

Synthesis of 1-Amino-1*H*-Indenes via a Sequential Suzuki–Miyaura Coupling/Petasis Condensation Sequence

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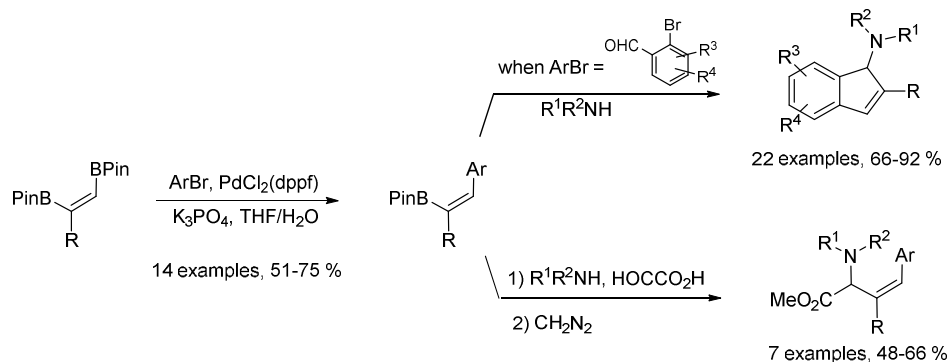
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Abstract:

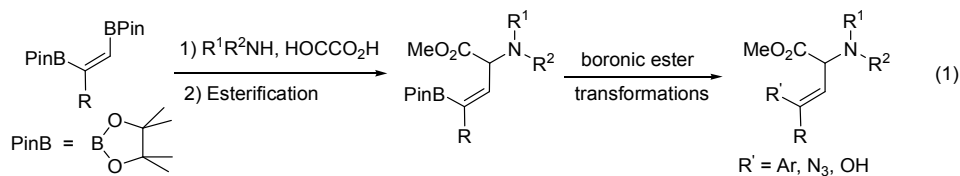
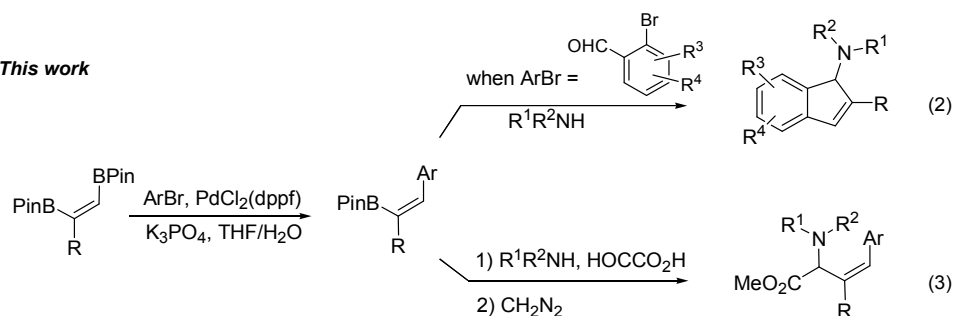
An efficient and straightforward synthesis of 1-amino-1*H*-indenes is reported from 1,2-bis(boronates) via a sequential Suzuki–Miyaura coupling / Petasis cyclisation reactions. Starting from the same monoboronate ester intermediates, an intermolecular version of this approach also afforded (*Z*)- α,β -unsaturated amino esters in moderate to good yields.



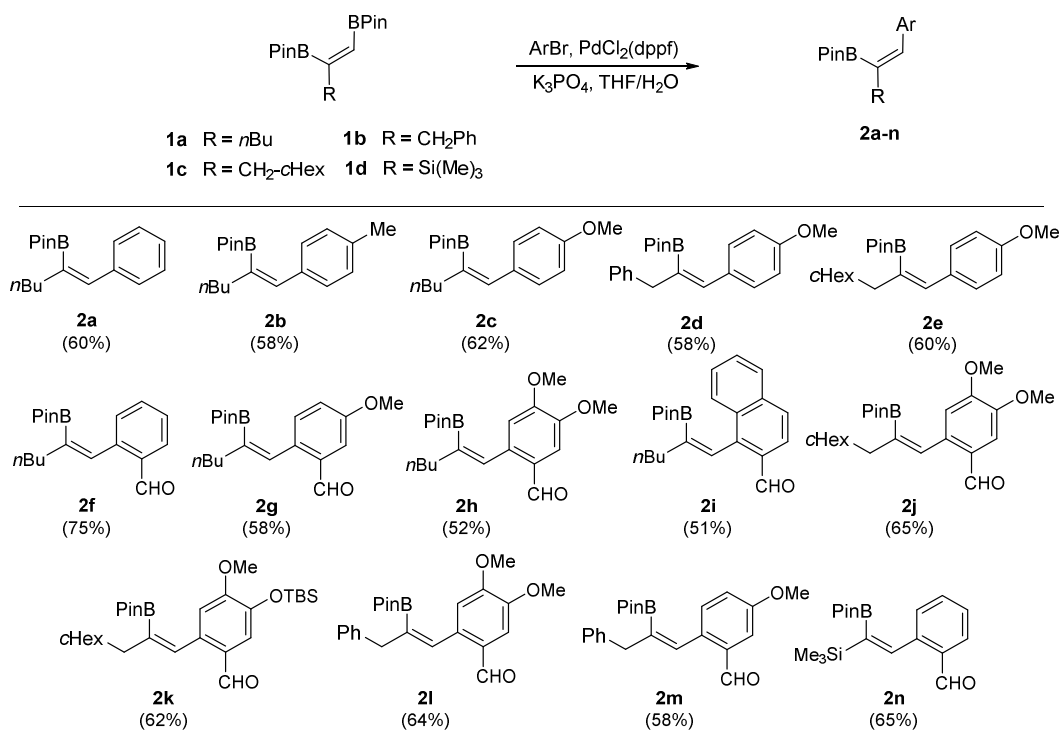
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8 The significance of organoboron chemistry has been amply demonstrated in diverse
9 areas of organic synthesis.¹ In particular, alkenyl boronic acids and derivatives were
10 recognized as versatile building blocks in a variety of chemical transformations being
11 engaged in a range of C-C and C-heteroatom bond formation,² Diels Alder cycloadditions,³
12 sigmatropic rearrangements,⁴ olefin metathesis,⁵ and conjugate additions.⁶ In the field of
13 multicomponent process, the three-component reactions of carbonyl compounds, amines, and
14 unsaturated organoboronic acids, referred as "Petasis reaction", give access to a variety of
15 structurally and functionally diverse amino compounds and heterocycles.⁷ In this context, we
16 recently demonstrated that this Borono-Mannich reaction occurred regio- and stereo-
17 selectively at the terminal C-B bond of (*E*)-alkenyl 1,2-bis(boronates) (Scheme 1, eq 1).^{8,9}

18 Indenes and their corresponding hydrogenated derivatives, indanes, have found
19 multiple applications as synthetic targets or building blocks, whether for their biological
20 properties, as ligands of metal complexes or in material science.¹⁰ The hitherto reported
21 strategies mainly based on: transition-metal catalyzed [3+2]annulation,¹¹ reaction of
22 metallacyclopentadienes with thiourea,¹² metathesis,¹³ α -amidoalkylation of enolizable
23 aldehydes,¹⁴ nitrene insertion,¹⁵ cascade reaction from propargyl alcohols,¹⁶ and
24 intramolecular cyclization of *N*-sulfonyl aldimines,¹⁷ or *o*-ethynylbenzaldehyde.¹⁸

25 Herein, we report an attractive and complementary alternative to these approaches
26 based on a two steps sequence starting with Suzuki-Miyaura couplings of (*E*)-alkenyl 1,2-
27 bis(boronic esters) and substituted 2-bromobenzaldehydes. Further cyclization *via* a Petasis
28 reaction provides access to substituted 1-amino-*IH*-indenes (Scheme 1, eq 2). When the
29 coupling partner is devoid of an aldehyde group, the monoboronic ester intermediates can be
30 engaged in an intermolecular Borono Mannich condensation with glyoxylic acid and amines
31 to afford (*E*)- α,β -unsaturated amino esters (Scheme 1, eq 3).
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Scheme 1. Multistep sequences involving a Petasis reaction and a Suzuki-Miyaura coupling.*Previous work (Ref 8)**This work*

(E)-Alkenyl 1,2-bis(boronates) **1a-d**, selected as model compounds, were first prepared in good yields from the corresponding 1-alkynes: 1-hexyne, 3-phenyl-1-propyne, 3-cyclohexyl-1-propyne and propargyl trimethylsilane, and bis(pinacolato)diboron in the presence of tetrakis(triphenylphosphine)platinum as catalyst, according to reported procedures.¹⁹ These boronic esters were then engaged in Suzuki–Miyaura cross-couplings with aromatic halides in the presence of [1,1'-bis(diphenylphosphino) ferrocene]dichloro palladium(II) and potassium phosphate tribasic monohydrate in THF/ H_2O at reflux.²⁰ As previously reported, this reaction occurred regioselectively at the terminal C-B bond that indicates that the coupling of a second aryl moiety is unfavorable. Yields are good to moderate with the formation of a single *(E)*-stereoisomer **2** (Scheme 2).

