Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry


**Electronic Supporting Information**

# Synthesis of substituted indenones and indanones by Suzuki-Miyaura coupling/acid-promoted cyclization sequence

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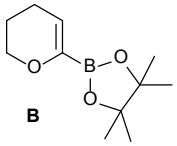
## General experimental procedure

All the reactions were performed in clean oven-dried glassware. Unless mentioned otherwise, all reactions were performed under argon atmosphere. THF, $CH_2Cl_2$, toluene, diethyl ether were dried on solvent system apparatus. Other solvents and chemicals were obtained from commercial suppliers and used as received. TLC was performed on silica gel plates visualized either with a UV lamp at 254 nm or using cerium ammonium nitrate and $KMnO_4$ stains, followed by heating. Flash chromatography was performed on Merck Geduran Si 60 silica gel (40–63 μm). Microwave reactions were carried out in Anton Paar or Biotage Initiator microwave reactor. NMR spectra were recorded on a Bruker AVANCE 400. $^1$H NMR spectra were recorded at 400 MHz and were referenced to residual solvents ($CDCl_3$ 7.28 ppm, $C_6D_6$ 7.16 ppm, DMSO-$d_6$ (2.50 ppm) and reported in part per million (ppm) relative to TMS (0 ppm). $^{13}$C NMR spectra were recorded at 100 MHz and were referenced to residual solvents ($CDCl_3$ 77.16±0.06 ppm, $C_6D_6$ 128.06±0.02 ppm, DMSO-$d_6$ 39.52±0.06 ppm) relative to TMS (0 ppm). Coupling constants (*J*) are reported in hertz (Hz). Abbreviations for multiplicity are reported as follows: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet or overlap of non-equivalent resonances. High resolution mass spectra (HRMS) were recorded at the Centre regional de microanalyse (Université Pierre et Marie Curie Paris VI). Melting points were obtained on a Büchi Melting Point M-560 apparatus. Infrared (IR) spectra were recorded on a Bruker TENSORTM 27 (IRFT), wave numbers are reported from 4000 to 750 $cm^{-1}$.

## Starting materials

Compounds **5a**, **5c, 7a**, **7b**, **7c** and **7e** are commercially available.

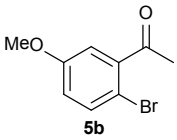
### 6-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-3,4-dihydro-2*H*-pyran (B)



**B**

Compound **B** was prepared according to the procedure previously reported by us.[1]

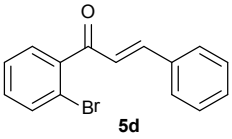
### 2-Bromo-5-methoxy-acetophenone (5b)



**5b**

Compound **5b** was synthesized according to reported procedure.[2]

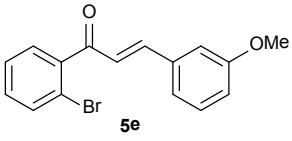
### (*E*)-1-(2-Bromophenyl)-3-phenylprop-2-en-1-one (5d)



**5d**

Compound **5d** was prepared according to published procedure.[3]

### (*E*)-1-(2-Bromophenyl)-3-(3-methoxyphenyl)prop-2-en-1-one (5e)



**5e**

2-Bromoacetophenone (1 mL, 7.4 mmol. 1 equiv), 3-methoxybenzaldehyde (902 µL, 7.4 mmol, 1 equiv), 15% aq. sol. NaOH (16 mL) and MeOH (16 mL) were added at room temperature. After reaction completion, EtOAc (20 mL) and $H_2O$ (mL) were added, the organic layers were separated, dried over $MgSO_4$, filtrated and concentrated under reduced pressure. The crude was purified by silica gel chromatography (petroleum ether/EtOAc 8:2) to give **5e** as yellow oil (2.18 g, 93%).

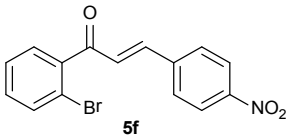
IR (neat): 2939, 2834, 1646, 1621, 1600, 1486, 1464, 1454, 1429, 1297, 1271, 1248, 1233, 1158, 1101, 1062, 1033, 979, 847, 781, 762, 734, 677, 603 $cm^{-1}$.

$^1H$ NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.5 Hz, 1H), 7.37 – 7.31 (m, 2H), 7.30 – 7.17 (m, 3H), 7.07 (d, *J* = 7.6 Hz, 1H), 7.03 – 6.96 (m, 2H), 6.91 – 6.85 (m, 1H), 3.75 (s, 3H).

$^{13}C$ NMR (100 MHz, $CDCl_3$) δ 194.9 (C), 160.0 (C), 146.7 (CH), 141.2 (C), 135.9 (C), 133.6 (CH), 131.5 (CH), 130.1 (CH), 129.3 (CH), 127.5 (CH), 126.5 (CH), 121.5 (CH), 119.6 (C), 117.0 (CH), 113.4 (CH), 55.5 ($CH_3$).

HRMS calcd for $C_{16}H_{13}O_2NaBr$ $[M+Na]^+$: 338.99966. Found: 338.99920.

**(*E*)-1-(2-Bromophenyl)-3-(4-nitrophenyl)prop-2-en-1-one (5f)[4]**



**5f**

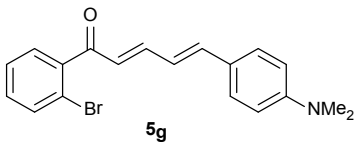
Compound **5f** was prepared according to the same procedure used to prepared **5e**. The compound was obtained as a yellow amorphous solid (91%) without purification.

IR (neat): 3076, 2922, 2846, 1670, 1654, 1611, 1595, 1518, 1344, 1302, 1212, 1100, 1062, 1014, 982, 843 $cm^{-1}$

$^1H$ NMR (400 MHz, $CDCl_3$) δ 8.28 (d, *J* = 8.5 Hz, 2H), 7.74 (d, *J* = 8.6 Hz, 2H), 7.69 (d, *J* = 7.9 Hz, 1H), 7.53 (d, *J* = 16.1 Hz, 1H), 7.48 (m, 2H), 7.40 (m, 1H), 7.26 (d, *J* = 16.2, Hz, 1H).

$^{13}C$ NMR (100 MHz, $CDCl_3$) δ 193.8 (C), 148.9 (C), 142.5 (CH), 140.73 (C), 140.69 (C), 133.7 (CH), 132.1 (CH), 129.6 (CH), 129.57 (CH), 129.2 (2CH), 127.7 (CH), 124.4 (2CH), 119.7 (C).

