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The Friedel–Crafts Reaction of Indoles with Michael Acceptors Catalyzed by Magnesium and Calcium Salts

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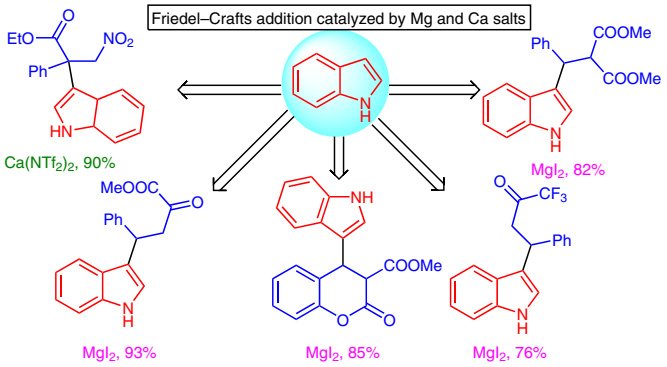

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Abstract Friedel–Crafts alkylation of indole and its derivatives with a variety of electron-deficient alkenes catalyzed by Mg and Ca salts has been studied. The dependence of the results on the nature of the starting olefins, substituents on indole, and Michael acceptors, as well as on the composition of the Lewis acid is discussed. High yields of the addition products were achieved in the addition of indole to β,γ-unsaturated α-keto esters and coumarin derivatives, some nitroolefins, and arylidenemalonates. Reactions involving arylidenemalonates were found to be the most versatile and smooth, the best yields reached 92%. Among the Mg and Ca salts tested, magnesium iodide (MgI_2) proved to be the most appropriate catalyst in the addition to various unsaturated carbonyl compounds, while calcium triflimide [$Ca(NTf_2)_2$] efficiently catalyzed the addition to nitroolefins.

Key words Friedel–Crafts reaction, Lewis acid catalysis, indole, Michael addition, alkenes

Catalysis with transition metal complexes has seriously changed the situation in fine organic synthesis in the last 15 years. The proof of this is in the three Nobel Prizes granted in the period of 2001–2010 and the rapidly proliferating studies in this area. However, in comparison with this type of catalysis, the results achieved by the application of Lewis acids and, in particular, asymmetric catalysis with the use of chiral complexes of scandium, indium, yttrium, and some lanthanides salts[1] have been, as yet, underdeveloped.

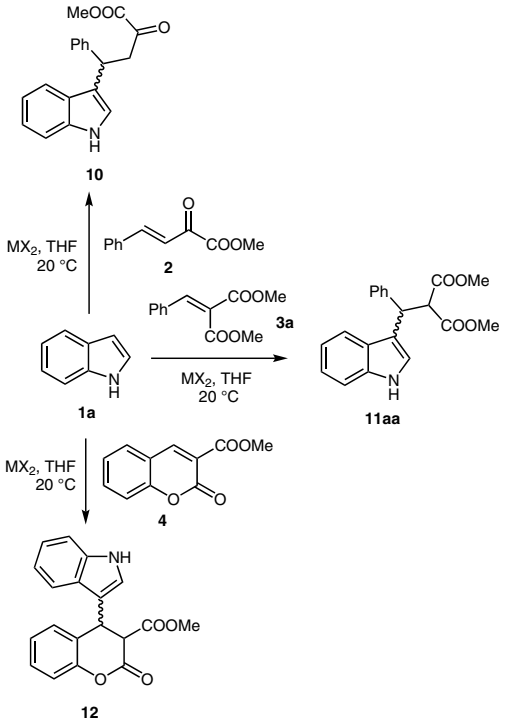
It is noted that recently the interest in the use of non-transition metal salts (primarily magnesium and calcium) has increased. Obviously these investigations are in a trend of green chemistry considering high price and toxicity of many transition metals. Ca and Mg as biogenic elements are non-toxic even in large amounts; they are abundant in Nature and rank 5th and 8th places, respectively, in abundancy in the Earth's core.

Catalysis by Mg salts and, more rarely, by Ca salts is already used in aldol condensation reactions,[2] for transformations of cyclopropanes,[3] epoxides[4] or aziridines,[5] in the Diels–Alder reaction,[6] ene-reaction,[7] in addition to imines,[8,9] in various dipolar cycloaddition processes,[10] and in the ring-opening reactions of vinylcyclopropanes.[11] The favorable influence of MgX_2 has been documented for many reactions catalyzed by transition metal complexes[9–12] or organocatalysts.[13] Mg salts and complexes are known to have been employed in the Michael addition reactions.[3a–c,14] One of the most interesting fields of asymmetric synthesis catalyzed by Lewis acids is associated with Friedel–Crafts reactions.[15] Further to our study of the reactions of indole with Michael acceptors catalyzed by copper salts and their complexes,[16a,b] we studied Michael addition/Friedel–Crafts reactions of indole using various Michael acceptors under catalysis by chiral Cu(II) complexes.[16c]

In the present work we discuss the results obtained during the investigation of the reactions of indoles **1** with methyl (*E*)-2-oxo-4-phenylbut-3-enoate (**2**), arylidenemalonates **3**, methyl 2-oxo-2*H*-chromene-3-carboxylate (**4**), α,β-unsaturated ketones **5**, ethyl (*Z*)-3-nitro-2-phenylacrylate (**6**), (*E*)-(2-nitrovinyl)benzene (**7**), methyl 2-nitro-3-phenylacrylate (**8**), and 3-nitro-2*H*-chromen-2-one (**9**) catalyzed by Mg and Ca salts. The influence of substituents in the reagents, the solvent, and the nature of the counterion on the results of these reactions was studied. In the first step of our investigation we chose Mg and Ca triflates as catalysts. Compounds **2**, **3a**, and **4** were taken as Michael acceptors and THF was used as a solvent (Table 1). The reactions showed good chemoselectivity, but with triflates the reaction rate was quite low, especially for less electrophilic olefins **3a** and **4**. Mg salts were much more active as catalysts than Ca salts, in particular with olefins **3a** and **4** (Table 1, entries 3–8). The reactions accelerated dramatically

when changing $Mg(OTf)_2$ for $Mg(NTf_2)_2$ (Table 1, entry 8). For this reason further investigation was carried out only with Mg salts.

Table 1 Indole (**1a**) Addition to Michael Acceptors **2**, **3a**, and **4** Catalyzed by Mg and Ca Salts[a]

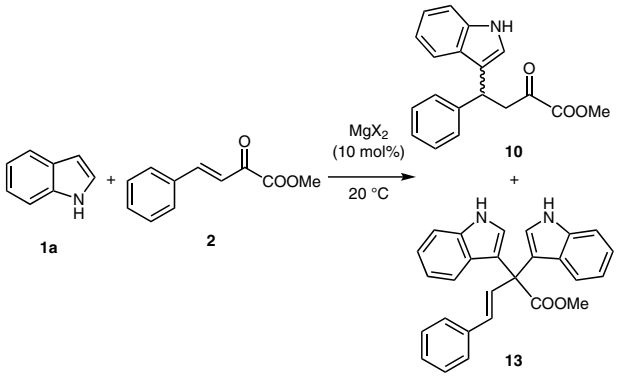


Entry	Michael acceptor	MX_2	Time	Product [yield[b] (%)]
1	**2**	$Ca(OTf)_2$	24 h	**10** (52)
2	**2**	$Mg(OTf)_2$	24 h	**10** (65)
3	**3a**	$Ca(OTf)_2$	60 d	–
4	**3a**	$Mg(OTf)_2$	60 d	**11aa** (68)
5	**4**	$Ca(OTf)_2$	60 d	–
6	**4**	$Mg(OTf)_2$	60 d	**12** (20)
7	**3a**	$Ca(NTf_2)_2$	60 d	**11aa** (32)
8	**3a**	$Mg(NTf_2)_2$	24 h	**11aa** (93)

[a] Reaction conditions: indole (**1a**, 0.5 mmol), Michael acceptor (0.25 mmol), catalyst (0.025 mmol), THF (0.5 mL), 20 °C.
[b] Isolated yield.

In the reaction of indole (**1a**) with β,γ-unsaturated α-keto ester **2** the addition can proceed not only with the C=C bond but also with the C=O bond resulting in the formation of a bisindole product **13** (Table 2).[17] Investigation of the influence of X in MgX_2 salts in the reactions of β,γ-unsaturated α-keto ester **2** showed that with all counterions (OTf^-, NTf_2^-, ClO_4^-, I^-) in THF or CH_2Cl_2 at room temperature the reaction went to completion in 24 hours (reaction time was not optimized) with full conversion of **2** but with different chemoselectivity. Formation of only 1,4-addition product **10** was noted in the presence of MgI_2 in THF (Table 2, entry 4). Insignificant amounts of the side product **13** were observed with $Mg(ClO_4)_2$ (Table 2, entry 7) and MgI_2 in CH_2Cl_2 (Table 2, entry 8).

Table 2 Indole (**1a**) Addition to Methyl 2-Oxo-3-phenylbut-3-enoate (**2**) Catalyzed by Mg Salts[a]



Entry	MgX_2	Solvent	Conv.[b] (%) of **2**	Ratio[b] **10**/**13**
1	$Mg(OTf)_2$	THF	100	65:35
2	$Mg(NTf_2)_2$	THF	100	55:45
3	$Mg(ClO_4)_2$	THF	100	55:45
4	MgI_2	THF	100 (92)[c]	100:0
5	$Mg(OTf)_2$	CH_2Cl_2	100	20:80
6	$Mg(NTf_2)_2$	CH_2Cl_2	100	66:34
7	$Mg(ClO_4)_2$	CH_2Cl_2	100	94:6
8	MgI_2	CH_2Cl_2	100	95:5

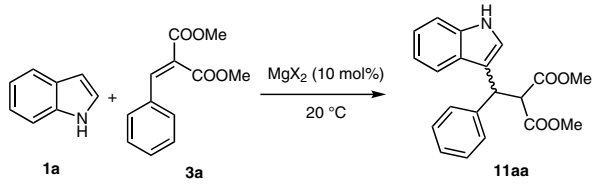
[a] Reaction conditions: indole (**1a**, 0.5 mmol), methyl 2-oxo-3-phenylbut-3-enoate (**2**, 0.25 mmol), catalyst (0.025 mmol), THF (0.5 mL), 20 °C, 24 h.
[b] Estimated by ^1H NMR.
[c] Isolated yield (%) of compound **10**.

The reaction of dimethyl benzylidenemalonate (**3a**) (Table 3) was found to be most sensitive to the nature of the counterion. $Mg(OTf)_2$ was not efficient enough (Table 3, entries 1 and 5), whilst the activity of $Mg(ClO_4)_2$ and $Mg(NTf_2)_2$ in THF was higher than in CH_2Cl_2 (Table 3, entries 2, 3, 6, and 7). The best catalytic activity was demonstrated by MgI_2. The reaction went to completion in THF in 6 hours (Table 3, entry 4), and in CH_2Cl_2 in only 5 minutes (Table 3, entry 8).