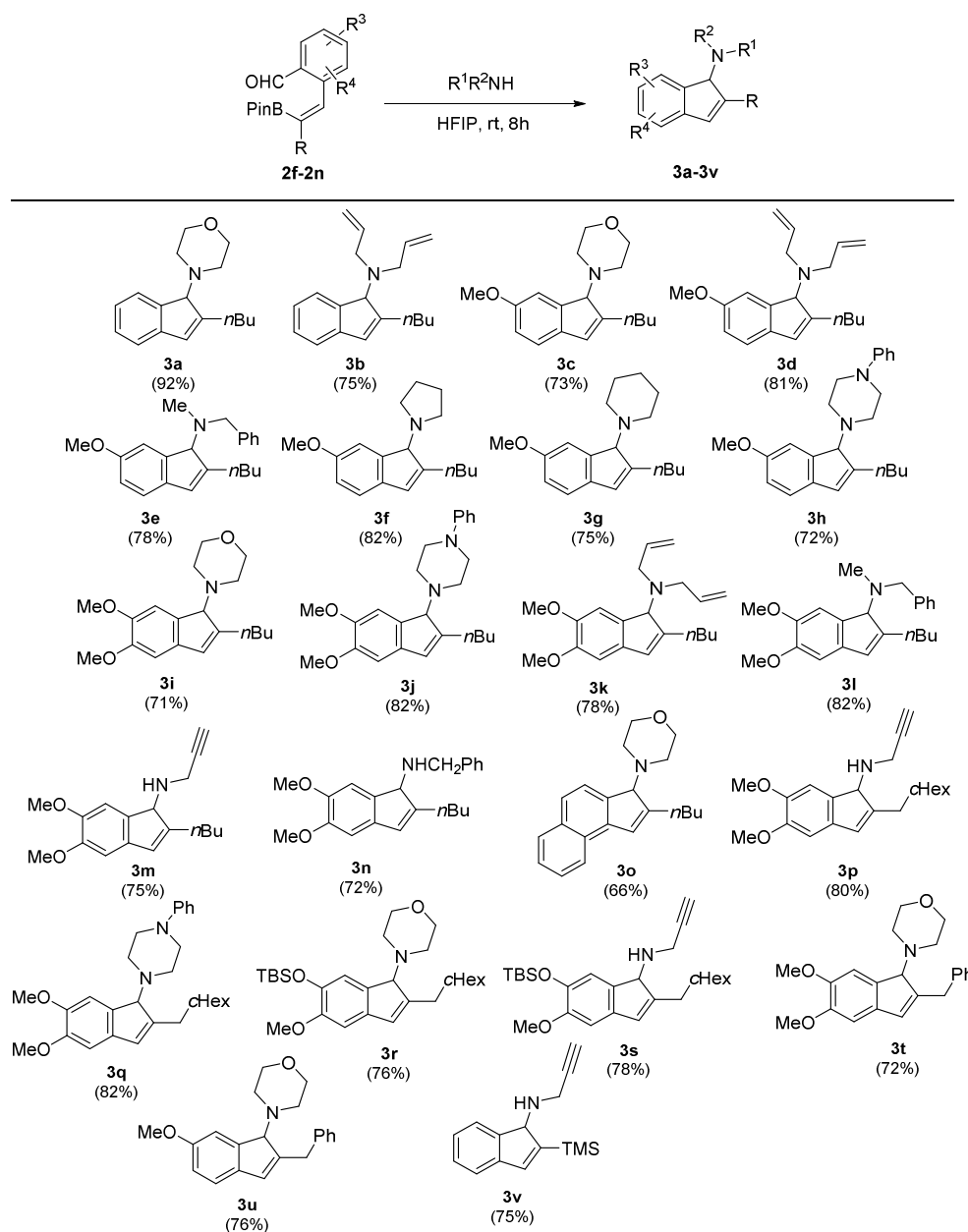
Scheme 2. Suzuki–Miyaura cross-couplings with 1,2-bis(boronates) **1a-1d**^{a,b}

^a General conditions: **1** (0.5 mmol), [1, 1'-bis(diphenyl phosphino)ferrocene] dichloropalladium(II) (0.01 mmol), potassium phosphate tribasic monohydrate (1.5 mmol) and aryl bromide (0.5 mmol), THF (5 mL)/water (0.1 mL), reflux, 1h. ^b Yields of isolated products.

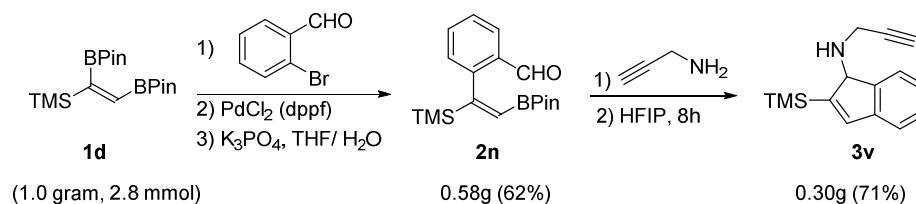
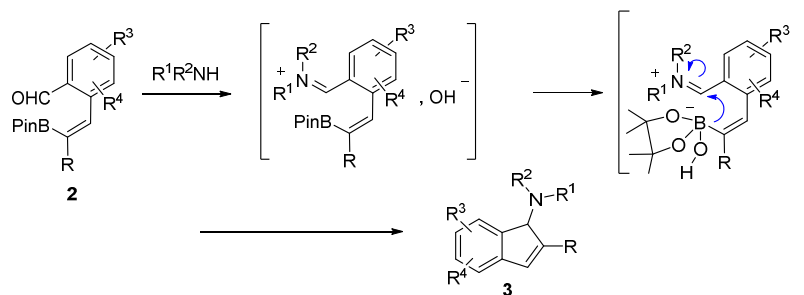
We then decided to explore the cyclization of compounds **2f-2n**, which have an aldehyde function in proper position for a Petasis condensation. While aryl aldehydes and pinacol boronic esters are usually poor substrates for such reaction, we expected that, in our case, entropic factors should greatly favor the formation of an indenyl substructure.²¹ To our delight, the treatment of boronates **2f-2n** with amines afforded the corresponding 1-amino-1*H*-indenes in yields ranging from 66% to 92% (Scheme 3). Best results were obtained in HFIP (1,1,1,3,3,3-hexafluoropropan-2-ol) as solvent, probably due to the beneficial effect of HFIP on charged intermediates and stabilization of polar transition states (see proposed mechanism, Scheme 5). By comparison, with MeOH and trifluoroethanol as solvents, we observed the formation of 1-amino-1*H*-indene **3a** in 58% and 37% respectively under the same experimental conditions. Secondary amines, cyclic or acyclic, are good partners for this cyclization, as primary amine, with no significant influence of the presence of one or two methoxy groups on the aryl moiety. Moreover, the reaction was proven to be scalable with 1,2-bis(boronates) **1d** as model substrate, delivering the desired product **3v** in 45% isolated yield over two steps (Scheme 4).

The postulated mechanism is outlined in the Scheme 54. The formation of an iminium ion was followed by the quaternarization of the boronate function to give the corresponding ate complex. The migration of the alkenyl moiety afforded the 1-amino-*1H*-indene.

Scheme 3. Petasis reactions from boronates **2f-n**. Synthesis of 1-amino-*1H*-indenes **3a-3v**.^{a,b}

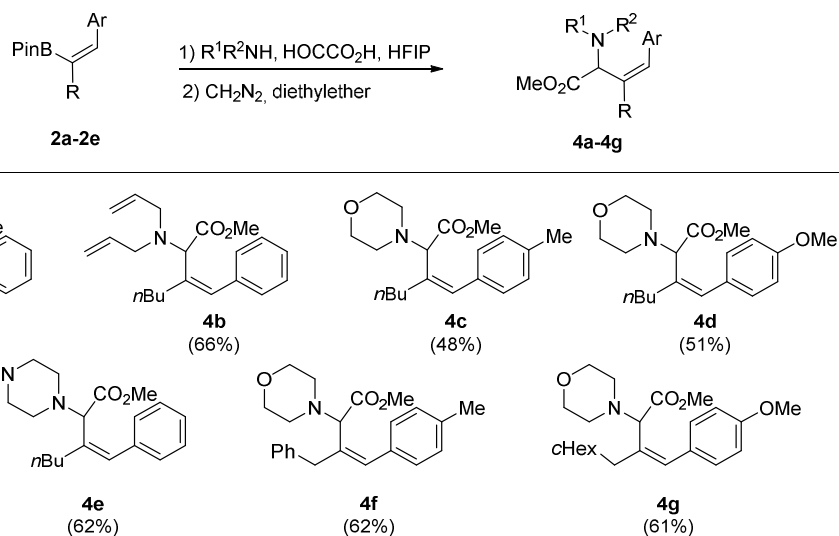


^aGeneral conditions: Amine (0.5 mmol), boronate **2f-n** (0.3 mmol) in 1,1,1,3,3,3-hexafluoropropan-2-ol (1 mL) rt, 8h. ^b Yields of isolated products.

Scheme 4. Gram scale synthesis of a 1-amino-1*H*-indene**Scheme 5.** Postulated mechanism for the formation of 1-amino-1*H*-indenes **3**

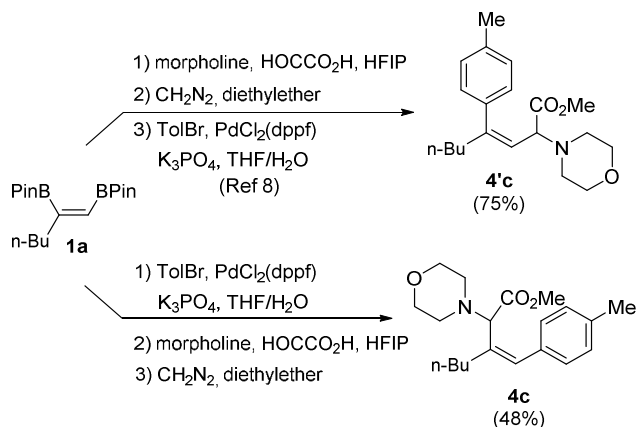
Due to the crucial role of amino acids and derivatives in biological processes, we also engaged the trisubstituted alkenyl boronates **2a-e** in intermolecular Petasis reactions to synthesize (*Z*)- α,β -unsaturated amino esters **4**. Various amines and glyoxylic acid reacted in HFIP at room temperature. The crude material was directly subjected to esterification with an ethereal solution of CH_2N_2 . Cyclic secondary amines, as morpholine or *N*-phenylpiperazine, can be used, as the acyclic diallylamine, with yields ranging from 48 to 66% (Scheme 6). These results, in addition to our precedent study,⁸ reveal that the simple inversion of the two reactions allows the divergent synthesis of structurally diverse α,β -unsaturated amino esters from a common precursor, as illustrated in Scheme 7.

Scheme 6. Intermolecular Petasis reactions from boronates **2a-e**. Synthesis of α,β -unsaturated amino esters **4a-4g**^{a,b}



^a General conditions: 1) Glyoxylic acid monohydrate (0.5 mmol), amine (0.5 mmol), **2a-e** (0.3 mmol) in HFIP (1 mL), rt, 78h. 2) Crude acid, CH₂N₂ in ether (2 mL, 0.5M), 0°C, 2h. ^b Yields of isolated products.

Scheme 7. Divergent synthesis of amino esters **4c** and **4'c**.



In conclusion, an efficient preparation of 1-amino-*IH*-indenes from easily accessible or commercially available reactants was described. The key features of this method are a regioselective Suzuki coupling at the terminal C-B bond of a (*E*)-1-alkene-1,2-diboronate ester and an Petasis condensation. We have also demonstrated the divergent approach to α,β -unsaturated aminoesters via an intermolecular version of this sequence starting from a common bis-boronate precursor.

