58), 380 (100), 378 (100), 212 (36), 167 (33); HRMS (EI): *m/z* calcd for $C_{19}H_{22}BrNO_4$: 407.0732 $[M]^+$ (^{79}Br); found: 407.0721.

8c: Prepared from 4-amino-3-bromobenzonitrile (0.79 g, 4.0 mmol), 3-oxo-2-(2-oxopropyl)pentanoic acid ethyl ester (0.96 g, 4.8 mmol), and $TsOH{\cdot}H_2O$ (5 mg, 1 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 3:1) provided **8c** (1.16 g, 80%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2977 (w), 2235 (m), 1694 (vs), 1532 (m), 1490 (m), 1192 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 600 MHz): δ = 8.03 (d, J = 1.9 Hz, 1H), 7.75 (dd, ^1J = 8.1 Hz, ^2J = 1.9 Hz, 1H), 7.40 (d, J = 8.1 Hz, 1H), 6.39 (s, 1H), 4.24 (q, J = 7.2 Hz, 2H), 2.70–2.77 (m, 1H), 2.41–2.48 (m, 1H), 1.87 (s, 3H), 1.31 (t, J = 7.2 Hz, 3H), 0.95 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 164.9, 141.7, 141.4, 136.9, 131.9, 131.4, 127.9, 125.2, 116.3, 114.7, 112.0, 108.6, 59.4, 19.3, 14.4, 14.2, 12.1 ppm; MS (EI, 70 eV): *m/z* (%) = 362 (62) $[M]^+$ (^{81}Br), 360 (61) $[M]^+$ (^{79}Br), 347 (40), 345 (41), 333 (99), 331 (100), 207 (36), 193 (71); HRMS (EI): *m/z* calcd for $C_{17}H_{17}BrN_2O_2$: 360.0473 $[M]^+$ (^{79}Br); found: 360.0470.

8d: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (0.98 g, 4.0 mmol), 2-(2-oxopropyl)cyclohexanone (0.74 g, 4.8 mmol), and $TsOH{\cdot}H_2O$ (15 mg, 2 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **8d** (1.04 g, 72%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2925 (m), 1721 (vs), 1598 (m), 1495 (m), 1244 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 600 MHz): δ = 8.35 (d, J = 1.9 Hz, 1H), 8.06 (dd, ^1J = 8.1 Hz, ^2J = 1.9 Hz, 1H), 7.34 (d, J = 8.1 Hz, 1H), 5.83 (s, 1H), 4.41 (q, J = 7.2 Hz, 2H), 2.44–2.58 (m, 2H), 2.08–2.23 (m, 2H), 1.96 (s, 3H), 1.66–1.79 (m, 4H), 1.41 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 164.6, 142.5, 134.3, 131.8, 130.5, 129.2, 127.8, 127.5, 124.3, 117.2, 106.0, 61.6, 23.7, 23.3, 22.9, 22.3, 14.3, 12.1 ppm; MS (EI, 70 eV): *m/z* (%) = 363 (97) $[M]^+$ (^{81}Br), 361 (100) $[M]^+$ (^{79}Br), 335 (60), 333 (62), 254 (12), 208 (11), 181 (41); HRMS (EI): calcd for $C_{18}H_{20}BrNO_2$: 361.0677 $[M]^+$ (^{79}Br); found: 361.0675.

8e: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (0.98 g, 4.0 mmol), 2-(2-oxopropyl)cyclopentanone (0.67 g, 4.8 mmol), and $TsOH{\cdot}H_2O$ (15 mg, 2 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **8e** (0.97 g, 70%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2854 (w), 1718 (vs), 1597 (m), 1498 (m), 1227 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.36 (d, J = 1.9 Hz, 1H), 8.05 (dd, ^1J = 8.1 Hz, ^2J = 1.9 Hz, 1H), 7.34 (d, J = 8.1 Hz, 1H), 5.86 (s, 1H), 4.41 (q, J = 7.2 Hz, 2H), 2.30–2.71 (m, 6H), 2.01 (s, 3H), 1.41 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75.0 MHz): δ = 164.6, 143.0, 137.7, 134.4, 132.1, 131.5, 129.7, 129.1, 125.8, 123.1, 102.9, 61.5, 28.5, 25.7, 25.1, 14.2, 12.8 ppm; MS (EI, 70 eV): *m/z* (%) = 349 (100) $[M]^+$ (^{81}Br), 347 (98) $[M]^+$ (^{79}Br), 321 (10), 319 (10), 268 (25), 240 (23), 194 (16); HRMS (EI): *m/z* calcd for $C_{17}H_{18}BrNO_2$: 347.0521 $[M]^+$ (^{79}Br); found: 347.0522.

8f: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (0.98 g, 4.0 mmol), 7-phenylheptane-2,5-dione (0.98 g, 4.8 mmol), and $TsOH{\cdot}H_2O$ (15 mg, 2 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **8f** (1.24 g, 75%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2898 (w), 1698 (vs), 1619 (s), 1284 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.38 (d, J = 1.9 Hz, 1H), 8.06 (dd, J_1 = 8.1 Hz, J_2 = 1.9 Hz, 1H), 7.11–7.30 (m, 4H), 7.00–7.08 (m, 2H), 5.98–6.05 (m, 2H), 4.43 (q, J = 7.2 Hz, 2H), 2.77–2.88 (m, 2H), 2.41–2.65 (m, 2H), 1.96 (s, 3H), 1.42 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 164.5, 142.4, 141.5, 134.4, 132.5, 132.1, 130.7, 129.3, 128.4, 128.3, 125.9, 124.6, 106.3, 105.5, 61.7, 35.4, 29.0, 14.3, 12.4 ppm; MS (EI, 70 eV): *m/z* (%) = 413 (10) $[M]^+$ (^{81}Br), 411 (10) $[M]^+$ (^{79}Br), 322 (100), 320 (100), 292 (8), 168 (11); HRMS (EI): *m/z* calcd for $C_{22}H_{22}BrNO_2$: 411.0834 $[M]^+$ (^{79}Br); found: 411.0848.

8g: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (1.22 g, 5.0 mmol), 2-acetyl-4-oxopentanoic acid ethyl ester (1.12 g, 6.0 mmol), and $TsOH{\cdot}H_2O$ (15 mg, 2 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane/diethyl ether = 3:1) provided **8g** (1.60 g, 81%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2979 (m), 1722 (s), 1697 (vs), 1538 (m), 1495 (m), 1410 (m), 1254 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.37 (d, J = 1.9 Hz, 1H), 8.09 (dd, ^1J = 8.1 Hz, ^2J = 1.9 Hz, 1H), 7.30 (d, J = 8.1 Hz, 1H), 6.38 (s, 1H), 4.39 (q, J = 7.2 Hz, 2H), 4.24 (q, J = 7.2 Hz, 2H), 2.19 (s, 3H), 1.88 (s, 3H), 1.39 (t, J = 7.2 Hz, 3H), 1.31 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.4, 164.3, 141.1, 135.6, 134.6, 132.7, 130.3, 129.5, 128.0, 124.0, 112.2, 107.9, 61.8, 59.3, 14.5, 14.2, 12.2, 11.9 ppm; MS (EI, 70 eV): *m/z* (%) = 395 (92) $[M]^+$ (^{81}Br), 393 (92) $[M]^+$ (^{79}Br), 366 (100), 364 (100), 350 (31), 348 (31), 240 (29), 168 (25); HRMS (EI): *m/z* calcd for $C_{18}H_{20}BrNO_4$: 393.0576 $[M]^+$ (^{79}Br); found: 393.0552.

10a: Prepared from 2-bromophenylamine (344 mg, 2.0 mmol), 1-phenylpentane-1,4-dione (394 mg, 2.2 mmol), and $TsOH{\cdot}H_2O$ (8 mg, 2 mol%) according to Procedure A. Reaction time: 2 h. Purification by flash chromatography (pentane) provided **10a** (445 mg, 71%) as a white solid. M.p.: 96.9–98.5 °C; IR (neat): $\tilde{\nu}$ = 2913 (w), 1646 (w), 1602 (w), 1516 (m), 1482 (s), 1395 (m), 1022 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.67 (d, J = 7.9 Hz, 1H), 7.23–7.38 (m, 3H), 7.07–7.20 (m, 5H), 6.41 (d, J = 3.5 Hz, 1H), 6.15 (d, J = 3.5 Hz, 1H), 2.08 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 139.0, 134.3, 133.31, 133.28, 131.6, 131.1, 129.6, 128.1, 128.0, 127.4, 125.9, 124.4, 108.4, 107.4, 12.7 ppm; MS (EI, 70 eV): *m/z* (%) = 313 (100) $[M]^+$ (^{81}Br), 311 (100) $[M]^+$ (^{79}Br), 230 (82), 217 (85), 154 (12), 115 (29); HRMS (EI): *m/z* calcd for $C_{17}H_{14}BrN$: 311.0310 $[M]^+$ (^{79}Br); found: 311.0319.

10b: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (1.22 g, 5.0 mmol), 1-phenylpentane-1,4-dione (0.97 g, 5.5 mmol), and TsOH·H_2O (10 mg, 1 mol%) according to Procedure A. Reaction time: 4 h. Purification by flash chromatography (pentane/diethyl ether = 20:1) provided **10b** (1.71 g, 89%) as a brown solid. M.p.: 92.3–93.6 °C; IR (neat): $\tilde{\nu}$ = 2903 (w), 1716 (vs), 1598 (m), 1496 (m), 1395 (s), 1240 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.32 (d, J = 1.8 Hz, 1H), 7.98 (dd, ^1J = 8.2 Hz, ^2J = 1.8 Hz, 1H), 7.29 (d, J = 8.2 Hz, 1H), 7.05–7.17 (m, 5H), 6.38 (d, J = 3.4 Hz, 1H), 6.13 (dd, ^1J = 3.4 Hz, ^2J = 0.8 Hz, 1 H), 4.39 (q, J = 7.1 Hz, 2H), 2.05 (d, J = 0.8 Hz, 3H), 1.40 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 164.6, 143.1, 134.5, 134.4, 133.0, 131.8, 131.4, 131.0, 129.2, 128.1, 127.5, 126.1, 124.4, 108.9, 108.0, 61.6, 14.2, 12.7 ppm; MS (EI, 70 eV): m/z (%) = 385 (100) $[M]^+$ (^{81}Br), 383 (100) $[M]^+$ (^{79}Br), 276 (40), 261 (36), 230 (63), 115 (21); HRMS (EI): m/z calcd for $C_{20}H_{18}BrNO_2$: 383.0521 $[M]^+$ (^{79}Br); found: 383.0499.

10c: Prepared from 2-bromo-4-trifluoromethylphenylamine (720 mg, 3.0 mmol), 1-phenylpentane-1,4-dione (630 mg, 3.6 mmol), and TsOH·H_2O (6 mg, 1 mol%) according to Procedure A. Reaction time: 4 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **10c** (920 mg, 81%) as a white solid. M.p.: 90.6–91.9 °C; IR (neat): $\tilde{\nu}$ = 2914 (w), 1605 (w), 1519 (w), 1500 (m), 1389 (m), 1325 (s), 1316 (s), 1128 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.93 (s, 1H), 7.58 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.36 (d, J = 7.9 Hz, 1H), 7.03–7.20 (m, 5H), 6.39 (d, J = 3.5 Hz, 1H), 6.15 (d, J = 3.5 Hz, 1H), 2.06 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 142.5, 134.5, 132.9, 131.7 (q, J_{C-F} = 33.2 Hz), 131.5, 131.4, 130.5 (q, J_{C-F} = 3.3 Hz), 128.2, 127.5, 126.3, 125.1 (q, J_{C-F} = 3.3 Hz), 124.9, 122.8, 109.1, 108.2, 12.7 ppm; MS (EI, 70 eV): m/z (%) = 381 (100) $[M]^+$ (^{81}Br), 379 (100) $[M]^+$ (^{79}Br), 298 (54), 285 (63), 230 (10), 115 (10); HRMS (EI): m/z calcd for $C_{18}H_{13}BrF_3N$: 379.0183 $[M]^+$ (^{79}Br); found: 379.0193.

10d: Prepared from 1-(4-amino-3-bromophenyl)ethanone (1.07 g, 5.0 mmol), 1-phenylpentane-1,4-dione (1.06 g, 6.0 mmol), and TsOH·H_2O (19 mg, 2 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 5:1) provided **10d** (1.33 g, 75%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2917 (w), 1687 (vs), 1593 (m), 1490 (m), 1388 (s), 1231 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.22 (d, J = 1.8 Hz, 1H), 7.88 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.32 (d, J = 7.9 Hz, 1H), 7.05–7.20 (m, 5H), 6.38 (d, J = 3.5 Hz, 1H), 6.14 (d, J = 3.5 Hz, 1H), 2.60 (s, 3H), 2.05 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75.0 MHz): δ = 195.7, 143.2, 137.8, 134.4, 133.3, 132.9, 131.4, 131.2, 128.1, 127.8, 127.4, 126.1, 124.9, 109.0, 108.0, 26.6, 12.7 ppm; MS (EI, 70 eV): m/z (%) 355 (100) $[M]^+$ (^{81}Br), 353 (100) $[M]^+$ (^{79}Br), 274(34), 259 (43), 230 (95), 115 (30); HRMS (ESI): m/z (%) calcd for $C_{19}H_{17}BrNO$: 354.0494 $[M+H]^+$ (^{79}Br); found: 354.0483.

