Supporting Information

Mechanochemistry-Amended Barbier Reaction as an Expedient Alternative to Grignard Synthesis

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1. General information

All chemicals and inorganic salts were used as obtained from commercial suppliers (BLD Pharma, Sigma-Aldrich and Alfa Aesar). Tetrahydrofuran (>99.9%, Honeywell) was dried and stored over 4 Å molecular sieves. Deuterchloroform used for treatment of the crude reaction mixtures was passed through basic alumina and stored over 4 Å molecular sieves. Ammonium chloride-d₄ (98% D), deuterium oxide (99.9% D) and tetrahydrofuran-d₈ (99.5% D) were purchased from Deutero. Lithium aluminium deuteride (97% D) was purchased from Euroisotop. Thin-layer chromatography (TLC) was carried out using Merck silica gel 60 plates (F₂₅₄) and visualized with UV light (254 nm) and phosphomolybdic acid (PMA) stain. Silica gel (40–63 μm, VWR Chemicals) was used for column chromatography. ¹H NMR (400 MHz), ¹³C NMR (100.6 MHz) spectra were recorded on a Bruker Avance III spectrometer. All chemical shifts are reported in ppm units and are referenced to the residual solvent signal (CDCl₃: δ ¹H 7.26 and δ ¹³C 77.16 ppm, DMSO-d₆: δ ¹H 2.50 and δ ¹³C 39.52) or tetramethylsilane (δ ¹H 0.00 and δ ¹³C 0.00 ppm) for ¹H and ¹³C respectively. Triphenylmethane was used as an internal standard to determine yields by quantitative ¹H NMR spectroscopy. High-Resolution Mass Spectra (HRMS) data was obtained on Agilent Technologies 6540 UHD Accurate-Mass Q-TOF LC/MS system using AJS-ESI in positive ion detection mode. Thermographic images were obtained using a FLIR ONE Pro thermal camera for smartphones.

Mechanochemical experiments were carried out in a FTS-1000 shaker mill (Form-Tech Scientific) at a specified milling frequency (typically 30 Hz) by using 14 mL ZrO₂-coated milling jars with 10 mm ZrO₂ (weight ca. 3 g) milling balls (Figure S1).

Figure S1. Equipment used in this study: (a) shaker mill; (b) ZrO₂-coated milling jars and balls.
Magnesium metal was used in 3 different forms (Figure S2):

**form a:** Magnesium beads (size 3 mm, Mg beads for water treatment, >99.9% Mg)

**form b:** Magnesium powder (particle size <75µm, >99.8% Mg, produced by Carl Roth GmbH)

**form c:** Activated magnesium powder, obtained from the powder (B) as follows: a 14 mL ZrO₂-coated milling jar was loaded with non-activated Mg powder (500 mg). A single 10 mm ZrO₂ milling ball was added and the jar was set to mill at 30 Hz for 3 hours. After this procedure, the original grey non-activated metal (B) turned into a powder with a distinct metal luster (Figure S2). The obtained activated magnesium was stored in a vial under air. No considerable decay in reactivity was observed upon storage, at least for several months. The metal luster has also been preserved during this time.

![Figure S2](image)

**Figure S2.** Types of magnesium metal used in this work: (a) beads, 3 mm; (b) powder, <75µm; (c) activated powder.
2. Optimization studies

2.1 Representative experimental protocols

The optimization studies have been performed with 2-naphthaldehyde (1) and 2-acetylnaphthalene (7) as model carbonyl compounds. Representative protocols are described below. The amount of chemicals and other specific conditions are indicated in the Tables S1−S10.

Mechanochemistry: procedure A, ball milling followed by hydrolytic work-up. A 14 mL milling jar was loaded under air with a carbonyl compound (200 mg), an organic halide (1.1–1.5 equiv.), magnesium powder (2.0–5.0 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF (1.5–4.0 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aqueous solution of NH₄Cl (200 µL) was added to the jar and milling was continued for additional 20 minutes. The quenched reaction mixture was transferred with solvent (ethyl acetate) into a beaker and diluted with ethyl acetate (total volume ca. 40 mL). The solution was filtered through a celite pad, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative ¹H NMR.

Mechanochemistry: procedure B, ball milling in the presence of proton donors. A 14 mL milling jar was loaded under air with a carbonyl compound (200 mg), an organic halide (1.1–1.5 equiv.), magnesium powder (2.0–5.0 equiv.), triphenylmethane as an internal standard (ca. 30 mg), a proton donor (e.g., NH₄Cl, 1.0 equiv.), and THF (3.0–4.0 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. The crude reaction mixture was transferred with solvent (ethyl acetate) into a beaker and diluted with ethyl acetate (total volume ca. 40 mL). The solution was filtered through a celite pad, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative ¹H NMR.