The lower yield of compound **11aa** was due to the formation of the symmetric bisindole derivative **14**, the possible mechanism of its formation is shown in Scheme 1.

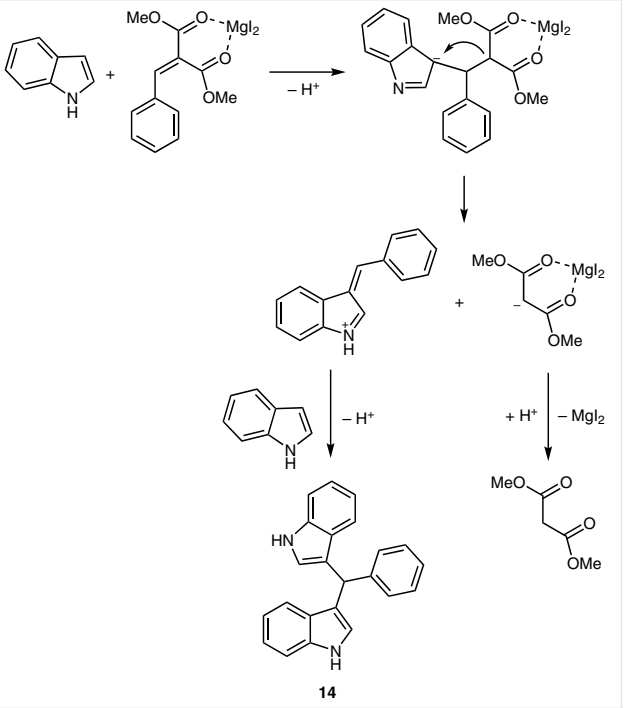
We studied the dependence of the products yield, reaction time, and chemoselectivity on the nature of the substituents in the starting compounds (Table 4). 7-Nitroindole (**1b**) was totally inert and even after 3 days no product was detected in the reaction mixture (Table 4, entry 2). The re-

Table 3 Indole (**1a**) Addition to Dimethyl Benzylidenemalonate (**3a**) Catalyzed by Mg Salts[a]



Entry	MgX_2	Solvent	Time	Conv.[b] (%) of **3a**
1	$Mg(OTf)_2$	THF	24 h	15
2	$Mg(NTf_2)_2$	THF	24 h	100
3	$Mg(ClO_4)_2$	THF	24 h	100
4	MgI_2	THF	6 h	100
5	$Mg(OTf)_2$	CH_2Cl_2	24 h	0
6	$Mg(NTf_2)_2$	CH_2Cl_2	24 h	77
7	$Mg(ClO_4)_2$	CH_2Cl_2	24 h	56
8	MgI_2	CH_2Cl_2	5 min	100 (82)[c]

[a] Reaction conditions: indole (**1a**, 0.5 mmol), dimethyl benzylidenemalonate (**3a**, 0.25 mmol), catalyst (0.025 mmol), solvent (0.5 mL), 20 °C.
[b] Estimated by ^{1}H NMR.
[c] Isolated yield (%) of **11aa**.

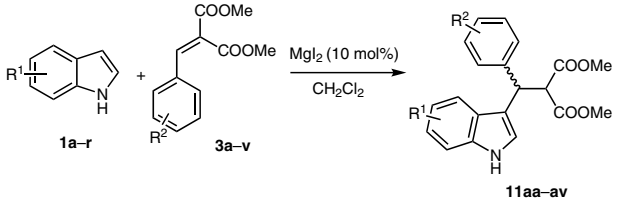


Scheme 1 Plausible mechanism of formation of bisindole derivative **14**

action with 1-methylindole (**1c**) was also very slow as only 50% conversion was observed after 18 horus (Table 4, entry 3). The reactions of other indole derivatives with electron withdrawing substituents like 5-NO_2 (Table 4, entry 4), 6-COOMe (Table 4, entry 5), 5-CN (Table 4, entry 6), 4-CN (Table 4, entry 7) gave the addition products in good yields (up to 75%) after column chromatography isolation. No bisindole side product was observed.

However, the reaction time increased up to 40 h due to a decrease in nucleophilicity of C3 of the indoles containing strong electron-withdrawing substituents. The introduction of halogens in positions 5 and 6 led to lower yields of the Michael addition products and resulted in the formation of notable amounts of the bisindole side products (Table 4, entries 8–12). Such bisindole derivatives became predominant for indoles with electron-donor substituents in the benzene or pyrrole ring. The reaction with 5-methoxyindole (**1m**) at room temperature produced exclusively a symmetric bisindole compound (Table 4, entry 13).

Table 4 Indoles Addition to Substituted Dimethyl Arylidenemalonates Catalyzed by MgI_2[a]



Entry	Indole, R^1	Malonate, R^2	Temp (°C)	Time[b]	Product [yield[c] (%)]
1	**1a**, H	**3a**, H	20	5 min	**11aa** (82)
2	**1b**, 7-NO_2	**3a**, H	20	72 h	**11ba** (–)
3	**1c**, 1-Me	**3a**, H	20	18 h	**11ca** (<50)
4	**1d**, 5-NO_2	**3a**, H	20	8 h	**11da** (75)
5	**1e**, 6-COOMe	**3a**, H	20	40 min	**11ea** (70)
6	**1f**, 5-CN	**3a**, H	20	40 h	**11fa** (73)
7	**1g**, 4-CN	**3a**, H	20	20 h	**11ga** (72)
8	**1h**, 5-F	**3a**, H	20	30 min	**11ha** (70)
9	**1i**, 5-Cl	**3a**, H	20	30 min	**11ia** (65[d])
10	**1j**, 5-Br	**3a**, H	20	30 min	**11ja** (55[d])
11	**1k**, 5-I	**3a**, H	20	30 min	**11ka** (51[d])
12	**1l**, 6-Cl	**3a**, H	20	20 min	**11la** (67[d])
13	**1m**, 5-OMe	**3a**, H	20	2 min	**11ma** (0[e])
14	**1m**, 5-OMe	**3a**, H	–40	3 h	**11ma** (80)
15	**1n**, 2-Me	**3a**, H	–40	4 h	**11na** (86)
16	**1o**, 5-Me	**3a**, H	–40	4 h	**11oa** (88)
17	**1p**, 5-OBn	**3a**, H	–40	4 h	**11pa** (85)
18	**1q**, 4-OMe	**3a**, H	–40	6 h	**11qa** (86)
19	**1r**, 4-OBn	**3a**, H	–40	8 h	**11ra** (80)
20	**1a**, H	**3b**, 4-NO_2	–40 to r.t.	72 h	**11ab** (0)
21	**1a**, H	**3c**, 4-COOMe	20	3 h	**11ac** (62)

Table 4 (continued)

Entry	Indole, R^1	Malonate, R^2	Temp (°C)	Time[b]	Product [yield[c] (%)]
22	**1a**, H	**3d**, 4-CF_3	20	4 h	**11ad** (76)
23	**1a**, H	**3e**, 3,5-$(CF_3)_2$	–40	18 h	**11ae** (87)
24	**1a**, H	**3f**, 2-F	–40	18 h	**11af** (70)
25	**1a**, H	**3g**, 3-F	–40	18 h	**11ag** (82)
26	**1a**, H	**3h**, 4-F	–40	18 h	**11ah** (76)
27	**1a**, H	**3i**, 2-Cl	–40	18 h	**11ai** (92)
28	**1a**, H	**3j**, 3-Cl	–40	18 h	**11aj** (75)
29	**1a**, H	**3k**, 4-Cl	–40	18 h	**11ak** (90)
30	**1a**, H	**3l**, 2-Br	–40	18 h	**11al** (68)
31	**1a**, H	**3m**, 3-Br	–40	18 h	**11am** (87)
32	**1a**, H	**3n**, 4-Br	–40	18 h	**11an** (81)
33	**1a**, H	**3o**, 4-OCF_3	–40	18 h	**11ao** (83)
34	**1a**, H	**3p**, 4-SMe	–40	18 h	**11ap** (81)
35	**1a**, H	**3q**, 2-Me	–40	18 h	**11aq** (62[d])
36	**1a**, H	**3r**, 4-Et	–40	18 h	**11ar** (60[d])
37	**1a**, H	**3s**, 2-OMe	–40	18 h	**11as** (60[d])
38	**1a**, H	**3t**, 4-OMe	–40	18 h	**11at** (51[d])
39	**1a**, H	**3u**[f]	–40	48 h	**11au** (90)
40	**1a**, H	**3v**[g]	–40	72 h	**11av** (0)

[a] Reaction conditions: indole (0.5 mmol), Michael acceptor (0.25 mmol), MgI_2 (0.025 mmol), CH_2Cl_2 (0.5 mL).
[b] Estimated by TLC.
[c] Isolated yield.
[d] 100% conversion of the starting Michael acceptor.
[e] Bisindole adduct was isolated in 85% yield.
[f] Dimethyl (thiophen-2-ylmethylene)malonate.
[g] Dimethyl (pyridin-2-ylmethylene)malonate.

Performing the reaction at –40 °C allowed the desired addition product of 5-methoxyindole (**1m**) to be obtained in 80% yield (Table 4, entry 14), and no bisindole derivative was observed. Adducts with other indoles possessing electron-donor substituents were isolated in high yields under low temperature conditions (Table 4, entries 15–19).

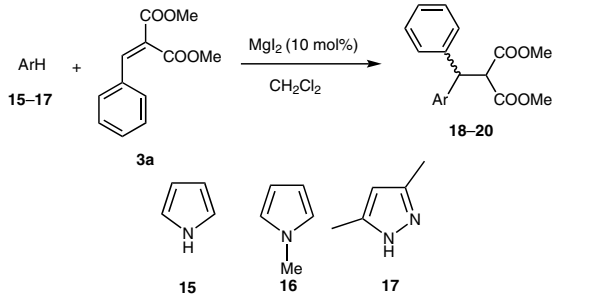
The studies of the influence of substituents in arylidenemalonate revealed some interesting facts. It is known that in the case of the catalysis by Cu(II) complexes the reaction is rapid when electron-withdrawing substituents like the *para*-nitro group are present in arylidenemalonates. In contrast, the introduction of electron-donor substituents like the *para*-methoxy group decreases the reaction rate. When the reaction is catalyzed by MgI_2, 4-nitrobenzylidenemalonate **3b** does not react with indole (**1a**) (Table 4, entry 20). Weaker electron-withdrawing substituents like COOMe and CF_3 (Table 4, entries 21 and 22) provided the products **11ac**,**ad** in good yields, but the reactions needed more time compared to the unsubstituted analogue **3a**. The introduction of two *meta*-CF_3 groups in arylidenemalonate **3e** (Table 4, entry 23) or halogen atoms in any position of the benzene ring (Table 4, entries 24–32) afforded the products in 70–92% yields.

