Supporting Information

© Copyright Wiley-VCH Verlag GmbH & Co. KGaA, 69451 Weinheim, 2019

A Cyanide-Free Synthesis of Acylcyanides through Ru-Catalyzed C(sp³)-H-Oxidation of Benzylic Nitriles

Pascal Eisele, Michael Bauder, Shih-Fan Hsu, and Bernd Plietker*© 2019 The Authors. Published by Wiley-VCH Verlag GmbH & Co. KGaA. This is an open access article under the terms of the Creative Commons Attribution Non-Commercial NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
Catalytic procedure ...................................................................................................... 3

1.1 General remarks ........................................................................................................... 3

1.2 Synthesis of Benzoyl cyanides and in-situ trapping .................................................... 3

GP-I...................................................................................................................................... 3

1.3 Sequential C-H oxidation – nucleophilic substitution ................................................. 4

GP-II (Esters and Thioesters) ......................................................................................... 4

GP-III (Amides) ........................................................................................................... 4

1.4 Sequential Ru-catalyzed oxidation-base-mediated acylcyanide rearrangement ....... 5

GP-IV (cyanohydrin esters) ......................................................................................... 5

2 Synthesis of starting material ....................................................................................... 5

3 Characterization Data ................................................................................................... 6

4 Selected Spectra ......................................................................................................... 29

5 Literature .................................................................................................................... 41
1 Catalytic procedure

1.1 General remarks

All reactions and manipulations, which are sensitive to air or moisture, were performed under dry nitrogen by using standard Schlenk techniques. All solvents were purified prior to use. All chemicals were purchased from Acros Organics, Sigma Aldrich/Merck, Fluorochem or Alfa Aesar. Purification via semi-preparative HPLC was carried out with a Knauer System, pump K-501 and RI-detector K-2400, and a Nucleodur 100-5 Si (250 mm x 20 mm) column. NMR spectra were recorded on a spectrometer at 300 MHz \(^{1}H\)-NMR), 75 MHz \(^{13}C\)-NMR) from Bruker Avance 300, on a spectrometer at 400 MHz \(^{1}H\)-NMR), 101 MHz \(^{13}C\)-NMR) from Bruker AscendTM 400, on a spectrometer at 500 MHz \(^{1}H\)-NMR), 125.6 MHz \(^{13}C\)-NMR) from Bruker Avance 500 and on a spectrometer at 700 MHz \(^{1}H\)-NMR), 176 MHz \(^{13}C\)-NMR) from Bruker AscendTM 700. \(^{1}H\)-chemical shifts are expressed in ppm with residual solvent or TMS (δ = 0.0 ppm) as references. Chemical shifts (δ) are reported with multiplicity (s = singlet, d = doublet, t = triplet, dd = doublet of doublets, dt = doublet of triplets, td = triplet of doublets, dq = doublets of quartets, quint = quintet, m = multiplet, b = broad) and coupling constants \((J)\) in Hz. \(^{13}C\)-chemical shifts are reported as chemical shifts (δ) with residual chloroform (δ = 77.16 ppm) as internal reference. IR spectra were measured on a FT-IR spectrometer, Vektor 22 from Bruker, in an ATR mode. Mass spectra were measured using electrospray ionization on a Bruker Micro-TOF-Q.

The catalyst 1-PF₆ and TBHP solution in benzene were prepared according to previous reports.\(^{[2,3]}\)

Amines and aldehydes were distilled prior to use.

1.2 Synthesis of Benzoyl cyanides and in-situ trapping

GP-I

A 15 mL Schlenk tube with a screwcap sealing was dried under high vacuum with a heat gun. After cooling to room temperature the catalyst 1-PF₆ (2.8 mg, 0.0025 mmol, 0.005 eq.) was dissolved in dry benzene (2 ml) under an atmosphere of N₂. The benzilnitrile (0.5 mmol, 1 eq.) was added followed by the addition of TBHP (5.08 M in dry benzene, 0.39 ml, 2 mmol, 4 eq.). The sealed tube was heated to 40 °C for 18 hours. The reaction mixture was cooled to room temperature, filtrated over Celite and washed with EtOAc. The solvent was removed
under reduced pressure and the yield of benzoyl cyanide was determined by $^1$H NMR with mesitylene as internal standard.

The crude benzoyl cyanide was redissolved in dry dichloromethane (1 ml) in a heated Schlenk tube under N$_2$ atmosphere. tert-butanol (0.47 ml, 5.0 mmol, 10 eq.) and 1,8-diazabicyclo(5.4.0)undec-7-ene (0.149 ml, 1.0 mmol, 2 eq.) were added and the mixture was stirred for 2 hours at room temperature. The mixture was filtered over silica gel, washed with EtOAc and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

### 1.3 Sequential C-H oxidation – nucleophilic substitution

**GP-II (Esters and Thioesters)**

A 15 mL Schlenk tube with a screwcap sealing was dried under high vacuum with a heat gun. After cooling to room temperature the catalyst 1-PF$_6$ (2.8 mg, 0.0025 mmol, 0.005 eq.) was dissolved in dry benzene (2 ml) under an atmosphere of N$_2$. The benzylnitrile (0.5 mmol, 1 eq.) was added followed by the addition of TBHP (5.08 M in dry benzene, 0.39 ml, 2 mmol, 4 eq.). The sealed tube was heated to 40 °C for 18 h. After cooling to room temperature the nucleophile (5.0 mmol, 10 eq.) was added followed by the addition of diazabicyclo(5.4.0)undec-7-ene (0.149 ml, 1.0 mmol, 2 eq.). The reaction mixture was stirred at 40 °C for 2 hours. After cooling to room temperature the mixture was filtered over silica gel, washed with EtOAc and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

**GP-III (Amides)**

A 15 mL Schlenk tube with a screwcap sealing was dried under high vacuum with a heat gun. After cooling to room temperature the catalyst 1-PF$_6$ (2.8 mg, 0.0025 mmol, 0.005 eq.) was dissolved in dry benzene (2 ml) under an atmosphere of N$_2$. The benzylnitrile (0.5 mmol, 1 eq.) was added followed by the addition of TBHP (5.08 M in dry benzene, 0.39 ml, 2 mmol, 4 eq.). The sealed tube was heated to 40 °C for 18 h. After cooling to room temperature the amine (0.5 mmol, 1 eq.) was added and the reaction mixture was stirred at 40 °C for 2 hours. After cooling to room temperature the mixture was filtered over silica gel, washed with
EtOAc and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

1.4 Sequential Ru-catalyzed oxidation-base-mediated acylcyanide rearrangement

GP-IV (cyanohydrin esters)

A 15 mL Schlenk tube with a screwcap sealing was dried under high vacuum with a heat gun. After cooling to room temperature the catalyst 1-PF₆ (2.8 mg, 0.0025 mmol, 0.005 eq.) was dissolved in dry benzene (2 ml) under an atmosphere of N₂. The benzylnitrite (0.5 mmol, 1 eq.) was added followed by the addition of TBHP (5.08 M in dry benzene, 0.39 ml, 2 mmol, 4 eq.). The sealed tube was heated to 40 °C for 18 h. After cooling to room temperature freshly distilled aldehyde (0.5 mmol, 1 eq.) and dry ethylamine (28 µl, 0.2 mmol, 0.4 eq.) were added. The reaction mixture was stirred at 40 °C for 2 hours. After cooling to room temperature the mixture was filtered over silica gel, washed with EtOAc and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel.