EXPERIMENTAL SECTION

General Information and Materials. All commercially available chemicals were used without further purification. Tetrahydrofuran (THF), diethylether and 1,1,1,3,3,3-hexafluoropropan-2-ol (HFIP) were used as received. Analytical thin layer chromatography was performed on Silica Gel 60 F254 plates. The compounds were characterized by ^1H , ^{13}C NMR and ^{11}B techniques. ^1H and ^{13}C spectra were recorded in CDCl_3 (internal standard: 7.26 ppm, ^1H ; 77.00 ppm, ^{13}C) and ^{11}B NMR chemical shifts to external $\text{BF}_3\cdot\text{OEt}_2$ (0.0 ppm). High-resolution mass spectra (HMRS) were recorded on a micro-TOF-Q II mass analyzer or Q-TOF 2 using positive ion electrospray. Compounds **1a**,²² **1b**,²³ **1c**,²⁴ and **1d**²⁵ have been prepared according to known protocol.¹⁹ The ethereal solution of CH_2N_2 was generated from N-nitroso-N-methylurea according to the literature.²⁶

General procedure for the Suzuki–Miyaura cross-couplings with 1,2-bis(boronates) 1a-1d. Synthesis of compounds 2a-2n. A solution of bispinacolate ester **1** (0.5 mmol) in THF (5 mL) and water (0.1 mL) was degassed under argon atmosphere, before the addition of [1, 1'-bis (diphenyl phosphino)ferrocene] dichloropalladium(II) (7.5 mg, 0.01 mmol), potassium phosphate tribasic monohydrate (346 mg, 1.5 mmol) and arylbromide (0.5 mmol). The reaction mixture was heated at reflux for 1h, cooled to room temperature, diluted with water and extracted with Et_2O (2 x 15 mL). The combined organic extracts were dried over MgSO_4 and evaporated under vacuum. The residue was purified by column chromatography (230-400 mesh Silica gel, EtOAc in cyclohexane) to give the corresponding Suzuki products.

(E)-4,4,5,5-tetramethyl-2-(1-phenylhex-1-en-2-yl)-1,3,2-dioxaborolane (**2a**): 86 mg (60%). Colourless oil, $R_f = 0.10$ (EtOAc/Hexane 10:90); ^1H NMR (500 MHz, CDCl_3): δ 7.33-7.31 (m, 2H), 7.25-7.22 (m, 2H), 7.20-7.16 (s, 1H), 6.87 (s, 1H), 2.31-2.28 (m, 2H), 1.49-1.43 (m, 2H), 1.38-1.34 (m, 2H), 1.25 (s, 12H), 0.90 (t, 3H, $J = 7.3$ Hz); ^{13}C NMR (100 MHz, CDCl_3): δ 139.6, 139.0, 128.0, 127.7, 126.7, 83.4, 37.7, 31.8, 24.7, 22.4, 14.0 (The carbon α to boron was not found); ^{11}B NMR (96 MHz, CDCl_3): δ 31.1 (br); IR (neat); 3746, 3395, 3060, 3026, 2957, 2925, 2854, 1713, 1622, 1599, 1454, 1373, 1303, 1252, 1213, 1143, 1078, 1032, 1007, 982, 964, 919, 854, 750, 697, 672, 620, 577; HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for $\text{C}_{18}\text{H}_{28}\text{BO}_2$ 287.2176, found 287.2161.

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(*E*)-4,4,5,5-tetramethyl-2-(1-*p*-tolylhex-1-en-2-yl)-1,3,2-dioxaborolane (**2b**). 87 mg (58%). Colourless oil, $R_f = 0.10$ (EtOAc/Hexane 10:90). ^1H NMR (300 MHz, CDCl_3): δ 7.21 (d, 2H, $J = 7.9$ Hz), 7.04 (d, 2H, $J = 7.7$ Hz), 6.83 (s, 1H), 2.34-2.25 (m, 5H), 1.51-1.41 (m, 2H), 1.34-1.26 (m, 2H), 1.27 (s, 12H), 0.89 (t, 3H, $J = 6.6$ Hz). ^{13}C NMR (75 MHz, CDCl_3): δ 139.6, 136.4, 136.1, 128.4, 128.0, 83.3, 38.1, 31.5, 24.7, 22.5, 21.1, 14.0 (The carbon α to boron was not found). ^{11}B NMR (96 MHz, CDCl_3): δ 31.1 (br) IR (neat): 3861, 3745, 3611, 2956, 2923, 2853, 1728, 1624, 1567, 1549, 1511, 1462, 1392, 1374, 1338, 1302, 1253, 1215, 1144, 1071, 1037, 964, 945, 860, 828, 804, 772, 708, 670, 574. HRMS (ESI+): m/z ($\text{M}^+ + \text{Na}$) calculated for $\text{C}_{19}\text{H}_{29}\text{O}_2\text{BNa}$ 323.2158, found 323.2156.

(*E*)-2-(1-(4-methoxyphenyl)-hex-1-en-2-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**2c**). 98 mg (62%). Colourless oil, $R_f = 0.15$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.27 (d, 2H, $J = 8.4$ Hz), 6.81 (s, 1H), 6.78 (d, 2H, $J = 8.8$ Hz), 3.79 (s, 3H), 2.28-2.24 (m, 2H), 1.50-1.42 (m, 2H), 1.35-1.30 (m, 2H), 1.27 (s, 12H), 0.89 (t, 3H, $J = 6.8$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 158.6, 138.9, 131.5, 129.1, 113.2, 83.2, 55.1, 38.1, 31.0, 25.0, 22.5, 13.8 (The carbon α to boron was not found). IR (neat); 3746, 3611, 2955, 2924, 2853, 1729, 1607, 1573, 1510, 1462, 1374, 1298, 1245, 1175, 1143, 1035, 965, 941, 859, 831, 771, 705, 671, 577. HRMS (ESI+): m/z ($\text{M}^+ + \text{H}$) calculated for $\text{C}_{19}\text{H}_{30}\text{BO}_3$ 317.2282, found 317.2287.

(*E*)-2-(1-(4-methoxyphenyl)-3-phenylprop-1-en-2-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**2d**). 101 mg (58%). Colourless oil, $R_f = 0.10$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.32 (d, 2H, $J = 8.6$ Hz), 7.25-7.15 (m, 5H), 6.90 (s, 1H), 6.80 (d, 2H, $J = 8.6$ Hz), 3.79 (s, 3H), 3.63 (s, 2H), 1.08 (s, 12H). ^{13}C NMR (100 MHz, CDCl_3): δ 158.8, 141.1, 140.6, 131.3, 129.4, 129.3, 128.1, 125.9, 113.2, 83.4, 55.3, 44.2, 25.0 (The carbon α to boron was not found). IR (neat); 3429, 3028, 2978, 2930, 2838, 1714, 1605, 1511, 1456, 1392, 1304, 1249, 1173, 1143, 1111, 1077, 1032, 965, 832, 737, 700, 672. HRMS (ESI+): m/z ($\text{M}^+ + \text{Na}$) calculated for $\text{C}_{22}\text{H}_{28}\text{BO}_3\text{Na}$ 373.1945, found 373.1945.

(*E*)-2-(3-cyclohexyl-1-(4-methoxyphenyl)prop-1-en-2-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (**2e**). 107 mg (60%). Colorless oil, $R_f = 0.10$ (EtOAc/Hexane 10:90). ^1H NMR

(500 MHz, CDCl₃): δ 7.31-7.27 (m, 2H), 6.81-6.77 (m, 3H), 3.79 (s, 1H), 2.16 (dt, 2H, *J* = 10.3, 5.2 Hz), 1.82-1.61 (m, 6H), 1.47-1.33 (m, 1H), 1.27 (s, 12H), 1.24-1.08 (m, 4H). ¹³C NMR (101 MHz, CDCl₃): δ 158.7, 140.6, 131.8, 129.4, 113.2, 83.3, 55.3, 46.2, 38.2, 33.3, 26.7, 26.4, 24.8 (The carbon α to boron was not found). IR (neat): 3445, 2976, 2921, 2850, 1707, 1607, 1511, 1444, 1393, 1373, 1346, 1302, 1243, 1174, 1135, 1080, 1038, 964, 886, 859, 829, 767, 713, 667. HRMS (ESI+): *m/z* (M⁺+Na) calculated for C₂₂H₃₃BO₃Na 379.2415, found 379.2414.

(*E*)-2-(2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-hex-1-enyl)benzaldehyde (**2f**). 118 mg (75%), colourless oil, *R_f* = 0.20 (EtOAc/Hexane 10:90). ¹H NMR (400 MHz, CDCl₃): δ 10.28 (s, 1H), 7.85 (dd, 1H, *J* = 1.8, 7.7 Hz), 7.45 (dd, 1H, *J* = 1.6, 7.5 Hz), 7.38-7.31 (m, 1H), 7.31-7.27 (m, 2H), 2.36 (td, 2H, *J* = 1.5, 7.5 Hz), 1.54-1.46 (m, 2H), 1.41-1.34 (m, 2H), 1.09 (s, 12H), 0.94 (t, 3H, *J* = 7.3 Hz). ¹³C NMR (100 MHz, CDCl₃): δ 192.4, 143.2, 141.2 (br), 135.9, 133.6, 133.0, 130.4, 127.7, 127.4, 83.0, 37.2, 31.7, 24.55, 24.4, 13.6. ¹¹B NMR (96 MHz, CDCl₃): δ 30.4 (br). HRMS (ESI+): *m/z* (M⁺+Na) calculated for C₁₉H₂₇O₃BNa 337.1950, found 337.1951.

(*E*)-5-methoxy-2-(2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-hex-1-enyl)benzaldehyde (**2g**). 100 mg (58%). Colourless oil, *R_f* = 0.40 (EtOAc/Hexane 20:80). ¹H NMR (500 MHz, CDCl₃): δ 10.25 (s, 1H), 7.36 (d, 1H, *J* = 2.8 Hz), 7.23-7.21 (m, 2H), 7.04 (dd, 1H, *J* = 2.8, 8.5 Hz), 3.85 (s, 3H), 2.37-2.33 (m, 2H), 1.52-1.46 (m, 2H), 1.41-1.34 (m, 2H), 1.11 (s, 12H), 0.93 (t, 3H, *J* = 7.3 Hz). ¹³C NMR (100 MHz, CDCl₃): δ 191.4, 158.7, 136.2, 135.6, 134.5, 131.6, 120.7, 109.8, 83.4, 55.4, 37.2, 31.8, 24.5, 22.4, 13.9 (The carbon α to boron was not found). IR (neat): 2956, 2924, 2853, 1741, 1691, 1602, 1564, 1493, 1463, 1392, 1308, 1262, 1220, 1161, 1144, 1037, 964, 862, 836, 772, 706. HRMS (ESI+): *m/z* (M⁺+Na) calculated for C₂₀H₂₉BO₄Na 367.2051, found 367.2059.