We also found out that the introduction of trifluoromethoxy and methylthio substituents in the *para*-position did not diminish the yields of the target products (entries 33 and 34) but the presence of alkyl or methoxy substituents in the *ortho*- and *para*-positions led to an increase in the yields of bisindole products (Table 4, entries 35–38). These facts envisage high reactivity of starting compounds in the presence of MgI_2. Similar influence was noted for heteroarylidenemalonates. Thus dimethyl (thiophen-2-ylmethylene)malonate (**3u**) formed the addition product in 90% yield at –40 °C (Table 4, entry 39) while with dimethyl (pyridin-2-ylmethylene)malonate (**3v**) the reaction did not occur even at room temperature (Table 4, entry 40).

One should stress that the observed influence of the substituents is opposite to that assumed as typical for Cu(II)-catalyzed reactions.[18]

Other electron-rich aromatic compounds also react with dimethyl benzylidenemalonate (**3a**) in the presence of MgI_2 (Table 5). Pyrrole (**15**) forms the addition product **18** in a high yield (82%, Table 5, entry 1), but its N-Me analogue **16** reacts very slowly (Table 5, entry 2). In the case of 3,5-dimethylpyrazole (**17**), full conversion of the starting benzylidenemalonate **3a** was observed (Table 5, entry 3), however, an attempt to purify the product using column chromatography was unsuccessful due to its complete decomposition. It was impossible to carry out the reactions with 2-methylfuran and electron-enriched 1,3-dimethoxyben-

Table 5 Friedel–Crafts Reaction of the Aromatic Compounds with Dimethyl Benzylidenemalonate (**3a**) Catalyzed by MgI_2[a]



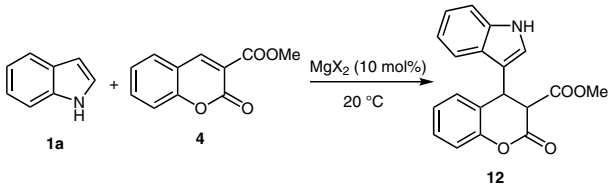
Entry	ArH	Time[b] (h)	Product [conv.[c] (%) of **3a**]
1	**15**, pyrrole	2	**18** (100, 82[d])
2	**16**, *N*-methylpyrrole	24	**19** (20)
3	**17**, 3,5-dimethylpyrazole	2	**20** (100)

[a] Reaction conditions: aromatic compound (0.5 mmol), dimethyl benzylidenemalonate (**3a**, 0.25 mmol), MgI_2 (0.025 mmol), CH_2Cl_2 (0.5 mL), –40 °C.
[b] Estimated by TLC.
[c] Estimated by ^1H NMR.
[d] Isolated yield (%) for **18**.

zene, 1,3,5-trimethoxybenzene, and *N*,*N*-diethylaniline because these compounds were not sufficiently nucleophilic to participate in this process.

The reaction of indole with methyl 2-oxo-2*H*-chromene-3-carboxylate (**4**) (Table 6) was found to be very sensitive to the nature of the solvent. Mg salts other than MgI_2 were not active in THF (Table 6, entries 1–3), and with MgI_2 the conversion reached only 32% after 72 hours (Table 6, entry 4). Similar poor results were observed in CH_2Cl_2 (entries 5–8). However, the yield could be increased up to 50–60% in 1,2-dichloroethane, acetone, acetonitrile (Table 6, entries 9–11). In chloroform it attained 85% (Table 6, entry 12). The synthesis of product **12** was fully diastereoselective giving one isomer with the coupling constant $^3J_{HH}$ = 7.1 Hz between H3 and H4 of the chromane.

Table 6 Indole (**1a**) Addition to Methyl 2-Oxo-2*H*-chromene-3-carboxylate (**4**) Catalyzed by Mg Salts[a]

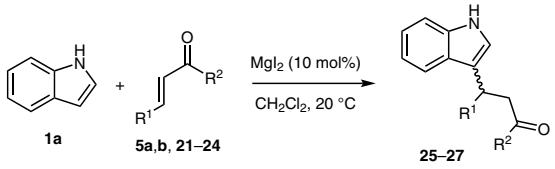


Entry	MgX_2	Solvent	Conv.[b] (%) of **4**
1	$Mg(OTf)_2$	THF	0
2	$Mg(NTf_2)_2$	THF	1
3	$Mg(ClO_4)_2$	THF	2
4	MgI_2	THF	32
5	$Mg(OTf)_2$	CH_2Cl_2	2
6	$Mg(NTf_2)_2$	CH_2Cl_2	6
7	$Mg(ClO_4)_2$	CH_2Cl_2	10
8	MgI_2	CH_2Cl_2	25
9	MgI_2	DCE	52
10	MgI_2	MeCN	56
11	MgI_2	acetone	60
12	MgI_2	$CHCl_3$	90 (85)[c]

[a] Reaction conditions: indole (**1a**, 0.5 mmol), methyl 2-oxo-2*H*-chromene-3-carboxylate (**4**, 0.25 mmol), Mg salt (0.025 mmol), solvent (0.5 mL), 20 °C, 24 h.
[b] Estimated by ^{1}H NMR.
[c] Isolated yield (%) of **12**.

Having investigated the regularities of the reactions of unsaturated compounds **2**–**4** with indoles, at the next step we studied several enones in this process (Table 7). We found out that cyclohex-2-enone (**21**) (Table 7, entry 1) and benzylideneacetone (**22**) (Table 7, entry 2) did not participate in the reaction with indole (**1a**) in the presence of MgI_2, and with cinnamaldehyde (**23**) a complex mixture of products was formed among which no Michael adducts were noted (Table 7, entry 3). In contrast, chalcone (**24**) reacted with indole (**1a**), however, the conversion of the unsaturated ketone did not surpass 40% (Table 7, entry 4). Methyl vinyl ketone (**5a**) and trifluorobenzylideneacetone **5b** were the most active unsaturated carbonyl compounds. The addition of indole (**1a**) to methyl vinyl ketone (**5a**) gave **26** in 75% isolated yield (Table 7, entry 5), the reaction with trifluorobenzylideneacetone **5b** resulted in **27** in 76% yield (Table 7, entry 6).

Table 7 Indole (**1a**) Addition to α,β-Unsaturated Ketones Catalyzed by MgI_2[a]



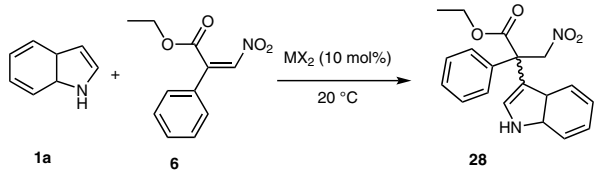
Entry	Michael acceptor	Time (h)	Product [conv.[b] (%)]
1	**21**	96	0
2	**22**	96	0
3	**23**	72	0
4	**24**	96	**25** (40)
5	**5a**	24	**26** (100, 75[c])
6	**5b**	24	**27** (100, 76[c])

[a] Reaction conditions: indole (**1a**, 0.5 mmol), ketone (0.25 mmol), MgI_2 (0.025 mmol), CH_2Cl_2 (0.5 mL), 20 °C.
[b] Estimated by ^{1}H NMR.
[c] Isolated yield (%).

The application of other catalysts can lead to much better yields of the addition products of this series, e.g. $FeCl_3/PdCl_2$ was shown to provide excellent yields of the indole adduct with chalcone.[20]

The influence of Mg and Ca salts on the addition to nitroolefins was studied using compound **6** as an example (Table 8). Magnesium triflate and iodide did not catalyze the reactions in THF at all (Table 8, entries 1 and 3), and the conversion with $Mg(NTf_2)_2$ was also low (Table 8, entry 2). In the case of Ca salts in THF the influence of the counterion was notable as triflate was inactive and iodide provided a good yield of the addition product (Table 8, entries 4 and 6). A better result was achieved with $Ca(NTf_2)_2$ (Table 8, entry 5). The variations in the nature of the solvent allowed a substantial increase in the conversion: 67% in THF, 90% in toluene, and 100% in chloroform (Table 8, entries 5, 7, and 8).

Table 8 Indole (**1a**) Addition to Ethyl (*Z*)-3-Nitro-2-phenylacrylate (**6**) Catalyzed by Ca and Mg Salts



1a **6** **28**

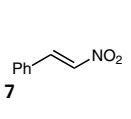
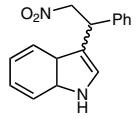
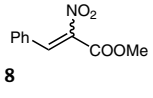
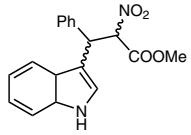
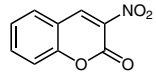
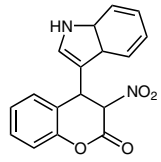
Entry[a]	MX_2	Solvent	Conv.[b] (%) of **6**
1	$Mg(OTf)_2$	THF	0
2	$Mg(NTf_2)_2$	THF	30
3	MgI_2	THF	0
4	$Ca(OTf)_2$	THF	0
5	$Ca(NTf_2)_2$	THF	67
6	CaI_2	THF	55
7	$Ca(NTf_2)_2$	toluene	90 (75)[c]
8	$Ca(NTf_2)_2$	$CHCl_3$	100 (90)[c]

[a] Reaction conditions: indole (**1a**, 0.5 mmol), nitroolefin **6** (0.25 mmol), catalyst (0.025 mmol), solvent (0.5 mL), 20 °C, 18 h.
[b] Estimated by ^{1}H NMR.
[c] Isolated yield (%) of **28**.

Other nitroolefins **7**, **8**, and **9** reacted much better and even at –30 °C produced adducts **29**–**31** in yields from good to high (Table 9, entries 1–3). According to TLC and ^{1}H NMR the conversion of the nitroolefins **7**–**9** was quantitative in each case, but due to the difficulties of the chromatographic isolation the preparative yields varied from 55% (Table 9, entry 3) to 90% (Table 9, entry 1). The formation of product **31** was fully diastereoselective affording a single isomer with the coupling constant between H3 and H4 of the chromanone moiety $^3J_{HH}$ = 9.8 Hz.

To sum up, the present investigation revealed that MgI_2 was the best catalyst for the addition of indole to Michael acceptors **2**–**5**, while $Ca(NTf_2)_2$ was found to be the best catalyst for the reactions with nitroolefins. The reactions of substituted indoles and arylidenemalonates were shown to tolerate various substituents giving addition products in good to high yields.