10e: Prepared from 2-bromophenylamine (0.86 g, 5.0 mmol), 3-oxo-2-(2-oxo-2-phenylethyl)butyric acid ethyl ester (1.49 g, 6.0 mmol), and TsOH·H_2O (10 mg, 1 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **10e** (1.72 g, 89%) as a colorless oil. IR (neat): $\tilde{\nu}$ = 2978 (w), 1717 (vs), 1700 (m), 1559 (m), 1493 (s), 1250 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.68 (d, J = 7.9 Hz, 1H), 7.07–7.40 (m, 8H), 6.84 (s, 1H), 4.34 (q, J = 7.1 Hz, 2H), 2.35 (s, 3H), 1.40 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75.0 MHz): δ = 165.4, 138.0, 137.7, 133.8, 133.5, 132.1, 130.8, 130.3, 128.3, 128.0, 127.9, 126.7, 124.0, 113.0, 109.8, 59.5, 14.5, 12.0 ppm; MS (EI, 70 eV): m/z (%) = 385 (51) $[M]^+$ (^{81}Br), 383 (51) $[M]^+$ (^{79}Br), 354 (49), 274 (9), 230 (100), 216 (11), 128 (11); HRMS (EI): m/z calcd for $C_{20}H_{18}BrNO_2$: 383.0521 $[M]^+$ (^{79}Br); found: 383.0485.

10f: Prepared from 2-bromo-4-trifluoromethylphenylamine (1.20 g, 5.0 mmol), 3-oxo-2-(2-oxo-2-phenylethyl)butyric acid ethyl ester (1.49 g, 6.0 mmol), and TsOH·H_2O (10 mg, 1 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 8:1) provided **10f** (1.85 g, 82%) as a white solid. M.p.: 81.3–82.7 °C; IR (neat): $\tilde{\nu}$ = 2986 (w), 1694 (vs), 1606 (m), 1379 (m), 1318 (s), 1223 (s), 1318 (s), 1072 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.92 (d, J = 1.8 Hz, 1H), 7.59 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.32 (d, J = 8.8 Hz, 1H), 7.11–7.20 (m, 3H), 7.01–7.10 (m, 2H), 6.81 (s, 1H), .4.32 (q, J = 7.1 Hz, 2H), 2.32 (s, 3H), 1.37 (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.3, 141.1, 137.7, 133.9, 132.4 (J_{C-F} = 33.2 Hz), 131.7, 131.4, 130.7 (J_{C-F} = 3.3 Hz), 128.3, 128.0, 127.1, 125.3 (J_{C-F} = 3.3 Hz), 124.7, 122.6 (J_{C-F} = 273.1 Hz), 113.7, 110.4, 59.7, 14.5, 12.1 ppm; MS (EI, 70 eV): m/z (%) = 453 (36) $[M]^+$ (^{81}Br), 451 (36) $[M]^+$ (^{79}Br), 424 (40), 342 (13), 298 (100), 228 (35), 128 (37); HRMS (EI): m/z calcd for $C_{21}H_{17}BrF_3NO_2$: 451.0395 $[M]^+$ (^{79}Br); found: 451.0357.

10g: Prepared from 4-amino-3-bromobenzoic acid ethyl ester (452 mg, 1.8 mmol), 3-oxo-2-(2-oxo-2-phenylethyl)butyric acid ethyl ester (546 mg, 2.2 mmol), and TsOH·H_2O (7 mg, 2 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 2:1) provided **10g** (591 mg, 72%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2933 (w), 1721 (s), 1700 (s), 1492 (m), 1449 (m), 1388 (m), 1274 (s), 1230 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.36 (s, 1H), 8.03 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.31 (d, J = 7.9 Hz, 1H), 7.00–7.25 (m, 5H), 6.85 (s, 1H), 4.42 (q, J = 7.1 Hz, 2H), 4.35 (q, J = 7.1 Hz, 2H), 2.36 (s, 3H), 1.36–1.46 ppm (m, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.2, 164.2, 141.5, 137.6, 134.5, 133.8, 132.3, 131.8, 130.8, 129.2, 128.1, 127.9, 126.9, 124.1, 113.4, 110.1, 61.7, 59.5, 14.4, 14.2, 12.0 ppm; MS (EI, 70 eV): m/z (%) = 457 (100) $[M]^+$ (^{81}Br), 455 (100) $[M]^+$ (^{79}Br), 428 (84), 302 (43), 274 (97), 228 (95), 128 (33); HRMS (EI): m/z calcd for $C_{23}H_{22}BrNO_4$: 455.0732 $[M]^+$ (^{79}Br); found: 455.0741.

10h: Prepared from 1-(4-amino-3-bromophenyl)ethanone (642 mg, 3.0 mmol), 3-oxo-2-(2-oxo-2-phenylethyl)butyric acid ethyl ester (893 mg, 3.6 mmol), and TsOH·H_2O (11 mg, 2 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 2:1) provided **10h** (891 mg, 69%) as a yellow solid. M.p.: 163.5–164.7 °C; IR (neat): $\tilde{\nu}$ = 2982 (w), 1682 (vs), 1558 (m), 1411 (m), 1250 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.21 (d, J = 1.8 Hz, 1H), 7.87 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.28 (d, J = 7.9 Hz, 1H), 7.03–7.20 (m, 5H), 6.80(s, 1H), 4.30 (q, J = 7.1 Hz, 2H), 2.59 (s, 3H), 2.31 (s, 3H), 1.35–1.38 ppm (m, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 195.5, 165.3, 141.8, 138.4, 137.7, 133.8, 133.4, 131.8, 131.2, 128.2, 127.99, 127.96, 127.0, 124.7, 113.6, 110.3, 59.6, 26.6, 14.5, 12.1 ppm; MS (EI, 70 eV): m/z (%) = 427 (100) $[M]^+$ (^{81}Br), 425 (100) $[M]^+$ (^{79}Br), 396 (84), 382 (33), 272 (60), 230 (75); HRMS (EI): m/z calcd for $C_{22}H_{20}BrNO_3$: 425.0627 $[M]^+$ (^{79}Br); found: 425.0598.

10i: $NaBH_4$ (98 mg, 2.6 mmol) was added to a solution of **10d** (789 mg, 2.2 mmol) in CH_3OH (25 mL) at 0 °C. After the mixture was stirred for 2 h at this temperature, water (1 mL) was added, and the CH_3OH was removed in vacuo. Purification by flash chromatography (pentane/diethyl ether = 3:1) provided **10i** (705 mg, 90%) as a yellow solid. M.p.: 93.7–94.8 °C; IR (neat): $\tilde{\nu}$ = 3266 (m), 2919 (w), 1600 (w), 1515 (m), 1494 (m), 1393 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.72 (dd, ^1J = 11.5 Hz, ^2J = 1.8 Hz, 1H), 7.21–7.40 (m, 2H), 7.07–7.21 (m, 5H), 6.43 (d, J = 3.5 Hz, 1H), 6.17 (d, J = 3.5 Hz, 1H), 4.92 (q, J = 7.1 Hz, 1H), 2.16 (brs, 1H), 2.10 (s, 3H), 1.54 ppm (d, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 147.7, 137.8, 134.3, 133.3, 131.7, (130.9, 130.8), (130.15, 130.10), 128.0, 127.4, 125.9, (125.1, 125.0), (124.4, 124.3), 108.4, 107.4, 69.1, 25.2, 12.7 ppm (values in brackets indicate that two diastereomers were formed); MS (EI, 70 eV): m/z (%) = 357 (100) $[M]^+$ (^{81}Br), 355 (100) $[M]^+$ (^{79}Br), 276 (24), 260 (23), 232 (60), 217 (65), 115 (22); HRMS (EI): m/z calcd for $C_{19}H_{18}BrNO$: 355.0572 $[M]^+$ (^{79}Br); found: 355.0572.

25: Prepared from 2,4-dibromophenylamine (1.25 g, 5.0 mmol), 3-oxo-2-(2-oxo-2-phenylethyl)butyric acid ethyl ester (1.49 g, 6.0 mmol), and TsOH·H_2O (10 mg, 1 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 4:1) provided **25** (1.92 g, 83%) as a white solid. M.p.: 103.5–105.2 °C; IR (neat): $\tilde{\nu}$ = 2974 (w), 1694 (s), 1474 (s), 1420 (s), 1217 (s), 1072 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.80 (d, J = 2.6 Hz, 1H), 7.45 (dd, ^1J = 8.8 Hz, ^2J = 1.8 Hz, 1H), 7.13–7.20 (m, 3H), 7.02–7.11 (m, 3H), 6.79 (s, 1H), 4.31 (q, J = 7.1 Hz, 2H), 2.31 (s, 3H), 1.36 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.3, 137.8, 136.9, 135.9, 133.8, 131.85, 131.80, 131.5, 128.2, 128.0, 127.0, 124.9, 123.2, 113.3, 110.1, 59.6, 14.5, 12.0 ppm; MS (EI, 70 eV): m/z (%) = 465 (45) $[M]^+$ ($^{81}Br^{81}Br$), 463 (90) $[M]^+$ ($^{79}Br^{81}Br$), 461 (45) $[M]^+$ ($^{79}Br^{79}Br$), 434 (85), 418 (33), 310 (65), 274 (33), 228 (100), 129 (34); HRMS (EI): m/z calcd for $C_{20}H_{17}Br_2NO_2$: 460.9626 $[M]^+$ ($^{79}Br^{79}Br$); found: 460.9620.

28: Prepared from 2-bromophenylamine (0.86 g, 5.0 mmol), 3-oxo-2-(2-oxo-2-phenylethyl)butyric acid ethyl ester (1.49 g, 6.0 mmol), and

$TsOH{\cdot}H_2O$ (10 mg, 1 mol%) according to Procedure A. Reaction time: 3 h. Purification by flash chromatography (pentane/diethyl ether = 5:1) provided **28** (1.99 g, 86%) as a white solid. M.p.: 95.8–96.7 °C; IR (neat): $\tilde{\nu}$ = 2974 (w), 1692 (s), 1566 (m), 1558 (m), 1479 (m), 1417 (m), 1226 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.66 (d, J = 7.9 Hz, 1H), 7.17–7.39 (m, 5H), 6.95 (d, J = 8.8 Hz, 2H), 6.82 (s, 1H), 4.32 (q, J = 7.1 Hz, 2H), 2.32 (s, 3H), 1.37 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.2, 138.4, 137.4, 133.6, 132.6, 131.2, 131.0, 130.7, 130.5, 129.3, 128.4, 123.9, 120.8, 113.2, 110.2, 59.6, 14.5, 12.0 ppm; MS (EI, 70 eV): m/z (%) = 465 (50) $[M]^+$ ($^{81}Br^{81}Br$), 463 (99) $[M]^+$ ($^{79}Br^{81}Br$), 461 (50) $[M]^+$ ($^{79}Br^{79}Br$), 434 (85), 418 (33), 308 (99), 274 (33), 228 (100), 129 (34); HRMS (EI): m/z calcd for $C_{20}H_{18}Br_2NO_2$: 461.9704 $[M+H]^+$ ($^{79}Br^{79}Br$); found: 461.9697.

7a: Prepared from **6a** according to Procedure C. Purification by flash chromatography (hexane) provided **7a** (144 mg, 85%) as a white solid. M.p.: 61.0–61.5 °C; IR (KBr): $\tilde{\nu}$ = 2918 (w), 1614 (m), 1597 (m), 1489 (s), 1455 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.34–7.44 (m, 2H), 7.27 (t, J = 7.7 Hz, 1H), 7.06 (t, J = 7.7 Hz, 1H), 6.00–6.05 (m, 1H), 5.94–5.99 (m, 1H), 3.80 (s, 2H), 2.58 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 142.0, 135.3, 134.5, 127.2, 125.9, 122.5 (2C), 111.2, 110.4, 100.5, 28.8, 13.2 ppm; MS (EI, 70 eV): m/z (%) = 169 (86) $[M]^+$, 154 (100), 139 (5), 83 (27); HRMS (EI): m/z calcd for $C_{12}H_{11}N$: 169.0891 $[M]^+$; found: 169.0884.

7b: Prepared from **6b** according to Procedure C. Purification by flash chromatography (hexane/diethyl ether = 20:1) afforded **7b** (195 mg, 81%) as a white solid. The yield was 83% from **6c**. M.p.: 77.9–78.9 °C; IR (neat): $\tilde{\nu}$ = 2984 (w), 1704 (s), 1612 (m), 1600 (m), 1408 (s), 1271 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.96–8.05 (m, 2H), 7.35 (d, J = 8.0 Hz, 1H), 6.03–6.05 (m, 1H), 5.95–5.99 (m, 1H), 4.37 (q, J = 7.1 Hz, 2H), 3.79 (s, 2H), 2.56 (d, J = 0.9 Hz, 3H), 1.40 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.4, 145.4, 135.3, 135.2, 130.0, 127.0, 124.6, 122.8, 112.5, 109.6, 101.4, 60.8, 28.4, 14.3, 13.1 ppm; MS (EI, 70 eV): m/z (%) = 241 (86) $[M]^+$, 226 (33), 212 (31), 198 (32), 168 (100), 90 (6); HRMS (EI): m/z calcd for $C_{15}H_{15}NO_2$: 241.1103 $[M]^+$; found: 241.1113.