(*E*)-4,5-dimethoxy-2-(2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hex-1-enyl)benzaldehyde (**2h**). 97 mg (52%). Colourless oil, *R_f* = 0.60 (EtOAc/Hexane 20:80). ¹H NMR (500 MHz, CDCl₃): δ 10.11 (s, 1H), 7.38 (s, 1H), 7.17 (s, 1H), 6.78 (s, 1H), 3.95 (s, 3H), 3.93 (s, 3H), 2.36 (dd, 2H, *J* = 11.0, 4.1 Hz), 1.53-1.47 (m, 2H), 1.43-1.35 (m, 2H), 1.09 (s, 12H), 0.94 (t, 3H, *J* = 7.3 Hz). ¹³C NMR (100 MHz, CDCl₃): δ 190.7, 152.9, 148.1, 141.3 (br), 138.7, 135.3, 127.3, 112.1, 108.1, 83.3, 55.7, 55.6, 37.0, 31.7, 24.5, 22.3, 13.8. IR (neat):

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4 1034, 1003, 964, 858, 772, 700, 671. HRMS (ESI+): m/z (M^+H) calculated for $C_{21}H_{32}BO_5$
5 375.2337, found 375.2323.
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11 *(E)*-1-(2-(4,4,5,5-tetramethyl-1,2,3-dioxaborolan-2-yl)-hex-1-enyl)-2-naphthaldehyde (**2i**). 93 mg
12 (51%). Colourless oil, $R_f = 0.15$ (EtOAc/Hexane 10:90). 1H NMR (500 MHz, $CDCl_3$): δ
13 10.43 (s, 1H), 8.12 (d, 1H, $J = 8.3$ Hz), 7.96 (d, 1H, $J = 8.5$ Hz), 7.83 (d, 1H, $J = 7.9$ Hz),
14 7.80 (d, 1H, $J = 8.6$ Hz), 7.60-7.57 (m, 1H), 7.54-7.51 (m, 1H), 7.36 (s, 1H), 2.54 (dd, 2H, J
15 = 16.9, 7.8 Hz), 1.64-1.58 (m, 2H), 1.50-1.44 (m, 2H), 0.99 (t, 3H, $J = 7.3$ Hz), 0.87 (s, 6H),
16 0.80 (s, 6H). ^{13}C NMR (125 MHz, $CDCl_3$): 193.0, 144.2, 135.6, 133.5, 132.4, 131.5, 128.4,
17 128.1, 127.3, 126.8, 126.4, 121.9, 83.2, 36.9, 31.9, 24.2, 22.6, 14.0 (The carbon α to boron
18 was not found). IR (neat): 3059, 2957, 2924, 2853, 1681, 1617, 1595, 1461, 1427, 1397,
19 1374, 1314, 1256, 1225, 1142, 1029, 964, 857, 818, 747, 705, 668. . HRMS (ESI+): m/z
20 (M^+Na) calculated for $C_{23}H_{29}BO_3Na$ 386.2138, found 386.2146.
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31 *(E)*-2-(3-cyclohexyl-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)prop-1-enyl)-4,5-
32 dimethoxybenzaldehyde (**2j**). 135 mg (65%). Colourless oil, $R_f = 0.60$ (EtOAc/Hexane
33 20:80). 1HNMR (500 MHz, $CDCl_3$): δ 10.13 (s, 1H), 7.39 (s, 1H), 7.13 (s, 1H), 6.77 (s, 1H),
34 3.95 (s, 3H), 3.93 (s, 3H), 2.26 (d, 2H, $J = 7.1$ Hz), 1.88-1.62 (m, 6H), 1.55-1.38 (m, 1H),
35 1.31-1.13 (m, 4H), 1.08 (s, 12H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 190.8, 153.0, 148.3, 138.8,
36 136.5, 127.4, 112.3, 108.2, 83.4, 56.0, 45.6, 37.9, 33.4, 26.5, 26.4, 24.5 (The carbon α to
37 boron was not found). IR (neat): 3860, 3812, 3669, 3610, 3593, 4370, 3396, 3342, 3287,
38 3245, 2977, 2921, 2847, 1785, 1752, 1678, 1595, 1566, 1522, 1510, 1449, 1388, 1337, 1309,
39 1270, 1216, 1137, 1109, 1034, 1004, 965, 852, 772. HRMS (ESI+): m/z (M^+H) calculated
40 for $C_{24}H_{36}BO_5$ 415.2650, found 415.2647.
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51 *(E)*-5-(tert-butyltrimethylsilyloxy)-2-(3-cyclohexyl-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-
52 2-yl)prop-1-enyl)-4-methoxybenzaldehyde (**2k**). 159 mg (62%). Colourless oil, $R_f = 0.20$
53 (EtOAc/Hexane 10:90). 1HNMR (500 MHz, $CDCl_3$): δ 10.18 (s, 1H), 7.36(s, 1H), 7.13 (s,
54 1H), 6.73 (s, 1H), 3.87 (s, 3H), 2.25 (d, 2H, $J = 7.1$ Hz), 1.82-1.61 (m, 6H), 1.51-1.40 (m,
55 1H), 1.32-1.16 (m, 4H), 1.08 (s, 12H), 0.99 (s, 9H), 0.15 (s, 6H). ^{13}C NMR (101 MHz,
56 1H), 1.32-1.16 (m, 4H), 1.08 (s, 12H), 0.99 (s, 9H), 0.15 (s, 6H). ^{13}C NMR (101 MHz,
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CDCl₃): δ 190.9, 155.2, 139.2, 137.0, 118.9, 112.8, 83.3, 77.36, 70.0, 76.7, 55.5, 45.5, 38.0, 33.4, 26.4 (The carbon α to boron was not found). IR (neat); 3744, 3609, 3394, 3338, 3308, 3246, 2925, 2853, 1657, 1642, 1550, 1513, 1448, 1389, 1325, 1286, 1219, 1140, 1064, 1012, 898, 838. HRMS (ESI⁺): m/z ($M^+ + H$) calculated for C₂₉H₄₈O₅BSi 515.3358, found 515.3347.

(E)-4,5-dimethoxy-2-(3-phenyl-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)prop-1-enyl)benzaldehyde (**2l**). 130 mg (64%). R_f = 0.60 (EtOAc/Hexane 20:80). ¹H NMR (400 MHz, CDCl₃): δ 10.11 (s, 1H), 7.38 (s, 1H), 7.33-7.27 (m, 4H), 7.24-7.17 (m, 2H), 6.80 (s, 1H), 3.95 (s, 3H), 3.93 (s, 3H), 3.69 (d, 2H, J = 1.2 Hz), 0.97 (s, 12H). ¹³C NMR (101 MHz, CDCl₃): δ 190.6, 153.0, 148.4, 139.9, 138.3, 137.0, 129.2, 128.3, 127.4, 126.2, 112.3, 108.5, 83.5, 56.1, 43.3, 24.5 (The carbon α to boron was not found). IR (neat); 3448, 3066, 2978, 2929, 2832, 2718, 1686, 1594, 1557, 1508, 1451, 1397, 1343, 1263, 1218, 1112, 1031, 1000, 960, 886, 858, 777, 699. HRMS (ESI⁺): m/z ($M^+ + Na$) calculated for C₂₄H₂₉BO₅Na, 431.2000; found, 431.1981.

(E)-5-methoxy-2-(3-phenyl-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)prop-1-enyl)benzaldehyde (**2m**). 109 mg (58%). Colourless oil, R_f = 0.30 (EtOAc/Hexane 10:90). ¹H NMR (400 MHz, CDCl₃): δ 10.24 (s, 1H), 7.36 (d, 1H, J = 2.8 Hz), 7.32-7.22 (m, 6H), 7.21-7.16 (m, 1H), 7.04 (dd, 1H, J = 8.5, 2.8 Hz), 3.86 (s, 3H), 3.69 (d, 2H, J = 1.2 Hz), 0.98 (s, 12H). ¹³C NMR (101 MHz, CDCl₃): δ 191.8, 159.0, 140.0, 137.2, 135.6, 134.6, 131.7, 129.2, 128.3, 126.1, 120.6, 110.4, 83.5, 55.5, 43.4, 24.4 (The carbon α to boron was not found). IR (neat): 3420, 2980, 2934, 2100, 1666, 1521, 1452, 1374, 1220, 1166, 1113, 1078, 1020, 854, 769, 697. HRMS (ESI⁺): m/z ($M^+ + H$) calculated for C₂₃H₂₈BO₄, 379.2075; found, 379.2070, ($M^+ + Na$) calculated for C₂₃H₂₇BO₄Na, 401.1894; found, 401.1890.

(E)-2-(2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-2-(trimethylsilyl)vinyl)benzaldehyde (**2n**). 117 mg (65%). Colourless oil, R_f = 0.10 (EtOAc/Hexane 10:90). ¹H NMR (400 MHz, CDCl₃): δ 10.28 (s, 1H), 7.85 (dt, 1H, J = 12.3, 6.1 Hz), 7.79 (s, 1H), 7.53-7.46 (m, 1H), 7.44-7.35 (m, 2H), 1.12 (s, 12H), 0.23 (s, 9H). ¹³C NMR (75 MHz, CDCl₃): δ 191.9, 146.7, 144.5, 133.1, 129.2, 128.7, 127.6, 83.4, 24.7, -1.0 (The carbon α to boron was not found). IR

(neat); 3743, 3438, 3396, 3064, 2954, 2897, 2837, 1696, 1587, 1557, 1466, 1370, 1317, 1245, 1215, 1138, 1096, 1008, 984, 951, 838, 760, 719, 690, 630. HRMS (ESI+): m/z (M^+Na) calculated for $C_{18}H_{27}BO_3SiNa$ 353.1714, found 353.1721.

General Procedure for Petasis cyclization from Boronates 2f-2n. Synthesis of Compounds 3a-3v. Amine (0.5 mmol) was added to a stirred solution of boronate **2** (0.3 mmol) in 1,1,1,3,3,3-hexafluoropropan-2-ol (1 mL) under argon atmosphere at room temperature. The reaction mixture was stirred during 8 h. The solvent was removed under reduced pressure to give a residue that was purified by column chromatography (230-400 mesh Silica gel, EtOAc in cyclohexane) to afford amino indenenes **3**.