Reaction in a slurry: procedure C. A 10 mL round-bottom flask equipped with a magnetic stirrer was loaded under air with a carbonyl compound (200 mg), an organic halide (1.1–1.2 equiv.), magnesium powder (2.0 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF (3.0–4.0 equiv.). The flask was closed with a septum cap and stirred. Approximately after a 10–15 min induction delay, an exothermic reaction started and formed a sticky solid reaction mixture that forcefully stopped stirring. After 60 min, the reaction mixture was quenched with saturated aqueous solution of NH₄Cl (10 mL) and was extracted with ethyl acetate (2×20 mL). The combined organic layers were dried over Na₂SO₄, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative ¹H NMR.

Solution: procedure D. Magnesium powder (2.0 equiv.) and triphenylmethane (ca. 30 mg, an internal standard) were placed in a dry, argon-flushed 10 mL round-bottom flask equipped with a magnetic stirrer. Then, anhydrous THF (1 mL), an organic halide (1.1–1.2 equiv.) and a solution of a carbonyl compound (200 mg in 1 mL THF) were added at stirring under inert atmosphere (argon). Approximately after 15–20 min, an exothermic reaction was observed and continued stirring for 2 hours at room temperature. Then reaction was quenched with saturated aqueous solution of NH₄Cl (10 mL) and extracted with ethyl acetate (2×20 mL). The combined organic layers were dried over Na₂SO₄, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative ¹H NMR.
2.2 The Barbier-Grignard reaction of 2-naphthaldehyde with 1,2,3-trichloropropane (TCP)

Scheme S1. Remediation of 1,2,3-trichloropropane (TCP) via the Barbier-Grignard reaction in solution and under ball milling conditions. Yields are determined by $^1$H NMR with internal standard after the hydrolytic workup (aq. NH$_4$Cl).

**Mechanochemistry:** The reaction was performed in accordance with procedure A, with 1 (200 mg, 1.28 mmol), TCP (207 mg, 1.40 mmol, 1.1 equiv.), Mg powder (type B, 62 mg, 2.59 mmol, 2 equiv.) and THF (310 μL, 3 equiv.). Preliminary screening of liquid-assisted grinding additives (THF, 2-MeTHF, CPME, TBME, DMSO, water) revealed THF and 2-MeTHF as the superior solvents.

**Solution:** The reaction was performed in accordance with procedure D, with 1 (200 mg, 1.28 mmol), TCP (207 mg, 1.40 mmol, 1.1 equiv.), Mg powder (type B, 62 mg, 2.59 mmol, 2 equiv.), THF (ca. 2 mL).

Yields were determined by $^1$H NMR in DMSO-$_d_6$ using triphenylmethane as an internal standard. Characteristic signals of CH$_2$OH of 2-naphthalenemethanol (3) at δ 4.68 (d, $J = 5.66$ Hz, 2H), and pinacols (4, mixture of dl- and meso-stereoisomers) at δ 4.92 (meso-CHOH, m, 2H), 4.86 (dl-CHOH, m, 2H) were identified as major side products. A characteristic region of $^1$H NMR spectrum is shown below (Fig. S3).
Figure S3. A characteristic region of $^1$H NMR (DMSO-d$_6$) spectrum of the crude reaction mixture containing alcohol 2a and the reduction side-products 3 and 4 (obtained in THF solution, procedure D).
2.3 The Barbier-Grignard reaction of 2-naphthaldehyde with allyl chloride

[Chemical structures and reaction scheme]