7c: Prepared from **6d** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **7c** (136 mg, 70%) as a white solid. The yield was 60% from **6e**. M.p.: 171.3–171.9 °C; IR (KBr): $\tilde{\nu}$ = 2898 (m), 2220 (m), 1614 (s), 1565 (m), 1492 (s), 1411 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.60 (s, 1H), 7.56 (d, J = 8.0 Hz, 1H), 7.36 (d, J = 8.0 Hz, 1H), 6.03–6.07 (m, 1H), 5.97–6.00 (m, 1H), 3.77 (s, 2H), 2.53 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 145.0, 136.2, 134.6, 132.6, 129.0, 122.9, 119.2, 113.2, 110.4, 105.4, 101.9, 28.3, 13.0 ppm; MS (EI, 70 eV): m/z (%) = 194 (76) $[M]^+$, 179 (100), 164 (6), 140 (5); HRMS (EI): m/z calcd for $C_{13}H_{10}N_2$: 194.0844 $[M]^+$; found: 194.0837.

7d: Prepared from **6f** according to Procedure C. Purification by flash chromatography (pentane) afforded **7d** (182 mg, 77%) as a white solid. M.p.: 63.0–63.8 °C; IR (KBr): $\tilde{\nu}$ = 2918 (w), 1623 (m), 1573 (w), 1497 (s), 1410 (s), 1320 (vs), 1282 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.60 (s, 1H), 7.55 (d, J = 8.0 Hz, 1H), 7.40 (d, J = 8.0 Hz, 1H), 6.04–6.06 (m, 1H), 5.98–6.01 (m, 1H), 3.81 (s, 2H), 2.56 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 144.5, 136.0, 134.8, 125.2 (q, J_{C-F} = 3.9 Hz), 124.5 (q, J_{C-F} = 271.2 Hz), 124.6 (q, J_{C-F} = 32.3 Hz), 122.9 (2xC), 112.5, 109.9, 101.5, 28.6, 13.1 ppm; MS (EI, 70 eV): m/z (%) = 237 (67) $[M]^+$, 222 (100), 168 (26); HRMS (EI): m/z calcd for $C_{13}H_{10}F_3N$: 237.0765 $[M]^+$; found: 237.0773.

7e: Prepared from **6g** according to Procedure C. Purification by flash chromatography (pentane) afforded **7e** (153 mg, 65%) as a white solid. M.p.: 51.7–52.5 °C; IR (KBr): $\tilde{\nu}$ = 2976 (w), 1629 (m), 1599 (m), 1500 (s), 1474 (vs), 1338 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.54 (s, 1H), 7.45 (d, J = 7.7 Hz, 1H), 7.33 (d, J = 7.7 Hz, 1H), 6.01–6.08 (m, 1H), 5.95–6.00 (m, 1H), 3.83 (s, 2H), 2.58 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 142.3, 139.4, 134.4, 130.0 (q, J_{C-F} = 32.3 Hz), 125.9, 122.8, 124.2 (q, J_{C-F} = 272.2 Hz), 119.5 (q, J_{C-F} = 3.9 Hz), 112.2, 106.9 (q, J_{C-F} = 3.8 Hz), 101.3, 28.7, 13.1 ppm; MS (EI, 70 eV): m/z (%) = 237 (77) $[M]^+$, 235 (72), 222 (100), 168 (26); HRMS (EI): calcd for $C_{13}H_{10}F_3N$: 237.0765 $[M]^+$; found: 237.0772.

7f: Prepared from **6h** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 4:1) afforded **7f** (167 mg, 61%) as a white solid. M.p.: 105.4–106.0 °C; IR (KBr): $\tilde{\nu}$ = 3066 (w), 1645 (m), 1607 (s), 1595 (s), 1489 (m), 1444 (m), 1408 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.89 (s, 1H), 7.73–7.82 (m, 3H), 7.54–7.60 (m, 1H), 7.44–7.51 (m, 2H), 7.41 (d, J = 8.3 Hz, 1H), 6.03–6.09 (m, 1H), 5.97–6.02 (m, 1H), 3.84 (s, 2H), 2.57 ppm (d, J = 1.0 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 195.7, 145.4, 138.2, 135.6, 135.3, 132.0, 131.8, 131.4, 129.7, 128.2, 127.8, 123.0, 112.7, 109.5, 101.7, 28.6, 13.2 ppm; MS (EI, 70 eV): m/z (%) = 273 (100) $[M]^+$, 258 (50), 196 (10), 168 (86), 105 (23); HRMS (EI): m/z calcd for $C_{19}H_{15}NO$: 273.1154 $[M]^+$; found: 273.1163.

7g: Prepared from **6i** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 15:1) afforded **7g** (167 mg, 66%) as a white solid. M.p.: 142.4–143.8 °C; IR (neat): $\tilde{\nu}$ = 2952 (w), 1649 (s), 1609 (vs), 1569 (m), 1409 (vs), 1194 cm^{-1} (vs); ^1H NMR (C_6D_6, 400 MHz): δ = 7.74 (s, 1H), 7.71 (d, J = 8.2 Hz, 1H), 6.87 (d, J = 8.2 Hz, 1H), 6.07–6.13 (m, 1H), 5.97–6.03 (m, 1H), 3.31 (s, 2H), 2.23 (s, 3H), 1.31 ppm (s, 9H); ^{13}C NMR (C_6D_6, 100 MHz): δ = 205.0, 144.3, 135.4, 135.1, 132.2, 129.2, 126.9, 122.5, 113.0, 109.3, 102.0, 43.9, 28.51, 28.49, 13.0 ppm; MS (EI, 70 eV): m/z (%) 253 (32) $[M]^+$, 196 (100), 167 (30), 153 (8); HRMS (EI): m/z calcd for $C_{17}H_{19}NO$: 253.1467 $[M]^+$; found: 253.1459.

7h: Prepared from **6j** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **7h** (192 mg, 69%) as a white solid. M.p.: 134.0–134.6 °C; IR (neat): $\tilde{\nu}$ = 2917 (w), 1668 (s), 1610 (w), 1593 (m), 1495 (m), 1180 cm^{-1} (m); ^1H NMR (C_6D_6, 400 MHz): δ = 7.87 (s, 1H), 7.82 (d, J = 8.2 Hz, 1H), 6.94 (d, J = 8.2 Hz, 1H), 6.07–6.13 (m, 1H), 5.97–6.03 (m, 1H), 3.33 (s, 2H), 3.00–3.10 (m, 1H), 2.22 (s, 3H), 1.82–1.96 (m, 2H), 1.50–1.80 (m, 5H), 1.10–1.32 ppm (m, 3H); ^{13}C NMR (C_6D_6, 100 MHz): δ = 201.0, 145.4, 136.0, 135.3, 131.3, 129.2, 126.3, 122.7, 113.3, 109.8, 102.2, 45.6, 30.0, 28.5, 26.4, 26.2, 13.1 ppm; MS (EI, 70 eV): m/z (%) = 279 (26) $[M]^+$, 264 (1), 224 (4), 211 (3), 196 (100), 168 (25); HRMS (EI): m/z calcd for $C_{19}H_{21}NO$: 279.1623 $[M]^+$; found: 279.1609.

7i: Prepared from **6k** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **7i** (108 mg, 55%) as a white solid. M.p.: 111.1–111.8 °C; IR (neat): $\tilde{\nu}$ = 2892 (w), 1683 (s), 1607 (s), 1567 (m), 1493 (s), 1207 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 9.92 (s, 1H), 7.88 (s, 1H), 7.79 (d, J = 8.1 Hz, 1H), 7.45 (d, J = 8.1 Hz, 1H), 6.04–6.10 (m, 1H), 5.95–6.03 (m, 1H), 3.83 (s, 2H), 2.57 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 190.9, 146.7, 136.3, 135.4, 131.9, 131.4, 126.2, 123.1, 113.2, 110.1, 101.9, 28.4, 13.2 ppm; MS (EI, 70 eV): m/z (%) = 197 (100) $[M]^+$; 182 (90), 168 (91), 154 (16), 139 (8); HRMS (EI): m/z calcd for $C_{13}H_{11}NO$: 197.0841 $[M]^+$, found: 197.0841.

7j: Prepared from **6l** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 6:1) afforded **7j** (70 mg, 33%) as golden crystals. M.p.: 142.0–142.5 °C; IR (KBr): $\tilde{\nu}$ = 2906 (w), 1620 (m), 1601 (m), 1574 (m), 1508 (s), 1486 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.19–8.25 (m, 2H), 7.37 (d, J = 7.1 Hz, 1H), 6.06–6.09 (m, 1H), 6.00–6.02 (m, 1H), 3.83 (s, 2H), 2.55 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 146.6, 143.0, 136.4, 135.3, 124.8, 123.2, 121.5, 113.7, 109.4, 102.5, 28.5, 13.0 ppm; MS (EI, 70 eV): m/z (%) = 214 (100) $[M]^+$, 199 (76), 167 (89), 153 (35); HRMS (EI): m/z calcd for $C_{12}H_{10}N_2O_2$: 214.0742 $[M]^+$; found: 214.0753.

9a: Prepared from **8a** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 15:1) afforded **9a** (179 mg, 70%) as a white solid. M.p.: 66.5–67.5 °C; IR (neat): $\tilde{\nu}$ = 2982 (m), 1710 (vs), 1602 (m), 1614 (m), 1489 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.03 (s, 1H), 8.01 (d, J = 8.8 Hz, 1H), 7.34 (d, J = 8.8 Hz, 1H), 6.05–6.10 (m, 1H), 5.98–6.03 (m, 1H), 4.37 (q, J = 7.0 Hz, 2H), 3.82 (s, 2H), 2.95 (q, J = 7.6 Hz, 2H), 1.40 (t, J = 7.0 Hz, 3H), 1.35 ppm (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.4, 145.3, 135.4, 135.3, 130.1, 129.6, 127.0, 124.6, 110.5, 110.0, 101.4, 60.8, 28.5, 20.6, 14.4, 13.0 ppm; MS (EI, 70 eV): m/z (%) = 255 (100) $[M]^+$, 240 (44), 226 (100), 198 (23), 167 (60); HRMS (EI): m/z calcd for $C_{16}H_{17}NO_2$: 255.1259 $[M]^+$; found: 255.1252.

9b: Prepared from **8b** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded **9b** (262 mg, 80%)

as a white solid. M.p.: 115.0–116.0 °C; IR (neat): $\tilde{\nu}$ = 2971 (m), 1712 (vs), 1701 (vs), 1616 (m), 1490 (s), 1263 cm^{-1} (s); ^1H NMR ($CDCl_3$, 600 MHz): δ = 8.04–8.08 (m, 2H), 7.45 (d, J = 9.0 Hz, 1H), 6.46 (t, J = 1.6 Hz, 1H), 4.37 (q, J = 7.2 Hz, 2H), 4.27 (q, J = 7.2 Hz, 2H), 3.83 (s, 2H), 3.34 (q, J = 7.6 Hz, 2H), 1.39 (t, J = 7.2 Hz, 3H), 1.34 (t, J = 7.2 Hz, 3H), 1.30 ppm (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 166.1, 165.3, 144.3, 135.9, 135.8, 134.1, 130.3, 127.2, 126.2, 116.6, 111.3, 103.4, 61.0, 59.5, 28.3, 19.0, 14.4, 14.3, 13.8 ppm; MS (EI, 70 eV): m/z (%) = 327 (74) $[M]^+$, 312 (34), 298 (53), 282 (28), 254 (100), 211 (20), 180 (30); HRMS (EI): m/z calcd for $C_{19}H_{21}NO_4$: 327.1471 $[M]^+$; found: 327.1477.

9c: Prepared from **8c** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded **9c** (227 mg, 81%) as a white solid. M.p.: 174.1–175.4 °C; IR (neat): $\tilde{\nu}$ = 2979 (m), 2218 (s), 1694 (vs), 1612 (m), 1485 cm^{-1} (s); ^1H NMR ($CDCl_3$, 600 MHz): δ = 7.66 (s, 1H), 7.65 (d, J = 8.6 Hz, 1H), 7.49 (d, J = 8.6 Hz, 1H), 6.48 (t, J = 1.6 Hz, 1H), 4.28 (q, J = 7.2 Hz, 2H), 3.85 (s, 2H), 3.32 (q, J = 7.6 Hz, 2H), 1.34 (t, J = 7.2 Hz, 3H), 1.29 ppm (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 165.0, 144.1, 136.8, 136.0, 133.5, 132.9, 129.4, 118.8, 117.3, 112.2, 107.3, 103.8, 59.7, 28.3, 18.9, 14.4, 13.7 ppm; MS (EI, 70 eV): m/z (%) = 280 (84) $[M]^+$, 265 (34), 251 (73), 235 (48), 207 (100), 192 (55); HRMS (EI): m/z calcd for $C_{17}H_{16}N_2O_2$: 280.1212 $[M]^+$; found: 280.1226.

9d: Prepared from **8d** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **9d** (180 mg, 64%) as a white solid. M.p.: 127.0–127.5 °C; IR (neat): $\tilde{\nu}$ = 2920 (w), 1706 (s), 1617 (m), 1498 (m), 1444 (m), 1278 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.05 (s, 1H), 8.04 (d, J = 8.1 Hz, 1H), 7.28 (d, J = 8.1 Hz, 1H), 5.94 (s, 1H), 4.42 (q, J = 7.1 Hz, 2H), 3.84 (s, 2H), 2.98 (t, J = 5.6 Hz, 2H), 2.62 (t, J = 5.6 Hz, 2H), 1.89–2.04 (m, 2H), 1.77–1.89 (m, 2H), 1.45 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.5, 145.3, 134.8, 134.3, 130.2, 126.9, 124.1, 123.9, 121.8, 109.2, 101.5, 60.7, 28.5, 23.7, 23.3, 23.2, 22.7, 14.4 ppm; MS (EI, 70 eV): m/z (%) 281 (100) $[M]^+$, 253 (62) $[M]^+$, 236 (10), 208 (58), 180 (53); HRMS (EI): m/z calcd for $C_{18}H_{19}NO_2$: 281.1416 $[M]^+$; found: 281.1396.