4-(2-Butyl-1H-inden-1-yl) morpholine (3a). 71 mg (92%). Colourless oil, R_f = 0.10 (EtOAc/Hexane 10:90). 1H NMR (400 MHz, $CDCl_3$): δ 7.45 (d, 1H, J = 7.3 Hz), 7.23-7.15 (m, 2H), 7.09-7.04 (m, 1H), 6.41 (s, 1H), 4.12 (s, 1H), 3.71-3.62 (m, 4H), 2.72-2.69 (m, 2H), 2.59-2.54 (m, 2H), 2.44-2.38 (m, 2H), 1.68-1.52 (m, 2H), 1.44-1.35 (m, 2H), 0.95 (t, 3H, J = 7.3 Hz). ^{13}C NMR (125 MHz, $CDCl_3$): δ 151.9, 144.3, 143.1, 127.5, 126.55, 124.5, 123.8, 120.2, 72.9, 67.75, 49.3, 30.6, 29.0, 22.6, 14.0. IR (neat): 3062, 2955, 2924, 2852, 1718, 1616, 1508, 1458, 1376, 1318, 1290, 1271, 1244, 1168, 1115, 1011, 929, 888, 848, 752, 732, 690. HRMS (ESI+): m/z (M^+H) calculated for $C_{17}H_{24}NO$, 258.1852; found, 258.1854.

N,N-Diallyl-2-butyl-1H-inden-1-amine (3b). 66 mg (75%). Colourless oil, R_f = 0.10 (EtOAc/Hexane 10:90). 1H NMR (500 MHz, $CDCl_3$): δ 7.47 (d, 1H, J = 7.3 Hz), 7.23-7.13 (m, 2H), 7.06 (td, 1H, J = 7.2, 1.4 Hz), 6.39 (s, 1H), 5.88-5.78 (m, 2H), 5.22 (dd, 2H, J = 17.2, 1.1 Hz), 5.10 (d, 2H, J = 10.1 Hz, $CH=H_2$), 4.38 (s, 1H), 3.14-3.01 (m, 4H), 2.46-2.33 (m, 2H), 1.66-1.46 (m, 2H), 1.44-1.33 (m, 2H), 0.94 (t, 3H, J = 7.3 Hz). ^{13}C NMR (125 MHz, $CDCl_3$): δ 153.8, 144.6, 144.35, 137.3, 127.3, 125.9, 124.2, 123.6, 120.3, 116.8, 67.2, 53.3, 30.3, 29.0, 22.45, 14.1. IR (neat): 3072, 2957, 2924, 2854, 1721, 1644, 1620, 1462, 1399, 1377, 1287, 1261, 1118, 1074, 995, 919, 876, 803, 751, 733. HRMS (ESI+): m/z (M^+Na) calculated for $C_{19}H_{25}NNa$ 290.1879, found 290.1883.