**Scheme S2.** Summary of the optimization studies showing the main influencers on yield of 2a.

**Table S1.** Effect of magnesium source, THF loadings and solid proton-donating additives.

<table>
<thead>
<tr>
<th>Entry</th>
<th>Allyl-Cl (equiv.)</th>
<th>Magnesium, (form, equiv.)</th>
<th>THF (equiv.)</th>
<th>Additive</th>
<th>Yields, b %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1a</td>
</tr>
<tr>
<td>1</td>
<td>1.0</td>
<td>powder (b, 2 equiv.)</td>
<td>0</td>
<td>–</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>powder (b, 2 equiv.)</td>
<td>1.5</td>
<td>–</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>1.0</td>
<td>powder (b, 5 equiv.)</td>
<td>1.8</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>powder (b, 2 equiv.)</td>
<td>3.0</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>1.2</td>
<td>activated powder (c, 2 equiv.)</td>
<td>3.0</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>1.2</td>
<td>beads (a, 2 equiv.)</td>
<td>3.0</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1.2</td>
<td>beads (a, 30 equiv.)</td>
<td>3.0</td>
<td>–</td>
<td>0.8</td>
</tr>
<tr>
<td>8d</td>
<td>1.2</td>
<td>powder (b, 2 equiv.)</td>
<td>3.0</td>
<td>NH4Cl</td>
<td>4</td>
</tr>
<tr>
<td>9d</td>
<td>1.2</td>
<td>powder (b, 2 equiv.)</td>
<td>3.0</td>
<td>K2HPO4</td>
<td>0</td>
</tr>
</tbody>
</table>
All the reactions were performed in accordance with the procedure A unless stated otherwise.

b Yields were determined by $^1$H NMR in CDCl$_3$ using triphenylmethane as an internal standard (signals of CHOH proton of homoallylic alcohol 2a at $\delta$ 4.92 ppm and CH$_2$OH protons of 3 at $\delta$ 4.84 ppm were integrated).

c Yield of unreacted aldehyde 1.

d The reactions were performed in accordance with procedure B.

**Table S2.** Effect of milling frequency.

<table>
<thead>
<tr>
<th>Entry</th>
<th>Frequency (Hz)</th>
<th>Yields, a %</th>
<th>Ratio 2/3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$^{1}b$ 2a</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>0$^c$</td>
<td>0</td>
<td>66</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>0.7</td>
<td>78</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>0</td>
<td>96</td>
</tr>
</tbody>
</table>

All the reactions were performed in accordance with the procedure A unless stated otherwise.

a Yields were determined by $^1$H NMR in CDCl$_3$ using triphenylmethane as an internal standard.

b Yield of unreacted aldehyde 1.

c Slurry stirring experiment (procedure C).

**Table S3.** Ex-situ monitoring of the reaction kinetics: yield of 2a vs time, and effect of the milling frequency.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 min</td>
</tr>
<tr>
<td>0$^a$</td>
<td>33</td>
</tr>
<tr>
<td>15</td>
<td>75</td>
</tr>
<tr>
<td>30</td>
<td>93</td>
</tr>
</tbody>
</table>

All the reactions were performed in accordance with the procedure A unless stated otherwise. The reaction mixtures were milled for indicated time, quenched and the yields were determined by $^1$H NMR in CDCl$_3$ using triphenylmethane as an internal standard.

a reaction in a slurry (procedure C).
Thermography measurement of temperature inside the milling jars. The reaction was performed according to general procedure A, with 1 (200 mg, 1.28 mmol), allylchloride (1.2 equiv.), magnesium powder (form b, 2 equiv.), THF (300 µL, ca. 3 equiv.). The mixture of chemicals was milled for 10 min at 30 Hz, and for 20 min at another experiment. The temperature outside of the milling jars was monitored during the milling with an aid of a FLIR ONE Pro thermal camera and did not show any significant temperature increase. Temperature inside of the milling jars was determined immediately after opening the jars (Figures S4) and did not exceed 29 °C in both cases (10 and 20 min).

![Thermography Measurements](image)

**Figure S4.** Thermography measurements of temperature inside the milling jars immediately after milling for 10 min (left image) and 20 min (right image).

### 2.4 The Barbier-Grignard reaction of 2-naphthaldehyde with ethyl bromide

**Table S4.** Effect of activated magnesium powder in the reactions with EtBr.

<table>
<thead>
<tr>
<th>Entry</th>
<th>type of Mg powder (pre-milling time)</th>
<th>Yields,(^a) %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1(^b)</td>
</tr>
<tr>
<td>1</td>
<td>powder (form b, 0 min)</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>activated powder (pre-milled 90 min)</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>activated powder (c, pre-milled 180 min)</td>
<td>0</td>
</tr>
</tbody>
</table>

All the reactions were performed in accordance with the procedure A.

\(^a\) Yields were determined by \(^1^H\) NMR in CDCl\(_3\) using triphenylmethane as an internal standard (signals of \(\text{CH}_2\text{OH}\) proton of alcohol 2b at \(\delta 4.77\) ppm, \(\text{CH}_2\text{OH}\) protons of 3 at \(\delta 4.84\) ppm, \(\text{CH}_2\text{CH}_3\) protons of 5b at 3.12 ppm, and \(\text{CH}_2\text{CH}_3\) of 27 at 0.76 ppm were integrated).