9e: Prepared from **8e** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **9e** (159 mg, 60%) as a white solid. M.p.: 108.3–109.0 °C; IR (neat): $\tilde{\nu}$ = 2852 (m), 1712 (s), 1614 (m), 1503 (s), 1269 (vs), 1254 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.97–8.02 (m, 2H), 7.12 (dd, ^1J = 7.4 Hz, ^2J = 1.2 Hz, 1H), 5.92 (t, J = 1.7 Hz, 1H), 4.36 (q, J = 7.2 Hz, 2H), 3.81 (s, 2H), 2.91–3.00 (m, 2H), 2.62–2.74 (m, 2H), 2.43–2.54 (m, 2H), 1.39 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.5, 144.4, 139.1, 134.3, 133.2, 130.2, 128.9, 127.0, 124.3, 108.6, 98.6, 60.7, 29.1, 29.0, 25.6, 24.6, 14.4 ppm; MS (EI, 70 eV): m/z (%) = 267 (70) $[M]^+$, 239 (100), 222 (10), 211 (18), 194 (63); HRMS (EI): m/z calcd for $C_{17}H_{17}NO_2$: 267.1259 $[M]^+$; found: 267.1245.

9f: Prepared from **8f** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **9f** (188 mg, 57%) as a yellow solid. M.p.: 69.0–70.1 °C; IR (neat): $\tilde{\nu}$ = 2986 (w), 1698 (vs), 1619 (s), 1492 (vs), 1285 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 600 MHz): δ = 8.08 (s, 1H), 8.05 (d, J = 8.1 Hz, 1H), 7.34–7.40 (m, 3H), 7.25–7.33 (m, 3H), 6.16 (d, J = 2.9 Hz, 1H), 6.05–6.09 (m, 1H), 4.41 (q, J = 7.2 Hz, 2H), 3.86 (s, 2H), 3.26 (t, J = 8.1 Hz, 2H), 3.08 (t, J = 8.1 Hz, 2H), 1.44 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 166.3, 145.2, 141.2, 135.42, 135.40, 130.1, 128.5, 128.3, 127.2, 127.0, 126.1, 124.7, 111.6, 109.9, 101.5, 60.8, 35.2, 29.3, 28.4, 14.3 ppm; MS (EI, 70 eV): m/z (%) = 331 (11) $[M]^+$, 286 (4), 240 (100), 167 (63); HRMS (EI): m/z calcd for $C_{22}H_{21}NO_2$: 331.1572 $[M]^+$; found: 331.1569.

9g and **9g′**: Prepared from **8g** according to Procedure C. Short flash chromatography (pentane/diethyl ether = 1:1) afforded the mixture of **9g** and **9g′** (251 mg, 80%, **9g**/**9g′** = 2:1) as a white solid. Repeated purification by flash chromatography (pentane/diethyl ether = 3:1) provided the more-polar pure **9g** as a white solid. **9g** (structure determined by H-H NOESY spectroscopic analysis): M.p.: 132.5–133.0 °C; IR (neat): $\tilde{\nu}$ = 2975 (w), 1712 (vs), 1677 (vs), 1607 (m), 1580 (s), 1083 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.10 (s, 1H), 8.05 (d, J = 8.3 Hz, 1H), 7.42 (d, J = 8.3 Hz, 1H), 6.43 (q, J = 1.0 Hz, 1H), 4.37 (q, J = 7.2 Hz, 2H), 4.28 (q, J = 7.2 Hz, 2H), 4.00 (s, 2H), 2.54 (s, 3H), 1.39 (t, J = 7.2 Hz, 3H), 1.35 ppm (t, J = 7.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.1, 164.6, 144.7, 141.6, 135.2, 130.1, 127.2, 125.9, 124.0, 112.6, 110.6, 109.2, 61.0, 59.7, 30.4, 14.5, 14.3, 13.1 ppm; MS (EI, 70 eV): m/z (%) = 313 (52%) $[M]^+$, 284 (100), 268 (21), 240 (88), 212 (24), 167 (32); HRMS (EI): m/z calcd for $C_{18}H_{19}NO_4$: 313.1314 $[M]^+$; found: 313.1291.

11a: Prepared from **10a** according to Procedure C. Purification by flash chromatography (pentane) afforded **11a** (215 mg, 93%) as a white solid. M.p.: 97.8–99.6 °C; IR (neat): $\tilde{\nu}$ = 1517 (m), 1438 (m), 1337 (m), 733 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.35 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 8.27 (d, J = 8.8 Hz, 1H), 8.20 (, J = 7.9 Hz, 1H), 7.97 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.40–7.50 (m, 2H), 7.30–7.39 (m, 2H), 6.91 (d, J = 3.5 Hz, 1H), 6.45 (d, J = 3.5 Hz, 1H), 2.93 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 135.6, 130.1, 128.0, 127.6, 127.2, 126.8, 125.4, 124.4, 123.8, 123.3, 122.9, 122.24, 122.21, 116.7, 113.7, 100.8, 18.9 ppm; MS (EI, 70 eV): m/z (%) = 231 (96) $[M]^+$, 230 (100), 215 (2), 202 (8), 114 (15); HRMS (EI): m/z calcd for $C_{17}H_{13}N$: 231.1048 $[M]^+$; found: 231.1058.

11b: Prepared from **10b** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 15:1) afforded **11b** (258 mg, 85%) as a white solid. M.p.: 118.0–119.0 °C; IR (neat): $\tilde{\nu}$ = 2976 (w), 1709 (vs), 1616 (m), 1519 (m), 1451 (m), 1287 (s), 1261 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.99 (d, J = 2.0 Hz, 1H), 8.18–8.29 (m, 2H), 8.06 (dd, ^1J = 9.0 Hz, ^2J = 2.0 Hz, 1H), 7.90–7.95 (m, 1H), 7.33–7.47 (m, 2H), 6.88 (d, J = 3.8 Hz, 1H), 6.45 (dd, ^1J = 3.8 Hz, ^2J = 0.8 Hz, 1H), 4.44 (q, J = 7.1 Hz, 2H), 2.89 (s, 3H), 1.45 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.2, 138.4, 130.4, 128.53, 128.46, 127.6, 126.7, 125.7 (2 C), 125.0, 123.9, 122.7, 122.5, 122.2, 116.3, 114.6, 101.5, 61.1, 18.9, 14.4 ppm; MS (EI, 70 eV): m/z (%) = 303 (100) $[M]^+$, 274 (74), 228 (51), 129 (10), 114 (13); HRMS (EI): m/z calcd for $C_{20}H_{17}NO_2$: 303.1259 $[M]^+$; found: 303.1234.

11c: Prepared from **10c** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 15:1) afforded **11c** (258 mg, 85%) as a white solid. M.p.: 152.7–153.6 °C; IR (neat): $\tilde{\nu}$ = 1611 (w), 1599 (w), 1518 (m), 1450 (m), 1344 (s), 1311 (s), 1108 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.46 (s, 1H), 8.21 (d, J = 8.8 Hz, 1H), 8.08 (d, J = 7.9 Hz, 1H), 7.87 (d, J = 7.9 Hz, 1H), 7.60 (dd, ^1J = 8.0 Hz, ^2J = 2.6 Hz, 1H), 7.42 (t, J = 7.9 Hz, 1H), 7.32 (t, J = 8.8 Hz, 1H), 6.84 (d, J = 3.5 Hz, 1H), 6.42 (d, J = 3.5 Hz, 1H), 2.84 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 137.3, 130.1, 128.8, 127.5, 126.8, 125.6, 125.0 (q, J_{C-F} = 33.0 Hz), 124.3 (q, J_{C-F} = 272.0 Hz), 123.9 (q, J_{C-F} = 3.3 Hz), 123.3, 123.0, 122.22, 122.18, 120.9 (q, J_{C-F} = 3.3 Hz), 116.8, 114.5, 101.5, 18.8 ppm; MS (EI, 70 eV): m/z (%) = 299 $[M]^+$, (100), 298 (100), 280 (5), 228 (33), 139 (10), 114 (10); HRMS (EI): m/z calcd for $C_{18}H_{12}F_3N$: 299.0922 $[M]^+$; found: 299.0900.

11d: Prepared from **10d** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 2:1 afforded **11d** (167 mg, 61%) as a brown solid. M.p.: 180.0–181.0 °C; IR (neat): $\tilde{\nu}$ = 2961 (w), 1681 (s), 1605 (s), 1517 (m), 1380 (m), 1356 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.81 (d, J = 2.6 Hz, 1H), 8.15 (t, J = 8.8 Hz, 2H), 7.89 (d, J = 8.8 Hz, 2H), 7.42 (t, J = 7.9 Hz, 1H), 7.33 (t, J = 7.9 Hz, 1H), 6.85 (d, J = 3.5 Hz, 1H), 6.42 (d, J = 3.5 Hz, 1H), 2.84 (s, 3H), 2.64 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 196.8, 138.4, 131.6, 130.4, 128.6, 127.6, 127.4, 126.7, 125.7, 124.2, 123.8, 122.6, 122.3, 122.2, 116.3, 114.7, 101.6, 26.4, 18.9 ppm; MS (EI, 70 eV): m/z (%) = 273 (100) $[M]^+$, 228 (50), 215 (5), 129 (10), 114 (11); HRMS (EI): m/z calcd for $C_{19}H_{15}NO$: 273.1154 $[M]^+$; found: 273.1131.

11e: Prepared from **10e** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 15:1) afforded **11e** (251 mg, 83%) as a white solid. M.p.: 148.8–150.0 °C; IR (neat): $\tilde{\nu}$ = 2954 (w), 1689 (s), 1528 (m), 1412 (m), 1214 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.32 (t, J = 8.8 Hz, 2H), 8.18 (d, J = 7.9 Hz, 1H), 7.98 (d, J = 7.1 Hz, 1H), 7.38–7.51 (m, 4H), 7.35 (s, 1H), 4.36 (q, J = 7.5 Hz, 2H), 3.22 (s, 3H), 1.41 ppm (t, J = 7.5 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.6, 134.6, 133.3, 133.0, 128.9, 128.2, 127.5, 126.13, 126.09, 124.7, 124.4, 123.8, 122.4, 122.1, 117.8, 116.2, 103.0, 59.8, 16.5, 14.5 ppm; MS (EI, 70 eV): m/z (%) = 303 (91) $[M]^+$, 274 (100), 258 (10), 228 (78), 114 (12); HRMS (EI): m/z calcd for $C_{20}H_{17}NO_2$: 303.1259 $[M]^+$; found: 303.1271.

11f: Prepared from **10f** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 3:1 afforded **11f** (319 mg, 86%)

as a white solid. M.p.: 154.2–156.1 °C; IR (neat): $\tilde{\nu}$ = 1605 (w), 1519 (w), 1389 (m), 1325 (s), 1316 (s), 1128 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.11 (s, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.72 (d, J = 7.9 Hz, 1H), 7.51 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.39 (dd, ^1J = 8.8 Hz, ^2J = 1.8 Hz, 1H), 7.10–7.23 (m, 2H), 6.90 (s, 1H), 4.30 (q, J = 7.1 Hz, 2H), 2.84 (s, 3H), 1.39 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): 165.1, 136.1, 132.9, 128.8, 128.4, 126.2, 125.9 (q, J_{C-F} = 33.2 Hz), 125.8, 123.9 (q, J_{C-F} = 272.0 Hz), 123.6 (q, J_{C-F} = 3.3 Hz), 123.55, 123.2, 122.1, 121.8, 120.6 (q, J_{C-F} = 3.3 Hz), 117.6, 116.7, 103.3, 59.9, 16.2, 14.4 ppm; MS (EI, 70 eV): m/z (%) = 371 (76), 342 (100), 326 (11), 298 (33), 228 (49); HRMS (EI): m/z calcd for $C_{21}H_{16}F_3NO_2$: 371.1133 $[M]^+$; found: 371.1141.

11g: Prepared from **10g** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded **11g** (315 mg, 84%) as a white solid. M.p.: 187.3–189.1 °C; IR (neat): $\tilde{\nu}$ = 2928 (w), 1716 (vs), 1703 (vs), 1526 (m), 1246 (m), 1210 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.78 (d, J = 1.8 Hz, 1H), 8.02–8.12 (m, 2H), 7.94 (dd, ^1J = 8.8 Hz, ^2J = 1.8 Hz, 1H), 7.79 (dd, ^1J = 8.8 Hz, ^2J = 1.8 Hz, 1H), 7.26–7.41 (m, 2H), 7.17 (s, 1H), 4.42 (q, J = 7.1 Hz, 2H), 4.34 (q, J = 7.1 Hz, 2H), 3.06 (s, 3H), 1.44 (t, J = 7.1 Hz, 3H), 1.41 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.8, 165.3, 137.3, 133.3, 132.2, 130.4, 129.1, 128.7, 128.2, 126.4, 126.0, 125.4, 124.1, 123.5, 122.3, 117.4, 116.9, 103.4, 61.1, 60.0, 16.5, 14.45, 14.37 ppm; MS (EI, 70 eV): m/z (%) = 375 (100), 346 (83), 330 (11), 318 (13), 273 (12), 228 (80); HRMS (EI): m/z calcd for $C_{23}H_{21}NO_4$: 375.1471 $[M]^+$; found: 375.1453.