2 Synthesis of starting material

2-(4-Methoxyphenyl)acetamide 41

4-Methoxyphenylacetic acid (1.662 g, 10 mmol, 1 eq.) was dissolved in dichloromethane (100 ml) and cooled to 0 °C. Thionyl chloride (1.09 ml, 15 mmol, 1.5 eq.) was added dropwise and the mixture was stirred over night at room temperature. Ammonia solution (25 wt%, 6.5 ml) was slowly added. The precipitation was filtered off and washed with cold water (2 x 10 ml). The resulting solid was dried under vacuum to obtain the pure product. The spectral data are in good agreement with previous reports.¹¹
Yield: 713.2 mg (4.3 mmol, 43%).

Physical State: white solid.

$^1$H NMR (Avance 500 MHz, CDCl$_3$) δ 7.23 - 7.17 (m, 2H), 6.92 - 6.87 (m, 2H), 5.42 (bd, $J = 31.6$ Hz, 2H), 3.81 (s, 3H), 3.53 (s, 2H) ppm.

$^{13}$C NMR (Avance 125 MHz, CDCl$_3$) δ 173.9, 159.0, 130.5, 126.8, 114.5, 55.3, 42.4 ppm.

IR (ATR, in CDCl$_3$) ν 3349 (b), 3172 (b), 1637 (s), 1612 (m), 1515 (m), 1414 (m), 1247 (s), 1026 (s) cm$^{-1}$.

HRMS (ESI, m/z) calcd. for C$_9$H$_{11}$NO$_2$+Na$^+$: 188.0682, found: 188.0682.

3 Characterization Data

$t$-Butyl 4-methoxybenzoate 10

4-Methoxyphenylacetonitrile was treated according to GP-I and product 10 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 100/1). The spectral data are in good agreement with previous reports.$^{[4]}$

Yield: 78.2 mg (0.38 mmol, 75%).

Physical State: yellow oil.

R$_f$ Value: 0.15 (petroleum ether/EtOAc – 100/1).

$^1$H NMR (Avance 500 MHz, CDCl$_3$) δ 7.96 - 7.92 (m, 2H), 6.92 - 6.87 (m, 2H), 3.85 (s, 3H), 1.58 (s, 9H) ppm.
13C NMR (Avance 125 MHz, CDCl3) δ 165.6, 162.9, 131.4, 124.5, 113.4, 80.5, 55.4, 28.3 ppm.

IR (ATR, in CDCl3) ν 2976 (w), 2933 (w), 1703 (s), 1605 (s), 1510 (m), 1367 (m), 1289 (s), 1250 (s) cm\(^{-1}\).

MS (EI) m/z (%): 208 (11), 152 (100), 135 (78), 92 (17), 77 (16).

---

t-Butyl 4-chlorobenzoate 11

![Chemical Structure](image)

4-Chlorophenylacetonitrile was treated according to GP-I and product 11 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 100/1). The spectral data are in good agreement with previous reports.[5]

**Yield:** 22.0 mg (0.10 mmol, 20%).

**Physical State:** colorless oil.

**Rf Value:** 0.27 (petroleum ether/EtOAc – 100/1).

1H NMR (Avance 700 MHz, CDCl3) δ 7.94 - 7.89 (m, 2H), 7.40 - 7.36 (m, 2H), 1.59 (s, 9H) ppm.

13C NMR (Avance 176 MHz, CDCl3) δ 164.9, 138.8, 130.8, 130.5, 128.5, 81.4, 28.2 ppm.

IR (ATR, in CDCl3) ν 2978 (w), 2933 (w), 1713 (s), 1593 (m), 1487 (w), 1368 (m), 1291 (s) cm\(^{-1}\).

MS (EI) m/z (%): 212 (2), 157 (56), 139 (100), 111 (48), 75 (45), 57 (56).

---

t-Butyl 4-bromobenzoate 12
4-Bromophenylacetonitrile was treated according to GP-I and product 12 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 100/1). The spectral data are in good agreement with previous reports.\textsuperscript{[6]}

**Yield:** 85.1 mg (0.33 mmol, 66%).

**Physical State:** yellow oil.

**R\textsubscript{f} Value:** 0.24 (petroleum ether/EtOAc – 100/1).

\textsuperscript{1}H NMR (Avance 500 MHz, CDCl\textsubscript{3}) $\delta$ 7.87 - 7.81 (m, 2H), 7.58 - 7.52 (m, 2H), 1.59 (s 9H) ppm.

\textsuperscript{13}C NMR (Avance 125 MHz, CDCl\textsubscript{3}) $\delta$ 165.0, 131.5, 131.0, 130.9, 127.4, 81.5, 28.2 ppm.

**IR** (ATR, in CDCl\textsubscript{3}) $\nu$ 2978 (w), 2932 (w), 1714 (s), 1588 (m), 1480 (w), 1394 (m), 1368 (m), 1293 (s) cm\textsuperscript{-1}.

**MS (EI) m/z (%):** 256 (4), 203 (62), 183 (100), 157 (46), 76 (46), 57 (69).

---

**Benzoic acid tert-butyl ester 13**

Phenylacetonitrile was treated according to GP-I and product 13 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 100/1). The spectral data are in good agreement with previous reports.\textsuperscript{[7]}

**Yield:** 24.0 mg (0.13 mmol, 27%).

**Physical State:** yellow oil.

**R\textsubscript{f} Value:** 0.34 (petroleum ether/EtOAc – 50/1).
\[ ^1 \text{H NMR} \ (\text{Avance 700 MHz, CDCl}_3) \delta 8.01 - 7.97 \ (m, 2H), \ 7.55 - 7.49 \ (m, 1H), \ 7.45 - 7.38 \ (m, 2H), \ 1.60 \ (s, 9H) \ \text{ppm.} \]

\[ ^{13} \text{C NMR} \ (\text{Avance 176 MHz, CDCl}_3) \delta 165.8, \ 132.4, \ 132.0, \ 129.4, \ 128.2, \ 81.0, \ 28.2 \ \text{ppm.} \]

\[ \text{IR} \ (\text{ATR, in CDCl}_3) \ \nu 2977 \ (w), \ 2931 \ (w), \ 1711 \ (s), \ 1451 \ (w), \ 1368 \ (m), \ 1291 \ (s), \ 1254 \ (m) \ \text{cm}^{-1}. \]

\[ \text{MS (EI)} \ m/z \ (%): \ 178 \ (1), \ 123 \ (70), \ 105 \ (100), \ 77 \ (74), \ 57 \ (59), \ 51 \ (49). \]

\[ \text{t-Butyl 3-methoxybenzoate 14} \]

\[ \text{3-Methoxyphenylacetonitrile was treated according to GP-I and product 14 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 100/1). The spectral data are in good agreement with previous reports.}^{[8]} \]