**(2*E*,4*E*)-1-(2-Bromophenyl)-5-(4-(dimethylamino)phenyl)penta-2,4-dien-1-one (5g)**




**5g**

A solution of NaOH (480 mg, 12 mmol, 1.55 equiv) in EtOH (3 mL) and $H_2O$ (2 mL) was cooled with ice-water bath, and 2-bromoacetophenone (1.05 mL, 1.55 g, 7.79 mmol) followed by the addition of 4-(dimethylamino)cinnamaldehyde (1.36 g, 7.77 mmol) were added. The resulting bright orange mixture was stirred at rt overnight, the mixture was neutralized with acetic acid (1 mL), diluted with water (20 mL) and left to crystallize in an ice-water bath. The product was filtered off and recrystallized from EtOH – $H_2O$ (1:1, 60 mL). Yield 2.75g (99%), orange crystals.

mp = 87 – 88 °C

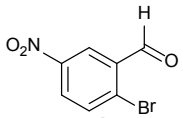
IR (neat): 3021, 2894, 2806, 2360, 1639, 1551, 1523, 1482, 1465, 1443, 1430, 1353, 1306, 1281,1251, 1188, 1152, 1122, 1102, 1063, 1020, 998, 946, 880, 834, 811, 766, 736 $cm^{-1}$.

$^1H$ NMR (400 MHz, $CDCl_3$): δ 7.60 (m, 1H), 7.41 – 7.33 (m, 4H), 7.29 (ddd, *J* = 8.0, 6.1, 3.0 Hz, 1H), 7.16 (dd, *J* = 15.2, 10.1 Hz, 1H), 6.88 – 6.75 (m, 2H), 6.68 – 6.63 (m, 2H), 6.49 (d, *J* = 15.2 Hz, 1H), 3.01 (s, 6H).

$^{13}C$ NMR (100 MHz, $CDCl_3$): δ 195.1 (C), 151.4 (C), 149.0 (CH), 143.9 (CH), 141.8 (C), 133.4 (CH), 130.9 (CH), 129.3 (2CH), 129.1 (CH), 127.3 (CH), 126.8 (CH), 124.0 (C), 122.1 (CH), 119.5 (C), 112.1 (2CH), 40.3 ($2CH_3$).

HRMS calcd for $C_{19}H_{19}ONBr$ $[M+H]^+$: 356.06445. Found: 356.06512.

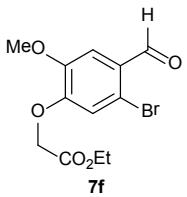
## 2-Bromo-5-nitrobenzaldehyde (7d)




**7d**

Compound **7d** was prepared according to the published procedure.[5]

## Ethyl 2-(5-bromo-4-formyl-2-methoxyphenoxy)acetate (7f)




**7f**

A solution of bromine (1.14 mL, 22 mmol, 1.2 equiv) in AcOH (20 mL) was added over a period of 10 min to a solution of ethyl 2-(4-formyl-2-methoxyphenoxy)acetate[6] (4.4 g, 18.3 mmol, 1 equiv) and AcONa (2.26 g, 27.5 mmol, 1.5 equiv) in AcOH (30 mL). The reaction mixture was stirred for 5 h at rt; TLC monitoring (EtOAc/petroleum ether 2:8; $R_f$ 0.4 for starting material, 0.65 for product) showed incomplete conversion. Additional AcONa (750 mg, 9.1 mmol, 0.5 equiv) and bromine (1 mL, 19 mmol, 1 equiv in 10 mL AcOH) were added and the mixture was stirred at rt for another 5 h period. Water (250 mL) was then added and the mixture was extracted with EtOAc (3 x 50 mL). The organic phases were washed with 10% aq. NaOH (2 x 50 mL), aq. $Na_2S_2O_3$ (2 x 50 mL), water, brine and dried over $Na_2SO_4$. The product was isolated by flash chromatography (silica gel, Petroleum ether/EtOAc =9:1 to 1:1) and recrystallized from $CH_2Cl_2$/petroleum ether. 3.5 g of **7f** were obtained, yield = 60%, light orange crystals.

IR (neat): 3680, 2981, 2938, 2859, 2615, 1754, 1679, 1588, 1500, 1463, 1386, 1339, 1262, 1196, 1156, 1066, 1040, 979, 871 $cm^{-1}$.

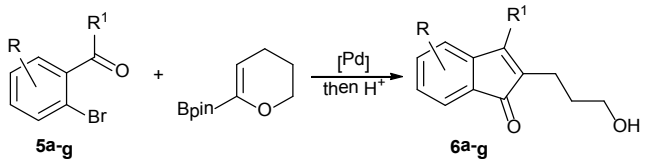
mp = 116-119 °C

$^1H$ NMR (400 MHz, $CDCl_3$) δ 10.20 (s, 1H), 7.46 (s, 1H), 6.98 (s, 1H), 4.77 (s, 2H), 4.31 (q, *J* = 7.1 Hz, 2H), 3.94 (s, 3H), 1.32 (t, *J* = 7.1 Hz, 3H).

$^{13}C$ NMR (100 MHz, $CDCl_3$) δ 190.9 (CH), 167.7 (C), 152.7 (C), 149.4 (C), 127.7 (C), 119.7 (C), 117.5 (CH), 111.4 (CH), 66.2 ($CH_2$), 62.0 ($CH_2$), 56.4 ($CH_3$), 14.3 ($CH_3$).

HRMS calcd for $C_{12}H_{13}O_5NaBr$ $[M+Na]^+$: 338.98441. Found: 338.98376.

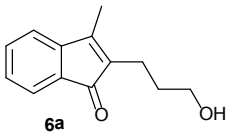
## Representative procedure for the Suzuki-Miyaura coupling/acid-promoted reaction sequence




To a mixture of (2-bromophenyl)ketone (1 mmol, 1 equiv), pinacol boronate (1.2 mmol, 1.2 equiv) and Pd(dppf)$Cl_2$·$CH_2Cl_2$ catalyst (16 mg, 0.02 mmol, 2 mol %) in 1,4-dioxane (2 mL), 4 M aqueous NaOH (0.5 mL, 2 mmol, 2 equiv) was added. The vial was flushed with argon and sealed. The reaction mixture was then heated under microwave irradiation at 100 °C for 10 min. After cooling to rt, the complete consumption of the starting material was checked by TLC, the vial was opened, and TsOH·$H_2O$ (418 mg, 2.2 mmol, 2.2 equiv) was added in one portion. The resulting mixture was stirred at rt for 10 min (TLC control) and then poured into a saturated aqueous $NaHCO_3$ (50 mL), extracted with EtOAc (3×30 mL), the combined organic layers were washed with brine and dried over $Na_2SO_4$. The product was isolated by flash chromatography on silica gel.