11h: Prepared from **10h** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 2:1) afforded **11h** (159 mg, 46%) as a white solid. M.p.: 187.7–189.9 °C; IR (neat): $\tilde{\nu}$ = 2984 (w), 1700 (vs), 1678 (vs), 1604 (m), 1531 (m), 1217 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.65 (d, J = 2.6 Hz, 1H), 7.98–8.06 (m, 2H), 7.74–7.82 (m, 2H), 7.25–7.40 (m, 2H), 7.16 (s, 1H), 4.34 (q, J = 7.1 Hz, 2H), 3.01 (s, 3H), 2.61 (s, 3H), 1.41 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 196.5, 165.2, 137.4, 133.3, 132.4, 129.0, 128.8, 127.2, 126.5, 126.0, 124.1, 124.0, 123.6, 122.4, 122.2, 117.4, 117.0, 103.5, 60.0, 26.4, 16.5, 14.5 ppm; MS (EI, 70 eV): m/z (%) = 345 (100), 316 (99), 300 (10), 273 (16), 228 (80); HRMS (EI): m/z calcd for $C_{22}H_{19}NO_3$: 345.1365 $[M]^+$; found: 345.1378.

11i: Prepared from **10i** according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 2:1) afforded **11i** (146 mg, 53%) as a white solid. M.p.: 144.8–145.9 °C; IR (neat): $\tilde{\nu}$ = 3308 (m), 2967 (w), 1518 (m), 1449 (m), 1526 (m), 774 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.25 (d, J = 2.2 Hz, 1H), 8.16 (d, J = 7.9 Hz, 1H), 8.14 (d, J = 8.8 Hz, 1H), 7.94 (dd, ^1J = 7.9 Hz, ^2J = 1.8 Hz, 1H), 7.25–7.45 (m, 3H), 6.88 (d, J = 4.4 Hz, 1H), 6.42 (d, J = 4.4 Hz, 1H), 4.98 (q, J = 6.2 Hz, 1H), 2.87 (s, 3H), 2.00 (brs, 1H), 1.55 ppm (d, J = 6.2 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 140.6, 134.7, 130.1, 128.1, 127.1, 126.8, 125.3, 124.7, 124.3, 122.8, 122.26, 122.21, 120.4, 116.7, 113.6, 100.7, 70.1, 25.3, 18.8 ppm; MS (EI, 70 eV): m/z (%) = 257 (100) $[M-H_2O]^+$, 241 (6), 228 (10), 127 (13); HRMS (EI): m/z calcd for $C_{19}H_{17}NO$: 275.1310 $[M]^+$; found: 275.1287.

12a: Prepared according to Procedure A. 4-Amino-3,5-dibromobenzoic acid ethyl ester (1.62 g, 5.0 mmol), 1-phenylhexane-2,5-dione (1.14 g, 6.0 mmol), and TsOH·H_2O (20 mg, 2 mol%) were dissolved in toluene (20 mL) and heated in a flask equipped with a Dean–Stark apparatus for 3 h. After the mixture was cooled, another portion of 1-phenylhexane-2,5-dione (1.14 g, 6.0 mmol) was added to the mixture, which was then heated under reflux for 3 h. Upon cooling, the dark-brown reaction mixture was concentrated in vacuo. Purification by flash chromatography (pentane/diethyl ether = 30:1) provided **12a** (1.32 g, 55%) as a yellow oil. IR (KBr): $\tilde{\nu}$ = 2981 (m), 1726 (vs), 1543 (m), 1399 (s), 1265 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.30 (s, 2H), 7.15–7.21 (m, 3H), 7.01–7.06 (m, 2H), 6.01–6.05 (m, 1H), 5.93 (d, J = 3.1 Hz, 1H), 4.46 (q, J = 7.1 Hz, 2H), 3.61 (s, 2H), 1.97 (s, 3H), 1.46 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 163.3, 141.3, 138.5, 133.0, 132.8, 131.0, 128.9, 128.0, 127.8, 126.1, 126.0, 107.6, 106.7, 61.9, 33.6, 14.1, 12.0 ppm; MS (EI, 70 eV): m/z (%) = 479 (57) $[M]^+$ ($^{81}Br^{81}Br$), 477 (100) $[M]^+$ ($^{81}Br^{79}Br$), 475 (57) $[M]^+$ ($^{79}Br^{79}Br$), 400 (71), 372 (31), 167 (30); HRMS (EI): m/z calcd for $C_{21}H_{19}Br_2NO_2$: 474.9783 $[M]^+$ ($^{79}Br^{79}Br$); found: 474.9766.

12b: Prepared from 4-amino-3,5-dibromobenzoic acid ethyl ester (1.62 g, 5.0 mmol), 1-*p*-tolylhexane-2,5-dione (3.06 g, 15.0 mmol), and TsOH·H_2O (10 mg, 1 mol%) according to Procedure A. Reaction time: 6 h. Purification by flash chromatography (pentane/diethyl ether = 20:1) provided **12b** (1.49 g, 61%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2915 (w), 1723 (s), 1542 (m), 1514 (m), 1240 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.27 (s, 2H), 6.98 (d, J = 8.0 Hz, 2H), 6.91 (d, J = 8.0 Hz, 2H), 5.97–6.03 (m, 1H), 5.87 (d, J = 3.3 Hz, 1H), 4.44 (q, J = 7.1 Hz, 2H), 3.53 (s, 2H), 2.29 (s, 3H), 1.94 (s, 3H), 1.44 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 163.5, 141.5, 135.52, 135.49, 133.1, 132.8, 131.4, 128.9, 128.7, 127.8, 126.2, 107.5, 106.7, 62.1, 33.2, 21.0, 14.2, 12.1 ppm; MS (EI, 70 eV): m/z (%) = 493 (51) $[M]^+$ ($^{81}Br^{81}Br$), 491 (100) $[M]^+$ ($^{81}Br^{79}Br$), 489 (52) $[M]^+$ ($^{79}Br^{79}Br$), 400 (36), 372 (31), 167 (30); HRMS (EI): m/z calcd for $C_{22}H_{21}Br_2NO_2$: 488.9939 $[M]^+$ ($^{79}Br^{79}Br$); found: 488.9925.

2-benzyl-1-(2,6-dibromo-4-iodophenyl)-5-methyl-1*H*-pyrrole (**12c′**): Prepared according to Procedure A. 2,6-Dibromo-4-iodophenylamine[23] (1.89 g, 5.0 mmol), 1-phenylhexane-2,5-dione (1.14 g, 6.0 mmol), and TsOH·H_2O (10 mg, 1 mol%) were dissolved in toluene (20 mL) and heated in a flask equipped with a Dean–Stark apparatus for 3 h. After the mixture was cooled, another portion of 1-phenylhexane-2,5-dione (1.14 g, 6.0 mmol) was added to the mixture, which was then heated under reflux for 3 h. Upon cooling, the dark-brown reaction mixture was concentrated in vacuo. Purification by flash chromatography (pentane/diethyl ether = 30:1) provided **12c′** (1.460 g, 55%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2907 (w), 1528 (m), 1450 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.94 (s, 2H), 7.12–7.21 (m, 3H), 6.98–7.05 (m, 2H), 5.97 (d, J = 3.5 Hz, 1H), 5.87 (d, J = 3.5 Hz, 1H), 3.57 (s, 2H), 1.94 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 140.5, 140.4, 138.7, 137.5, 131.2, 129.1, 128.1, 126.8, 126.1, 107.5, 106.6, 94.1, 33.7, 12.1 ppm; MS (EI, 70 eV): m/z (%) = 531 (100) $[M]^+$ ($^{81}Br^{79}Br$), 454 (78), 404 (10), 327 (12), 241 (11); HRMS (EI): m/z calcd for $C_{18}H_{13}Br_2IN$: 527.8459 $[M-H]^+$ ($^{79}Br^{79}Br$); found: 527.8437.

12c: Prepared from **12c′** (1.06 g, 2.0 mmol), *i*PrMgCl·LiCl (1.5 mL, 1.5 M in THF), and benzoyl chloride (3.5 mmol) according to Procedure B. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided pure **12c** (0.83 g, 81%) as a white solid. M.p.: 155.0–155.9 °C; IR (neat): $\tilde{\nu}$ = 2912 (w), 1663 (s), 1597 (m), 1261 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.99 (s, 2H), 7.83 (d, J = 7.4 Hz, 2H), 7.68 (t, J = 7.4 Hz, 1H), 7.56 (t, J = 7.4 Hz, 2H), 7.13–7.22 (m, 3H), 7.00–7.09 (m, 2H), 6.00–6.05 (m, 1H), 5.94 (d, J = 3.3 Hz, 1H), 3.65 (s, 2H), 2.00 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 192.8, 140.9, 139.7, 138.6, 135.9, 133.4, 133.2, 131.1, 130.0, 129.0, 128.7, 128.1, 128.0, 126.2, 126.1, 107.8, 106.7, 33.8, 12.2 ppm; MS (EI, 70 eV): 509 $[M]^+$ ($^{81}Br^{79}Br$), (100), 432 (38), 430 (18), 105 (32); HRMS (EI): m/z calcd for $C_{25}H_{19}Br_2NO$: 506.9833 $[M]^+$ ($^{79}Br^{79}Br$); found: 506.9844.

13: Prepared from **12a** according to Procedure C. Reaction time: 12 h. Purification by flash chromatography (hexane/diethyl ether = 20:1) provided **13** (245 mg, 62%) as a white solid. M.p.: 112.0–113.1 °C; IR (KBr): $\tilde{\nu}$ = 2978 (w), 1721 (vs), 1469 (m), 1229 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.33 (d, J = 1.9 Hz, 1H), 8.20 (d, J = 1.9 Hz, 1H), 7.55–7.60 (m, 1H), 7.28–7.34 (m, 2H), 7.19–7.23 (m, 1H), 5.89–5.95 (m, 2H), 4.43 (qd, ^1J = 7.1 Hz, ^2J = 1.7 Hz, 2H), 3.71 (d, J = 14.4 Hz, 1H), 3.51 (d, J = 14.4 Hz, 1H), 2.15 (s, 3H), 1.42 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.2, 142.0, 140.1, 139.2, 137.2, 136.0, 133.9, 131.5, 131.2, 130.4, 129.8, 129.2, 127.5, 127.3, 121.8, 109.3, 104.1, 62.0, 33.5, 14.8, 14.2 ppm; MS (EI, 70 eV): m/z (%) = 397 (99) $[M]^+$ (^{81}Br), 395 (100) $[M]^+$ (^{79}Br), 380 (17), 286 (11), 241 (89), 228 (29), 120 (47); HRMS (EI): m/z calcd for $C_{21}H_{18}BrNO_2$: 395.0521 $[M]^+$(^{79}Br); found: 395.0514.

14a: Prepared from **12a** (477 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), $(p\text{-Tol})_3P$ (30 mg, 10 mol%), and Cs_2CO_3 (717 mg, 2.2 mmol) according to Procedure C. Reaction time: 24 h. Purification by flash chromatography (hexane/diethyl ether = 30:1) afforded **14a** (193 mg, 61%) as a white solid. M.p.: 114.8–115.7 °C; IR (KBr): $\tilde{\nu}$ = 2977 (w), 1709 (vs), 1606 (m), 1500 (vs), 1269 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.51 (s, 1H), 8.00 (s, 1H), 7.70 (d, J = 8.0 Hz, 1H), 7.26–7.40 (m, 3H), 6.06–6.12 (m, 2H), 4.42 (q, J = 7.1 Hz, 2H), 4.12 (s, 2H), 3.90 (s, 2H), 1.43 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.6, 141.3, 136.2, 135.8, 134.9, 133.9, 131.2, 130.3, 128.4 (2 x C), 127.4, 125.7, 125.6, 125.3, 123.0,

109.7, 103.4, 61.0, 34.5, 29.4, 14.3 ppm; MS (EI, 70 eV): *m/z* (%) = 315 (100) $[M]^+$, 286 (21), 242 (77), 135(10), 120 (33); HRMS (EI): *m/z* calcd for $C_{21}H_{17}NO_2$: 315.1259 $[M]^+$; found: 315.1272.

14b: Prepared from **12b** (295 mg, 0.6 mmol), $Pd(OAc)_2$ (7 mg, 5 mol%), (*p*-Tol)$_3$P (18 mg, 10 mol%), and Cs_2CO_3 (411 mg, 2.2 mmol) according to Procedure C. Reaction time: 24 h. Purification by flash chromatography (pentane/diethyl ether = 20:1) afforded **14b** (110 mg, 56%) as a white solid. M.p.: 155.0–157.0 °C; IR (neat): $\tilde{\nu}$ = 2979 (w), 1716 (vs), 1608 (m), 1499 (s), 1287 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.44 (s, 1H), 7.92 (d, J = 1.1 Hz, 1H), 7.42 (s, 1H), 7.15 (d, J = 8.1 Hz, 1H), 7.03 (d, J = 8.1 Hz, 1H), 5.97–6.04 (m, 2H), 4.36 (q, J = 7.1 Hz, 2H), 4.00 (s, 2H), 3.81 (s, 2H), 2.31 (s, 3H), 1.37 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.7, 141.4, 136.9, 135.8, 134.6, 133.8, 133.3, 131.1, 130.9, 129.1, 128.4, 125.66, 125.60, 125.4, 123.2, 109.5, 103.3, 61.0, 34.0, 29.4, 21.0, 14.4 ppm; MS (EI, 70 eV): *m/z* (%) = 329 (100) $[M]^+$, 314 (15), 300 (15), 256 (46), 241 (13); HRMS (EI): *m/z* calcd for $C_{22}H_{19}NO_2$: 329.1416 $[M]^+$; found: 329.1430.