**Yield:** 60.6 mg (0.29 mmol, 58%).

**Physical State:** yellow oil.

**R_f Value:** 0.26 (petroleum ether/EtOAc – 100/1).

\[ ^1 \text{H NMR} \ (\text{Avance 500 MHz, CDCl}_3) \delta 7.61 - 7.50 \ (m, 2H), \ 7.32 \ (t, \ J = 7.9 \ Hz, 1H), \ 7.09 - 7.05 \ (m, 1H), \ 3.85 \ (s, 3H), \ 1.59 \ (s, 9H) \ \text{ppm.} \]

\[ ^{13} \text{C NMR} \ (\text{Avance 125 MHz, CDCl}_3) \delta 165.6, \ 159.5, \ 133.4, \ 129.2, \ 121.8, \ 118.8, \ 114.0, \ 81.1, \ 55.4, \ 28.2 \ \text{ppm.} \]

\[ \text{IR} \ (\text{ATR, in CDCl}_3) \ \nu 3401 \ (w), \ 2976 \ (w), \ 2935 \ (w), \ 1711 \ (s), \ 1586 \ (m), \ 1453 \ (m), \ 1368 \ (m), \ 1290 \ (s) \ \text{cm}^{-1}. \]

\[ \text{MS (EI)} \ m/z \ (%): \ 208 \ (27), \ 152 \ (100), \ 135 \ (43), \ 107 \ (10), \ 92 \ (15), \ 77 \ (14). \]
**t-Butyl 3-methylbenzoate 15**

3-Methylphenylacetonitrile was treated according to GP-I and product 15 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 100/1). The spectral data are in good agreement with previous reports.⁹

**Yield:** 48.0 mg (0.25 mmol, 50%).

**Physical State:** colorless oil.

**Rₚ Value:** 0.14 (petroleum ether/EtOAc – 100/1).

**¹H NMR** (Avance 500 MHz, CDCl₃) δ 7.82 - 7.76 (m, 2H), 7.36 - 7.27 (m, 2H), 2.39 (s, 3H), 1.59 (s, 9H) ppm.

**¹³C NMR** (Avance 125 MHz, CDCl₃) δ 166.0, 137.9, 133.1, 131.9, 129.9, 128.1, 126.5, 80.8, 28.2, 21.3 ppm.

**IR** (ATR, in CDCl₃) ν 2977 (w), 2930 (w), 1712 (s), 1590 (w), 1456 (w), 1367 (w), 1293 (s), 1255 (m) cm⁻¹.

**MS (EI) m/z (%):** 192 (4), 137 (69), 119 (100), 91 (95), 65 (57), 57 (71).

---

**t-Butyl 3,4-methylenedioxybenzoate 16**

3,4-methylenedioxyphenylacetonitrile was treated according to GP-I and product 16 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 90/1).

**Yield:** 23.6 mg (0.11 mmol, 22%).

**Physical State:** colorless oil.
Methyl 4-methoxybenzoate 17

![Methyl 4-methoxybenzoate](image)

4-Methoxyphenylacetonitrile was reacted with methanol according to GP-II and product 17 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 10/1). The spectral data are in good agreement with previous reports."[10]

Yield: 71.0 mg (0.43 mmol, 85%).

Physical State: white crystals.

Rf Value: 0.50 (petroleum ether/EtOAc – 10/1).

**1H NMR** (Avance 400 MHz, CDCl₃) δ 7.99 (d, J = 8.7 Hz, 2H), 6.92 (d, J = 8.7 Hz, 2H), 3.88 (s, 3H), 3.86 (s, 3H) ppm.

**13C NMR** (Avance 101 MHz, CDCl₃) δ 167.0, 163.5, 131.7, 122.8, 113.7, 55.6, 52.0 ppm.

**IR** (ATR, in CDCl₃) ν 2953 (w), 1714 (s), 1606 (s), 1512 (s), 1435 (m), 1317 (w), 1280 (s), 1256 (s), 1169 (s), 1104 (m), 1030 (w) cm⁻¹.

**MS (EI)** m/z (%): 166 (42), 135 (100), 107 (9), 92 (10), 77 (13).
### Isopropyl 4-methoxybenzoate 18

![Chemical Structure of Isopropyl 4-methoxybenzoate](image)

4-Methoxyphenylacetonitrile was reacted with 2-propanol according to **GP-II** and product 18 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 10/1). The spectral data are in good agreement with previous reports.\(^{[10]}\)

**Yield:** 79.4 mg (0.41 mmol, 82%).

**Physical State:** white crystals.

**R\(_f\) Value:** 0.48 (petroleum ether/EtOAc – 10/1).

**\(^1\)H NMR** (Avance 400 MHz, CDCl\(_3\)) \(\delta\) 7.99 (d, \(J = 8.8\) Hz, 2H), 6.91 (d, \(J = 8.8\) Hz, 2H), 5.22 (sept, \(J = 6.2\) Hz, 1H), 3.85 (s, 3H), 1.35 (d, \(J = 6.2\) Hz, 6H) ppm.

**\(^{13}\)C NMR** (Avance 101 MHz, CDCl\(_3\)) \(\delta\) 166.0, 163.3, 131.6, 123.5, 113.6, 68.0, 55.5, 22.1 ppm.

**IR** (ATR, in CDCl\(_3\)) \(\nu\) 2979 (w), 2937 (w), 1704 (s), 1605 (s), 1510 (m), 1464 (w), 1273 (m), 1250 (s), 1166 (s), 1096 (s), 1029 (m) cm\(^{-1}\).

**MS** (EI) m/z (%): 194 (24), 179 (6), 152 (42), 135 (100), 107 (5), 92 (9).

### Allyl 4-methoxybenzoate 19

![Chemical Structure of Allyl 4-methoxybenzoate](image)

4-Methoxyphenylacetonitrile was reacted with Prop-2-en-1-ol according to **GP-II** and product 19 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 20/1 → 10/1). The spectral data are in good agreement with previous reports.\(^{[11]}\)

**Yield:** 75.5 mg (0.39 mmol, 78%).
Physical State: colorless oil.

R<sub>f</sub> Value: 0.45 (petroleum ether/EtOAc – 10/1).

<sup>1</sup>H NMR (Avance 400 MHz, CDCl<sub>3</sub>) δ 8.02 (d, J = 8.9 Hz, 2H), 6.92 (d, J = 8.9 Hz, 2H), 6.09 - 5.98 (m, 1H), 5.40 (dq, J = 17.2, 1.6 Hz, 1H), 5.27 (dq, J = 10.4, 1.3 Hz, 1H), 4.80 (dt, J = 5.6, 1.4 Hz, 2H), 3.86 (s, 3H) ppm.

<sup>13</sup>C NMR (Avance 101 MHz, CDCl<sub>3</sub>) δ 166.1, 163.5, 132.6, 131.8, 122.7, 118.1, 113.8, 65.4, 55.6 ppm.

IR (ATR, in CDCl<sub>3</sub>) ν 1709 (s), 1605 (s), 1580 (w), 1510 (m), 1360 (w), 1316 (w), 1249 (s), 1165 (s), 1097 (s), 1027 (m) cm<sup>-1</sup>.