Table 9 Indole (**1a**) Addition to Nitroolefins Catalyzed by $Ca(NTf_2)_2$[a]

Entry	Michael acceptor	Product	Conv.[b] (%) [yield[c] (%)]
1	 **7**	 **29**	100 (90)
2	 **8**	 **30**	100 (78)
3	 **9**	 **31**	100 (55)[d]

[a] Reaction conditions: indole (0.5 mmol), nitroolefin (0.25 mmol), $Ca(NTf_2)_2$ (0.025 mmol), $CHCl_3$ (0.5 mL), –30 °C, 18 h.
[b] Yield estimated by ^{1}H NMR.
[c] Isolated yield.
[d] The addition of indole to **9** with full conversion into **31** in *i*-PrOH catalyzed by $Mg(OTf)_2$ was described in the literature.[19]

All commercially available reagents were used without further purification. Solvents were purified using known procedures. Compounds **2**,[21] **3a**–**v**,[22] **4**,[23] **5**,[24] **6**,[25] **7**,[26] **8**,[27] and **9**[28] were prepared according to reported methods. All reactions were performed under an air atmosphere. ^{1}H, ^{13}C, and ^{19}F NMR spectra were recorded in $CDCl_3$ with Bruker Avance-400 and Agilent 400-MR spectrometers at r.t. (^{13}C spectra were ^{1}H decoupled) relative to the residual solvent peak ($CHCl_3$: δ = 7.26 for ^{1}H) or to solvent ($CDCl_3$: δ = 77.00 for ^{13}C) as internal standards or to an external standard (CF_3COOH: δ = –78.5 for ^{19}F). Accurate-mass measurements (HRMS) were performed by ESI-TOF with a Thermo Scientific Orbitrap Elite mass spectrometer or by MALDI-TOF with poly(ethylene glycols) as internal standards with Bruker Autoflex II spectrometer. Analytical TLC was carried out using Macherey-Nagel silica gel 60 F254 plates, the spots were visualized by UF. Preparative column chromatography was performed using Macherey-Nagel silica gel 60 (0.040–0.063 mm, 230–400 mesh). Petroleum ether = PE. Melting points were measured with an Electrothermal IA 9200 apparatus and are uncorrected.

Compounds **3e**,**m**,**o**,**p** were obtained according to a known procedure[22] using 2 mmol of the starting material.

Dimethyl 2-[3,5-Bis(trifluoromethyl)benzylidene]malonate (3e)

Purified by column chromatography (PE/EtOAc, 5:1); white solid; yield: 427 mg (60%); mp 71–72 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.90 (s, 1 H), 7.86 (s, 2 H), 7.79 (s, 1 H), 3.88 (s, 3 H), 3.84 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 165.7, 163.5, 139.1, 134.9, 132.4 (q, *J* = 33.8 Hz, 2 C), 129.4, 128.8–128.9 (m), 123.6 (septet, *J* = 3.6 Hz), 122.8 (q, *J* = 273.5 Hz, 2 C), 53.1, 52.8.

^{19}F NMR (376 MHz, $CDCl_3$): δ = –63.24 (s, 6 F).

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{14}H_{10}F_6NaO_4$: 379.0381; found: 379.0360.

Dimethyl 2-(3-Bromobenzylidene]malonate (3m)

Recrystallized (hot MeOH); white solid; yield: 328 mg (55%); mp 72–73 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.68 (s, 1 H), 7.54 (s, 1 H), 7.51 (d, *J* = 8.0 Hz, 1 H), 7.34 (d, *J* = 7.8 Hz, 1 H), 7.26 (t, *J* = 7.8 Hz, 1 H), 3.84 (s, 3 H), 3.84 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 166.5, 164.0, 141.0, 134.8, 133.4, 132.0, 130.3, 127.7, 127.0, 122.9, 52.8, 52.7.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{12}H_{11}BrO_4$: 297.9842; found: 297.9781.

Dimethyl 2-[4-(Trifluoromethoxy)benzylidene]malonate (3o)

Purified by column chromatography (PE/EtOAc, 5:1); yellow liquid; yield: 426 mg (70%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.72 (s, 1 H), 7.43–7.46 (m, 2 H), 7.19–7.22 (m, 2 H), 3.84 (s, 3 H), 3.83 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 166.7, 164.1, 150.5 (q, *J* = 1.9 Hz), 141.0, 131.2, 130.9, 126.3, 120.9 (q, *J* = 1.1 Hz), 120.2 (q, *J* = 258.4 Hz), 52.6 (2 C).

^{19}F NMR (376 MHz, $CDCl_3$): δ = –57.73 (s, 3 F).

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{13}H_{11}F_3NaO_5$: 327.0456; found: 327.0452.

Dimethyl 2-[4-(Methylthio)benzylidene]malonate (3p)

Purified by column chromatography (PE/EtOAc, 4:1); dark-brown oil; yield: 425 mg (80%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.68 (s, 1 H), 7.32 (d, *J* = 8.4 Hz, 2 H), 7.18 (d, *J* = 8.4 Hz, 2 H), 3.84 (s, 3 H), 3.82 (s, 3 H), 2.47 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 167.2, 164.5, 142.9, 142.2, 129.8, 128.8, 125.6, 124.1, 52.6, 52.5, 14.8.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{13}H_{14}NaO_4S$: 289.0510; found: 289.0505.

Friedel–Crafts Alkylation Reaction; General Procedure

The calcium or magnesium salt (0.025 mmol, 10 mol%) and Michael acceptor (0.25 mmol) were dissolved in solvent (0.5 mL), and the mixture was stirred at r.t. for 30 min in a glass vial. The aromatic compound (0.5 mmol) was added and the reaction was stirred at the temperature indicated in Tables 2–9; reaction progress was monitored by TLC. When the reaction was complete, the solvent was evaporated under reduced pressure. The crude residue was purified by column chromatography to afford the product.

Methyl 4-(1*H*-Indol-3-yl)-2-oxo-4-phenylbutanoate (10)[29]

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **2** (47 mg, 0.25 mmol) in THF using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a yellow solid; yield: 70 mg (92%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.02 (s, 1 H), 7.43 (d, *J* = 8.0 Hz, 1 H), 7.33 (m, 3 H), 7.27 (t, *J* = 7.5 Hz, 2 H), 7.14–7.20 (m, 2 H), 7.01–7.04 (m, 2 H), 4.93 (t, *J* = 7.6 Hz, 1 H), 3.77 (s, 3 H), 3.70 (dd, *J* = 17.1, 7.6 Hz, 1 H), 3.62 (dd, *J* = 17.1 Hz, 7.6 Hz, 1 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 192.6, 161.2, 143.1, 136.5, 128.4 (2 C), 127.7 (2 C), 126.6, 126.3, 122.2, 121.5, 119.4, 119.3, 118.2, 111.2, 52.9, 45.7, 37.7.

Dimethyl 2-[(1*H*-Indol-3-yl)(phenyl)methyl]malonate (11aa)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 69 mg (82%); mp 153–154 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08 (s, 1 H), 7.52 (d, *J* = 8.1 Hz, 1 H), 7.34 (d, *J* = 7.7 Hz, 2 H), 7.29 (d, *J* = 8.1 Hz, 1 H), 7.24 (t, *J* = 7.8 Hz, 2 H), 7.17–7.12 (m, 3 H), 7.03 (t, *J* = 7.8 Hz, 1 H), 5.11 (d, *J* = 11.9 Hz, 1 H), 4.33 (d, *J* = 11.9 Hz, 1 H), 3.56 (s, 3 H), 3.52 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 166.4, 166.2, 141.2, 136.2, 128.4 (2 C), 128.0 (2 C), 126.8, 126.6, 122.3, 120.1, 119.5, 119.3, 116.7, 111.0, 56.2, 52.6, 52.4, 42.9.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{20}H_{19}NO_4$: 337.1314; found: 337.1295.

Dimethyl 2-[(5-Nitro-1*H*-indol-3-yl)(phenyl)methyl]malonate (11da)

Following the GP using indole **1d** (81 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by column chromatography (CH_2Cl_2), the product was obtained as a yellow solid; yield: 72 mg (75%); mp 174–176 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.83 (s, 1 H), 8.50 (s, 1 H), 8.02 (d, *J* = 8.8 Hz, 1 H), 7.25–7.36 (m, 6 H), 7.17–7.20 (t, *J* = 7.3 Hz 1 H), 5.13 (d, *J* = 11.6 Hz, 1 H), 4.29 (d, *J* = 11.6 Hz, 1 H), 3.58 (s, 3 H), 3.55 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 167.4, 141.6, 140.2, 139.2, 128.7 (2 C), 127.9 (2 C), 127.3, 126.0, 124.2, 119.2, 118.0, 116.5, 111.3, 57.9, 52.8, 52.6, 42.4.

HRMS (ESI): *m*/*z* [M]$^+$ calcd for $C_{20}H_{18}N_2O_6$: 382.1165; found: 382.1109.

Dimethyl 2-{[6-(Methoxycarbonyl)-1*H*-indol-3-yl](phenyl)methyl}malonate (11ea)

Following the GP using indole **1e** (88 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 69 mg (70%); mp 196–198 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.55 (s, 1 H), 8.06 (s, 1 H), 7.72 (dd, *J* = 8.5, 0.56 Hz, 1 H), 7.54 (d, *J* = 8.5 Hz, 1 H), 7.32–7.34 (m, 3 H), 7.25 (t, *J* = 7.4 Hz, 2 H), 7.16 (t, *J* = 7.3 Hz, 1 H), 5.10 (d, *J* = 11.8 Hz, 1 H), 4.32 (d, *J* = 11.8 Hz, 1 H), 3.90 (s, 3 H), 3.53 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.1, 167.9, 167.9, 140.9, 135.5, 129.8 (2 C), 128.2 (2 C), 127.3, 126.6, 124.6, 123.2, 119.9, 118.4, 116.3, 113.6, 57.8, 52.4, 52.2, 51.6, 42.5.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M]^+$ calcd for $C_{22}H_{21}NO_6$: 395.1369; found: 395.1361.

Dimethyl 2-[(5-Cyano-1*H*-indol-3-yl)(phenyl)methyl]malonate (11fa)

Following the GP using indole **1f** (88 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 69 mg (73%); mp 142–143 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.60 (s, 1 H), 7.84 (s, 1 H), 7.34 (d, *J* = 0.6 Hz, 2 H), 7.24–7.32 (m, 5 H), 7.18 (t, *J* = 7.1 Hz, 1 H), 5.05 (d, *J* = 11.6 Hz, 1 H), 4.29 (d, *J* = 11.6 Hz, 1 H), 3.58 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 167.8, 140.3, 137.8, 128.6 (2 C), 127.9 (2 C), 127.2, 126.4, 125.2, 124.9, 123.1, 120.6, 117.6, 112.1, 102.4, 57.9, 52.7, 52.5, 42.6.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M + H]^+$ calcd for $C_{21}H_{19}N_2O_4$: 363.1267; found: 363.1345.

Dimethyl 2-[(4-Cyano-1*H*-indol-3-yl)(phenyl)methyl]malonate (11ga)

Following the GP using indole **1g** (88 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 68 mg (72%); mp 171–172 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 9.16 (s, 1 H), 7.50–7.52 (m, 2 H), 7.46 (d, *J* = 7.6 Hz, 2 H), 7.37 (d, *J* = 7.3 Hz, 1 H), 7.22 (t, *J* = 7.5 Hz, 2 H), 7.08–7.16 (m, 2 H), 5.77 (d, *J* = 11.8 Hz, 1 H), 4.33 (d, *J* = 11.8 Hz, 1 H), 3.54 (s, 3 H), 3.49 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 167.9, 140.5, 136.3, 128.6 (2 C), 128.3 (2 C), 126.9, 126.8, 125.6, 124.4, 121.5, 119.5, 116.4, 101.7, 59.1, 52.7, 52.4, 41.0 (one aromatic quaternary carbon atom was not unambiguously assigned).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M + H]^+$ calcd for $C_{21}H_{19}N_2O_4$: 363.1267; found: 363.1245.