14c: Prepared from **12c** (509 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), (*p*-Tol)$_3$P (30 mg, 10 mol%), and Cs_2CO_3 (717 mg, 2.2 mmol) according to Procedure C. Reaction time: 24 h. Purification by flash chromatography (hexane/diethyl ether = 15:1) afforded **14c** (174 mg, 50%) as a white solid. M.p.: 162.0–163.0 °C; IR (neat): $\tilde{\nu}$ = 2924 (m), 1697 (s), 1657 (vs), 1593 (s), 1577 (m), 1302 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 8.24 (s, 1H), 7.80–7.89 (m, 3H), 7.45–7.65 (m, 4H), 7.26–7.40 (m, 3H), 6.12–6.16 (m, 1H), 6.06–6.12 (m, 1H), 4.15 (s, 2H), 3.93 ppm (s, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 195.9, 141.2, 138.3, 136.3, 135.9, 134.8, 133.9, 133.0, 132.1, 131.2, 130.3, 129.8, 129.6, 128.5, 128.3, 127.4, 126.4, 125.3, 122.8, 109.9, 103.5, 34.5, 29.5 ppm; MS (EI, 70 eV): *m/z* (%) = 345 (100) $[M-H_2]^+$, 315 (9), 268 (9), 240 (66), 119 (8); HRMS (EI): *m/z* calcd for $C_{25}H_{17}NO$: 347.1310 $[M]^+$; found: 347.1286.

19a: Prepared from 2-bromobenzamide (2.00 g, 10.0 mmol), 2,5-hexanedione (1.37 g, 12.0 mmol), and TsOH·H_2O (19 mg, 1.0 mol%) according to Procedure A. Reaction time: 5 h. Purification by flash chromatography (pentane/diethyl ether = 4:1) provided **19a** (1.20 g, 43%) as a brown solid. M.p.: 58.0–59.0 °C; IR (KBr): $\tilde{\nu}$ = 2919 (w), 1690 (vs), 1588 (m), 1542 (m), 1355 (vs), 1226 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.61 (dd, ^1J = 7.1 Hz, ^2J = 1.3 Hz, 1H), 7.31–7.43 (m, 3H), 5.84 (s, 2H), 2.03 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 168.7, 138.3, 133.5, 132.1, 130.9, 129.9, 127.5, 120.6, 111.7, 15.4 ppm; MS (EI, 70 eV): *m/z* (%) = 279 (17) $[M]^+$ (^{81}Br), 277 (19) $[M]^+$ (^{79}Br), 198 (9), 185 $[M]^+$ (^{81}Br) (100), 183 (100) $[M]^+$ (^{79}Br); HRMS (EI): *m/z* calcd for $C_{13}H_{12}BrNO$: 277.0102 $[M]^+$ (^{79}Br); found: 277.0106.

19b: *n*BuLi (2.0 M, 3.0 mL) was added dropwise to a solution of 2,5-dimethyl-1*H*-pyrrole (0.57 g, 6.0 mmol) in THF (10 mL) at −78 °C under nitrogen. The resulting mixture was stirred at −78 °C for 30 min. A solution of 2-bromo-5-methoxybenzoic acid methyl ester (1.23 g, 5.0 mmol) in THF (5 mL) was added, and the resulting mixture was stirred at −78 °C for 1 h. The reaction mixture was warmed to room temperature and stirred for 2 h before the reaction was quenched with aqueous NH_3. The reaction mixture was diluted with water and extracted with diethyl ether (3 × 30 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and evaporated. Purification by flash chromatography (pentane/diethyl ether = 8:1) afforded **19b** (1.30 g, 84%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2960 (m), 2924 (m), 1695 (vs), 1593 (m), 1570 (m), 1471 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.47 (d, J = 8.4 Hz, 1H), 6.93 (d, J = 3.1 Hz, 1H), 6.89 (dd, ^1J = 8.4 Hz, ^2J = 3.1 Hz, 1H), 5.84 (s, 2H), 3.78 (s, 3H), 2.06 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 168.5, 159.0, 138.9, 134.2, 131.0, 118.3, 115.0, 111.8, 110.9, 55.7, 15.4 ppm; MS (EI, 70 eV): *m/z* (%) = 309 (7) $[M]^+$ (^{81}Br), 307 (7) $[M]^+$ (^{79}Br),, 228 (44), 215 (99) $[M]^+$ (^{81}Br), 213 (100) $[M]^+$ (^{79}Br), 185 (10); HRMS (EI): *m/z* calcd for $C_{14}H_{14}BrNO_2$: 307.0208 [M]$^+$ (^{79}Br); found: 307.0218.

19c: *n*BuLi (2.0 M, 3.0 mL) was added dropwise to a solution of 2,5-dimethyl-1*H*-pyrrole (0.57 g, 6.0 mmol) in THF (10 mL) at −78 °C under nitrogen. The resulting mixture was stirred at −78 °C for 30 min. A solution of 2-bromo-3,4,5-trimethoxybenzoic acid methyl ester (1.53 g, 5.0 mmol) in THF (5 mL) was added, and the resulting mixture was stirred at −78 °C for 1 h. The reaction mixture was warmed to room temperature and stirred for 3 h before the reaction was quenched with aqueous NH_3. The reaction mixture was diluted with water and extracted with diethyl ether (3 × 30 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and evaporated. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded **19c** (1.33 g, 72%) as a yellow oil. IR (KBr): $\tilde{\nu}$ = 2938 (m), 1694 (vs), 1564 (m), 1349 (vs), 1289 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 6.76 (s, 1H), 5.83 (s, 2H), 3.91 (s, 3H), 3.87 (s, 3H), 3.83 (s, 3H), 2.05 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 168.4, 153.2, 151.4, 145.4, 133.4, 130.9, 111.7, 108.6, 108.1, 61.3, 61.1, 56.4, 15.3 ppm; MS (EI, 70 eV): *m/z* (%) = 369 (5) $[M]^+$ (^{81}Br), 367 (5) $[M]^+$ (^{79}Br), 275 (100) (^{81}Br), 273 (100) (^{79}Br), 230 (10), 93 (5); HRMS (EI): *m/z* calcd for $C_{16}H_{18}BrNO_4$: 367.0419 $[M]^+$ (^{79}Br); found: 367.0421.

21c: A solution of $NaClO_2$ (80% purity, 3.2 g, 28 mmol) in water (30 mL) was added dropwise to a stirred mixture of 1-bromo-3,4-dihydronaphthalene-2-carbaldehyde[24] (4.74 g, 20 mmol) in CH_3CN (20 mL), NaH_2PO_4 (0.64 g) in water (10 mL), and 30% aqueous H_2O_2 (2.4 mL) over 2 h at 0 °C. The resulting mixture was stirred for 2 h at 10 °C. The mixture was poured into saturated aqueous Na_2CO_3 (50 mL) and washed with diethyl ether (30 mL). The ether phase was discarded. The aqueous phase was poured into aqueous HCl (1 N, 200 mL) and extracted with diethyl ether (3 × 50 mL).The extract was dried over Na_2SO_4. The combined organic phases were concentrated in vacuo to afford bromo-3,4-dihydronaphthalene-2-carboxylic acid (3.54 g, 70%) as a white solid. M.p.: 122.7–123.8 °C; IR (neat): $\tilde{\nu}$ = 2829 (vs), 1654 (s), 1554 (s), 1283 cm^{-1} (s); ^1H NMR ($CDCl_3$, 400 MHz): δ = 10.81–11.82 (brs, 1H), 7.82–7.88 (m, 1H), 7.25–7.32 (m, 2H), 7.12–7.17 (m, 1H), 2.80–2.91 (m, 2H), 2.68–2.78 ppm (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ = 172.7, 137.3, 133.3, 130.1, 129.4, 129.3, 128.5, 127.1, 127.0, 27.5, 27.3 ppm; MS (EI, 70 eV): *m/z* (%) = 254 (25) $[M]^+$ (^{81}Br), 252 (25) $[M]^+$ (^{79}Br), 155 (25), 128 (100); HRMS (EI): *m/z* calcd for $C_{11}H_9BrO_2$: 251.9786 $[M]^+$ (^{79}Br); found: 251.9765. A mixture of bromo-3,4-dihydronaphthalene-2-carboxylic acid (1.265 g, 5.0 mmol), CH_3I (1.42 g, 10.0 mmol), and K_2CO_3 (828 mg, 6.0 mmol) in DMF (15 mL) was stirred overnight. The reaction mixture was diluted with diethyl ether (50 mL) and washed with water (3 × 20 mL). The organic phase was dried over Na_2SO_4, filtered, and evaporated. Purification by flash chromatography (pentane/diethyl ether = 6:1) afforded **21c** (1.14 g, 85%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2949 (w), 1719 (s), 1694 (s), 1596 (s), 1444 (m), 1433 cm^{-1} (m); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.60–7.79 (m, 1H), 7.14–7.26 (m, 2H), 7.00–7.08 (m, 1H), 3.77 (s, 3H), 2.74–2.81 (m, 2H), 2.54–2.61 ppm (m, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 167.9, 136.8, 133.1, 130.8, 129.6, 128.7, 127.1, 126.9, 125.2, 52.0, 27.5, 27.4 ppm; MS (EI, 70 eV): *m/z* (%) = 268 (35) $[M]^+$ (^{81}Br), 266 (35) $[M]^+$ (^{79}Br), 235 (25), 187 (20), 155 (21), 128 (100); HRMS (EI): *m/z* calcd for $C_{12}H_{11}BrO_2$: 265.9942 $[M]^+$ (^{79}Br); found: 265.9939.

19d: *n*BuLi (2.0 M, 3.0 mL) was added dropwise to a solution of 2,5-dimethyl-1*H*-pyrrole (0.57 g, 6.0 mmol) in THF (10.0 mL) at −78 °C under nitrogen. The resulting mixture was stirred at −78 °C for 30 min. A solution of **21c** (1.34 g, 5.0 mmol) in THF (5 mL) was added, and the resulting mixture was stirred at −78 °C for 1 h. The reaction mixture was warmed to room temperature and stirred for 3 h before the reaction was quenched with aqueous NH_3. The reaction mixture was diluted with water and extracted with diethyl ether (3 × 30 mL). The combined organic phases were washed with brine, dried over Na_2SO_4, filtered, and evaporated. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded **19d** (905 mg, 63%) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2921 (w), 1680 (s), 1543 (m), 1450 (w), 1361 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.65–7.72 (m, 1H), 7.23–7.31 (m, 2H), 7.11–7.17 (m, 1H), 5.86 (s, 2H), 2.98 (t, J = 8.3 Hz, 2H), 2.73 (t, J = 8.3 Hz, 2H), 2.34 ppm (s, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 170.1, 136.1, 134.9, 132.3, 130.3, 129.8, 128.0, 127.3, 127.1, 123.5, 111.6, 28.1, 27.4, 15.4 ppm; MS (EI, 70 eV): *m/z* (%) = 331 (5) $[M]^+$ (^{81}Br), 329 (5) $[M]^+$ (^{79}Br), 235 (100), 128 (80); HRMS (EI): *m/z* calcd for $C_{17}H_{16}BrNO$: 329.0415 $[M]^+$ (^{79}Br); found: 329.0382.

20a: Prepared from **19a** (278 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), (*p*-Tol)$_3$P (30 mg, 10 mol%), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 20:1) afforded **20a** (148 mg, 75%) as a white solid. M.p.: 83.8–

84.3 °C; IR (KBr): $\tilde{\nu}$ = 2976 (w), 1703 (vs), 1633 (s), 1610 (m), 1467 (m), 1317 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.79 (d, J = 7.5 Hz, 1H), 7.51–7.57 (m, 1H), 7.38–7.44 (m, 2H), 6.30–6.35 (m, 1H), 6.07 (d, J = 5.6 Hz, 1H), 5.30–5.35 (m, 1H), 4.76 (s, 1H), 1.57 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 171.2, 150.9, 146.0, 136.1, 133.0, 131.9, 129.6, 128.6, 125.1, 121.6, 96.3, 77.1, 28.3 ppm; MS (EI, 70 eV): m/z (%) = 197 (10) $[M]^+$, 182 (100), 153 (4 5), 127 (12); HRMS (EI): m/z calcd for $C_{13}H_{11}NO$: 197.0841 $[M]^+$; found: 197.0821.