\(^b\) Yield of unreacted aldehyde 1.
2.5 The Barbier-Grignard reactions of other organic halides

Table S5. The Barbier-Grignard reactions of other halides. Effect of halide, organic radical and additional optimization studies.

![Reaction Scheme](image)

<table>
<thead>
<tr>
<th>Entry</th>
<th>R–X</th>
<th>Mg (form, equiv.)</th>
<th>Yields, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R =</td>
<td></td>
<td>addition</td>
</tr>
<tr>
<td>1</td>
<td>Ph</td>
<td>Cl</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Br</td>
<td>b, 2 equiv.</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>Br</td>
<td>c, 2 equiv.</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>I</td>
<td>b, 2 equiv.</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>PhCH₂</td>
<td>Br</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>n-Bu</td>
<td>Br</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Cl</td>
<td>c, 2 equiv.</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>PhCH₂CH₂</td>
<td>Br</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>c-C₆H₁₁</td>
<td>Br</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Br</td>
<td>c, 6 equiv.</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Br</td>
<td>c, 12 equiv.</td>
<td>1</td>
</tr>
</tbody>
</table>

All the reactions were performed in accordance with the procedure A.

a Yields were determined by ¹H NMR in CDCl₃ using triphenylmethane as an internal standard.

b Yield of unreacted aldehyde 1.
Table S6. Comparison of the Barbier-Grignard reactions performed by ball milling, in a slurry and in THF solution.

![Diagram of Barbier-Grignard reaction]

<table>
<thead>
<tr>
<th>Entry</th>
<th>R–X</th>
<th>Ball milling&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Solution&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Slurry&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>allyl (2a), Et (2b), Ph (2c), PhCH&lt;sub&gt;2&lt;/sub&gt;CH&lt;sub&gt;2&lt;/sub&gt; (2d), c-C&lt;sub&gt;8&lt;/sub&gt;H&lt;sub&gt;11&lt;/sub&gt; (2l)</td>
<td>&gt;98 : 1</td>
<td>73 : 11</td>
<td>66 : 12</td>
</tr>
<tr>
<td>2</td>
<td>94 : 2</td>
<td>72 : 11</td>
<td>56 : 20</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>92 : 3</td>
<td>57 : 20</td>
<td>not performed</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>88 : 7</td>
<td>52 : 17</td>
<td>53 : 22&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;f&lt;/sup&gt;</td>
<td>50 : 17&lt;sup&gt;f&lt;/sup&gt;</td>
<td>not performed</td>
<td>30 : 30&lt;sup&gt;f&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Yields were determined by <sup>1</sup>H NMR in CDCl<sub>3</sub> using triphenylmethane as an internal standard.

<sup>b</sup> The reactions were performed in accordance with procedure A: 1 (200 mg, 1.28 mmol), RX (1.1 equiv.), activated Mg powder (form c, 63 mg, 2.59 mmol, 2 equiv.), THF (310 µL, ca. 3 equiv.).

<sup>c</sup> The reactions were performed in accordance with procedure D: 1 (200 mg, 1.28 mmol), RX (1.1 equiv.), activated Mg powder (form c, 63 mg, 2.59 mmol, 2 equiv.), THF (2 mL).

<sup>d</sup> The reactions were performed in accordance with procedure C: 1 (200 mg, 1.28 mmol), RX (1.1 equiv.), activated Mg powder (form c, 63 mg, 2.59 mmol, 2 equiv.), THF (310 µL, ca. 3 equiv.).

<sup>e</sup> Mg powder was additionally activated with 1,2-dibromoethane (ca. 20 µL) to initiate the reaction.

<sup>f</sup> The reactions were performed with 12 equiv. of Mg.
2.6 Addition of Grignard reagents to 2-naphthaldehyde in THF solution

2.6.1 Reaction of allylmagnesium chloride with 2-naphthaldehyde.

A solution of 1 (270 mg, 1.8 mmol) in THF (3 mL) was added dropwise to a solution of allylMgCl (1 mL, 2 mmol, 2 M in THF) at stirring and cooling with an ice bath. The reaction mixture was stirred for 30 minutes and hydrolyzed with saturated aqueous solution of NH₄Cl (10 mL) followed by extraction with ethyl acetate (2×10 mL). The combined organic layers were dried over Na₂SO₄, filtered and concentrated under reduced pressure. The residue was analyzed by ¹H NMR, showing the formation of secondary alcohol 2a (98%).