## Characterization data

### 2-(3-Hydroxypropyl)-3-methyl-1*H*-inden-1-one (6a)




Compound **6a** was prepared from 2'-bromoacetophenone **5a** following the representative procedure. **6a** was obtained as viscous yellow oil with a yield of 37%.

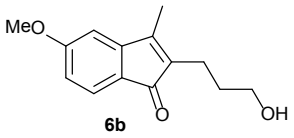
IR (neat): 3392 (br), 2936, 2869, 2361, 2342, 1700, 1628, 1609, 1593, 1455, 1385, 1330, 1285, 1149, 1084, 1059, 1000, 943, 912, 755cm$^{-1}$.

$^1$H NMR (400 MHz, $CDCl_3$): δ 7.34 (ddd, *J* = 13.8, 7.0, 0.9 Hz, 2H), 7.17 (ddd, *J* = 7.8, 7.1, 0.9Hz, 1H), 7.02 (dt, *J* = 7.1, 0.7 Hz, 1H), 3.59 ($t_{app}$, *J* = 6.1 Hz, 2H), 2.46 (brs, 1H), 2.39 (t, *J* = 7.2 Hz,2H), 2.14 (s, 3H), 1.77 – 1.67 (m, 2H).

$^{13}$C NMR (100 MHz, $CDCl_3$): δ 199.1 (C), 155.2 (C), 146.2 (C), 134.3 (C), 133.6 (CH), 130.8(C), 128.4 (CH), 121.8 (CH), 118.9 (CH), 61.5 ($CH_2$), 31.8 ($CH_2$), 18.4 ($CH_2$), 11.6 ($CH_3$).

HRMS calcd for $C_{13}H_{14}O_2Na$ $[M+Na]^+$: 225.08860. Found: 225.08836.

**2-(3-Hydroxypropyl)-5-methoxy-3-methyl-1*H*-inden-1-one (6b)**



**6b**

Compound **6b** was prepared from 2-bromo-4-methoxyacetophenone **5b** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and trifluoroacetic acid (4 equiv) instead of $TsOH \cdot H_2O$. **6b** was isolated in 33% yield as a red resin (acetone-deactivated silica gel, petroleum ether/EtOAc gradient elution 3:1 to 7:3).

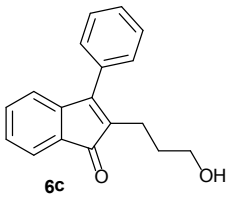
IR (neat): 3433 (br), 2923, 2359, 1702, 1621, 1478, 1451, 1431, 1364, 1280, 1242, 1221, 1022, 819 $cm^{-1}$.

$^1H$ NMR (400 MHz, $C_6D_6$) δ 7.11 (d, *J* = 2.1 Hz, 1H), 6.56 – 6.49 (m, 2H), 3.48 (t, *J* = 6.1 Hz, 2H), 3.22 (s, 3H), 2.53 (brs, 1H), 2.31 (t, *J* = 7.3 Hz, 2H), 1.66 (s, 3H),– 1.59 (m, 2H).

$^{13}C$ NMR (100 MHz, $C_6D_6$): δ 198.0 (C), 161.0 (C), 155.7 (C), 138.4 (C), 133.6 (C), 133.5(C), 119.7 (CH), 116.2 (CH), 109.8 (CH), 61.5 ($CH_2$), 55.2 ($CH_3$), 32.3 ($CH_2$), 19.0 ($CH_2$), 11.2 ($CH_3$).

HRMS calcd for $C_{14}H_{16}O_3Na$ $[M+Na]^+$: 225.09971. Found: 225.09940.

**2-(3-Hydroxypropyl)-3-phenyl-1*H*-inden-1-one (6c)**



**6c**

Compound **6c** was prepared from 2-bromobenzophenone **5c** following the representative procedure. Compound **6c** was isolated as viscous yellow oil (68%).

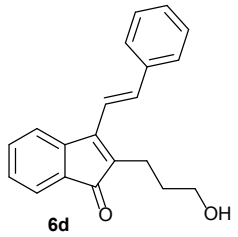
IR (neat): 3391 (br), 3058, 2931, 2871, 2360, 1699, 1608, 1596, 1493, 1456, 1444, 1361, 1341, 1284, 1176, 1160, 1131, 1057, 1028, 949, 931, 776, 754 $cm^{-1}$.

$^1H$ NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.49 (m, 2H), 7.49 – 7.44 (m, 4H), 7.30 (ddd, *J* = 7.7, 7.2,1.2 Hz, 1H), 7.21 (ddd, *J* = 7.8, 7.1, 1.0 Hz, 1H), 7.01 (dt, *J* = 7.2, 0.8 Hz, 1H), 3.58 (t, *J* = 6.2Hz, 2H), 2.45 (dd, *J* = 7.7, 6.9 Hz, 2H), 2.15 (brs, 1H), 1.79 – 1.71 (m, 2H).

$^{13}$C NMR (100 MHz, $CDCl_3$): δ 199.1 (C), 156.3 (C), 145.8 (C), 134.6 (C), 133.5 (CH), 132.6(C), 131.0 (C), 129.5 (CH), 129.0 (2CH), 128.5 (CH), 127.8 (2CH), 122.8 (CH), 120.9 (CH), 61.7 ($CH_2$), 32.4 ($CH_2$), 19.1 ($CH_2$).

HRMS calcd for $C_{18}H_{16}O_2Na$ $[M+Na]^+$: 287.10425. Found: 287.10434.

**2-(3-Hydroxypropyl)-3-[(*E*)-2-phenylethenyl]-1*H*-inden-1-one (6d)**



**6d**

Compound **6d** was prepared from (*E*)-1-(2-bromophenyl)-3-phenyl-2-propen-1-one **5d** following the representative procedure. Compound **6d** was isolated as orange crystals (68%).

mp = 89 – 90 °C

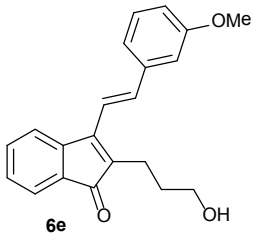
IR (neat): 3422 (br), 3060, 2930, 2872, 2361, 2248, 1690, 1619, 1605, 1575, 1495, 1456, 1373, 1290, 1211, 1178, 1144, 1096, 1067, 958, 908 $cm^{-1}$.