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3 4-(2-Butyl-6-methoxy-1H-inden-1-yl) morpholine (**3c**). 63 mg (73%). Colourless oil, $R_f = 0.25$
4 (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.08 (s, 1H), 7.04 (d, 1H, $J = 8.2$
5 Hz), 6.75 (dd, 1H, $J = 2.2, 8.0$ Hz), 6.34 (s, 1H), 4.09 (s, 1H), 3.81 (s, 3H), 3.70-3.63 (m,
6 4H), 2.71-2.70 (m, 2H), 2.60-2.55 (m, 2H), 2.40-2.34 (m, 2H), 1.63-1.51 (m, 2H), 1.43-1.35
7 (m, 2H), 0.94 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (75 MHz, CDCl_3): δ 157.0, 149.7, 144.9, 137.2,
8 126.2, 120.4, 112.1, 111.8, 72.8, 67.8, 55.9, 49.4, 30.6, 29.0, 22.5, 14.2. IR (neat): 2955,
9 2922, 2852, 1728, 1609, 1581, 1468, 1318, 1284, 1219, 1115, 1034, 1010, 854, 771 cm^{-1} .
10 HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{18}\text{H}_{26}\text{NO}_2$, 288.1958; found, 288.1949.
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20 *N,N*-Diallyl-2-butyl-6-methoxy-1H-inden-1-amine (**3d**). 72 mg (81%). Colourless oil, $R_f =$
21 0.10 (EtOAc/Hexane 10:90). ^1H NMR (400 MHz, CDCl_3): δ 7.09 (dd, 1H, $J = 3.9, 2.9$ Hz),
22 7.05 (d, 1H, $J = 8.1$ Hz), 6.74 (dd, 1H, $J = 8.1, 2.4$ Hz), 6.33 (d, 1H, $J = 0.9$ Hz), 5.90-5.80
23 (m, 2H), 5.23 (dd, 2H, $J = 17.2, 1.3$ Hz), 5.13-5.08 (m, 2H), 4.30 (s, 1H), 3.81 (s, 3H), 3.15-
24 3.04 (m, 4H), 2.40-2.34 (m, 2H), 1.63-1.51 (m, 2H), 1.43-1.35 (m, 2H), 0.93 (t, 3H, $J = 7.3$
25 Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 156.8, 151.5, 146.3, 137.3, 125.3, 120.1, 116.7, 112.0,
26 111.1, 67.4, 55.5, 53.4, 30.6, 28.8, 22.6, 14.0. IR (neat): 3745, 3076, 2955, 2923, 2853, 2832,
27 1641, 1607, 1581, 1471, 1429, 1355, 1282, 1258, 1153, 1136, 1092, 1035, 995, 918, 859,
28 804, 772, 726. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{20}\text{H}_{28}\text{NO}$, 298.2165; found,
29 298.2155.
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40 *N*-Benzyl-2-butyl-6-methoxy-*N*-methyl-1H-inden-1-amine (**3e**). 75 mg (78%). Colourless oil,
41 $R_f = 0.25$ (EtOAc/Hexane 10:90). ^1H NMR (400 MHz, CDCl_3): δ 7.39 (d, 2H, $J = 7.2$ Hz),
42 7.31 (dd, 2H, $J = 10.2, 4.7$ Hz, Ar-), 7.23 (dd, 1H, $J = 8.3, 6.2$ Hz), 7.16 (d, 1H, $J = 2.1$ Hz),
43 7.08-7.05 (m, 1H), 6.75 (dd, 1H, $J = 8.1, 2.4$ Hz), 6.35 (d, 1H, $J = 0.8$ Hz), 4.30 (s, 1H), 3.81
44 (s, 3H), 3.76-3.67 (m, 2H), 2.45-2.41 (m, 2H), 2.20 (s, 3H), 1.63-1.51 (m, 2H), 1.43-1.35 (m,
45 2H), 0.93 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 157.1, 151.0, 145.6, 140.1,
46 137.5, 128.7, 128.3, 126.9, 125.6, 120.2, 112.4, 111.4, 71.8, 58.2, 55.6, 37.8, 30.8, 28.7, 23.0,
47 13.5. IR (neat): 3060, 3027, 2953, 2927, 2855, 2833, 2794, 1705, 1605, 1581, 1471, 1438,
48 1359, 1310, 1282, 1255, 1230, 1133, 1103, 1034, 976, 923, 861, 806, 771, 739, 698, 603.
49 HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{22}\text{H}_{28}\text{NO}$, 322.2165; found, 322.2152.
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3 *1-(2-Butyl-6-methoxy-1H-indene-1-yl) pyrrolidine (3f)*. 66 mg (82%). Colourless oil, $R_f =$
4 0.10 (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.10 (s, 1H), 7.04 (d, 1H, $J =$
5 8.2 Hz), 6.73 (dd, 1H, $J = 2.4, 8.1$ Hz), 6.30 (s, 1H), 4.42 (s, 1H), 3.80 (s, 3H), 2.83-2.81 (m,
6 2H), 2.60-2.56 (m, 2H), 2.40-2.33 (m, 2H), 1.75-1.70 (m, 4H), 1.64-1.51 (m, 2H), 1.43-1.36
7 (m, 2H), 0.94 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (101 MHz, CDCl_3): δ 156.9, 151.4, 145.7, 137.7,
8 124.6, 119.8, 112.5, 111.3, 68.2, 55.5, 48.2, 30.6, 29.1, 24.0, 22.6, 14.0. IR (neat): 3448,
9 3027, 2594, 2853, 1742, 1605, 1509, 1452, 1385, 1247, 1175, 1116, 1072, 1028, 873, 829,
10 771, 699. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{18}\text{H}_{26}\text{NO}$, 272.2014; found, 272.2003.
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20 *1-(2-Butyl-6-methoxy-1H-indene-1-yl) piperidine (3g)*. 64 mg (75%). Colourless oil, $R_f = 0.10$
21 (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.08 (s, 1H), 7.02 (d, 1H, $J = 8.2$
22 Hz), 6.72 (dd, 1H, $J = 2.3, 8.7$ Hz), 6.31 (s, 1H), 4.08 (s, 1H), 3.81 (s, 3H), 2.65-2.61 (m,
23 2H), 2.50-2.48 (m, 2H), 2.35 (t, 2H, $J = 7.6$ Hz), 1.64-1.50 (m, 6H), 1.43-1.36 (m, 4H), 0.94
24 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 156.8, 151.0, 145.7, 137.4, 125.0, 120.0,
25 112.3, 111.2, 73.6, 55.5, 50.1, 30.6, 29.0, 26.8, 24.7, 22.6, 14.0. IR (neat): 3051, 2929, 2854,
26 2802, 2744, 1711, 1607, 1582, 1471, 1432, 1379, 1357, 1308, 1281, 1207, 1166, 1134, 113,
27 1090, 1034, 1002, 858, 770, 602. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{19}\text{H}_{28}\text{NO}$,
28 286.2165; found, 286.21.
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38 *1-(2-Butyl-6-methoxy-1H-indene-1-yl)-4-phenyl piperazine (3h)*. 78 mg (72%). Colourless
39 oil, $R_f = 0.10$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.25-7.22 (m, 2H, 7.10
40 (s, 1H), 7.05 (d, 1H, $J = 8.0$ Hz), 6.90 (d, 2H, $J = 7.9$ Hz), 6.83 (t, 1H, $J = 7.3$ Hz), 6.74 (dd,
41 1H, $J = 2.2, 8.0$ Hz), 6.36 (s, 1H), 4.20 (s, 1H), 3.80 (s, 3H), 3.20-3.10 (m, 4H), 2.90-2.80
42 (m, 2H), 2.75-2.71 (m, 2H), 2.42-2.36 (m, 2H), 1.64-1.51 (m, 2H), 1.45-1.36 (m, 2H), 0.94 (t,
43 3H, $J = 7.3$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 157.0, 151.5, 149.9, 144.9, 137.2, 128.9,
44 125.8, 120.1, 119.5, 116.0, 1112.2, 111.8, 72.6, 55.5, 50.0, 48.7, 30.6, 29.0, 22.6, 14.0. IR
45 (neat): 3745, 3639, 3017, 2925, 2852, 1730, 1694, 1694, 1600, 1499, 1470, 1380, 1282,
46 1216, 1140, 1033, 1013, 926, 858, 770, 667. HRMS (ESI+): m/z (M^+H) calculated for
47 $\text{C}_{24}\text{H}_{31}\text{N}_2\text{O}$, 363.2430; found, 363.2421.
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3 4-(2-Butyl-5,6-dimethoxy-1H-inden-1-yl) morpholine (**3i**). 67 mg (71%). Colourless oil, $R_f =$
4 0.80 (EtOAc/Hexane 20:80). ^1H NMR (500 MHz, CDCl_3): δ 7.08 (s, 1H), 6.76 (s, 1H), 6.32
5 (s, 1H), 4.07 (s, 1H), 3.90 (s, 3H), 3.88 (s, 3H), 3.75-3.64 (m, 4H), 2.74-2.70 (m, 2H), 2.60-
6 2.57 (m, 2H), 2.41-2.33 (m, 2H), 1.63-1.50 (m, 2H), 1.44-1.35 (m, 2H), 0.95 (t, 3H, $J = 7.3$
7 Hz). ^{13}C NMR (100 MHz, CDCl_3): δ 150.7, 148.7, 146.0, 137.1, 135.1, 125.9, 109.5, 104.2,
8 72.8, 67.7, 56.4, 55.9, 49.2, 30.7, 29.0, 22.5, 13.9. IR (neat): 3745, 3611, 3396, 2954, 2923,
9 2852, 1694, 1602, 1582, 1490, 1461, 1411, 1315, 1216, 1140, 1114, 1089, 1012, 992, 933,
10 861, 772. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{19}\text{H}_{28}\text{NO}_3$, 318.2063; found, 318.2051.
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20 1-(2-Butyl-5,6-dimethoxy-1H-indene-1-yl)-4-phenyl piperazine (**3j**). 96 mg (82%). Colourless
21 oil, $R_f = 0.70$ (EtOAc/Hexane 20:80). ^1H NMR (500 MHz, CDCl_3): δ 7.26-7.22 (m, 2H), 7.09
22 (s, 1H), 6.92 (dd, 2H, $J = 8.7, 0.8$ Hz), 6.84 (t, 1H, $J = 7.3$ Hz), 6.79 (s, 1H), 6.34 (s, 1H),
23 4.17 (s, 1H), 3.88 (s, 6H), 3.20-3.11 (m, 4H), 2.88-2.83 (m, 2H), 2.77-2.72 (m, 2H), 2.41-
24 2.37 (m, 2H), 1.64-1.51 (m, 2H), 1.44-1.34 (m, 2H), 0.94 (t, 3H, $J = 7.2$ Hz). ^{13}C NMR (125
25 MHz, CDCl_3): δ 151.4, 151.0, 148.7, 145.9, 137.1, 135.2, 128.9, 125.8, 119.5, 116.0, 109.5,
26 104.2, 72.6, 56.3, 55.9, 49.9, 48.7, 30.7, 29.0, 22.5, 13.9. IR (neat): 3057, 2953, 2926, 2854,
27 2827, 1677, 1599, 1492, 1455, 1410, 1380, 1304, 1232, 1143, 1085, 1101, 992, 927, 863,
28 814, 760. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{25}\text{H}_{33}\text{N}_2\text{O}_2$, 393.2536; found,
29 393.2524.
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40 *N,N*-Diallyl-2-butyl-5,6-dimethoxy-1H-inden-1-amine (**3k**). 78 mg (78%). Colourless oil, $R_f =$
41 0.60 (EtOAc/Hexane 20:80). ^1H NMR (500 MHz, CDCl_3): δ 7.07 (s, 1H), 6.75 (s, 1H), 6.30
42 (s, 1H), 5.88-5.80 (m, 2H), 5.22 (dd, 2H, $J = 17.2, 1.2$ Hz), 5.11 (d, 2H, $J = 10.1$ Hz), 4.31 (s,
43 1H), 3.90 (s, 3H), 3.87 (s, 3H), 3.15-3.04 (m, 4H), 2.42-2.35 (m, 2H), 1.63-1.46 (m, 2H),
44 1.42-1.32 (m, 2H), 0.94 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 152.6, 148.6,
45 145.9, 137.2, 136.6, 125.4, 116.6, 109.3, 104.2, 67.6, 56.5, 55.9, 53.5, 30.7, 29.0, 22.6, 14.0.
46 IR (neat): 3360, 2926, 2833, 1742, 1659, 1487, 1453, 1415, 1336, 1218, 1112, 1017, 918,
47 772. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{21}\text{H}_{30}\text{NO}_2$, 328.2271; found, 328.2259.
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3 *N*-Benzyl- 2-butyl-5, 6- dimethoxy-*N*-methyl-1*H*-inden-1-amine (**3l**). 86 mg (82%). Colourless
4 oil, $R_f = 0.50$ (EtOAc/Hexane 20:80). ^1H NMR (400 MHz, CDCl_3): δ 7.40-7.37 (m, 2H),
5 7.33-7.30 (m, 2H), 7.25-7.22 (m, 1H), 7.13 (s, 1H), 6.80 (s, 1H), 6.33 (s, 1H), 4.21 (s, 1H),
6 3.92 (s, 3H), 3.88 (s, 3H), 3.71-3.62 (m, 2H), 2.50-2.43 (m, 2H), 2.33 (s, 3H, NCH_3), 1.65-
7 1.50 (m, 2H, CH_2), 1.46-1.37 (m, 2H, CH_2), 0.95 (t, 3H, $J = 7.3$ Hz, CH_3). ^{13}C NMR (125
8 MHz, CDCl_3): δ 151.9, 148.7, 146.0, 139.9, 137.3, 135.8, 128.5, 128.1, 126.8, 125.5, 109.5,
9 104.2, 71.8, 57.9, 56.5, 55.9, 37.9, 30.8, 29.1, 22.7, 14.0. IR (neat): 2924, 2853, 1679, 1491,
10 1463, 1335, 1218, 1099, 1027, 772. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{23}\text{H}_{30}\text{NO}_2$,
11 352.2271; found, 352.224760.
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21 *2*-Butyl-5,6-dimethoxy-*N*-(prop-2-ynyl)-1*H*-inden-1-amine (**3m**). 64 mg (75%). Colourless
22 oil, $R_f = 1.50$ (EtOAc/Hexane 20:80). ^1H NMR (500 MHz, CDCl_3): δ 7.08 (s, 1H), 6.77 (s,
23 1H), 6.36 (s, 1H), 4.27 (s, 1H), 3.90 (s, 3H), 3.88 (s, 3H), 3.04 (d, 2H, $J = 2.5$ Hz), 2.42-2.31
24 (m, 2H), 2.18 (t, 1H, $J = 2.4$ Hz), 1.94 (s, 1H), 1.66-1.50 (m, 2H), 1.45-1.37 (m, 2H), 0.95 (t,
25 3H, $J = 7.3$ Hz). ^{13}C NMR (75 MHz, CDCl_3): δ 150.3, 148.7, 146.6, 136.5, 135.6, 126.0,
26 107.8, 104.1, 82.4, 71.1, 65.3, 56.1, 55.9, 32.4, 30.5, 28.0, 22.4, 13.8. IR (neat): 3745, 3610,
27 3286, 3062, 2954, 2927, 2857, 1673, 1645, 1605, 1496, 1312, 1265, 1215, 1125, 1030, 864,
28 771, 668. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{18}\text{H}_{24}\text{NO}_2$, 286.1801; found, 286.1791.
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38 *N*-Benzyl-2-butyl-5,6-dimethoxy-1*H*-inden-1-amine (**3n**). 73 mg (72%). Colourless oil, $R_f =$
39 0.70 (EtOAc/Hexane 20:80). ^1H NMR (400 MHz, CDCl_3): δ 7.28-7.17 (m, 5H), 7.06 (s, 1H),
40 6.80 (s, 1H), 6.40 (s, 1H), 4.30 (s, 1H), 3.90 (s, 3H), 3.88 (s, 3H), 3.40 (d, 1H, $J = 12.8$ Hz),
41 3.34 (d, 1H, $J = 12.8$ Hz) 2.47-2.33 (m, 2H), 1.85 (br, 1H), 1.67-1.51 (m, 2H), 1.46-1.37 (m,
42 2H), 0.95 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (100 MHz, CDCl_3): δ 151.4, 148.7, 146.7, 140.8,
43 136.8, 128.2, 128.1, 126.8, 125.7, 107.9, 104.2, 66.2, 56.3, 56.0, 47.4, 30.7, 28.2, 22.6, 13.9.
44 IR (neat): 2924, 2923, 2853, 1652, 1604, 1492, 1460, 1312, 1264, 1217, 1126, 1028, 993,
45 863, 771, 700. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{22}\text{H}_{28}\text{NO}_2$, 338.2114; found,
46 338.2103.
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4-(2-Butyl-3H-cyclopenta[α]naphthalen-3-yl) morpholine (3o). 61 mg (66%). Colourless oil, $R_f = 0.10$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 8.02 (d, 1H, $J = 8.3$ Hz), 7.84 (d, 1H, $J = 7.9$ Hz), 7.68 (d, 1H, $J = 8.2$ Hz), 7.61 (d, 1H, $J = 8.2$ Hz), 7.48-7.40 (m, 2H), 7.00 (s, 1H), 4.25 (s, 1H), 3.73-3.64 (m, 4H), 2.77 (br, 2H, C_2), 2.65-2.61 (m, 2H), 1.73-1.60 (m, 2H), 1.69-1.56 (m, 2H), 1.49-1.36 (m, 2H), 0.98 (t, 3H, $J = 7.3$ Hz). ^{13}C NMR (101 MHz, CDCl_3) δ 152.9, 140.6, 140.3, 133.3, 128.3, 127.1, 125.4, 125.1, 123.8, 123.7, 123.6, 122.9, 73.8, 67.8, 49.6, 31.0, 29.4, 22.7, 14.1. IR (neat): 3056, 2956, 2924, 2853, 1682, 1620, 1595, 1563, 1515, 1459, 1374, 1315, 1255, 1226, 1143, 1116, 1071, 1015, 963, 858, 820, 766, 670. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for $\text{C}_{21}\text{H}_{25}\text{NO}$, 308.2008; found, 308.2010.