Dimethyl 2-[(5-Fluoro-1*H*-indol-3-yl)(phenyl)methyl]malonate (11ha)

Following the GP using indole **1h** (68 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 62 mg (70%); mp 164–166 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08 (s, 1 H), 7.32 (d, *J* = 7.3 Hz, 2 H), 7.12–7.27 (m, 6 H), 6.87 (t, *J* = 8.3 Hz, 1 H), 5.01 (d, *J* = 12.3 Hz, 1 H), 4.29 (d, *J* = 12.3 Hz, 1 H), 3.57 (s, 3 H), 3.52 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.3, 168.0, 158.70 (d, *J* = 234.6 Hz), 140.8, 132.7, 128.5 (2 C), 128.0 (2 C), 127.0, 126.9, 122.5, 116.9 (d, *J* = 5.0 Hz), 111.7 (d, *J* = 9.5 Hz), 110.7 (d, *J* = 26.7 Hz), 104.2 (d, *J* = 24.0 Hz), 58.0, 52.7, 52.5, 42.8.

^{19}F NMR (376 MHz, $CDCl_3$): δ = –124.26 (dt, *J* = 9.8, 4.1 Hz, 1 F).

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{20}H_{18}FNNaO_4$: 378.1118; found: 378.1114.

Dimethyl 2-[(5-Chloro-1*H*-indol-3-yl)(phenyl)methyl]malonate (11ia)

Following the GP using indole **1i** (76 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 60 mg (65%); mp 146–147 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11 (s, 1 H), 7.48 (d, *J* = 1.5 Hz, 1 H), 7.32 (d, *J* = 7.7 Hz, 2 H), 7.25 (t, *J* = 7.4 Hz, 2 H), 7.15–7.21 (m, 3 H), 7.08 (dd, *J* = 6.8, 1.9 Hz, 1 H), 5.03 (d, *J* = 11.8 Hz, 1 H), 4.29 (d, *J* = 11.8 Hz, 1 H), 3.56 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.3, 168.0, 140.7, 134.5, 128.5 (2 C), 127.88 (2 C), 127.5, 127.0, 125.2, 122.6, 122.2, 118.6, 116.4, 112.1, 58.1, 52.7, 52.5, 42.6.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{20}H_{18}ClNNaO_4$: 394.0822; found: 394.0819.

Dimethyl 2-[(5-Bromo-1*H*-indol-3-yl)(phenyl)methyl]malonate (11ja)

Following the GP using indole **1j** (98 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 67 mg (55%); mp 146–148 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12 (s, 1 H), 7.63 (d, *J* = 1.7 Hz, 1 H), 7.30–7.32 (m, 2 H), 7.24 (dt, *J* = 7.6, 0.6 Hz, 2 H), 7.12–7.21 (m, 4 H), 5.01 (d, *J* = 11.7 Hz, 1 H), 4.27 (d, *J* = 11.7 Hz, 1 H), 3.54 (s, 3 H), 3.51 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 167.9, 140.7, 134.8, 128.5 (2 C), 128.18 (2 C), 127.9, 127.0, 125.2, 122.1, 121.8, 116.4, 112.9, 112.5, 58.2, 52.7, 52.5, 42.5.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{20}H_{18}BrNNaO_4$: 438.0317; found: 438.0312.

Dimethyl 2-[(5-Iodo-1*H*-indol-3-yl)(phenyl)methyl]malonate (11ka)

Following the GP using indole **1k** (122 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 59 mg (51%); mp 170–172 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12 (s, 1 H), 7.86 (d, *J* = 1.4 Hz, 1 H), 7.38 (dd, *J* = 8.5, 1.5 Hz, 1 H), 7.32 (d, *J* = 7.2 Hz, 2 H), 7.26 (t, *J* = 7.5 Hz, 2 H), 7.17 (t, *J* = 7.2 Hz, 1 H), 7.10 (s, 1 H), 7.07 (d, *J* = 8.5 Hz, 1 H), 5.01 (d, *J* = 11.8 Hz, 1 H), 4.27 (d, *J* = 11.8 Hz, 1 H), 3.56 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.0, 140.8, 135.2, 130.6, 129.1, 128.5 (2 C), 128.0 (2 C), 127.9, 127.0, 121.8, 116.1, 113.1, 83.1, 58.2, 52.7, 52.5, 42.45.

HRMS (ESI): *m*/*z* $[M + Na]^+$ calcd for $C_{20}H_{18}INNaO_4$: 486.0178; found: 486.0174.

Dimethyl 2-[(6-Chloro-1*H*-indol-3-yl)(phenyl)methyl]malonate (11la)

Following the GP using indole **1l** (76 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 62 mg (67%); mp 146–147 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.13 (s, 1 H), 7.40 (d, *J* = 8.5 Hz, 1 H), 7.32 (d, *J* = 7.3 Hz, 2 H), 7.23–7.27 (m, 3 H), 7.17 (t, *J* = 7.1 Hz, 1 H), 7.12 (d, *J* = 2.0 Hz, 1 H), 6.99 (dd, *J* = 8.5, 1.7 Hz, 1 H), 5.06 (d, *J* = 11.8 Hz, 1 H), 4.30 (d, *J* = 11.8 Hz, 1 H), 3.56 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.4, 168.1, 140.8, 136.5, 128.5 (2 C), 128.2, 127.9 (2 C), 127.0, 125.1, 121.4, 120.3, 120.1, 116.9, 111.0, 58.0, 52.7, 52.5, 42.7.

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{20}H_{18}ClNNaO_4$: 394.0822; found: 394.0817.

Dimethyl 2-[(5-Methoxy-1*H*-indol-3-yl)(phenyl)methyl]malonate (11ma)

Following the GP using indole **1m** (73 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 73 mg (80%); mp 120–122 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.94 (s, 1 H), 7.32–7.34 (m, 2 H), 7.20–7.24 (m, 2 H), 7.11–7.16 (m, 3 H), 6.91 (d, *J* = 2.3 Hz, 1 H), 6.78 (dd, *J* = 9.0, 2.4 Hz, 1 H), 5.03 (d, *J* = 11.8 Hz, 1 H), 5.01, 4.27 (d, *J* = 11.8 Hz, 1 H), 3.75 (s, 3 H), 3.55 (s, 3 H), 3.50 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.5, 168.2, 153.9, 141.1, 131.3, 128.4 (2 C), 128.1 (2 C), 127.0, 126.8, 121.53, 116.5, 112.5, 111.7, 101.1, 58.1, 55.7, 52.8, 52.5, 42.8.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_5$: 367.1420; found: 367.1397.

Dimethyl 2-[(2-Methyl-1*H*-indol-3-yl)(phenyl)methyl]malonate (11na)

Following the GP using indole **1n** (66 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 76 mg (86%); mp 128–129 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.77 (s, 1 H), 7.63 (dd, *J* = 6.4, 2.5 Hz, 1 H), 7.35 (m, 2 H), 7.22–7.24 (m, 2 H), 7.16–7.20 (m, 1 H), 7.09–7.12 (m, 1 H), 7.00–7.06 (m, 2 H), 5.07 (d, *J* = 12.2 Hz, 1 H), 4.71 (d, *J* = 12.20 Hz, 1 H), 3.62 (s, 3 H), 3.37 (s, 3 H), 2.42 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.3, 141.6, 135.2, 132.1, 128.4 (2 C), 127.3 (2 C), 127.1, 126.4, 120.8, 119.3, 118.9, 111.1, 110.4, 55.5, 52.6, 52.3, 42.3, 12.2.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_4$: 351.1471; found: 367.1427.

Dimethyl 2-[(5-Methyl-1*H*-indol-3-yl)(phenyl)methyl]malonate (11oa)

Following the GP using indole **1o** (66 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 77 mg (88%); mp 145–146 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.94 (s, 1 H), 7.35 (d, 2 H), 7.31 (s, 1 H), 7.24 (t, *J* = 7.8 Hz, 2 H), 7.17 (t, *J* = 8.3 Hz, 2 H), 7.12 (s, 1 H), 6.96 (d, *J* = 8.1 Hz, 1 H), 5.07 (d, *J* = 11.9 Hz, 1 H), 4.29 (d, *J* = 11.9 Hz, 1 H), 3.55 (s, 3 H), 3.52 (s, 3 H), 2.38 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.4, 168.2, 141.3, 134.1, 128.7, 128.3 (2 C), 128.0 (2 C), 126.7, 123.8, 120.9, 118.8, 116.1, 110.6, 58.2, 52.6, 52.4, 42.9, 21.5; (one aromatic quaternary carbon atom was not unambiguously assigned).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_4$: 351.1471; found: 351.1418.

Dimethyl 2-{[5-(Benzyloxy)-1*H*-indol-3-yl](phenyl)methyl}malonate (11pa)

Following the GP using indole **1p** (112 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 94 mg (85%); mp 157–158 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.94 (s, 1 H), 7.44 (d, *J* = 7.0 Hz, 2 H), 7.28 (t, *J* = 7.2 Hz, 2 H), 7.32 (d, *J* = 8.3 Hz, 3 H), 7.23 (t, *J* = 7.4 Hz, 2 H), 7.15–7.18 (m, 2 H), 7.13 (d, *J* = 1.8 Hz, 1 H), 7.03 (d, *J* = 2.2 Hz, 1 H), 6.87 (dd, *J* = 8.8, 2.2 Hz, 1 H), 4.98–5.05 (m, 3 H), 4.30 (d, *J* = 11.8 Hz, 1 H), 3.56 (s, 3 H), 3.52 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.4, 168.2, 153.1, 141.1, 131.5, 128.5 (2 C), 128.4 (2 C), 128.0 (2 C), 127.7 (2 C), 127.6, 127.0, 126.8, 121.4, 116.6, 113.3, 111.7, 102.8, 100.0, 70.8, 58.0, 52.7, 52.5, 42.9.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{27}H_{25}NO_5$: 443.173; found: 443.137.