20b: Prepared from **19b** (308 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol %), (p-Tol)$_3$P (30 mg, 10 mol %), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Purification by flash chromatography (hexane/diethyl ether = 3:1) afforded **20b** (181 mg, 80 %) as a white solid. M.p.: 147.7–149.9 °C; IR (KBr): $\tilde{\nu}$ = 2972 (m), 1709 (vs), 1637 (m), 1615 (m), 1495 (s), 1334 (vs), 1319 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.23 (d, J = 8.6 Hz, 1H), 7.20 (d, J = 2.2 Hz, 1H), 7.04 (dd, ^1J = 8.6 Hz, ^2J = 2.2 Hz, 1H), 6.24–6.27 (m, 1H), 5.99 (d, J = 5.8 Hz, 1H), 5.25–5.27 (m, 1H), 4.69 (s, 1H), 3.75 (s, 3H), 1.49 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 171.2, 160.3, 146.0, 143.3, 136.5, 133.2, 129.3, 122.4, 121.3, 107.4, 96.1, 76.7, 55.6, 28.2 ppm; MS (EI, 70 eV): m/z (%) = 227 (13) $[M]^+$, 212 (100), 197 (12), 169 (6); HRMS (EI): m/z calcd for $C_{14}H_{13}NO_2$: 227.0946 $[M]^+$; found: 227.0960.

20c: Prepared from **19c** (368 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol %), (p-Tol)$_3$P (30 mg, 10 mol %), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded **20c** (232 mg, 81 %) as a white solid. M.p.: 75.5–78.6 °C; IR (KBr): $\tilde{\nu}$ = 2939 (w), 1715 (vs), 1634 (m), 1609 (m), 1479 (s), 1346 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.06 (s, 1H), 6.34–6.45 (m, 1H), 6.04 (d, J = 5.9 Hz, 1H), 5.21–5.31 (m, 1H), 4.70 (s, 1H), 3.99 (s, 3H), 3.89 (s, 3H), 3.87 (s, 3H), 1.59 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 171.0, 155.3, 147.9, 146.1, 145.9, 136.39, 136.36, 129.1, 127.3, 102.6, 95.5, 76.2, 60.97, 60.92, 56.3, 26.9 ppm; MS (EI, 70 eV): m/z (%) = 287 (19) $[M]^+$, 272 (100), 256 (6), 242 (15); HRMS (EI): m/z calcd for $C_{16}H_{17}NO_4$: 287.1158 $[M]^+$; found: 287.1142.

20d: Prepared from **19d** (330 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol %), (p-Tol)$_3$P (30 mg, 10 mol %), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Reaction temperature: 80 °C. Purification by flash chromatography (pentane/diethyl ether = 1:1) afforded **20d** (184 mg, 74 %) as a yellow oil. IR (neat): $\tilde{\nu}$ = 2927 (w), 1698 (vs), 1633 (m), 1566 (m), 1449 (m, 1386 (s), 1320 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 7.07–7.36 (m, 4H), 6.36–6.44 (m, 1H), 6.05 (d, J = 5.8 Hz, 1H), 5.14–5.22 (m, 1H), 4.64 (s, 1H), 2.78–3.00 (m, 2H), 2.50–2.62 (m, 1H), 2.30–2.47 (m, 1H), 1.57 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 173.9, 157.5, 145.5, 138.4, 135.4, 130.9, 130.4, 130.0, 128.83, 128.82, 126.8, 124.4, 95.2, 77.8, 28.1, 27.2, 18.1 ppm; MS (EI, 70 eV): m/z (%) = 249 (59) $[M]^+$, 234 (100), 220 (6), 206 (25), 102 (5); HRMS (EI): m/z calcd for $C_{17}H_{15}NO$: 249.1154 $[M]^+$; found: 249.1158.

22a: A solution of $NaClO_2$ (80 % purity, 3.20 g, 28 mmol) in water (30 mL) was added dropwise to a stirred mixture of 2-bromocyclopent-1-enecarbaldehyde[25] (3.50 g, 20 mmol) in CH_3CN (20 mL), NaH_2PO_4 (0.64 g) in water (10 mL), and 30 % aqueous H_2O_2 (2.4 mL) over 2 h at 0 °C. The resulting mixture was stirred for 2 h at 10 °C. The mixture was poured into saturated aqueous Na_2CO_3 (50 mL) and washed with diethyl ether (30 mL). The ether phase was discarded. The aqueous phase was poured into aqueous HCl (1 N, 200 mL) and extracted with diethyl ether (3 × 50 mL).The extract was dried over Na_2SO_4. The combined organic phase was concentrated in vacuo to afford 2-bromo-1-cyclopentenecarboxylic acid (3.42 g, 89 %) as a white solid. M.p.: 122.7–123.8 °C; IR (neat): $\tilde{\nu}$ = 2488–3045 (bs), 1665 (vs), 1613 (vs), 1281 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 11.44 (br s, 1H, COOH), 2.83 (tt, ^1J = 7.7 Hz, ^2J = 2.5 Hz, 2H), 2.65 (tt, ^1J = 7.7 Hz, ^2J = 2.5 Hz, 2H), 1.96 ppm (quint, J = 7.7 Hz, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 169.5, 135.7, 131.4, 43.5, 32.8, 21.5 ppm; MS (EI, 70 eV): m/z (%) = 192 (89) $[M]^+$ (^{81}Br), 190 (89) $[M]^+$ (^{79}Br), 145 (34), 11 (100), 83 (40). Oxalyl dichloride (9.81 g, 30 mmol) was added to a solution of 2-bromo-1-cyclopentenecarboxylic acid (1.91 g, 10.0 mmol) in CH_2Cl_2 (40 mL) at 0 °C. 2–3 drops of dry DMF were added, and the resulting mixture was stirred for 4 h at this temperature. Hexamethyldisilazane (12.10 g, 75 mmol) was added dropwise at 0 °C, and the mixture was stirred at room temperature overnight. After the mixture was cooled to 0 °C, methanol (15 mL) was added, and the mixture was stirred for 3 h at room temperature. Usual workup and purification by flash chromatography (diethyl ether) afforded **22a** (1.34 g, 70 %) as a white solid. M.p.: 146.0–147.0 °C; IR (neat): $\tilde{\nu}$ = 3330 (s), 3156 (s), 1657 (s), 1613 (vs), 1398 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 6.06–6.74 (m, 2H, NH_2), 2.82 (tt, ^1J = 7.7 Hz, ^2J = 2.5 Hz, 2H), 2.67 (tt, ^1J = 7.7 Hz, ^2J = 2.5 Hz, 2H), 1.92 ppm (quint, J = 7.7 Hz, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 166.0, 135.2, 125.1, 43.1, 33.5, 21.1 ppm; MS (EI, 70 eV): m/z (%) = 191 (52) $[M]^+$ (^{81}Br), 189 (51) $[M]^+$ (^{79}Br), 175 (23), 147 (9), 110 (100), 67 (88); HRMS (EI): m/z calcd for C_6H_8BrNO: 188.9789 $[M]^+$ (^{79}Br); found: 188.9767.

23a: Compound **22a** (570 mg, 3.0 mmol), 2,5-hexanedione (684 mg, 6.0 mmol), and TsOH·H_2O (6 mg, 1 mol %) were dissolved in toluene (20 mL) and heated in a flask equipped with a Dean–Stark apparatus for 6 h. Upon cooling, the dark-brown reaction mixture was concentrated in vacuo. Purification by flash chromatography (pentane/diethyl ether = 10:1) to provide **23a** (322 mg, 40 %) as crystals. M.p.: 54.4–55.4 °C; IR (neat): $\tilde{\nu}$ = 2914 (w), 1677 (vs), 1615 (m), 1542 (m), 1361 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 5.82 (s, 2H), 2.70–2.85 (m, 4H), 2.24 (s, 6H), 2.01–2.12 ppm (m, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 167.6, 137.6, 129.7, 128.1, 111.0, 42.0, 34.0, 22.2, 14.7 ppm; MS (EI, 70 eV): m/z (%) = 269 (18) $[M]^+$ (^{81}Br), 267 (18) $[M]^+$ (^{79}Br), 188 (6), 175 (99) (^{81}Br), 173 (100) (^{79}Br), 95 (28); HRMS (EI): m/z calcd for $C_{12}H_{14}BrNO$: 267.0259 $[M]^+$ (^{79}Br); found: 267.0252.

22b: A solution of $NaClO_2$ (80 % purity, 3.20 g, 28 mmol) in water (30 mL) was added dropwise to a stirred mixture of 2-bromocyclohex-1-enecarbaldehyde[26] (3.78 g, 20 mmol) in CH_3CN (20 mL), NaH_2PO_4 (0.64 g) in water (10 mL), and 30 % aqueous H_2O_2 (2.4 mL) over 2 h at 0 °C. The resulting mixture was stirred for 2 h at 10 °C. The mixture was poured into saturated aqueous Na_2CO_3 (50 mL) and washed with diethyl ether (30 mL). The ether phase was discarded. The aqueous phase was poured into aqueous HCl (1 N, 200 mL) and extracted with diethyl ether (3 × 50 mL). The combined organic phase was dried over Na_2SO_4 and concentrated in vacuo to afford 2-bromo-1-cyclohexenecarboxylic acid (3.50 g, 85 %) as a white solid. M.p.: 102.0–103.0 °C; IR (KBr): $\tilde{\nu}$ = 2488–3055 (bs), 1687 (vs), 1672 (vs), 1248 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 11.14 (br s, 1H, COOH), 2.56–2.67 (m, 2H), 2.36–2.46 (m, 2H), 1.62–1.75 ppm (m, 4H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 172.9, 129.6, 129.4, 38.0, 28.6, 23.9, 21.3 ppm; MS (EI, 70 eV): m/z (%) = 206 (33) $[M]^+$ (^{81}Br), 204 $[M]^+$ (33), 125 (34), 97 (35), 79 (100). Oxalyl dichloride (1.91 g, 15.0 mmol) was added to a solution of 2-bromo-1-cyclohexenecarboxylic acid (1.03 g, 5.0 mmol) in CH_2Cl_2 (20 mL) at 0 °C. 2–3 drops of dry DMF was added, and the resulting mixture was stirred for 4 h at this temperature. Hexamethyldisilazane (4.83 g, 30 mmol) was added dropwise at 0 °C, and the mixture was stirred at room temperature overnight. After the mixture was cooled to 0 °C, methanol (10 mL) was added, and the mixture was stirred for 3 h at room temperature. Usual workup and purification by flash chromatography (diethyl ether) afforded **22b** (0.82 g, 80 %) as a white solid. M.p.: 163.0–164.0 °C; IR (KBr): $\tilde{\nu}$ = 3362 (m), 3171 (m), 2929 (m), 1638 (vs), 1620 (vs), 1392 cm^{-1} (s); ^1H NMR ($CDCl_3$, 300 MHz): δ = 5.67–6.39 (m, 2H, NH_2), 2.48–2.61 (m, 2H), 2.27–2.41 (m, 2H), 1.59–1.78 ppm (m, 4H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 171.1, 134.3, 121.3, 36.4, 29.2, 24.1, 21.4 ppm; MS (EI, 70 eV): m/z (%) = 205 (44) $[M]^+$ (^{81}Br), 203 (43) $[M]^+$ (^{79}Br), 124 (86), 81 (100); HRMS (EI): m/z calcd for $C_7H_{10}BrNO$: 202.9946 $[M]^+$ (^{79}Br); found: 202.9926.

23b: Compound **22b** (612 mg, 3.0 mmol), 2,5-hexanedione (684 mg, 6.0 mmol), and TsOH·H_2O (6 mg, 1 mol %) were dissolved in toluene (20 mL) and heated in a flask equipped with a Dean–Stark apparatus for 4 h. Upon cooling, the dark-brown reaction mixture was concentrated in vacuo. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **23b** (668 mg, 79 %) as crystals. M.p.: 38.7–39.6 °C; IR (neat): $\tilde{\nu}$ = 2927 (m), 1684 (vs), 1543 (m), 1362 cm^{-1} (vs); ^1H NMR ($CDCl_3$, 300 MHz): δ = 5.82 (s, 2H), 2.50–2.58 (m, 2H), 2.38–2.44 (m, 2H), 2.31 (s, 6H), 1.72–1.79 ppm (m, 4H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 170.1, 134.9, 130.5, 124.5, 111.6, 36.2, 29.3, 23.8, 21.3, 15.4 ppm; MS (EI, 70 eV): m/z (%) = 283 (15) $[M]^+$ (^{81}Br), 281 (16) $[M]^+$ (^{79}Br), 189

(99) (^{81}Br), 187 (100) (^{79}Br), 95 (34), 79 (35); HRMS (EI): *m/z* calcd for $C_{13}H_{16}BrNO$: 281.0415 $[M]^+$ (^{79}Br); found: 281.0419.