2-(Cyclohexylmethyl)-5,6-dimethoxy-N-(prop-2-ynyl)-1H-1-amine (3p). 78 mg (80%). Colourless oil, $R_f = 0.60$ (EtOAc/Hexane 10:90). ^1H NMR (400 MHz, CDCl_3): δ 7.08 (s, 1H), 6.78 (s, 1H), 6.36 (s, 1H), 4.25 (s, 1H), 3.90 (s, 3H), 3.89 (s, 3H), 3.02 (d, 2H, $J = 2.5$ Hz), 2.29 (ddd, 1H, $J = 14.7, 5.5, 1.3$ Hz), 2.25 – 2.17 (m, 2H), 1.91-1.70 (m, 5H), 1.61-1.47 (m, 1H), 1.34-1.15 (m, 4H), 1.10-0.96 (m, 1H), 0.94-0.80 (m, 1H). ^{13}C NMR (75 MHz, CDCl_3): δ 148.8, 146.8, 136.7, 135.8, 127.6, 108.0, 104.3, 82.6, 71.2, 65.5, 56.4, 56.1, 37.5, 36.4, 34.1, 32.9, 32.5, 26.5, 26.4, 26.2. IR (neat); 3855, 3744, 3611, 3525, 3416, 3395, 3285, 3116, 3051, 2995, 2920, 2847, 1695, 1608, 1579, 1490, 1448, 1410, 1315, 1286, 1215, 1125, 1085, 1028, 991, 868, 845, 760, 694, 670, 642. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for $\text{C}_{21}\text{H}_{28}\text{NO}_2$, 326.2114; found, 326.2108.

1-(2-(Cyclohexylmethyl)-5,6-dimethoxy-1H-inden-1-yl)-4-phenylpiperazine (3q). 106 mg (82%). Colourless oil, $R_f = 0.30$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.29-7.20 (m, 2H), 7.10 (d, 1H, $J = 8.1$ Hz), 6.92 (d, 2H, $J = 8.1$ Hz), 6.83 (dd, 1H, $J = 13.3, 6.0$ Hz), 6.78 (s, 1H), 6.33 (s, 1H), 4.14 (s, 1H), 3.88 (s, 6H), 3.22-3.09 (m, 4H), 2.86 (dd, 2H, $J = 10.5, 5.2$ Hz), 2.80-2.68 (m, 2H), 2.37 (dd, 1H, $J = 14.7, 4.6$ Hz), 2.27-2.14 (m, 1H), 1.80-1.62 (m, 5H), 1.29-1.18 (m, 4H), 1.07-0.96 (m, 1H), 0.93- 0.82 (m, 1H). ^{13}C NMR (101 MHz, CDCl_3): δ 151.6, 149.5, 148.8, 146.0, 137.1, 135.4, 129.0, 127.1, 119.6, 116.1, 109.6, 104.3, 72.6, 56.5, 56.0, 50.0, 48.9, 37.3, 34.2, 33.1, 26.6, 26.4, 26.3. IR (neat); 3315, 2925, 2848, 1637, 1493, 1450, 1232, 1143, 1014. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for $\text{C}_{28}\text{H}_{37}\text{N}_2\text{O}_2$ 433.2855, found 433.2856.

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3 4-(6-(*Tert*-butyldimethylsilyloxy)-2-(cyclohexylmethyl)-5-methoxy-1*H*-inden-1-yl) morpholine
4 (**3r**). 104 mg (76%). Colourless oil, $R_f = 0.20$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz,
5 CDCl_3) δ 7.00 (s, 1H), 6.71 (s, 1H), 6.29 (s, 1H), 4.02 (s, 1H), 3.79 (s, 3H), 3.72–3.56 (m,
6 4H), 2.64 (br s, 2H), 2.54 (dd, 2H, $J = 7.3, 4.0$ Hz), 2.32 (dt, 1H, $J = 17.1, 8.6$ Hz), 2.22–2.11
7 (m, 1H), 1.87–1.64 (m, 4H), 1.60–1.49 (m, 1H), 1.33–1.12 (m, 4H), 1.01 (s, 9H), 0.93–0.81
8 (m, 2H), 0.17 (s, 3H), 0.15 (s, 3H). ^{13}C NMR (75 MHz, CDCl_3): δ 150.4, 149.3, 141.6, 138.0,
9 135.3, 127.3, 118.2, 104.7, 72.6, 67.8, 55.6, 49.3, 37.3, 37.2, 34.2, 33.0, 26.6, 26.4, 26.3,
10 25.8, 18.5, -4.4, -4.5. IR (neat); 3317, 2951, 2926, 2847, 1645, 1484, 1450, 1412, 1343, 1294,
11 1250, 1213, 1115, 1013, 906. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for $\text{C}_{27}\text{H}_{44}\text{NO}_3\text{Si}$
12 458.3090, found 458.3094.
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21 6-(*Tert*-butyldimethylsilyloxy)-2-(cyclohexylmethyl)-5-methoxy-*N*-(prop-2-ynyl)-1*H*-inden-1-
22 amine (**3s**). 99 mg (78%). Colourless oil, $R_f = 0.60$ (EtOAc/Hexane 30:70). ^1H NMR (400
23 MHz, CDCl_3) δ 6.97 (s, 1H), 6.73 (s, 1H), 6.33 (s, 1H), 4.23 (s, 1H), 3.80 (s, 3H), 3.03–3.01
24 (m, 2H), 2.28 (dt, 1H, $J = 16.1, 8.0$ Hz), 2.24–2.13 (m, 2H), 1.82 (d, 1H, $J = 12.8$ Hz), 1.72
25 (dd, 4H, $J = 12.8, 3.3$ Hz), 1.60–1.47 (m, 1H), 1.35–1.10 (m, 4H), 1.00 (s, 9H), 0.88 (ddd,
26 2H, $J = 11.6, 10.2, 3.2$ Hz), 0.16 (s, 3H), 0.14 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3): δ 150.7,
27 149.0, 142.4, 137.7, 136.1, 127.6, 116.8, 104.8, 82.6, 71.1, 65.2, 55.7, 37.4, 36.4, 34.1, 33.0,
28 32.6, 26.5, 26.4, 26.2, 25.8, 18.5, -4.5, -4.6. IR (neat); 3744, 3671, 3609, 3395, 3341, 3310,
29 3282, 2993, 2925, 2853, 1785, 1752, 1645, 1577, 1549, 1487, 1451, 1415, 1344, 1296, 1252,
30 1215, 1126, 1086, 1014, 908, 839, 780, 631. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for
31 $\text{C}_{26}\text{H}_{40}\text{NO}_2\text{Si}$ 426.2828, found 426.2836.
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42 4-(2-Benzyl-5,6-dimethoxy-1*H*-inden-1-yl) morpholine (**3t**). 76 mg (72%). Colourless oil, $R_f =$
43 0.50 (EtOAc/Hexane 30:70). ^1H NMR (500 MHz, CDCl_3): δ 7.35–7.24 (m, 4H), 7.21 (t, 1H,
44 $J = 7.0$ Hz), 7.04 (s, 1H), 6.74 (s, 1H), 6.25 (s, 1H), 4.02 (s, 1H), 3.87 (s, 3H), 3.85 (s, 1H,,
45 3.77–3.62 (m, 6H), 2.74–2.63 (m, 2H), 2.63–2.51 (m, 2H). ^{13}C NMR (101 MHz, CDCl_3): δ
46 149.4, 148.8, 146.3, 140.2, 136.8, 135.3, 129.1, 128.3, 127.7, 126.0, 109.5, 104.7, 72.4, 67.8,
47 56.4, 56.0, 49.3, 36.0. IR (neat): 3451, 2952, 2850, 1627, 1490, 1457, 1410, 1314, 1288,
48 1244, 1214, 1140, 1113, 1088, 991, 861, 769, 702. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for
49 $\text{C}_{22}\text{H}_{26}\text{NO}_3$ 352.1907; found, 352.1894.
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3 4-(2-Benzyl-6-methoxy-1H-inden-1-yl) morpholine (**3u**). 73 mg (76%). Colourless oil, R_f =
4 0.30 (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.34-7.23 (m, 5H), 7.21 (t, 1H, J
5 = 7.0 Hz), 7.08-7.00 (m, 1H), 6.73 (dd, 1H, J = 8.1, 1.9 Hz), 6.28 (s, 1H), 4.05 (s, 1H, N-C),
6 3.79 (s, 3H), 3.76-3.60 (m, 6H), 2.80-2.66 (m, 2H), 2.64- 2.48 (m, 2H). ^{13}C NMR (101 MHz,
7 CDCl_3): δ 157.3, 148.3, 144.9, 140.2, 136.9, 129.1, 128.3, 127.7, 126.0, 120.7, 112.2, 111.9,
8 72.3, 67.8, 55.5, 49.2, 36.0. IR (neat): 3445, 3058, 3025, 2929, 2822, 2741, 1606, 1576,
9 1468, 1428, 1349, 1316, 1282, 1233, 1147, 1106, 1022, 921, 852, 809, 755, 695. HRMS
10 (ESI+): m/z (M^+H) calculated for $\text{C}_{21}\text{H}_{24}\text{NO}_2$, 322.1801; found, 322.1793.
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19 *N*-(Prop-2-ynyl)-2-(trimethylsilyl)-1H-inden-1-amine (**3v**). 54 mg (75%). Colourless oil, R_f =
20 0.10 (EtOAc/Hexane 10:90). ^1H NMR (300 MHz, CDCl_3): δ 7.48 (d, 1H, J = 7.2 Hz), 7.30-
21 7.22 (m, 2H), 7.21-7.15 (m, 1H), 7.00 (d, 1H, J = 1.8 Hz), 4.66 (d, 1H, J = 1.6 Hz), 3.13-3.01
22 (m, 2H), 2.16 (t, 1H, J = 2.5 Hz), 1.76 (br s, 1H), 0.27 (s, 9H). ^{13}C NMR (101 MHz, CDCl_3):
23 δ 152.8, 148.3, 145.1, 142.6, 128.6, 126.5, 124.1, 122.1, 83.5, 72.0, 69.9, 34.1, 0.02. IR
24 (neat): 3299, 3067, 2926, 2099, 1710, 1650, 1605, 1541, 1461, 1327, 1282, 1248, 1208,
25 1118, 1083, 1023, 841, 758, 635. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{15}\text{H}_{20}\text{NSi}$
26 242.1365, found, 242.1378.
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34 **General procedure for the intermolecular Petasis reactions from boronates 2a-2e.**