MS (ESI) m/z (%): 258 (79), 227 (14), 215 [M+Na]<sup>+</sup> (100), 209 (14), 191 (17), 135 (24).

<sup>(IR,2S,5R)</sup>-2-Isopropyl-5-methylcyclohexyl 4-methoxybenzoate 20

![Chemical Structure Image]

4-Methoxyphenylacetonitrile was reacted with L-(-)-Menthol according to GP-II and product 20 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 10/1 → 5/1) followed by HPLC. The spectral data are in good agreement with previous reports.<sup>[10]</sup>

Yield: 119.3 mg (0.41 mmol, 82%).

Physical State: colorless oil.

R<sub>f</sub> Value: 0.72 (petroleum ether/EtOAc – 5/1).

<sup>1</sup>H NMR (Avance 400 MHz, CDCl<sub>3</sub>) δ 7.99 (d, J = 8.9 Hz, 2H), 6.92 (d, J = 9.0 Hz, 2H), 4.90 (td, J = 10.9, 4.4 Hz, 1H), 3.86 (s, 3H), 2.15 - 2.08 (m, 1H), 1.99 - 1.91 (m, 1H), 1.72 (d, J = 11.4 Hz, 2H), 1.56 - 1.48 (m, 2H), 1.19 - 1.05 (m, 2H), 0.99 - 0.85 (m, 1H), 0.92 (dd, J = 6.8, 4.7 Hz, 6H), 0.79 (d, J = 7.0 Hz, 3H) ppm.
$^{13}$C NMR (Avance 176 MHz, CDCl$_3$) δ 166.0, 163.3, 131.7, 123.5, 113.7, 74.6, 55.6, 47.4, 41.2, 34.5, 31.6, 26.6, 23.8, 22.2, 20.9, 16.7 ppm.

IR (ATR, in CDCl$_3$) ν 2954 (w), 2869 (w), 1705 (s), 1606 (s), 1510 (m), 1457 (w), 1420 (w), 1252 (s), 1166 (s), 1114 (m), 1101 (s), 1032 (m) cm$^{-1}$.

HRMS (ESI, m/z) calcd. for C$_{18}$H$_{26}$O$_3$+Na$: 313.1774$, found: 313.1767.

\[ \text{S-}(n\text{-Butyl}) \text{ 4-methoxybenzothioate 21} \]

4-Methoxyphenylacetonitrile was reacted with Butane-1-thiol according to GP-II and product 21 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc $\rightarrow$ 20/1 $\rightarrow$ 10/1). The spectral data are in good agreement with previous reports.$^{[12]}$

**Yield:** 91.1 mg (0.43 mmol, 86%).

**Physical State:** colorless oil.

**R$_r$ Value:** 0.30 (petroleum ether/EtOAc $\rightarrow$ 20/1).

$^1$H NMR (Avance 400 MHz, CDCl$_3$) δ 7.95 (d, $J = 8.9$ Hz, 2H), 6.92 (d, $J = 8.9$ Hz, 2H), 3.86 (s, 3H), 3.04 (t, $J = 7.2$ Hz, 2H), 1.70 (dq, $J = 14.9$, 7.4 Hz, 2H), 1.03 (t, $J = 7.4$ Hz, 3H) ppm.

$^{13}$C NMR (Avance 101 MHz, CDCl$_3$) δ 190.6, 163.4, 130.2, 129.3, 113.7, 55.5, 30.8, 23.1, 13.5 ppm.

IR (ATR, in CDCl$_3$) ν 2963 (w), 2932 (w), 1652 (s), 1600 (s), 1577 (m), 1507 (m), 1458 (w), 1308 (m), 1256 (s), 1211 (s), 1131 (m), 1028 (s) cm$^{-1}$.

HRMS (ESI, m/z) calcd. for C$_{11}$H$_{14}$O$_2$S+H: 211.0787, found: 211.0782.
S-Benzyl 4-methoxybenzenecarbothioate 22

4-Methoxyphenylacetonitrile was reacted with benzyl mercaptan according to GP-II and product 22 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 40/1 → 20/1). The spectral data are in good agreement with previous reports.[13]

**Yield:** 77.6 mg (0.3 mmol, 60%).

**Physical State:** colorless oil.

**Rf Value:** 0.48 (petroleum ether/EtOAc – 20/1).

**1H NMR** (Avance 400 MHz, CDCl₃) δ 7.95 (d, J = 9.1 Hz, 2H), 7.40 - 7.21 (m, 5H), 6.91 (d, J = 9.1 Hz, 2H), 4.30 (s, 2H), 3.85 (s, 3H) ppm.

**13C NMR** (Avance 101 MHz, CDCl₃) δ 189.9, 163.9, 137.9, 129.8, 129.6, 129.1, 128.8, 127.4, 113.9, 55.6, 33.3 ppm.

**IR** (ATR, in CDCl₃) ν 2933 (w), 2838 (w), 1652 (s), 1599 (s), 1577 (m), 1507 (m), 1454 (w), 1308 (m), 1258 (s), 1213 (s), 1165 (s), 1029 (m) cm⁻¹.

**HRMS** (ESI, m/z) calcd. for C₁₅H₁₄O₂S+Na⁺: 281.0607, found: 281.0601.

N-Benzyl-4-methoxybenzamide 23

4-Methoxyphenylacetonitrile was reacted with benzylamine according to GP-III and product 23 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 5/1 → 2/1). The spectral data are in good agreement with previous reports.[14]

**Yield:** 109.3 mg (0.45 mmol, 90%).

**Physical State:** white crystals.
N-Butyl-p-methoxybenzamide 24

4-Methoxyphenylacetonitrile was reacted with n-butylamine according to GP-III and product 24 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 2/1). The spectral data are in good agreement with previous reports.[15]

**Yield:** 91.9 mg (0.44 mmol, 88%).

**Physical State:** pale yellow oil.

**R_f Value:** 0.28 (petroleum ether/EtOAc – 2/1).

\(^1\)H NMR (Avance 400 MHz, CDCl\(_3\)) \(\delta\) 7.73 (d, \(J = 8.8\) Hz, 2H), 6.91 (d, \(J = 8.8\) Hz, 2H), 6.09 (bs, 1H), 3.84 (s, 3H), 3.44 (q, \(J = 6.7\) Hz, 2H), 1.59 (quint, \(J = 7.4\) Hz, 2H), 1.41 (sext, \(J = 7.4\) Hz, 2H), 0.95 (t, \(J = 7.3\) Hz, 3H) ppm.

\(^{13}\)C NMR (Avance 101 MHz, CDCl\(_3\)) \(\delta\) 167.2, 162.1, 128.7, 127.2, 113.8, 55.5, 39.9, 31.9, 20.3, 13.9 ppm.

IR (ATR, in CDCl\(_3\)) \(\nu\) 3321 (b), 2958 (w), 2932 (w), 1632 (s), 1607 (s), 1546 (m), 1505 (s), 1464 (w), 1303 (w), 1253 (s), 1179 (m) cm\(^{-1}\).