$^1$H NMR (400 MHz, $CDCl_3$): δ 7.62 – 7.58 (m, 2H), 7.53 – 7.46 (m, 3H), 7.45 – 7.34 (m, 4H), 7.29 – 7.22 (m, 2H), 3.62 (t, *J* = 5.9 Hz, 2H), 2.62 (t, *J* = 7.1 Hz, 2H), 2.25 (brs, 1H), 1.86 – 1.77 (m, 2H).

$^{13}$C NMR (100 MHz, $CDCl_3$): δ 198.3 (C), 151.3 (C), 144.2 (C), 137.0 (CH), 136.5 (C), 135.7(C), 133.3 (CH), 132.0 (C), 129.4 (CH), 129.0 (2CH), 128.4 (CH), 127.4 (2CH), 122.5 (CH), 121.0 (CH), 120.0 (CH), 61.3 ($CH_2$), 32.0 ($CH_2$), 18.9 ($CH_2$).

HRMS calcd for $C_{20}H_{18}O_2Na$ $[M+Na]^+$: 313.11990. Found: 313.11925.

**(*E*)-2-(3-Hydroxypropyl)-3-(3-methoxystyryl)-1*H*-inden-1-one (6e)**



**6e**

Compound **6e** was prepared from (*E*)-1-(2-bromophenyl)-3-(3-methoxyphenyl)prop-2-en-1-one **5e** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and trifluoroacetic acid (4 equiv) instead of $TsOH{\cdot}H_2O$. Yield in **6e** = 63% (acetone-deactivated silica gel, petroleum ether/EtOAc = 7:3), red resin.

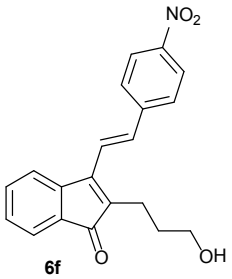
IR (neat): 3431 (br), 2938, 1693, 1602, 1579, 1456, 1373, 1259, 1157, 1047, 959, 760 $cm^{-1}$.

$^1H$ NMR (400 MHz, $C_6D_6$) δ 7.49 (ddd, *J* = 7.0, 1.2, 0.6 Hz, 1H), 7.33 (d, *J* = 16.6 Hz, 1H), 7.22 (d, *J* = 16.6 Hz, 1H), 7.12 (m, 4H), 6.97 (td, *J* = 6.4, 0.9 Hz, 1H), 6.86 (m, 1H), 6.75 (ddd, *J* = 7.7, 2.5, 1.5 Hz, 1H), 3.38 (m, 5H), 2.55 (t, *J* = 7.2 Hz, 2H), 1.97 (bs, 1H), 1.64 (m, 2H).

$^{13}C$ NMR (100 MHz, $C_6D_6$): δ 197.6 (C), 160.6 (C), 150.8 (C), 144.7 (C), 138.6 (C), 136.7 (CH), 136.6 (C), 133.1 (CH), 132.5 (C), 130.2 (CH), 128.4 (CH), 122.6 (CH), 121.1 (CH), 120.9 (CH), 120.2 (CH), 115.0 (CH), 113.2 (CH), 61.2 ($CH_2$), 54.9 ($CH_3$), 32.3 ($CH_2$), 19.4 ($CH_2$).

HRMS calcd for $C_{21}H_{20}O_3Na$ $[M+Na]^+$: 343.1310. Found: 343.13048

**(*E*)-2-(3-Hydroxypropyl)-3-(4-nitrostyryl)-1*H*-inden-1-one (6f)**



**6f**

Compound **6f** was prepared from (*E*)-1-(2-bromophenyl)-3-(4-nitrophenyl)prop-2-en-1-one **5f** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and trifluoroacetic acid (4 equiv) instead of $TsOH{\cdot}H_2O$. Yield **6f** = 43% (acetone-deactivated silica gel, petroleum ether/EtOAc = 7:3), orange amorphous solid.

IR (neat): 3431 (br), 2952, 2360, 2237, 1697, 1592, 1517, 1455, 1341, 1249, 1103, 859, 836, 764 $cm^{-1}$.

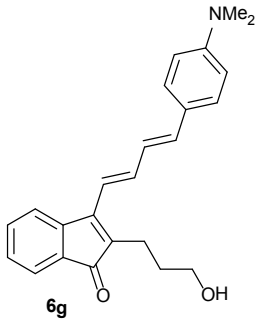
$^1H$ NMR (400 MHz, DMSO-$d_6$) δ 8.28 (d, *J* = 8.9 Hz, 2H), 8.09 (d, *J* = 8.8 Hz, 2H), 7.85 (d, *J* = 7.4 Hz, 1H), 7.74 (d, *J* = 16.8 Hz, 1H), 7.66 (d, *J* = 16.8 Hz, 1H), 7.51 (td, *J* = 7.6, 1.1 Hz, 1H),

7.43 (d, *J* = 7.1 Hz, 1H), 7.33 (t, *J* = 7.4 Hz, 1H), 4.56 (t, *J* = 5.1 Hz, 1H), 3.44 (2d, *J* = 6.2 Hz, 2H), 2.58 – 2.51 (m, 2H), 1.67 – 1.56 (m, 2H).

$^{13}$C NMR (100 MHz, DMSO-$d_6$) δ 196.5 (C), 149.3 (C), 147.1 (C), 143.3 (C), 143.1 (C), 137.7 (C), 134.1 (CH), 133.8 (CH), 131.0 (C), 128.52 (CH), 128.5 (3CH), 124.2 (CH), 123.9 (CH), 122.0 (CH), 121.8 (CH), 60.1 ($CH_2$), 31.9 ($CH_2$), 19.2 ($CH_2$).

HRMS calcd for $C_{20}H_{17}O_4NNa$ $[M+Na]^+$: 358.10553. Found: 358.1049.