22c: A solution of $NaClO_2$ (80% purity, 3.20 g, 28 mmol) in water (32 mL) was added dropwise to a stirred mixture of 2-bromocyclohept-1-enecarbaldehyde (3.78 g, 20 mmol) in CH_3CN (20 mL), NaH_2PO_4 (0.64 g) in water (10 mL), and 30% aqueous H_2O_2 (2.4 mL) over 2 h at 0 °C. The resulting mixture was stirred for 2 h at 10 °C. The mixture was poured into saturated aqueous Na_2CO_3 (50 mL) and washed with diethyl ether (30 mL). The ether phase was discarded. The aqueous phase was poured into aqueous HCl (1 N, 200 mL) and extracted with diethyl ether (3× 50 mL). The combined organic phase was dried over Na_2SO_4 and concentrated in vacuo to afford 2-bromocyclohept-1-enecarboxylic acid (3.64 g, 83%) as a white solid. M.p.: 104.4–105.5 °C; IR (KBr): $\tilde{\nu}$ = 2678–3055 (bs, s), 1687 (vs), 1626 (s), 1289 cm^{-1} (vs); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 11.40 (br s, 1H, COOH), 2.80–2.93 (m, 2H), 2.40–2.56 (m, 2H), 1.70–1.81 (m, 2H), 1.53–1.68 ppm (m, 4H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 174.0, 135.2, 132.1, 42.9, 31.1, 31.0, 25.5, 24.6 ppm; MS (EI, 70 eV): *m/z* (%) = 220 (25) $[M]^+$ (^{81}Br), 218 (25) $[M]^+$ (^{79}Br), 139 (34), 11 (30), 93 (100); HRMS (EI): *m/z* calcd for $C_8H_{11}BrO_2$: 217.9942 $[M]^+$ (^{79}Br); found: 217.9926. Oxalyl dichloride (1.91 g, 15.0 mmol) was added to a solution of 2-bromocyclohept-1-enecarboxylic acid (1.10 g, 5.0 mmol) in CH_2Cl_2 (20 mL) at 0 °C. 2–3 drops of dry DMF was added, and the resulting mixture was stirred for 4 h at this temperature. Hexamethyldisilazane (4.83 g, 30 mmol) was added dropwise at 0 °C, and the mixture was stirred at room temperature overnight. After the mixture was cooled to 0 °C, methanol (10 mL) was added, and the mixture was stirred for 3 h at room temperature. Usual workup and purification by flash chromatography (diethyl ether) afforded **22c** (0.93 g, 85%) as a white solid. M.p.: 144.3–145.0 °C; IR (KBr): $\tilde{\nu}$ = 3378 (m), 3160 (m), 1638 (vs), 1613 (vs), 1409 cm^{-1} (s); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 6.03 (br s, 1H), 5.70 (br s, 1H), 2.69–2.86 (m, 2H), 2.32–2.49 (m, 2H), 1.68–1.81 (m, 2H), 1.53–1.67 ppm (m, 4H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 172.3, 139.4, 124.7, 41.8, 31.9, 31.0, 26.1, 25.0 ppm; MS (EI, 70 eV): *m/z* (%) = 219 (25) $[M]^+$ (^{81}Br), 217 (25) $[M]^+$ (^{79}Br), 138 (100), 110 (95), 95 (74); HRMS (EI): *m/z* calcd for $C_8H_{12}BrNO$: 217.0102 $[M]^+$ (^{79}Br); found: 217.0079.

23c: Compound **22c** (1.09 g, 5.0 mmol), 2,5-hexanedione (1.14 g, 10.0 mmol), and $TsOH\cdot H_2O$ (10 mg, 1 mol%) were dissolved in toluene (20 mL) and heated in a flask equipped with a Dean–Stark apparatus for 4 h. Upon cooling, the dark-brown reaction mixture was concentrated in vacuo. Purification by flash chromatography (pentane/diethyl ether = 10:1) provided **23c** (1.20 g, 81%) as a yellow oil. IR (KBr): $\tilde{\nu}$ = 2923 (m), 1684 (vs), 1627 (m), 1541 (m), 1364 cm^{-1} (vs); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 5.81 (s, 2H), 2.76–2.87 (m, 2H), 2.39–2.51 (m, 2H), 2.30 (s, 6H), 1.60–1.85 ppm (m, 6H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 171.5, 139.8, 130.9, 128.5, 111.9, 42.5, 32.8, 31.3, 26.5, 25.1, 16.0 ppm; MS (EI, 70 eV): *m/z* (%) = 297 (11) $[M]^+$ (^{81}Br), 295 (11) $[M]^+$ (^{79}Br), 216 (45), 200 (100), 122 (40), 93 (51); HRMS (EI): *m/z* calcd for $C_{14}H_{18}BrNO$: 295.0572 $[M]^+$ (^{79}Br); found: 295.0570.

24a: Prepared from **23a** (268 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), (p-Tol)$_3$P (30 mg, 10 mol%), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Purification by flash chromatography (hexane/diethyl ether = 3:1) afforded **24a** (149 mg, 80%) as a white solid. M.p.: 90.0–91.0 °C; IR (KBr): $\tilde{\nu}$ = 2926 (w), 1692 (vs), 1632 (s), 1316 (vs), 1295 cm^{-1} (vs); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 6.07 (d, J = 5.8 Hz, 1H), 6.01 (d, J = 5.8 Hz, 1H), 5.08 (s, 1H), 4.58 (s, 1H), 2.23–2.57 (m, 6H), 1.40 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 174.6, 171.5, 146.4, 141.4, 134.6, 130.2, 94.5, 76.4, 27.9, 27.6, 25.4, 25.1 ppm; MS (EI, 70 eV): *m/z* (%) = 187 (35) $[M]^+$, 172 (100), 158 (13), 144 (42); HRMS (EI): *m/z* calcd for $C_{12}H_{13}NO$: 187.0997 $[M]^+$; found: 187.0973.

24b: Prepared from **23b** (282 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), (p-Tol)$_3$P (30 mg, 10 mol%), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Purification by flash chromatography (hexane/diethyl ether = 3:1) afforded **24b** (171 mg, 85%) as a white solid. M.p.: 108.2–109.0 °C; IR (KBr): $\tilde{\nu}$ = 2926 (w), 1690 (vs), 1658 (m), 1632 (m), 1310 cm^{-1} (vs); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 6.08–6.12 (m, 1H), 6.00 (d, J = 5.8 Hz, 1H), 5.13 (s, 1H), 4.62 (s, 1H), 2.11–2.29 (m, 4H), 1.58–1.77 (m, 4H), 1.37 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 175.5, 162.6, 146.4, 135.1, 131.0, 129.8, 95.0, 79.1, 25.2, 22.8, 21.9, 21.6, 20.1 ppm; MS (EI, 70 eV): *m/z* (%) = 201 (25) $[M]^+$, 186 (100), 158 (13), 130 (9); HRMS (EI): *m/z* calcd for $C_{13}H_{15}NO$: 201.1154 $[M]^+$; found: 201.1151.

24c: Prepared from **23c** (296 mg, 1.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), (p-Tol)$_3$P (30 mg, 10 mol%), and Cs_2CO_3 (391 mg, 1.2 mmol) according to Procedure C. Purification by flash chromatography (hexane/diethyl ether = 3:1) afforded **24c** (160 mg, 74%) as a white solid. M.p.: 99.0–100.0 °C; IR (KBr): $\tilde{\nu}$ = 2918 (w), 1686 (s), 1656 (m), 1631 (m), 1309 cm^{-1} (s); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 6.09–6.13 (m, 1H), 5.99 (d, J = 5.8 Hz, 1H), 5.10–5.14 (m, 1H), 4.58–4.64 (m, 1H), 2.22–2.46 (m, 4H), 1.42–1.90 (m, 6H), 1.38 ppm (s, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 175.8, 164.8, 146.7, 135.3, 134.3, 129.8, 94.9, 79.1, 30.9, 28.4, 26.9, 26.7, 25.0, 24.4 ppm; MS (EI, 70 eV): *m/z* (%) = 215 (21) $[M]^+$, 200 (100), 186 (2), 172 (5), 158 (2), 130 (4); HRMS (EI): *m/z* calcd for $C_{14}H_{17}NO$: 215.1310 $[M]^+$; found: 215.1306.

27a: The reaction was performed in a sealed tube with a mixture of **25** (463 mg, 1.0 mmol), benzeneboronic acid (146 mg, 1.2 mmol), $Pd(OAc)_2$ (22 mg, 10 mol%), (p-Tol)$_3$P (60 mg, 20 mol%), and Cs_2CO_3 (717 mg, 2.2 mmol) at 110 °C for 12 h with toluene (10 mL) as solvent. Upon cooling to room temperature, water (10 mL) was added. The mixture was extracted with diethyl ether (3×30 mL). The combined extracts were washed with brine, dried over Na_2SO_4, and concentrated in vacuo. Purification by flash chromatography (pentane/diethyl ether = 3:1) provided a mixture of the desired product **27a** and the double Suzuki coupling compound (< 10%). Pure **27a** was obtained (246 mg, 65%) after recrystallization (diethyl ether/pentane = 1:10) as a white solid. M.p.: 155.0–156.2 °C; IR (neat): $\tilde{\nu}$ = 2983 (w), 1687 (s), 1526 (m), 1442 (m), 1218 (s), 1063 cm^{-1} (m); ^{1}H NMR ($CDCl_3$, 600 MHz): δ = 8.32 (s, 1H), 8.10 (d, J = 8.8 Hz, 1H), 8.06 (d, J = 7.9 Hz, 1H), 7.82 (d, J = 7.5 Hz, 1H), 7.62 (d, J = 7.1 Hz, 2H), 7.53 (d, J = 8.4 Hz, 1H), 7.48 (t, J = 7.1 Hz, 2H), 7.39 (t, J = 7.5 Hz, 1H), 7.35 (t, J = 7.1 Hz, 1H), 7.28 (t, J = 7.5 Hz, 1H), 7.21 (s, 1H), 4.36 (q, J = 7.1 Hz, 2H), 3.08 (s, 3H), 1.43 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 150 MHz): δ = 165.5, 139.9, 136.8, 133.7, 132.9, 128.8, 128.7, 128.2, 127.4, 126.9, 126.12, 126.06, 126.0, 124.6, 123.9, 122.4, 122.0, 121.9, 118.0, 116.1, 103.0, 59.8, 16.4, 14.5 ppm; MS (EI, 70 eV): *m/z* (%) = 379 (100), 350 (95), 334 (8), 304 (53), 228 (20), 152 (15); HRMS (ESI): *m/z* calcd for $C_{26}H_{22}NO_2$: 380.1651 $[M+H]^+$; found: 380.1655.

27b: Prepared according to the procedure for **27a** from **25** (232 mg, 0.5 mmol), 3-methoxybenzeneboronic acid (91 mg, 0.6 mmol), $Pd(OAc)_2$ (11 mg, 10 mol%), (p-Tol)$_3$P (30 mg, 20 mol%), and Cs_2CO_3 (359 mg, 1.1 mmol). Reaction conditions: 110 °C, 20 h. Purification by flash chromatography (pentane/diethyl ether = 3:1) provided **27b** (182 mg, 89%) as a white solid. M.p.: 132.1–133.2 °C; IR (neat): $\tilde{\nu}$ = 2976 (w), 1691 (s), 1606 (m), 1580 (m), 1439 (m), 1120 cm^{-1} (s); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.43 (s, 1H), 8.24 (d, J = 7.9 Hz, 1H), 8.17 (d, J = 7.9 Hz, 1H), 7.92 (d, J = 7.9 Hz, 1H), 7.62 (d, J = 8.8 Hz, 1H), 7.17–7.50 (m, 6H), 6.94 (d, J = 7.9 Hz, 1H), 4.36 (q, J = 7.1 Hz, 2H), 3.89 (s, 3H), 3.18 (s, 3H), 1.43 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.6, 160.1, 141.6, 136.98, 136.95, 134.0, 133.1, 129.9, 128.9, 128.4, 126.33, 126.26, 124.8, 124.2, 122.5, 122.3, 122.2, 119.5, 118.2, 116.3, 113.0, 112.7, 103.2, 59.9, 55.4, 16.5, 14.5 ppm; MS (EI, 70 eV): *m/z* (%) = 409 (100) $[M]^+$, 380 (86), 337 (19), 292 (23), 190 (10); HRMS (EI): *m/z* calcd for $C_{27}H_{23}NO_3$: 409.1678 $[M]^+$; found: 409.1661.

29: Prepared according to the procedure for **27a** from **28** (232 mg, 0.5 mmol), 3-methoxybenzeneboronic acid (91 mg, 0.6 mmol), $Pd(OAc)_2$ (11 mg, 10 mol%), (p-Tol)$_3$P (30 mg, 20 mol%), and Cs_2CO_3 (359 mg, 1.1 mmol). Reaction conditions: 110 °C, 12 h. Purification by flash chromatography (pentane/diethyl ether = 4:1) provided **29** (121 mg, 59%) as a white solid. M.p.: 157.9–158.5 °C; IR (neat): $\tilde{\nu}$ = 2972 (w), 1696 (s), 1604 (w), 1580 (m), 1559 (m), 1414 (s), 1214 cm^{-1} (vs); ^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.40 (d, J = 7.1 Hz, 1H), 8.35 (s, 1H), 8.30 (d, J = 7.9 Hz, 1H), 8.01 (dd, ^1J = 7.9 Hz, ^2J = 3.5 Hz, 1H), 7.69 (d, J = 7.9 Hz, 1H), 7.19–7.58 (m, 6H), 6.97 (dd, ^1J = 7.9 Hz, ^2J = 2.6 Hz, 1H), 4.42 (q, J = 7.1 Hz, 2H), 3.94 (s, 3H), 3.24 (s, 3H), 1.47 ppm (t, J = 7.1 Hz, 3H); ^{13}C NMR ($CDCl_3$, 75 MHz): δ = 165.6, 160.1, 142.4, 138.8, 134.9, 133.3, 129.9, 128.8, 127.8, 127.5, 125.4, 125.1, 124.6, 124.0, 123.9, 123.0, 120.8, 119.6, 118.0, 116.5, 113.0, 112.6, 103.2, 59.9, 55.4, 16.6, 14.5 ppm; MS (EI, 70 eV): *m/z* (%) = 409 (100), 380 (85), 337 (14), 292 (13), 207 (30), 145 (15); HRMS (EI): *m/z* calcd for $C_{27}H_{23}NO_3$: 409.1678 $[M]^+$, found: 409.1697.

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