HRMS (ESI, m/z) calcd. for C\(_{12}\)H\(_{17}\)NO\(_2\)+Na\(^+\): 230.1151, found: 230.1155.
4-Methoxy-N-phenylbenzamide 25

4-Methoxyphenylacetonitrile was reacted with aniline according to GP-III and product 25 was obtained after column chromatography on silica gel (gradient elution petroleum ether/EtOAc – 5/1 → 2/1). The spectral data are in good agreement with previous reports.[16]

Yield: 91.3 mg (0.40 mmol, 80%).

Physical State: pale yellow crystals.

Rf Value: 0.22 (petroleum ether/EtOAc – 5/1).

$^1$H NMR (Avance 300 MHz, DMSO-d$_6$) δ 7.96 (d, $J = 8.9$ Hz, 2H), 7.77 (d, $J = 8.3$ Hz, 2H), 7.34 (t, $J = 7.9$ Hz, 2H), 7.11 - 7.03 (m, 3H), 3.84 (s, 3H) ppm.

$^{13}$C NMR (Avance 75 MHz, CDCl$_3$) δ 164.8, 161.8, 139.3, 129.5, 128.5, 126.9, 123.4, 120.3, 113.5, 55.4 ppm.

IR (ATR, in CDCl$_3$) ν 3335 (s), 1653 (s), 1597 (m), 1526 (m), 1508 (m), 1437 (m), 1256 (m), 1182 (w), 1029 (m) cm$^{-1}$.

MS (ESI): m/z (%): 250 [M+Na]$^+$ (55), 228 [M+H]$^+$ (100), 135 (88).

N-Benzylamide 26
Phenylacetonitrile was reacted with benzylamine according to GP-III and product 26 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 2/1). The spectral data are in good agreement with previous reports.[17]

Yield: 58.0 mg (0.27 mmol, 55%).

**Physical State:** yellow crystals.

**Rf** Value: 0.50 (petroleum ether/EtOAc – 2/1).

**1H NMR** (Avance 300 MHz, CDCl₃) δ 7.79 (d, J = 7.4 Hz, 2H), 7.51 (t, J = 6.9 Hz, 1H), 7.43 (t, J = 7.6 Hz, 2H), 7.37 (d, J = 4.2 Hz, 4 H), 7.33 - 7.27 (m, 1H), 6.35 (bs, 1H), 4.66 (d, J = 5.6 Hz, 2H) ppm.

**13C NMR** (Avance 75 MHz, CDCl₃) δ 167.5, 138.3, 134.4, 131.6, 128.8, 128.6, 127.9, 127.6, 127.1, 44.1 ppm.

**IR** (ATR, in CDCl₃) ν 3307 (b), 1637 (s), 1577 (m), 1536 (s), 1488 (m), 1453 (m), 1420 (w), 1294 (s), 1078 (w), 1028 (m) cm⁻¹.

**MS** (EI): m/z (%): 211 (100), 105 (89), 91 (10), 77 (29).

---

**N-Butylbenzamide 27**

Phenylacetonitrile was reacted with \(n\)-butylamine according to GP-III and product 27 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 5/1 → 2/1). The spectral data are in good agreement with previous reports.[15]

Yield: 29.4 mg (0.16 mmol, 33%).

**Physical State:** pale yellow solid.

**Rf** Value: 0.63 (petroleum ether/EtOAc – 2/1).

**1H NMR** (Avance 500 MHz, CDCl₃) δ 7.76 (d, J = 7.3 Hz, 2H), 7.49 (t, J = 7.3 Hz, 1H), 7.42 (t, J = 7.4 Hz, 2H), 6.13 (bs, 1H), 3.46 (q, J = 6.7 Hz, 2H), 1.61 (quint, J = 7.4 Hz, 2H), 1.42 (sext, J = 7.4 Hz, 2H), 0.96 (t, J = 7.4 Hz, 3H) ppm.
$^{13}$C NMR (Avance 126 MHz, CDCl$_3$) $\delta$ 167.6, 135.0, 131.4, 128.7, 126.9, 39.9, 31.9, 20.3, 13.9 ppm.

IR (ATR, in CDCl$_3$) $\nu$ 3314 (b), 2958 (w), 2931 (w), 1637 (s), 1578 (m), 1541 (s), 1491 (m), 1308 (m) cm$^{-1}$.

HRMS (ESI, m/z) calcd. for C$_{11}$H$_{15}$NO$^+$/Na$^+$: 200.1046, found: 200.1048.

$N$-Phenyl benzoyl amide 28

![N-Phenyl benzoyl amide 28](image)

Phenylacetonitrile was reacted with aniline according to GP-III and product 28 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 10/1). The spectral data are in good agreement with previous reports.[18]

Yield: 44.6 mg (0.23 mmol, 45%).

Physical State: white solid.

R$_f$ Value: 0.30 (petroleum ether/EtOAc – 10/1).

$^1$H NMR (Avance 400 MHz, CDCl$_3$) $\delta$ 7.87 (d, $J = 7.8$ Hz, 2H), 7.80 (bs, 1H), 7.64 (d, $J = 8.3$ Hz, 2H), 7.56 (t, $J = 7.2$ Hz, 1H), 7.49 (t, $J = 7.8$ Hz, 2H), 7.38 (t, $J = 7.8$ Hz, 2H), 7.16 (t, $J = 7.5$ Hz, 1H) ppm.

$^{13}$C NMR (Avance 101 MHz, CDCl$_3$) $\delta$ 165.7, 137.9, 135.1, 131.9, 129.1, 128.8, 127.0, 124.6, 120.2 ppm.

IR (ATR, in CDCl$_3$) $\nu$ 2984 (w), 1736 (s), 1372 (m), 1233 (s), 1043 (s) cm$^{-1}$.

HRMS (ESI, m/z) calcd. for C$_{13}$H$_{11}$NO$^+$/Na$^+$: 220.0733, found: 220.0736.

$\alpha$-Cyanobenzyl $p$-methoxybenzoate 29
4-Methoxyphenylacetonitrile was reacted with benzaldehyde according to GP-IV and product 29 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 100/1 → 10/1). The spectral data are in good agreement with previous reports.[19]

Yield: 100.5 mg (0.38 mmol, 75%).

Physical State: colorless opaque oil.

R<sub>f</sub> Value: 0.25 (petroleum ether/EtOAc – 10/1).

<sup>1</sup>H NMR (Avance 400 MHz, CDCl<sub>3</sub>) δ 8.07 - 8.00 (m, 2H), 7.66 - 7.58 (m, 2H), 7.52 - 7.44 (m, 2H), 6.98 - 6.90 (m, 2H), 6.67 (s, 1H), 3.87 (s, 3H) ppm.

<sup>13</sup>C NMR (Avance 101 MHz, CDCl<sub>3</sub>) δ 164.3, 132.3, 132.1, 130.3, 129.3, 127.8, 120.4, 116.4, 114.0, 63.1, 55.6 ppm.

IR (ATR, in CDCl<sub>3</sub>) ν 2937 (w), 2841 (w), 1720 (s), 1604 (s), 1510 (s), 1457 (m), 1246 (s) cm<sup>-1</sup>.

MS (ESI) m/z (%): 267 (11), 135 (100), 116 (45), 92 (21), 77 (27), 63 (19).