**3-{(1*E*,3*E*)-4-[4-(Dimethylamino)phenyl]-1,3-butadienyl}-2-(3-hydroxypropyl)-1*H*-inden-1-one (6g)**



**6g**

Compound **6g** was prepared from (2*E*,4*E*)-1-(2-bromophenyl)-5-(4-(dimethylamino)phenyl)penta-2,4-dien-1-one **5g** following the representative procedure using 3.5 equiv of TsOH·$H_2O$. Yield **6g** = 34%, dark purple crystals.

mp = 153 – 155 °C

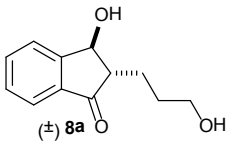
IR (neat): 3439 (br), 2927, 2361, 2341, 1685, 1592, 1568, 1541, 1522, 1456, 1361, 1286, 1189, 1154, 1077, 985, 947, 809, 761 $cm^{-1}$.

$^1$H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.3 Hz, 1H), 7.45 (ddd, *J* = 7.1, 1.2, 0.6 Hz, 1H), 7.41 – 7.33 (m, 4H), 7.23 (m, 1H), 6.90 – 6.79 (m, 2H), 6.74 – 6.67 (m, 3H), 3.60 (t, *J* = 5.9 Hz, 2H), 3.02 (s, 6H), 2.58 (t, *J* = 7.0 Hz, 2H), 2.52 (brs, 1H), 1.83 – 1.74 (m, 2H).

$^{13}$C NMR (100 MHz, $CDCl_3$) δ 198.4 (C), 151.9 (C), 150.9 (C), 144.3 (C), 139.5 (CH), 138.9 (CH), 133.9 (C), 133.0 (CH), 132.6 (C), 128.6 (2CH), 128.3 (CH), 125.2 (CH), 124.8 (C), 122.2 (CH), 121.4 (CH), 121.1 (CH), 112.3 (2CH), 61.3 ($CH_2$), 40.4 ($2CH_3$), 32.0 ($CH_2$), 18.7 ($CH_2$).

HRMS calcd for $C_{24}H_{26}O_2N$ $[M+H]^+$: 360.19581. Found: 360.19627.

**(±)-(2*S*,3*S*)-3-Hydroxy-2-(3-hydroxypropyl)-2,3-dihydro-1*H*-inden-1-one (8a)**




Compound (±)-**8a** was prepared from 2-bromobenzaldehyde **7a** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and TsOH·$H_2O$ (2.2 equiv). Yield **8a** (mixture of 2 inseparable isomers, dr *trans* : *cis* 91:9)= 50% (acetone-deactivated silica gel, petroleum ether/EtOAc = 2:8 to 1:9), light yellow resin.

data for the major *trans* isomer

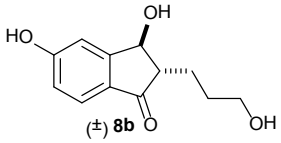
IR (neat): 3369 (br), 2929, 2868, 1702, 1605, 1465, 1334, 1287, 1217, 1055, 753 $cm^{-1}$.

$^1H$ NMR (400 MHz, DMSO-$d_6$) δ 7.77 – 7.70 (m, 2H), 7.62 (d, *J* = 7.6 Hz, 1H), 7.50 (m, 1H), 5.86 (d, *J* = 6.8 Hz, 1H), 4.89 (dd, *J* = 6.8, 3.8 Hz, 1H), 4.44 (t, *J* = 5.2 Hz, 1H), 3.48 – 3.41 (m, 2H), 2.45 (m, 1H), 1.87 (m, 1H), 1.70 – 1.50 (m, 3H).

$^{13}C$ NMR (100 MHz, DMSO-$d_6$) δ 204.6 (C), 155.4 (C), 135.3 (C), 135.1 (CH), 128.8 (CH), 125.9 (CH), 122.2 (CH), 73.2 (CH), 60.7 ($CH_2$), 57.1 (CH), 30.2 ($CH_2$), 25.0 ($CH_2$).

HRMS calcd for $C_{12}H_{14}O_3Na$ $[M+Na]^+$: 229.08406. Found: 229.08364.

**(±)-(2*S*,3*S*)-3,5-Dihydroxy-2-(3-hydroxypropyl)-2,3-dihydro-1*H*-inden-1-one (8b)**




Compound (±)-**8b** was prepared from 2-bromo-5-hydroxybenzaldehyde **7b** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and TsOH·$H_2O$ (2.2 equiv). Yield **8b** (mixture of 2 inseparable isomers, dr *trans* : *cis* 88:12)= 35% (acetone-deactivated silica gel, EtOAc : 100%), colourless resin.

data for the major *trans* isomer

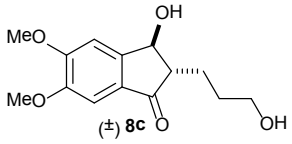
IR (neat): 3260 (br), 2939, 1683, 1588, 1471, 1271, 1099, 1051, 833, 752 $cm^{-1}$.

$^1H$ NMR (400 MHz, DMSO-$d_6$) δ 10.72 (s, 1H), 7.63 (d, *J* = 8.3 Hz, 1H), 7.16 (s, 1H), 7.02 (d, *J* = 8.3 Hz, 1H), 5.89 (d, *J* = 6.5 Hz, 1H), 4.91 (m, *J* = 6.1, 3.8 Hz, 1H), 4.58 ($brt_{app}$, *J* = 4.8 Hz, 1H), 3.59 (m, 2H), 2.56 – 2.46 (m, 1H), 2.00 (m, 1H), 1.82 – 1.59 (m, 3H).

$^{13}$C NMR (100 MHz, DMSO-$d_6$) δ 202.3 (C), 164.0 (C), 158.5 (C), 127.1 (C), 124.4 (CH), 117.1 (CH), 111.1 (CH), 73.1 (CH), 60.8 ($CH_2$), 56.9 (CH), 30.2 ($CH_2$), 25.3 ($CH_2$).

HRMS calcd for $C_{12}H_{14}O_3Na$ [M+Na]$^+$: 245.07898. Found: 245.07852.

**(±)-(2*S*,3*S*)-3-Hydroxy-2-(3-hydroxypropyl)-5,6-dimethoxy-2,3-dihydro-1*H*-inden-1-one (8c)**




Compound (±)-**8c** was prepared from 2-bromo-4,5-dimethoxybenzaldehyde **7c** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and TsOH·$H_2O$ (2.2 equiv). Yield **8c** (mixture of 2 inseparable isomers, dr *trans* : *cis* 93:7)= 38% (acetone-deactivated silica gel, petroleum ether/EtOAc = 2:8 to 100%), yellow resin.