Dimethyl 2-[(4-Methoxy-1*H*-indol-3-yl)(phenyl)methyl]malonate (11qa)

Following the GP using indole **1q** (73 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 79 mg (86%); mp 157–159 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.04 (s, 1 H), 7.32 (d, *J* = 7.4 Hz, 2 H), 7.21 (t, *J* = 7.2 Hz, 2 H), 7.09–7.13 (m, 2 H), 7.03 (t, *J* = 7.8 Hz, 1 H), 6.90 (d, *J* = 8.2 Hz, 1 H), 6.41 (d, *J* = 7.4 Hz, 1 H), 5.51 (d, *J* = 12.1 Hz, 1 H), 4.31 (d, *J* = 12.1 Hz, 1 H), 3.84 (s, 3 H), 3.58 (s, 3 H), 3.51 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.6, 168.5, 154.7, 142.2, 137.9, 128.6 (2 C), 127.9 (2 C), 126.3, 123.1, 119.3, 117.3, 116.8, 104.2, 99.7, 58.6, 54.8, 52.53, 52.3, 43.4.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_5$: 367.1420; found: 367.1438.

Dimethyl 2-{[4-(Benzyloxy)-1*H*-indol-3-yl](phenyl)methyl}malonate (11ra)

Following the GP using indole **1r** (112 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 89 mg (80%); mp 180–181 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07 (s, 1 H), 7.34–7.41 (m, 5 H), 7.07–7.09 (m, 6 H), 6.98 (t, *J* = 7.98 Hz, 1 H), 6.89 (d, *J* = 8.08 Hz, 1 H), 6.43 (d, *J* = 7.58 Hz, 1 H), 5.58 (d, *J* = 12.1 Hz, 1 H), 5.21 (d, *J* = 11.9 Hz, 1 H), 5.19 (d, *J* = 11.9 Hz, 1 H), 4.29 (d, *J* = 12.1 Hz, 1 H), 3.57 (s, 3 H), 3.46 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.0, 167.8, 153.0, 141.8, 137.8, 136.9, 128.1 (2 C), 127.9 (2 C), 127.4 (2 C), 127.3 (2 C), 127.2, 125.6, 121.9, 119.4, 116.26, 116.0, 104.3, 100.0, 69.3, 58.1, 51.9, 51.6, 42.7,

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{27}H_{25}NO_5$: 443.173; found: 443.138.

Dimethyl 2-{(1*H*-Indol-3-yl)[4-(methoxycarbonyl)phenyl]methyl}malonate (11ac)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3c** (70 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 61 mg (62%); mp 156–157 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.44 (s, 1 H), 7.96 (d, *J* = 8.3 Hz, 2 H), 7.51 (d, *J* = 7.8 Hz, 1 H), 7.46 (d, *J* = 8.3 Hz, 2 H), 7.30 (d, *J* = 8.1 Hz, 1 H), 7.14–7.17 (m, 2 H), 7.08 (t, *J* = 7.5 Hz, 1 H), 5.21 (d, *J* = 11.6 Hz, 1 H), 4.40 (d, *J* = 11.6 Hz, 1 H), 3.89 (s, 3 H), 3.57 (s, 3 H), 3.56 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.1, 167.9, 166.8, 146.6, 136.2, 129.7 (2 C), 128.6, 128.1 (2 C), 126.2, 122.3, 121.0, 119.5, 118.9, 115.6, 111.2, 57.6, 52.7, 52.5, 52.1, 42.7.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{22}H_{21}NO_6$: 395.1314; found: 395.1422.

Dimethyl 2-{(1*H*-Indol-3-yl)[4-(trifluoromethyl)phenyl]methyl}malonate (11ad)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3d** (72 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 77 mg (76%); mp 145–147 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.09 (s, 1 H), 7.47–7.51 (m, 5 H), 7.32 (d, *J* = 8.1 Hz, 1 H), 7.20 (d, *J* = 2.2 Hz, 1 H), 7.16 (t, *J* = 7.6 Hz, 1 H), 7.05 (t, *J* = 7.5 Hz, 1 H), 5.17 (d, *J* = 11.6 Hz, 1 H), 4.33 (d, *J* = 11.6 Hz, 1 H), 3.57 (s, 3 H), 3.55 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.1, 167.9, 145.4, 136.2, 128.83 (q, *J* = 32.4 Hz), 128.4 (2 C), 126.2 (2 C), 125.4 (q, *J* = 3.6 Hz), 124.2 (q, *J* = 271.7 Hz), 122.5, 121.0, 119.7, 119.0, 115.8, 111.2, 57.6, 52.8, 52.6, 42.6.

^{19}F NMR (376 MHz, $CDCl_3$): δ = –62.48 (s, 3 F).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{18}F_3NO_4$: 405.1188; found: 405.1264.

Dimethyl 2-{[3,5-Bis(trifluoromethyl)phenyl](1*H*-indol-3-yl)methyl}malonate (11ae)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3e** (89 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 103 mg (87%); mp 155–156 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.16 (s, 1 H), 7.82 (s, 2 H), 7.70 (s, 1 H), 7.46 (d, *J* = 8.0 Hz, 1 H), 7.35 (d, *J* = 8.1 Hz, 1 H), 7.24 (d, *J* = 2.4 Hz, 1 H), 7.19 (dt, *J* = 7.5, 0.6 Hz, 1 H), 7.08 (t, *J* = 7.5 Hz, 1 H), 5.25 (d, *J* = 11.8 Hz, 1 H), 4.33 (d, *J* = 11.8 Hz, 1 H), 3.58 (s, 3 H), 3.57 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 167.7, 167.7, 143.9, 136.2, 131.7 (q, *J* = 32.9 Hz, 2 C), 128.7 (2 C), 126.0, 123.2 (q, *J* = 272.97 Hz, 2 C), 122.8, 121.3, 121.1–120.9 (m), 120.0, 118.6, 114.7, 111.4, 57.5, 52.9, 52.6, 42.3.

^{19} F NMR (376 MHz, $CDCl_3$): δ = –62.82 (s, 6 F).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{22}H_{17}F_6NO_4$: 473.1062; found: 473.0981.

Dimethyl 2-[(2-Fluorophenyl)(1*H*-indol-3-yl)methyl]malonate (11af)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3f** (60 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 62 mg (70%); mp 114–116 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.14 (s, 1 H), 7.62 (d, *J* = 8.0 Hz, 1 H), 7.34 (t, *J* = 7.5 Hz, 1 H), 7.26 (d, *J* = 8.0 Hz, 1 H), 6.95–7.15 (m, 6 H), 5.39 (d, *J* = 11.9 Hz, 1 H), 4.51 (d, *J* = 11.9 Hz, 1 H), 3.55 (s, 3 H), 3.52 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.0, 160.5 (d, *J* = 246.6 Hz), 135.9, 129.6 (d, *J* = 4.2 Hz), 128.4 (d, *J* = 8.4 Hz), 128.3, 126.3, 124.1 (d, *J* = 3.4 Hz), 122.2, 121.3, 119.6, 118.7, 115.7 (d, *J* = 22.5 Hz), 115.3, 111.1, 56.6 (d, *J* = 1.5 Hz), 52.7, 52.6, 36.3 (d, *J* = 2.3 Hz).

^{19}F NMR (376 MHz, $CDCl_3$): δ = –116.50 (ddd, *J* = 11.9, 7.6, 5.6 Hz, 1 F).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{20}H_{18}FNO_4$: 355.1220; found: 355.1178.

Dimethyl 2-[(3-Fluorophenyl)(1*H*-indol-3-yl)methyl]malonate (11ag)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3g** (60 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 73 mg (82%); mp 140–141 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.13 (s, 1 H), 7.49 (d, *J* = 7.9 Hz, 1 H), 7.29 (d, *J* = 8.3 Hz, 1 H), 7.12–7.25 (m, 4 H), 7.00–7.06 (m, 2 H), 6.82–6.86 (m, 1 H), 5.10 (d, *J* = 11.7 Hz, 1 H), 4.29 (d, *J* = 11.7 Hz, 1 H), 3.55 (s, 3 H), 3.55 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.0, 162.7 (d, *J* = 245.9 Hz), 143.9 (d, *J* = 6.6 Hz), 136.2, 129.8 (d, *J* = 8.1 Hz), 126.4, 123.8 (d, *J* = 2.2 Hz), 122.4, 120.9, 119.6, 119.1, 116.1, 115.0 (d, *J* = 22.0 Hz), 113.8 (d, *J* = 21.2 Hz), 111.1, 57.9, 52.7, 52.6, 42.5.

^{19}F NMR (376 MHz, $CDCl_3$): δ = –112.98 (dt, *J* = 9.5, 6.0 Hz, 1 F).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{20}H_{18}FNO_4$: 355.1220; found: 355.1164.

Dimethyl 2-[(4-Fluorophenyl)(1*H*-indol-3-yl)methyl]malonate (11ah)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3h** (60 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 68 mg (76%); mp 183–185 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.03 (s, 1 H), 7.45 (d, *J* = 7.8 Hz, 1 H), 7.26–7.32 (m, 3 H), 7.13–7.18 (m, 2 H), 7.03 (t, *J* = 7.5 Hz, 1 H), 6.92 (t, *J* = 5.6 Hz, 2 H), 5.09 (d, *J* = 11.8 Hz, 1 H), 4.26 (d, *J* = 11.8 Hz, 1 H), 3.57 (s, 3 H), 3.54 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.3, 168.1, 161.4 (d, *J* = 246.16 Hz), 136.6, 136.2, 129.6 (d, *J* = 7.59 Hz, 2 C), 126.4, 122.4, 120.7, 119.6, 119.2, 116.4, 115.2 (d, *J* = 21.05 Hz, 2 C), 111.1, 58.0, 52.7, 52.5, 42.13.

^{19}F NMR (376 MHz, $CDCl_3$): δ = –115.96 (tt, *J* = 8.5, 5.1 Hz, 1 F).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{20}H_{18}FNO_4$: 355.1220; found: 355.1138.

Dimethyl 2-[(2-Chlorophenyl)(1*H*-indol-3-yl)methyl]malonate (11ai)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3i** (63 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 85 mg (92%); mp 130–131 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08 (s, 1 H), 7.65 (d, *J* = 8.1 Hz, 1 H), 7.35 (dt, *J* = 8.1, 1.5 Hz, 2 H), 7.29 (d, *J* = 8.1 Hz, 1 H), 7.04–7.19 (m, 5 H), 5.68 (d, *J* = 11.6 Hz, 1 H), 4.43 (d, *J* = 11.6 Hz, 1 H), 3.57 (s, 3 H), 3.54 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.3, 167.9, 138.7, 135.9, 133.8, 129.9, 128.8, 127.9, 126.9, 126.4, 122.1, 121.8, 119.5, 119.2, 115.3, 111.1, 57.3, 52.6, 52.5, 38.5.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M]^+$ calcd for $C_{20}H_{18}ClNO_4$: 371.0924; found: 371.1007.