(4-(<i>tert</i>-Butyl)phenyl)(cyano)methyl-4-methoxybenzoate 30

4-Methoxyphenylacetonitrile was reacted with 4-<i>tert</i>-butylbenzaldehyde according to GP-IV and product 30 was obtained after column chromatography on silica gel (gradient elution: petroleum ether/EtOAc – 100/1 → 10/1).

Yield: 96.0 mg (0.30 mmol, 59%).
Physical State: yellow oil.

Rf Value: 0.35 (petroleum ether/EtOAc – 10/1).

1H NMR (Avance 500 MHz, CDCl3) δ 8.04 - 8.00 (m, 2H), 7.57 - 7.46 (m, 4H), 6.95 - 6.90 (m, 2H), 6.63 (s, 1H), 3.86 (s, 3H), 1.33 (s, 9H) ppm.

13C NMR (Avance 125 MHz, CDCl3) δ 164.4, 164.2, 153.7, 132.3, 129.1, 127.7, 126.2, 120.5, 116.5, 113.9, 62.9, 55.5, 34.8, 31.2 ppm.

IR (ATR, in CDCl3) ν 2963 (m), 2905 (w), 2870 (w), 1721 (s), 1604 (s), 1510 (s), 1461 (m), 1248 (s) cm⁻¹.

MS (ESI) m/z (%): 346 (84), 253 (40), 172 (100), 157 (40), 145 (24), 135 (37).

HRMS (ESI, m/z ) calcd. for C20H21NO3+Na+: 346.1414, found: 346.1423.

Cyano-(4-fluorophenyl)methyl-4-methoxybenzoate 31

4-Methoxyphenylacetonitrile was reacted with 4-fluorobenzaldehyde according to GP-IV and product 31 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 10/1).

Yield: 105.0 mg (0.37 mmol, 74%).

Physical State: colorless oil.

Rf Value: 0.29 (petroleum ether/EtOAc – 10/1).

1H NMR (Avance 500 MHz, CDCl3) δ 8.05 - 7.98 (m, 2H), 7.64 - 7.57 (m, 2H), 7.20 - 7.12 (m, 2H), 6.97 - 6.90 (m, 2H), 6.64 (s, 1H), 3.87 (s, 3H) ppm.

13C NMR (Avance 125 MHz, CDCl3) δ 164.4, 164.2, 132.3, 130.0 (d), 128.2 (d), 120.2, 116.5, 116.3, 116.2, 114.0, 62.4, 55.6 ppm.
(4-Chlorophenyl)(cyano)methyl-4-methoxybenzoate 32

4-Methoxyphenylacetonitrile was reacted with 4-Chlorobenzaldehyde according to GP-IV and product 32 was obtained after column chromatography on silica gel (gradient elution petroleum ether/EtOAc – 100/1 → 10/1).

Yield: 111.0 mg (0.37 mmol, 74%).

Physical State: colorless oil.

Rf Value: 0.33 (petroleum ether/EtOAc – 10/1).

$^1$H NMR (Avance 500 MHz, CDCl$_3$) δ 8.04 - 7.98 (m, 2H), 7.58 - 7.52 (m, 2H), 7.48 - 7.42 (m, 2H), 6.97 - 6.89 (m, 2H), 6.63 (s, 1H), 3.87 (s, 3H) ppm.

$^{13}$C NMR (Avance 125 MHz, CDCl$_3$) δ 164.4, 164.2, 136.6, 132.3, 130.7, 129.6, 129.2, 120.1, 116.0, 114.0, 62.4, 55.6 ppm.

IR (ATR, in CDCl$_3$) ν 2938 (w), 2841 (w), 1725 (s), 1605 (s), 1511 (s), 1318 (m), 1251 (s) cm$^{-1}$.

MS (ESI) m/z (%): 353 (53), 324 (100), 297 (57), 231 (26), 197 (27), 184 (27), 150 (65), 135 (97).

HRMS (ESI, m/z ) calcd. for C$_{16}$H$_{12}$ClNO$_3$: 324.0398, found: 324.0396.
(4-Bromophenyl)(cyano)methyl-4-methoxybenzoate 33

![Structure of 33](image)

4-Methoxyphenylacetonitrile was reacted with 4-bromobenzaldehyde according to GP-IV and product 33 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 10/1).

**Yield:** 135.5 mg (0.39 mmol, 78%).

**Physical State:** colorless oil.

**Rf Value:** 0.29 (petroleum ether/EtOAc – 10/1).

**1H NMR** (Avance 500 MHz, CDCl3) δ 8.03 - 7.96 (m, 2H), 7.65 - 7.58 (m, 2H), 7.54 - 7.48 (m, 2H), 6.98 - 6.91 (m, 2H), 6.63 (s, 1H), 3.87 (s, 3H) ppm.

**13C NMR** (Avance 125 MHz, CDCl3+ DMSO d6) δ 164.3, 164.1, 132.4, 132.2, 131.1, 129.4, 124.6, 119.9, 116.0, 114.0, 62.4, 55.5 ppm.

**IR** (ATR, in CDCl3) ν 2935 (w), 2841 (w), 1722 (s), 1604 (s), 1510 (s), 1319 (m), 1249 (s) cm⁻¹.

**MS** (ESI) m/z (%): 347 (12), 196 (15), 135 (100), 115 (6), 92 (6), 77 (6).

**HRMS** (ESI, m/z ) calcd. for C16H12BrNO3: 345.0001, found: 345.0006.

---

(E)-1-Cyano-3-phenylallyl-4-methoxybenzoate 34

![Structure of 34](image)
4-Methoxyphenylacetonitrile was reacted with trans-Cinnamaldehyde according to GP-IV and product 34 was obtained after column chromatography on silica gel (gradient elution petroleum ether/EtOAc – 100/1 → 10/1).

**Yield:** 59.0 mg (0.20 mmol, 40%).

**Physical State:** colorless liquid.

**R$_f$ Value:** 0.29 (petroleum ether/EtOAc – 10/1).

**$^1$H NMR** (Avance 500 MHz, CDCl$_3$) δ 8.07 - 8.00 (m, 2H), 7.48 - 7.43 (m, 2H), 7.41 - 7.28 (m, 3H), 7.10 - 7.02 (m, 1H), 6.98 - 6.91 (m, 2H), 6.36 - 6.25 (m, 2H), 3.88 (s, 3H) ppm.

**$^{13}$C NMR** (Avance 125 MHz, CDCl$_3$) δ 164.3, 164.3, 137.8, 134.5, 132.3, 129.4, 128.9, 127.2, 120.4, 118.7, 115.8, 114.0, 61.8, 55.5 ppm.

**IR** (ATR, in CDCl$_3$) ν 3028 (w), 2937 (w), 2841 (w), 1720 (s), 1604 (s), 1510 (s), 1451 (w), 1318 (m), 1249 (s) cm$^{-1}$.

**MS** (ESI) m/z (%): 293 (11), 142 (19), 135 (100), 115 (14), 77 (5).

**HRMS** (ESI, m/z ) calcd. for C$_{18}$H$_{15}$NO$_3$: 293.1052, found: 293.1047.

---

1-Cyanoheptyl-4-methoxybenzoate 35

4-Methoxyphenylacetonitrile was reacted with heptanal according to GP-IV and product 35 was obtained after column chromatography on silica gel (gradient elution petroleum ether/EtOAc – 100/1 → 10/1).