<u>data for the major *trans* isomer</u>

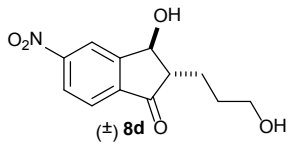
IR (neat): 3369 (br), 2939, 2360, 1686, 1594, 1500, 1458, 1289, 1219, 1124, 1059, 866 cm$^1$.

$^1$H NMR (400 MHz, DMSO-$d_6$) δ 7.19 (s, 1H), 7.05 (s, 1H), 5.70 (d, *J* = 6.5 Hz, 1H), 4.79 (dd, *J* = 6.4, 3.0 Hz, 1H), 4.43 (t, *J* = 5.1 Hz, 1H), 3.89 (s, 3H), 3.81 (s, 3H), 3.43-3.40 (m, 2H), 2.37 (m, 1H), 1.85 (m, 1H), 1.56 (m, 3H).

$^{13}$C NMR (100 MHz, DMSO-$d_6$) δ 201.9 (C), 154.3 (C), 149.4 (C), 149.2 (C), 126.9 (C), 106.1 (CH), 102.0 (CH), 72.0 (CH), 59.7 ($CH_2$), 55.9 (CH), 54.9 ($CH_3$), 54.7 ($CH_3$), 29.2 ($CH_2$), 24.8 ($CH_2$).

HRMS calcd for $C_{14}H_{18}O_5Na$ [M+Na]$^+$: 289.10519. Found: 289.10483.

**(±)-(2*S*,3*S*)-3-Hydroxy-2-(3-hydroxypropyl)-5-nitro-2,3-dihydro-1*H*-inden-1-one (8d)**



Compound (±)-**8d** was prepared from 2-bromo-5-nitrobenzaldehyde **7d** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and TsOH·$H_2O$ (2.2 equiv). Yield **8d** (mixture of 2 inseparable isomers, dr *trans* : *cis* 88:12)= 51% (acetone-deactivated silica gel, petroleum ether/EtOAc = 3:7), light orange resin.

data for the major *trans* isomer

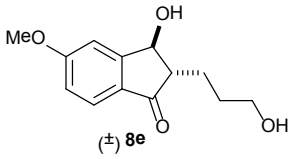
IR (neat): 3364 (br), 2930, 2870, 1718, 1618, 1525, 1348, 1334, 1262, 1052, 1020, 825, 739 $cm^{-1}$.

$^1H$ NMR (400 MHz, DMSO-$d_6$) δ 8.47 (s, 1H), 8.27 (dd, *J* = 8.3, 1.9 Hz, 1H), 7.84 (d, *J* = 8.3 Hz, 1H), 6.17 (d, *J* = 6.2 Hz, 1H), 5.00 (m, 1H), 4.45 (t, *J* = 5.1 Hz, 1H), 3.45 (m, 2H), 2.60 (m, 1H), 1.90 (m, 1H), 1.70 – 1.55 (m, 3H).

$^{13}C$ NMR (100 MHz, DMSO-$d_6$) δ 203.3 (C), 136.5 (C), 151.7 (C), 139.4 (C), 124.1 (CH), 123.9 (CH), 120.9 (CH), 72.7 (CH), 60.6 ($CH_2$), 57.7 (CH), 30.1 ($CH_2$), 24.8 ($CH_2$).

HRMS calcd for $C_{12}H_{13}O_5NNa$ $[M+Na]^+$: 274.06914. Found: 274.06895.

## (±)-(2*S*,3*S*)-3-Hydroxy-2-(3-hydroxypropyl)-5-methoxy-2,3-dihydro-1*H*-inden-1-one (8e)



(±) **8e**

Compound (±)-**8e** was prepared from 2-bromo-5-methoxybenzaldehyde **7e** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and TsOH·$H_2O$ (2.2 equiv). Yield **8e** (mixture of 2 inseparable isomers, dr *trans* : *cis* 89:11)= 75% (acetone-deactivated silica gel, petroleum ether/EtOAc = 2:8 to 100%), light orange resin.

data for the major *trans* isomer

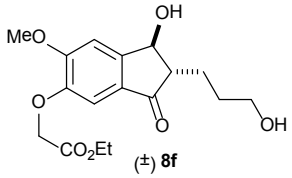
IR (neat): 3368 (br), 2941, 1688, 1597, 1489, 1354, 1340, 1299, 1147, 1096, 1056, 1022, 833 $cm^{-1}$.

$^1H$ NMR (400 MHz, DMSO-$d_6$) δ 7.55 (d, *J* = 8.5 Hz, 1H), 7.19 (s, 1H), 7.03 (d, *J* = 8.5 Hz, 1H), 5.79 (s, 1H), 4.81 (m, 1H), 4.40 (m, 1H), 3.88 (s, 3H), 3.43 (m, 2H), 2.40 (m, 1H), 1.85 (m, 1H), 1.67 – 1.45 (m, 3H).

$^{13}$C NMR (100 MHz, DMSO-$d_6$) δ 202.6 (C), 165.1 (C), 158.4 (C), 128.4 (C), 124.1 (CH), 116.7 (CH), 108.9 (CH), 73.1 (CH), 60.7 ($CH_2$), 57.0 (CH), 55.8 ($CH_3$), 30.2 ($CH_2$), 25.2 ($CH_2$).

HRMS calcd for $C_{13}H_{16}O_4Na$ [M+Na]$^+$: 259.09463. Found: 259.09449.

**Ethyl (±)-2-{[(1*S*,2*S*)-1-hydroxy-2-(3-hydroxypropyl)-6-methoxy-3-oxo-2,3-dihydro-1*H*-inden-5-yl]oxy}acetate (8f)**



(±) **8f**

Compound (±)-**8f** was prepared from ethyl 2-(5-bromo-4-formyl-2-methoxyphenoxy)acetate **7f** following the representative procedure using 4 mol % palladium catalyst, pinacol boronate (1.6 equiv) and TsOH·$H_2O$ (2.2 equiv). Yield of **8f** (mixture of 2 inseparable isomers, dr *trans* : *cis* 88:12)= 42% isolated yield (acetone-deactivated silica gel, EtOAc/MeOH = 98:2), light yellow resin.

data for the major *trans* isomer

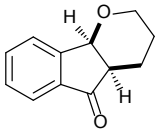
IR (neat): 3391 (br), 2928, 1754, 1697, 1596, 1499, 1294, 1204, 1127, 1110, 1058, 1030, 753 cm$^{-1}$.