Dimethyl 2-[(3-Chlorophenyl)(1*H*-indol-3-yl)methyl]malonate (11aj)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3j** (63 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 69 mg (75%); mp 112–114 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.14 (s, 1 H), 7.52 (d, *J* = 7.8 Hz, 1 H), 7.28–7.34 (m, 3 H), 7.14–7.22 (m, 4 H), 7.08 (dt, *J* = 7.6, 1.0 Hz, 1 H), 5.11 (d, *J* = 11.9 Hz, 1 H), 4.31 (d, *J* = 11.9 Hz, 1 H), 3.59 (s, 3 H), 3.58 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.0, 143.3, 136.2, 134.1, 129.6, 128.1, 127.0, 126.3, 122.3, 120.9, 119.6, 119.0, 115.8, 111.2, 57.8, 52.7, 52.6, 42.4 (one aromatic quaternary carbon atom was not unambiguously assigned).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M]^+$ calcd for $C_{20}H_{18}ClNO_4$: 371.0924; found: 371.0965.

Dimethyl 2-[(4-Chlorophenyl)(1*H*-indol-3-yl)methyl]malonate (11ak)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3k** (63 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 83 mg (90%); mp 148–149 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.09 (s, 1 H), 7.48 (d, *J* = 7.8 Hz, 1 H), 7.15–7.34 (m, 7 H), 7.06 (dt, *J* = 7.6, 1.0 Hz, 1 H), 5.10 (d, *J* = 11.9 Hz, 1 H), 4.30 (d, *J* = 11.6 Hz, 1 H), 3.59 (s, 3 H), 3.58 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.0, 139.8, 136.2, 132.5, 129.4 (2 C), 128.5 (2 C), 126.3, 122.4, 120.8, 119.6, 119.0, 116.1, 111.1, 57.9, 52.7, 52.6, 42.2.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M]^+$ calcd for $C_{20}H_{18}ClNO_4$: 371.0924; found: 371.0916.

Dimethyl 2-[(2-Bromophenyl)(1*H*-indol-3-yl)methyl]malonate (11al)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3l** (75 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 71 mg (68%); mp 138–139 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08 (s, 1 H), 7.68 (d, *J* = 8.0 Hz, 1 H), 7.54 (dd, *J* = 8.1, 1.2 Hz, 1 H), 7.36 (dd, *J* = 7.7, 1.67 Hz, 1 H), 7.29 (d, *J* = 8.0 Hz, 1 H), 7.18–7.22 (m, 2 H), 7.15 (dt, *J* = 7.5, 1.0 Hz, 1 H), 7.07 (dd, *J* = 7.5, 1.0 Hz, 1 H), 7.02 (dd, *J* = 7.5, 1.8 Hz, 1 H), 5.67 (d, *J* = 11.5 Hz, 1 H), 4.40 (d, *J* = 11.5 Hz, 1 H), 3.57 (s, 3 H), 3.53 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 167.8, 140.4, 136.0, 133.2, 128.9, 128.4, 127.5, 126.5, 124.8, 122.2, 121.90, 119.6 (2 C), 115.7, 111.0, 57.5, 52.6, 52.6, 41.2.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* $[M]^+$ calcd for $C_{20}H_{18}BrNO_4$: 415.042; found: 415.020.

Dimethyl 2-[(3-Bromophenyl)(1*H*-indol-3-yl)methyl]malonate (11am)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3m** (75 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 91 mg (87%); mp 123–124 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11 (s, 1 H), 7.47–7.51 (m, 2 H), 7.28–7.32 (m, 3 H), 7.14–7.18 (m, 2 H), 7.11 (t, *J* = 7.9 Hz, 1 H), 7.06 (dt, *J* = 7.0, 1.0 Hz, 1 H), 5.07 (d, *J* = 11.7 Hz, 1 H), 4.27 (d, *J* = 11.7 Hz, 1 H), 3.57 (s, 3 H), 3.56 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.1, 168.0, 143.6, 136.1, 131.0, 130.0, 129.9, 126.8, 126.2, 122.4 (2 C), 121.0, 119.6, 119.0, 115.7, 111.2, 57.8, 52.7, 52.6, 42.3.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{20}H_{18}BrNO_4$: 415.0419; found: 415.0414.

Dimethyl 2-[(4-Bromophenyl) (1*H*-indol-3-yl)methyl]malonate (11an)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3n** (75 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 84 mg (81%); mp 135–137 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.06 (s, 1 H), 7.46 (d, *J* = 7.4 Hz, 1 H), 7.34–7.38 (m, 2 H), 7.31 (d, *J* = 8.2 Hz, 1 H), 7.21–7.26 (m, 2 H), 7.13–7.17 (m, 2 H), 7.04 (dt, *J* = 8.0, 1.0 Hz, 1 H), 5.07 (d, *J* = 11.7 Hz, 1 H), 4.27 (d, *J* = 11.7 Hz, 1 H), 3.57 (s, 3 H), 3.56 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.1, 168.0, 140.2, 136.2, 131.5 (2 C), 129.8 (2 C), 126.3, 122.4, 120.8, 120.6, 119.5, 119.0, 116.0, 111.1, 57.7, 52.7, 52.5, 42.3.

HRMS (ESI): *m*/*z* $[M]^+$ calcd for $C_{20}H_{18}BrNO_4$: 415.0419; found: 415.0414.

Dimethyl 2-{(1*H*-Indol-3-yl)[4-(trifluoromethoxy)phenyl]methyl}malonate (11ao)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3o** (76 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 87 mg (83%); mp 180–181 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.17 (s, 1 H), 7.47 (d, *J* = 8.1 Hz, 1 H), 7.36 (d, *J* = 8.6 Hz, 2 H), 7.29 (d, *J* = 8.1 Hz, 1 H), 7.13–7.17 (m, 2 H), 7.02–7.09 (m, 3 H), 5.12 (d, *J* = 11.6 Hz, 1 H), 4.29 (d, *J* = 11.6 Hz, 1 H), 3.55 (s, 3 H), 3.52 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.2, 168.0, 147.9 (q, *J* = 1.9 Hz, 2 C), 140.0, 136.2, 129.5, 126.3, 122.5, 121.6, 120.8 (q, *J* = 0.8 Hz, 2 C), 120.3 (q, *J* = 256.9 Hz), 119.7, 119.1, 116.1, 111.2, 58.0, 52.7, 52.5, 42.2.

^{19}F NMR (376 MHz, $CDCl_3$): δ = –57.90 (s, 3 F).

HRMS (ESI): *m*/*z* [M]$^+$ calcd for $C_{21}H_{18}FNO_5$: 421.1137; found: 421.1132.

Dimethyl 2-{(1*H*-Indol-3-yl)[4-(methylthio)phenyl]methyl}malonate (11ap)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3p** (67 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 78 mg (81%); mp 142–144 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07 (s, 1 H), 7.51 (d, *J* = 7.8 Hz, 1 H), 7.28–7.33 (m, 3 H), 7.13–7.18 (m, 4 H), 7.05 (dt, *J* = 7.1, 0.8 Hz, 1 H), 5.09 (d, *J* = 11.8 Hz, 1 H), 4.30 (d, *J* = 11.9 Hz, 1 H), 3.58 (s, 3 H), 3.57 (s, 3 H), 2.43 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.3, 168.1, 138.2, 136.6, 136.2, 128.5 (2 C), 126.6 (2 C), 126.4, 122.2, 120.8, 119.5, 119.2, 116.4, 111.1, 58.0, 52.5, 52.5, 42.3, 15.7.

HRMS (ESI): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_4S$: 383.1191; found: 383.1184.

Dimethyl 2-[(1*H*-Indol-3-yl)(*o*-tolyl)methyl]malonate (11aq)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3q** (59 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 55 mg (62%); mp 116–120 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12 (s, 1 H), 7.61 (d, *J* = 7.8 Hz, 1 H), 7.36 (d, *J* = 7.6 Hz, 1 H), 7.27 (d, *J* = 7.6 Hz, 1 H), 7.06–7.18 (m, 5 H), 6.97 (s, 1 H), 5.36 (d, *J* = 11.8 Hz, 1 H), 4.41 (d, *J* = 11.8 Hz, 1 H), 3.55 (s, 3 H), 3.46 (s, 3 H), 2.48 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.7, 168.3, 139.9, 136.2, 135.9, 130.8, 126.5, 126.5, 126.0, 126.0, 122.3, 121.9, 119.5, 119.1, 116.1, 111.1, 58.2, 52.5, 52.4, 38.0, 19.8.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_4$: 351.1471; found: 351.1446.

Dimethyl 2-[(4-Ethylphenyl)(1*H*-indol-3-yl)methyl]malonate (11ar)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3r** (62 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 55 mg (60%); mp 116–120 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.16 (s, 1 H), 7.59 (d, *J* = 7.8 Hz, 1 H), 7.30 (m, 3 H), 7.05–7.18 (m, 5 H), 5.12 (d, *J* = 11.9 Hz, 1 H), 4.37 (d, *J* = 11.9 Hz, 1 H), 3.57 (s, 6 H), 2.59 (q, *J* = 7.6 Hz, 2 H), 1.20 (t, *J* = 7.6 Hz, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.5, 168.3, 142.5, 138.3, 136.2, 127.8 (4 C), 126.5, 122.1, 120.8, 119.4, 119.3, 116.8, 111.0, 58.2, 52.6, 52.4, 42.5, 28.4, 15.2.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{22}H_{23}NO_4$: 365.1627; found: 365.1575.

Dimethyl 2-[(1*H*-Indol-3-yl)(2-methoxyphenyl)methyl]malonate (11as)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3s** (63 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 56 mg (60%); mp 141–142 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.06 (s, 1 H), 7.67 (d, *J* = 7.7 Hz, 1 H), 7.30 (dd, *J* = 7.6, 1.4 Hz, 1 H), 7.26–7.28 (m, 1 H), 7.20 (d, *J* = 2.4 Hz, 1 H), 7.11–7.16 (m, 2 H), 7.04–7.08 (m, 1 H), 6.86 (d, *J* = 7.5 Hz, 1 H), 6.8 (d, *J* = 8.0 Hz, 1 H), 5.50 (d, *J* = 11.8 Hz, 1 H), 4.59 (d, *J* = 11.8 Hz, 1 H), 3.85 (s, 3 H), 3.53 (s, 3 H), 3.51 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.8, 168.5, 157.0, 135.8, 129.5, 128.9, 127.8, 126.9, 121.9, 121.7, 120.5, 119.3 (2 C), 116.3, 111.0, 110.9, 56.7, 55.5, 52.5, 52.3, 36.6.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_5$: 367.1420; found: 367.1428.

Dimethyl 2-[(1*H*-Indol-3-yl)(4-methoxyphenyl)methyl]malonate (11at)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3t** (63 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 47 mg (51%); mp 141–142 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.05 (s, 1 H), 7.49 (d, *J* = 7.8 Hz, 1 H), 7.24–7.30 (m, 3 H), 7.11–7.14 (m, 2 H), 7.02 (t, *J* = 7.7 Hz, 1 H), 6.77 (d, *J* = 8.6 Hz, 2 H), 5.05 (d, *J* = 11.8 Hz, 1 H), 4.27 (d, *J* = 11.8 Hz, 1 H), 3.73 (s, 3 H), 3.56 (s, 3 H), 3.54 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.5, 168.2, 158.2, 136.2, 133.2, 129.0 (2 C), 126.5, 122.2, 120.6, 119.4, 119.3, 116.9, 113.6 (2 C), 111.0, 58.2, 55.2, 52.6, 52.5, 42.0.