**Yield:** 103.0 mg (0.37 mmol, 75%).

**Physical State:** colorless oil.

**R$_f$ Value:** 0.41 (petroleum ether/EtOAc – 10/1).
\(^1\)H NMR (Avance 700 MHz, CDCl\(_3\)) \(\delta\) 8.03 - 7.96 (m, 2H), 6.97 - 6.92 (m, 2H), 5.56 (t, \(J = 6.7\) Hz, 1H), 3.88 (s, 3H), 2.06 - 1.99 (m, 2H), 1.61 - 1.53 (m, 2H), 1.43 - 1.36 (m, 2H), 1.36 - 1.28 (m, 4H), 0.92 - 0.87 (m, 3H) ppm.

\(^{13}\)C NMR (Avance 176 MHz, CDCl\(_3\)) \(\delta\) 164.5, 164.2, 132.1, 120.6, 117.2, 113.9, 61.4, 55.5, 32.5, 31.5, 28.5, 24.6, 22.5, 14.0 ppm.

IR (ATR, in CDCl\(_3\)) \(\nu\) 2955 (w), 2930 (w), 2859 (w), 1723 (s), 1605 (s), 1511 (s), 1461 (m), 1317 (m), 1253 (s) cm\(^{-1}\).

MS (ESI) m/z (%): 298 (15), 135 (100).

HRMS (ESI, m/z ) calcd. for C\(_{16}\)H\(_{21}\)NO\(_3\)+Na\(^+\): 298.1414, found: 298.1409.

1-Cyanobutyl-4-methoxybenzoate 36

4-Methoxyphenylacetonitrile was reacted with butanal according to **GP-IV** and product 36 was obtained after column chromatography on silica gel (petroleum ether/EtOAc – 10/1).

**Yield:** 95.6 mg (0.41 mmol, 82%).

**Physical State:** colorless liquid.

**R\(_f\) Value:** 0.30 (petroleum ether/EtOAc – 10/1).

\(^1\)H NMR (Avance 500 MHz, CDCl\(_3\)) \(\delta\) 8.04 - 7.98 (m, 2H), 6.97 - 6.92 (m, 2H), 5.58 (t, \(J = 6.7\) Hz, 1H), 3.88 (s, 3H), 2.06 - 1.98 (m, 2H), 1.68 - 1.56 (m, 2H), 1.03 (t, \(J = 7.4\) Hz, 3H) ppm.

\(^{13}\)C NMR (Avance 125 MHz, CDCl\(_3\)) \(\delta\) 164.5, 164.2, 132.1, 120.6, 117.2, 113.9, 61.1, 55.5, 34.5, 18.1, 13.4 ppm.

IR (ATR, in CDCl\(_3\)) \(\nu\) 2964 (w), 2843 (w), 1720 (s), 1604 (s), 1510 (s), 1461 (m), 1317 (m), 1251 (s) cm\(^{-1}\).

MS (ESI) m/z (%): 233 (24), 152 (72), 135 (100), 92 (13), 77 (14).
Cyano(cyclohexyl)methyl-4-methoxybenzoate 37

4-Methoxyphenylacetonitrile was reacted with cyclohexanecarboxaldehyde according to GP-IV and product 37 was obtained after column chromatography on silica gel (gradient elution petroleum ether/EtOAc – 100/1 → 10/1).

**Yield:** 84.5 mg (0.31 mmol, 62%).

**Physical State:** colorless oil.

**Rf Value:** 0.37 (petroleum ether/EtOAc – 10/1).

$^1$H NMR (Avance 500 MHz, CDCl$_3$) δ 8.04 - 7.98 (m, 2H), 6.98 - 6.91 (m, 2H), 5.43 (d, $J = 5.9$ Hz, 1 H), 3.88 (s, 3H), 2.05-1.78 (m, 5H), 1.77-1.70 (m, 2H), 1.37 - 1.16 (m, 4H) ppm.

$^{13}$C NMR (Avance 125 MHz, CDCl$_3$) δ 164.5, 164.2, 132.1, 120.7, 116.5, 113.9, 65.8, 55.5, 40.3, 28.2, 28.1, 25.8, 25.4, 25.3 ppm.

**IR** (ATR, in CDCl$_3$) ν 2931 (m), 2855 (m), 1721 (s), 1604 (s), 1511 (s), 1451 (m), 1250 (s) cm$^{-1}$.

**MS** (ESI) m/z (%): 296 (14), 135 (100).

**HRMS** (ESI, m/z ) calcd. for C$_{16}$H$_{19}$NO$_3$+Na$: 296.1257$, found: 296.1262.

(3S)-1-Cyano-3,7-dimethyloct-6-en-1-yl 4-methoxybenzoate 38
4-Methoxyphenylacetonitrile was reacted with (S)-(−)-citronellal according to GP-IV and product 38 was obtained after column chromatography on silica gel (gradient elution petroleum ether/EtOAc – 100/1 → 10/1).

**Yield:** 96.0 mg (0.30 mmol, 61%).

**Physical State:** colorless oil.

**R_f Value:** 0.43 (petroleum ether/EtOAc – 10/1).

**1H NMR** (Avance 500 MHz, CDCl<sub>3</sub>) δ 8.05 - 7.97 (m, 2H), 6.99 - 6.90 (m, 2H), 5.65 – 5.59 (m, 1H), 5.10 - 5.03 (m, 1H), 3.88 (s, 3H), 2.18 – 1.94 (m, 3H), 1.91 - 1.71 (m, 2H), 1.70 - 1.64 (m, 3H), 1.62 - 1.58 (m, 3H), 1.48 - 1.38 (m, 1H), 1.34 - 1.23 (m, 1H), 1.07 - 0.97 (m, 3H) ppm.

**13C NMR** (Avance 125 MHz, CDCl<sub>3</sub>) δ 164.4 (d), 164.3, 132.2, 124.0 (d), 120.7 (d), 117.5 (d), 114.0, 60.2 (d), 55.6, 39.5 (d), 36.8 (d), 29.0 (d), 25.8 (d), 25.2 (d), 19.4 (d), 17.8 (d) ppm.

**IR** (ATR, in CDCl<sub>3</sub>) ν 2963 (w), 2915 (w), 2853 (w), 1722 (s), 1604 (s), 1511 (s), 1459 (m), 1317 (m), 1252 (s) cm<sup>−1</sup>.

**MS** (ESI) m/z (%): 338 (11), 135 (100).

**HRMS** (ESI, m/z ) calcd. for C<sub>19</sub>H<sub>25</sub>NO<sub>3</sub>+Na<sup>+</sup>: 338.1727, found: 338.1697.

---

(E)-1-Cyano-3,7-dimethylocta-2,6-dien-1-yl 4-methoxybenzoate 39

![Structure](image)

4-Methoxyphenylacetonitrile was reacted with citral according to GP-IV and product 39 was obtained after column chromatography on silica gel (petroleum ether/EtOAc –10/1) and HPLC (petroleum ether/EtOAc – 15/1).