$^1$H NMR (400 MHz, DMSO-$d_6$) δ 7.23 (s, 1H), 6.97 (s, 1H), 5.72 (d, $J$ = 6.6 Hz, 1H), 4.87 (s, 2H), 4.79 (dd, $J$ = 6.6, 3.3 Hz, 1H), 4.42 ($t_{app}$, $J$ = 5.7 Hz, 1H), 4.16 ($q_{app}$, $J$ = 7.1 Hz, 2H), 3.91 (s, 3H), 3.46 – 3.39 (m, 2H), 2.36 (m, 1H), 1.82 (m, 1H), 1.65 – 1.44 (m, 3H), 1.21 (t, $J$ = 7.6, 7.6 Hz, 3H).

$^{13}$C NMR (100 MHz, DMSO-$d_6$) δ 202.8 (C), 168.5 (C), 155.4 (C), 151.0 (C), 148.3 (C), 127.7 (C), 107.6 (CH), 104.7 (CH), 73.0 (CH), 65.1 ($CH_2$), 60.7 ($2CH_2$), 56.9 (CH), 56.0 ($CH_3$), 30.5 ($CH_2$), 25.3 ($CH_2$), 14.0 ($CH_3$).

HRMS calcd for $C_{17}H_{22}O_7Na$ [M+Na]$^+$: 361.12632. Found: 361.12596.

**(±)-(4a*R*,9b*S*)-2,3,4,4a-Tetrahydroindeno[1,2-*b*]pyran-5(9b*H*)-one (10a)**



(±)-10a

To a mixture of 2-bromobenzaldehyde **7a** (60 µL, 0.6 mmol, 1 equiv), pinacol boronate (150 mg, 0.7 mmol, 1.2 equiv) and $Pd(dppf)Cl_2 \cdot CH_2Cl_2$ catalyst (9.7 mg, 0.01 mmol, 2 mol %) in 1,4-dioxane (1.2 mL), 4 M aqueous NaOH solution (0.3 mL, 1.2 mmol, 2 equiv) was added. The vial was flushed with argon and sealed. The reaction mixture was then heated under microwave irradiation at 100 °C for 10 min. After cooling to rt, the complete consumption of the starting material was checked by TLC, the vial was opened, and $TsOH \cdot H_2O$ (566 mg, 3 mmol, 5 equiv) was added in one portion. The resulting mixture was stirred at 100 °C (TLC monitoring) and then poured into saturated aqueous $NaHCO_3$ (50 mL), extracted with EtOAc (3×20 mL), the combined organic layers were washed with brine and dried over $Na_2SO_4$. Product (±)-**10a** was isolated by flash chromatography on silica gel (acetone-deactivated silica gel, petroleum ether/EtOAc = 7:3) in 24% yield (yellow resin).

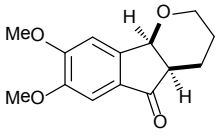
IR (neat): 3016, 1719, 1216, 1053, 906, 754 $cm^{-1}$.

$^1H$ NMR (400 MHz, $C_6D_6$) δ 7.75 (d, *J* = 7.6 Hz, 1H), 7.39 (d, *J* = 7.6 Hz, 1H), 7.15 (td *J* = 7.5, 1.2 Hz, 1H), 6.98 (td, *J* = 7.4, 0.9 Hz, 1H), 4.64 (d, *J* = 5.0 Hz, 1H), 3.47 (dt, *J* = 9.5, 4.2 Hz, 1H), 3.15 (ddd, *J* = 11.1, 9.7, 3.6 Hz, 1H), 2.16 (m, 2H), 1.50 (m, 1H), 1.25 (m, 1H), 1.03 (m, 1H).

$^{13}C$ NMR (100 MHz, $C_6D_6$) δ 204.0 (C), 152.4 (C), 137.3 (C), 134.2 (CH), 129.5 (CH), 126.6 (CH), 123.7 (CH), 74.0 (CH), 65.1 ($CH_2$), 47.2 (CH), 22.5 ($CH_2$), 20.6 ($CH_2$).

HRMS calcd for $C_{12}H_{12}O_2Na$ $[M+Na]^+$: 211.07350. Found: 211.07301.

## (±)-(4a*R*,9b*S*)-7,8-Dimethoxy-2,3,4,4a-tetrahydroindeno[1,2-*b*]pyran-5(9b*H*)-one (10b)



(±)-10b

Compound (±)-**10b** was prepared from 2-bromo-4,5-dimethoxybenzaldehyde **7c** following the representative procedure for (±)-**10a** using 4 mol % palladium catalyst, pinacol boronate 1.6 equiv and $TsOH \cdot H_2O$ (2.2 equiv). Yield **10b** = 32% (acetone-deactivated silica gel, petroleum ether/EtOAc = 4:6 to 3:7), light red amorphous solid.

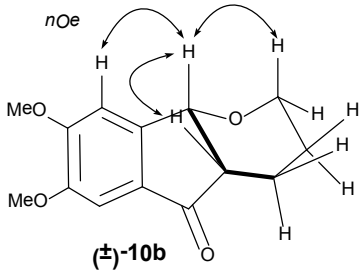
IR (neat): 2940, 1706, 1594, 1501, 1464, 1344, 1286, 1217, 1130, 1097, 1055, 1026, 994, 863 $cm^{-1}$.

$^{1}H$ NMR (400 MHz, $C_6D_6$) δ 7.24 (s, 1H), 6.82 (s, 1H), 4.76 (d, *J* = 5.5 Hz, 1H), 3.56 (m, 1H), 3.30 (m, 1H), 3.25 (s, 3H), 3.22 (s, 3H), 2.37 (m, 1H), 2.21 (m, 1H), 1.70 (m, 1H), 1.30 (m, 1H), 1.15 (m, 1H).