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{21}H_{21}NO_5$: 367.1420; found: 367.1397.

Dimethyl 2-[(1*H*-Indol-3-yl)(thiophen-2-yl)methyl]malonate (11au)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **3u** (57 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 77 mg (90%); mp 136–138 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12 (s, 1 H), 7.60 (d, *J* = 7.8 Hz, 1 H), 7.31 (d, *J* = 8.3 Hz, 1 H), 7.17 (t, *J* = 7.3 Hz, 2 H), 7.06–7.10 (m, 2 H), 6.98 (d, *J* = 3.0 Hz, 1 H), 6.87 (t, *J* = 4.4 Hz, 1 H), 5.42 (d, *J* = 11.6 Hz, 1 H), 4.35 (d, *J* = 11.6 Hz, 1 H), 3.66 (s, 3 H), 3.50 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 168.1, 167.8, 145.5, 136.1, 126.5, 126.2, 125.1, 124.4, 122.3, 121.4, 119.7, 119.2, 116.3, 111.1, 59.1, 52.7, 52.6, 37.9.

HRMS (ESI): *m*/*z* [M]$^+$ calcd for $C_{18}H_{17}NO_4S$: 343.0878; found: 343.0873.

Dimethyl 2-[Phenyl(1*H*-pyrrol-2-yl)methyl]malonate (18)

Following the GP using pyrrole (**15**, 33 mg, 0.5 mmol) and **3a** (55 mg, 0.25 mmol) in CH_2Cl_2 using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at –40 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 59 mg (82%); mp 112–114 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.39 (s, 1 H), 7.21–7.32 (m, 5 H), 6.66 (dd, *J* = 2.7, 1.6 Hz, 1 H), 6.09 (q, *J* = 2.9, 1.7 Hz, 1 H), 5.95–5.97 (m, 1 H), 4.81 (d, *J* = 10.74 Hz, 1 H), 4.20 (d, *J* = 10.74 Hz, 1 H), 3.70 (s, 3 H), 3.48 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 169.0, 167.8, 139.6, 130.8, 128.6 (2 C), 128.1 (2 C), 127.3, 117.6, 108.1, 106.4, 57.7, 52.9, 52.5, 44.3.

HRMS (ESI): *m*/*z* [M + H]$^+$ calcd for $C_{16}H_{18}NO_4$: 288.1236; found: 288.1231.

Methyl 4-(1*H*-Indol-3-yl)-2-oxochromane-3-carboxylate (12)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **4** (51 mg, 0.25 mmol) in $CHCl_3$ using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by column chromatography (CH_2Cl_2), the product was obtained as a white solid; yield: 68 mg (85%); mp 180–182 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.28 (s, 1 H), 7.49 (d, *J* = 8.0 Hz, 1 H), 7.40 (d, *J* = 8.3 Hz, 1 H), 7.31–7.35 (m, 1 H), 7.21–7.25 (m, 1 H), 7.08–7.18 (m, 4 H), 6.83 (s, 1 H), 5.05 (d, *J* = 7.1 Hz, 1 H), 4.23 (d, *J* = 7.1 Hz, 1 H), 3.65 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 167.6, 164.6, 136.7, 129.0, 128.9, 125.3, 125.1, 123.7, 123.2, 122.6, 119.9, 118.6, 116.9, 112.8, 111.7, 53.0, 36.4, 25.8. (one aromatic quaternary carbon atom was not unambiguously assigned).

HRMS (MALDI, dithranol, PEG-300): *m*/*z* [M]$^+$ calcd for $C_{19}H_{15}NO_4$: 321.0933; found: 321.1001.

4-(1*H*-Indol-3-yl)butan-2-one (26)[30]

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **5a** (18 mg, 0.25 mmol) in $CHCl_3$ using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by column chromatography (CH_2Cl_2), the product was obtained as a white solid; yield: 35 mg (75%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.98 (s, 1 H), 7.60 (d, *J* = 8.0 Hz, 1 H), 7.36 (d, *J* = 8.1 Hz, 1 H), 7.18–7.22 (m, 1 H), 7.11–7.15 (m, 1 H), 6.98 (d, *J* = 1.9 Hz, 1 H), 3.06 (t, *J* = 7.6 Hz, 2 H), 2.86 (t, *J* = 7.5 Hz, 2 H), 2.15 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 208.8, 136.3, 127.1, 122.0, 121.4, 119.3, 118.6, 115.1, 111.1, 44.1, 30.0, 19.3.

1,1,1-Trifluoro-4-(1*H*-indol-3-yl)-4-phenylbutan-2-one (27)[31]

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **5b** (50 mg, 0.25 mmol) in $CHCl_3$ using MgI_2 (6.9 mg, 0.025 mmol) as the catalyst at r.t. After purification by column chromatography (CH_2Cl_2), the product was obtained as a white solid; yield: 60 mg (76%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.99 (s, 1 H), 7.40 (d, *J* = 8.0 Hz, 1 H), 7.23–7.33 (m, 5 H), 7.13–7.19 (m, 2 H), 7.02 (t, *J* = 7.9 Hz, 1 H), 6.95 (d, *J* = 2.2 Hz, 1 H), 4.91 (t, *J* = 7.9 Hz, 1 H), 3.56 (dd, *J* = 18.5, 7.9 Hz, 1 H), 3.45 (dd, *J* = 18.5, 7.9 Hz, 1 H).

^{19}F NMR (376 MHz, $CDCl_3$): δ = –79.36 (s, 3 F).

Ethyl 2-(1*H*-Indol-3-yl)-3-nitro-2-phenylpropanoate (28)[32]

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **6** (55 mg, 0.25 mmol) in $CHCl_3$ using $Ca(NTf_2)_2$ (15 mg, 0.025 mmol) as the catalyst at r.t. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 76 mg (90%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.28 (s, 1 H), 7.49 (d, *J* = 2.5 Hz, 1 H), 7.30–7.38 (m, 6 H), 7.11 (t, *J* = 7.6 Hz, 1 H), 6.87 (t, *J* = 7.6 Hz, 1 H), 6.77 (d, *J* = 8.21 Hz, 1 H), 5.66 (d, *J* = 13.6 Hz, 1 H), 5.45 (d, *J* = 13.6 Hz, 1 H), 4.20–4.33 (m, 2 H), 1.21 (t, *J* = 7.07 Hz, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 170.7, 137.8, 136.4, 128.2 (2 C), 127.7 (2 C), 127.7, 125.1, 124.9, 121.5, 120.2, 119.1, 111.4, 80.6, 61.8, 54.5, 13.6; (one aromatic quaternary carbon atom was not unambiguously assigned).

3-(2-Nitro-1-phenylethyl)-1*H*-indole (29)[33]

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **7** (37 mg, 0.25 mmol) in $CHCl_3$ using $Ca(NTf_2)_2$ (15 mg, 0.025 mmol) as the catalyst at –30 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 1:1, then CH_2Cl_2/PE, 3:1), the product was obtained as a grey solid; yield: 59 mg (90%).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07 (s, 1 H), 7.47 (d, *J* = 8.0 Hz, 1 H), 7.20–7.35 (m, 6 H), 7.22 (t, *J* = 7.5 Hz, 1 H), 7.08 (t, *J* = 7.5 Hz, 1 H), 6.99 (d, *J* = 1.8 Hz, 1 H), 5.20 (t, *J* = 8.2 Hz, 1 H), 5.07 (dd, *J* = 12.5, 8.2 Hz, 1 H), 4.95 (dd, *J* = 12.5, 8.2 Hz, 1 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 139.1, 136.4, 128.9 (2 C), 127.7 (2 C), 127.50, 126.0, 122.6, 121.6, 119.9, 118.8, 114.3, 111.4, 76.7, 41.5.

Methyl 3-(1*H*-Indol-3-yl)-2-nitro-3-phenylpropanoate (30)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **8** (52 mg, 0.25 mmol) in $CHCl_3$ using $Ca(NTf_2)_2$ (15 mg, 0.025 mmol) as the catalyst at –30 °C. After purification by gradient column chromatography (CH_2Cl_2/PE, 4:1, then CH_2Cl_2), the product was obtained as a white solid; yield: 64 mg (78%); mp 70–74 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ (1:1 diastereomers) = 8.15 (s, 1 H), 8.11 (s, 1 H), 7.59 (d, *J* = 7.7 Hz, 1 H), 7.47 (d, *J* = 7.8 Hz, 1 H), 7.04–7.48 (m, 18 H), 5.95 (d, *J* = 11.0 Hz, 1 H), 5.92 (d, *J* = 11.0 Hz, 1 H), 5.39 (d, *J* = 11.0 Hz, 1 H), 5.38 (d, *J* = 11.0 Hz, 1 H), 3.57 (s, 3 H), 3.54 (s, 3 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ (1:1 diastereomers) = 163.81 (2 C), 138.4, 137.3, 136.2, 136.0, 128.9 (2 C), 128.8 (2 C), 128.4 (2 C), 127.8, 127.7 (3 C), 126.1, 122.7, 121.7, 120.6, 120.0, 119.9, 118.9, 118.8, 113.7, 112.8, 111.7 (2 C), 91.6, 91.5, 53.6, 53.4, 44.5, 43.8.

HRMS (ESI): *m*/*z* [M – H]$^+$ calcd for $C_{18}H_{15}N_2O_4$: 323.1032; found: 323.1037.

4-(1*H*-Indol-3-yl)-3-nitrochroman-2-one (31)

Following the GP using indole (**1a**, 58 mg, 0.5 mmol) and **9** (47 mg, 0.25 mmol) in $CHCl_3$ using $Ca(NTf_2)_2$ (15 mg, 0.025 mmol) as the catalyst at –30 °C. After purification by column chromatography (CH_2Cl_2), the product was obtained as a white solid; yield: 42 mg (55%); mp 90–92 °C.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25 (s, 1 H), 7.36–7.42 (m, 2 H), 7.32 (d, *J* = 8.2 Hz, 1 H), 7.20–7.27 (m, 2 H), 7.07–7.14 (m, 3 H), 7.00 (d, *J* = 2.7 Hz, 1 H), 5.82 (d, *J* = 9.8 Hz, 1 H), 5.37 (d, *J* = 9.8 Hz, 1 H).

^{13}C NMR (101 MHz, $CDCl_3$): δ = 159.2, 149.8, 136.8, 129.9, 129.1, 125.9, 124.6, 124.6, 123.1, 120.9, 120.5, 118.6, 117.2, 112.0, 108.5, 86.3, 39.0.

HRMS (ESI): *m*/*z* [M – H]$^+$ calcd for $C_{17}H_{11}N_2O_4$: 307.0719; found: 307.0723.

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Supporting Information

Supporting information for this article is available online at https://doi.org/10.1055/s-0036-1589068.

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