**Yield:** 63.6 mg (0.20 mmol, 40%).

**Physical State:** colorless oil.

**R_f Value:** 0.38 (petroleum ether/EtOAc – 10/1).
1H NMR (Avance 400 MHz, CDCl₃) δ 8.03 - 7.97 (m, 2H), 6.97 - 6.89 (m, 2H), 6.24 (d, J = 9.6 Hz, 1H), 5.50 (dd, J = 9.7, 1.2 Hz, 1H), 5.13 - 5.05 (m, 1H), 3.87 (s, 3H), 2.38 - 2.24 (m, 1H), 2.23 - 2.08 (m, 3H), 1.85 (d, J = 1.3 Hz, 3H), 1.67 (s, 3H), 1.60 (s, 3H) ppm.

13C NMR (Avance 101 MHz, CDCl₃) δ 164.3, 164.1, 133.4, 132.1, 122.6, 120.8, 116.9, 116.4, 113.9, 58.0, 55.5, 32.7, 26.1, 25.7, 23.4, 17.7 ppm.

IR (ATR, in CDCl₃) ν 2970 (w), 1720 (s), 1604 (s), 1580 (w), 1511 (m), 1459 (w), 1422 (w), 1318 (w), 1249 (s), 1167 (s), 1079 (s), 1024 (m) cm⁻¹.

HRMS (EI, m/z) calcd. for C₁₀H₂₃NO₃: 313.1678, found: 313.1679.

(3S)-1-Cyano-3,7-dimethylct-6-en-1-yl 2-naphthoate 40

2-Naphthylacetonitrile was reacted with (S)-(−)-citronellal according to GP-IV and product 40 was obtained after column chromatography on silica gel (petroleum ether/EtOAc –15/1) and HPLC (petroleum ether/EtOAc –15/1).

Yield: 73.2 mg (0.22 mmol, 44%).

Physical State: colorless oil.

Rₗ Value: 0.40 (petroleum ether/EtOAc –15/1).

1H NMR (Avance 400 MHz, CDCl₃) δ 8.63 (s, 1H), 8.07 - 8.02 (m, 1H), 8.00 - 7.95 (m, 1H), 7.94 - 7.88 (m, 2H), 7.61 (dt, J = 22.6, 7.4 Hz, 2H), 5.74 - 5.69 (m, 1H), 5.13 - 5.05 (m, 1H), 2.25 - 1.79 (m, 5H), 1.67 (d, J = 9.6 Hz, 3H), 1.61 (d, J = 5.8 Hz, 3H), 1.52 - 1.41 (m, 1H), 1.37 - 1.25 (m, 1H), 1.06 (dd, J = 10.3, 6.5 Hz, 3H) ppm.

13C NMR (Avance 101 MHz, CDCl₃) δ 165.2, 165.1, 163.1, 136.1, 132.5, 132.0, 129.6, 129.0, 128.7, 128.0, 127.1, 125.7 (d), 125.2 (d), 124.0 (d), 117.4 (d), 60.6 (d), 39.7 (d), 36.8, 29.1 (d), 25.8 (d), 25.3 (d), 19.5 (d), 17.9 (d) ppm.

IR (ATR, in CDCl₃) ν 2918 (w), 1720 (s), 1464 (w), 1356 (w), 1278 (m), 1223 (m), 1192 (s), 1129 (m), 1084 (s) cm⁻¹.

HRMS (EI, m/z) calcd. for C₁₂H₂₅NO₂: 335.1885, found: 335.1886.
4 Selected Spectra

Compound 16

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
Compound 30

\(^1\text{H NMR}\) (500 MHz, CDCl\(_3\))

\(^{13}\text{C NMR}\) (125 MHz, CDCl\(_3\))
Compound 31

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)

Compound 32

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
Compound 33

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$ + few drops DMSO-d$_6$)
Compound 34

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
Compound 35

$^1$H NMR (700 MHz, CDCl$_3$)

$^{13}$C NMR (175 MHz, CDCl$_3$)
Compound 36

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
Compound 37

$^1$H NMR (500 MHz, CDCl$_3$)

$^{13}$C NMR (125 MHz, CDCl$_3$)
Compound 38

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
Compound 39

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
Compound 40

$^1$H NMR (400 MHz, CDCl$_3$)

$^{13}$C NMR (101 MHz, CDCl$_3$)
5 Literature

[1] Z. Yang, N. Huang, B. Xu, W. Huang, T. Xie, F. Cheng, K. Zou, Molecules, 2016, 21, 232.

[2] S.-F. Hsu, B. Plietker, ChemCatChem, 2013, 5, 126-129.

[3] J. Hill, B. Rossiter, K. Sharpless, J. Org. Chem. 1983, 48, 3607-3608.

[4] Y. Nishimoto, S. Babu, M. Yasuda, A. Baba, J. Org. Chem. 2008, 73 (23), 9465-9468.

[5] S. Pramanik, R. Reddy, P. Ghorai, Org. Lett. 2015, 17 (6), 1393-1396.

[6] A. Smith, C. Risatti, O. Atasoylu, C. Bennett, J. Liu, H. Cheng, K. TenDyke, Q. Xu, J. Am. Chem. Soc. 2011, 133 (35), 14042-14053.

[7] Z. Xin, T. Gogsig, A. Lindhardt, T. Skrydstrup, Org. Lett. 2012, 14 (1), 284-287.

[8] M. La, H.-K. Kim, Tetrahedron, 2018, 74 (24), 3748-3754.

[9] A. Nagaki, H. Kim, Y. Moriwaki, C. Matsuo, J. Yoshida, Chem. Eur. J. 2010, 16, 11167-11177.

[10] W. Guo, L.-Q. Lu, Y. Wang, Y.-N. Wang, J.-R. Chen, W.-J. Xiao, Angew. Chem. Int. Ed. 2015, 54, 2265-2269.

[11] T. Debnar, T. Wang, D. Menche, Org. Lett. 2013, 15 (11), 2774-2777.

[12] J.-W. Zeng, Y.-C. Liu, P.-A. Hsieh,Y.-T. Huang, C.-L. Yi, S. Badsara, C.-F. Lee, Green Chem. 2014, 16, 2644-2652.

[13] M. Ji, X. Wang, Y. Lim, Y.-W. Kang, H.-Y. Jang, Eur. J. Org. Chem. 2013, 35, 7881-7885

[14] E.-L. Howard, N. Guzzardi, V. Tsanova, A. Stika, B. Patel, Eur. J. Org. Chem. 2018, 6, 794-797.

[15] X.-F. Wu, M. Sharif, A. Pews-Davtyan, P. Langer, K. Ayub, M. Beller, Eur. J. Org. Chem. 2013, 14, 2783-2787.

[16] C. Digwal, U. Yadav, P. Ramya, S. Sana, B. Swain, A. Kama, J. Org. Chem. 2017, 82 (14), 7332-7345.

[17] J. Zhang, Y. Hou, Y. Ma, M. Szostak, J. Org. Chem. 2019, 84 (1), 338-345.

[18] I. Güell, X. Ribas, Eur. J. Org. Chem. 2014, 15, 3188-3195.
[19] M. Okimoto, T. Chiba, *Synthesis*, **1996**, 1188-1190.