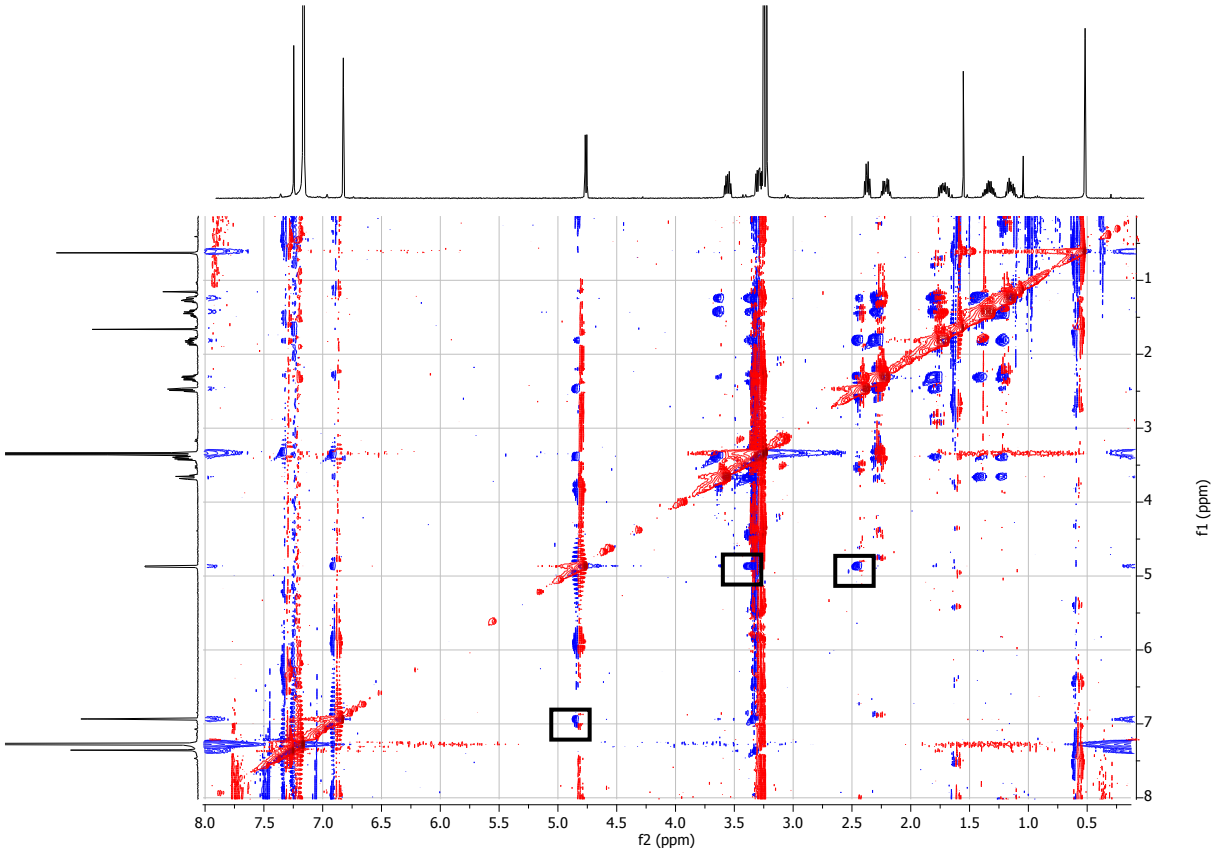
$^{13}C$ NMR (100 MHz, $C_6D_6$) 203.0 (C), 155.9 (C), 151.7 (C), 147.3 (C), 130.2 (C), 108.0 (CH), 104.8 (CH), 73.9 (CH), 64.4 ($CH_2$), 55.4 ($CH_3$), 55.3 ($CH_3$), 42.2 (CH), 22.4 ($CH_2$), 21.0 ($CH_2$).

HRMS calcd for $C_{14}H_{16}O_4Na$ $[M+Na]^+$: 271.09463. Found: 271.09440.

## NOESY experiment for compound (±)-10b



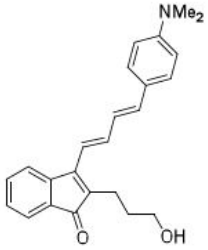

(±)-10b

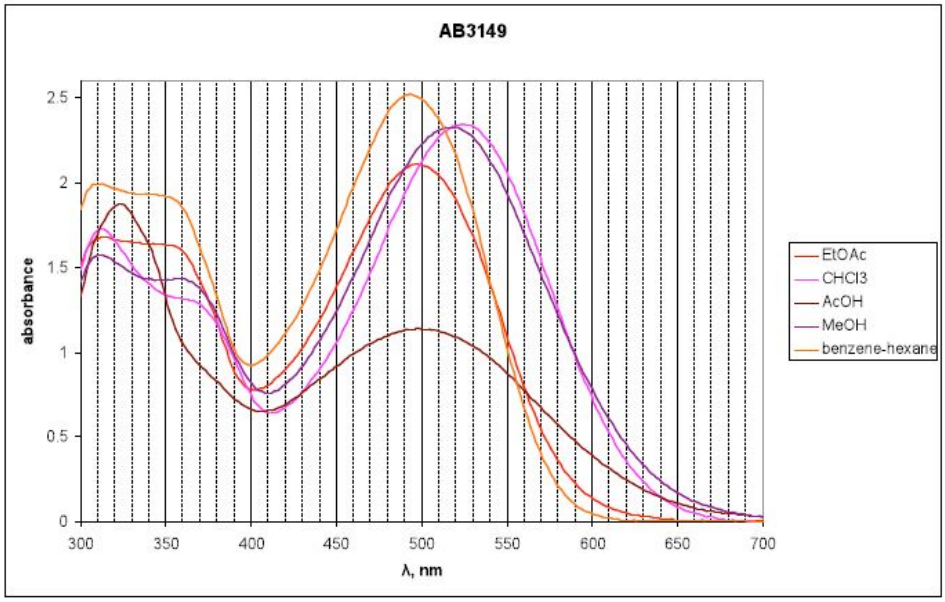


## Solvatochromic dye properties of compound 6g

The indenone with a conjugate π-system of a push-pull type (compound **6g**, Table 1) demonstrates solvatochromic dye properties

*Absorption spectra of **6g** in different solvents*




$\lambda_{max}$(hexane-benzene 3:1) = 494 nm (not soluble in pure hexane)
$\lambda_{max}$(EtOAc) = 498 nm
$\lambda_{max}$(AcOH) = 498 nm
$\lambda_{max}$(MeOH) = 518 nm
$\lambda_{max}$($CHCl_3$) = 524 nm
Observed colour of the solutions (left to right: hexane-benzene, EtOAc, AcOH, MeOH, $CHCl_3$):

The dye exhibits positive solvatochromism (bathochromic shift of absorption maxima with increase in solvent polarity: hexane → EtOAc → methanol), typical for this type of conjugated push-pull systems, however the high $\lambda_{max}$($CHCl_3$) cannot be explained easily. An additional absorption maximum in AcOH solution is likely due to the presence of protonated form of the dye.

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## Copies of $^{1}H$ and $^{13}C$ spectra