35 **Synthesis of compounds 4a-4g.** Glyoxylic acid monohydrate (51 mg, 0.5 mmol) and amine
36 (0.5 mmol) were added to a stirred solution of the boronate **2** (0.3 mmol) in 1,1,1,3,3,3-
37 hexafluoropropan-2-ol) (1 mL) under argon atmosphere at room temperature. The reaction
38 mixture was stirred during 78h. The solvent was removed under reduced pressure to give a
39 residue which was directly used for further esterification reaction. To a solution of the crude
40 acid in diethyl ether (5 mL) at 0 °C a solution of CH_2N_2 in ether (2 mL, 0.5M) (**Due to its**
41 **explosiveness and toxicity**, diazomethane was directly generated in diethyl ether and used
42 without further purification after simple decantation)²² was added until the persistence of
43 yellow color. After 2 h, the solvent was evaporated and residue was purified by column
44 chromatography (230-400 mesh Silica gel, EtOAc in cyclohexane) to afford unsaturated
45 amino esters **4**.
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3 *Methyl-(Z)-3-benzylidene-2-morpholinoheptanoate (4a)*. 57 mg (60%). Colourless oil, $R_f =$
4 0.50 (EtOAc/Hexane 30:70). $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.36-7.31 (m, 4H), 7.27-7.24
5 (m, 1H), 6.69 (s, 1H), 4.07 (s, 1H), 3.75 (s, 3H), 3.73-3.64 (m, 4H), 2.31 (br, 4H) 2.27-2.24
6 (m, 2H), 1.55-1.46 (m, 2H), 1.43-1.37 (m, 2H), 0.94 (t, 3H, $J = 7.1$ Hz). $^{13}\text{C NMR}$ (125 MHz,
7 CDCl_3): δ 171.3, 137.0, 136.5, 131.7, 130.0, 128.1, 126.7, 69.1, 66.6, 52.0, 51.4, 30.5, 30.3,
8 22.5, 14.1. IR (neat): 3745, 3730, 3610, 3056, 3022, 2955, 2923, 2853, 2812, 2765, 1745,
9 1644, 1598, 1570, 1549, 1492, 1452, 1380, 1337, 1266, 1245, 1193, 1167, 1136, 1118, 1072,
10 1025, 989, 931, 905, 881, 860, 772, 744, 700, 667, 635, 585. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$)
11 calculated for $\text{C}_{19}\text{H}_{28}\text{NO}_3$ 318.2063, found 318.2062.
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20 *Methyl-(Z)-3-benzylidene-2-(diallylamino)heptanoate (4b)*. 65 mg (66%). Colourless oil, $R_f =$
21 0.20 (EtOAc/Hexane 10:90). $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.37-7.32 (m, 4H), 7.26-7.22
22 (m, 1H), 6.64 (s, 1H), 5.71-5.63 (m, 2H), 5.04-5.00 (m, 4H), 4.48 (s, 1H), 3.69 (s, 3H), 3.17-
23 3.05 (m, 4H), 2.32-2.28 (m, 2H), 1.53-1.47 (m, 2H), 1.43-1.37 (m, 2H), 0.94 (t, 3H, $J = 7.3$
24 Hz). $^{13}\text{C NMR}$ (100 MHz, CDCl_3): δ 172.1, 138.0, 137.1, 134.7, 130.7, 129.0, 127.6, 126.6,
25 117.7, 64.5, 53.0, 51.7, 31.0, 31.0, 22.6, 14.1. IR (neat): 3859, 3825, 3746, 3610, 3076, 3019,
26 2955, 2923, 2853, 1743, 1642, 1549, 1493, 1461, 1372, 1261, 1214, 1193, 1163, 1122, 1073,
27 1013, 995, 919, 854, 747, 700, 667, 572. HRMS (ESI+): m/z ($\text{M}^+\text{+H}$) calculated for
28 $\text{C}_{21}\text{H}_{29}\text{NO}_2\text{Na}$ 350.2091, found 350.2116.
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36 *Methyl-(Z)-3-(4-methylbenzylidene)-2-morpholinoheptanoate (4c)*. 48 mg (48%). Colourless
37 oil, $R_f = 0.40$ (EtOAc/Hexane 30:70). $^1\text{H NMR}$ (400 MHz, CDCl_3): δ 7.21 (d, 2H, $J = 7.9$
38 Hz), 7.16 (d, 2H, $J = 7.9$ Hz), 6.65 (s, 1H), 4.08 (s, 1H), 3.75 (s, 3H), 3.73-3.64 (m, 4H), 2.36
39 (s, 3H), 2.32 (br, 4H), 2.17 (t, 2H, $J = 7.2$ Hz), 1.55-1.44 (m, 2H), 1.43-1.36 (m, 2H), 0.93 (t,
40 3H, $J = 7.2$ Hz). $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 171.2, 136.4, 136.0, 134.1, 131.7, 128.8,
41 69.1, 66.6, 52.0, 51.4, 30.5, 30.3, 22.6, 21.1, 14.1. IR (neat): 3860, 3745, 3669, 3610, 2955,
42 2923, 2853, 2812, 1746, 1549, 1511, 1454, 1379, 1339, 1266, 1244, 1214, 1194, 1166, 1138,
43 1118, 1071, 1024, 990, 948, 905, 879, 810, 668, 640, 576. HRMS (ESI+): m/z ($\text{M}^+\text{+Na}$)
44 calculated for $\text{C}_{20}\text{H}_{29}\text{NO}_3\text{Na}$ 354.2045, found 354.2042.
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52 *Methyl-(Z)-3-(4-methoxybenzylidene)-2-morpholinoheptanoate (4d)*. 53 mg (51%).
53 Colourless oil, $R_f = 0.40$ (EtOAc/Hexane 30:70). $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.29 (d, 2H,
54 $J = 8.5$ Hz), 6.90 (d, 2H, $J = 8.6$ Hz), 6.63 (s, 1H), 4.08 (s, 1H), 3.83 (s, 3H), 3.76 (s, 3H),
55 3.73-3.64 (m, 4H), 2.35-2.28 (m, 4H) 2.24-2.12 (m, 2H), 1.54-1.44 (m, 2H), 1.38-1.31 (m,
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2H), 0.90 (t, 3H, $J = 6.8$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 172.0, 158.4, 135.5, 131.3, 130.2, 129.5, 113.5, 69.2, 66.6, 55.2, 52.0, 51.4, 31.7, 30.6, 22.6, 14.0. IR (neat): 3733, 3611, 2954, 2922, 2853, 2813, 1744, 1607, 1574, 1510, 1457, 1379, 1338, 1246, 1212, 1175, 1135, 1118, 1070, 1031, 990, 942, 866, 838, 766, 667, 595. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{20}\text{H}_{30}\text{NO}_4$ 348.2169, found 348.2168, m/z (M^+Na) calculated for $\text{C}_{20}\text{H}_{29}\text{NO}_4\text{Na}$ 370.1988, found 370.1987.

Methyl-(Z)-3-(4-methoxybenzylidene)-2-(4-phenylpiperazin-1-yl)heptanoate (4e). 78 mg (62%). Colourless oil, $R_f = 0.30$ (EtOAc/Hexane 10:90). ^1H NMR (500 MHz, CDCl_3): δ 7.30 (d, 1H, $J = 8.5$ Hz), 7.23 (dd, 1H, $J = 8.6, 7.4$ Hz), 7.24-7.21 (m, 2H), 6.90-6.81 (m, 5H), 6.64 (s, 1H), 4.14 (s, 1H), 3.81 (s, 3H), 3.77 (s, 3H), 3.22-3.12 (m, 4H), 2.50 (br, 4H), 2.27 (t, 1H, $J = 7.9$ Hz), 1.53-1.47 (m, 2H), 1.42-1.37 (m, 2H), 0.94 (t, 3H, $J = 7.1$ Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 171.7, 158.4, 151.1, 136.0, 131.0, 130.2, 129.5, 129.0, 119.6, 116.0, 113.5, 69.0, 55.2, 52.0, 51.0, 50.0, 30.6, 30.4, 22.6, 14.1. IR (neat): 3020, 2928, 1743, 1602, 1509, 1452, 1384, 1214, 1023, 908, 746, 667, 625. HRMS (ESI+): m/z (M^+H) calculated for $\text{C}_{26}\text{H}_{34}\text{N}_2\text{O}_3$ 423.26425, found 423.2645.

(Z)-Methyl 3-benzyl-4-(4-methoxyphenyl)-2-morpholinobut-3-enoate (4f). 71 mg (62%). Colourless oil, $R_f = 0.40$ (EtOAc/Hexane 30:70). ^1H NMR (500 MHz, CDCl_3): δ 7.30-7.21 (m, 7H), 6.87 (d, 2H, $J = 8.6$ Hz), 6.41 (s, 1H), 4.16 (s, 1H), 3.82 (s, 3H), 3.73-3.68 (m, 4H), 3.60 (s, 2H), 3.59 (s, 3H), 2.41-2.37 (m, 4H). ^{13}C NMR (125 MHz, CDCl_3): δ 171.7, 158.7, 139.3, 134.8, 134.7, 130.3, 129.6, 128.3, 126.2, 113.6, 68.9, 66.8, 55.3, 51.9, 51.5, 37.8. IR (neat): 3448, 3027, 2594, 2853, 1742, 1605, 1509, 1452, 1385, 1247, 1175, 1116, 1072, 1028, 873, 829, 771, 699. HRMS (ESI+): m/z (M^+Na) calculated for $\text{C}_{23}\text{H}_{27}\text{NO}_4\text{Na}$ 404.1832, found, 404.1850.

(Z)-methyl3-(cyclohexylmethyl)-4-(4-methoxyphenyl)-2-morpholinobut-3-enoate (4g). 71 mg (61%). Colourless oil, $R_f = 0.50$ (EtOAc/Hexane 30:70). ^1H NMR (300 MHz, CDCl_3): δ 7.30 (d, 2H, $J = 8.6$ Hz), 6.90 (d, 2H, $J = 8.6$ Hz), 6.63 (s, 1H), 4.09 (s, 1H), 3.83 (s, 3H), 3.75 (s, 3H), 3.68 (ddd, 4H, $J = 16.0, 9.4, 4.7$ Hz), 2.33 (s, 4H), 2.11 (dd, 2H, 15.6, 7.2 Hz), 1.88-1.66 (m, 4H), 1.58-1.39 (m, 1H), 1.38-1.05 (m, 4H), 0.94-0.82 (m, 2H). ^{13}C NMR (126 MHz, CDCl_3): δ 171.5, 158.5, 133.1, 132.6, 130.3, 129.5, 113.6, 69.1, 66.7, 55.2, 51.8, 51.5, 38.8, 36.2, 33.5, 33.2, 26.6, 26.5. IR (neat): 3451, 2923, 2849, 1744, 1606, 1509, 1448, 1247, 1174,

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3 1117, 1070, 1030, 945, 874, 830, 771. HRMS (ESI+): m/z ($M^+ + H$) calculated for $C_{23}H_{34}NO_4$
4 388.2482, found 388.2490.
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8 **Supporting Information.** 1H and ^{13}C spectra of compounds **2a-n**, **3a-3v** and **4a-4g**. This
9 material is available free of charge via the Internet at <http://pubs.acs.org>.
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12 13 Notes

14 The authors declare no competing financial interest.
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