2.6.2 Reaction of ethylmagnesium bromide with 2-naphthaldehyde.

(a) Preparation of ethylmagnesium bromide. A solution of EtMgBr (1.05 M) in THF was prepared in a 25 mL Schlenk tube under argon (Schlenk line) by portion-wise addition of EtBr (0.57 g, 5 mmol) in THF (2 mL) to Mg turnings (122 mg, 5 mmol) in THF (2 mL) at stirring. The concentration of EtMgBr in solution was determined by Knochel method.[¹]

(b) Reaction of EtMgBr with 2-naphthaldehyde. A solution of 1 (422 mg, 2.7 mmol) in THF (3 mL) was added dropwise to a solution of EtMgBr (2.7 mL, 2.8 mmol, 1.05 M in THF) at stirring and cooling with an ice bath. The reaction mixture was stirred for 30 minutes and hydrolyzed with saturated aqueous solution of NH₄Cl (10 mL) followed by extraction with ethyl acetate (2×10 mL). The combined organic layers were dried over Na₂SO₄, filtered and concentrated under reduced pressure. The residue was analyzed by ¹H NMR, showing the formation of secondary alcohol 2b (96%) along with by-products 3 (3%) and 5b (0.5%).

2.6.3 Reaction of phenethyl bromide with 2-naphthaldehyde.

(a) Preparation of 2-phenylethylmagnesium bromide. A solution of 2-phenylethylmagnesium bromide in THF was prepared in a 25 mL Schlenk tube under argon (Schlenk line) by portion-wise addition of 2-phenylethyl bromide (2.23 g, 12 mmol) in THF (6 mL) to Mg turnings (0.32 g, 13 mmol) in THF (4 mL) at stirring. The concentration of the Grignard reagent (0.85 M) was determined by Knochel method.[¹]
(b) Reaction of PhCH$_2$CH$_2$MgBr with 2-naphthaldehyde. A solution of I (1.24 g, 7.9 mmol) in THF (7 mL) was added dropwise to a solution of 2-phenylethylmagnesium bromide (9.5 mL, 8.1 mmol, 0.85 M in THF) at stirring and cooling with an ice bath. The reaction mixture was stirred for 1.5 hours at room temperature and hydrolyzed with saturated aqueous solution of NH$_4$Cl (50 mL) followed by extraction with ethyl acetate (3×30 mL). The combined organic layers were dried (Na$_2$SO$_4$), filtered and concentrated under reduced pressure. The residue was analyzed by quantitative $^1$H NMR with triphenylmethane as internal standard. Further purification by silica gel column chromatography (4% EtOAc in petroleum ether) afforded alcohol 2d as pale-yellow oil (1.9 g, 90% yield based on aldehyde I).

2.6.4 Reaction of cyclohexylmagnesium bromide with 2-naphthaldehyde.

(a) Preparation of cyclohexylmagnesium bromide. A solution of c-C$_6$H$_{11}$MgBr (0.66 M) in THF was prepared in a 25 mL Schlenk tube under argon (Schlenk line) by portion-wise addition of bromocyclohexane (0.814 g, 5 mmol) in THF (2 mL) to Mg turnings (122 mg, 5 mmol) in THF (2 mL) at stirring. The concentration of c-C$_6$H$_{11}$MgBr in solution was determined by Knochel method.[1]

(b) Reaction of cyclohexylmagnesium bromide with 2-naphthaldehyde. A solution of c-C$_6$H$_{11}$MgBr (1.6 mL, 1.1 mmol, 0.66 M in THF) was added dropwise at room temperature to a stirred solution of I (156 mg, 1 mmol) and triphenylmethane (26.2 mg, internal standard) in THF (1.5 mL). The reaction mixture was stirred for 2 h and hydrolyzed with saturated aqueous solution of NH$_4$Cl (5 mL) followed by extraction with ethyl acetate (2×10 mL). The combined organic layers were dried over Na$_2$SO$_4$, filtered and concentrated under reduced pressure. The residue was analyzed by $^1$H NMR, showing the formation of secondary alcohol 2i (50%) along with reduction by-product 3 (27%). The latter is formed in significant amount due to highly pronounced β-hydride transfer from the secondary Grignard reagent (a typical side-reaction of Grignard synthesis).
2.7 Competition experiments

A 14 mL milling jar was loaded with 1 (200 mg, 1.28 mmol), organic halide I (0.64 mmol, 0.5 equiv.), organic halide II (0.64 mmol, 0.5 equiv.), magnesium powder (type B, 62 mg, 2.6 mmol, 2 equiv.), triphenylmethane (15.6 mg, internal standard) and THF (310 µL, 3.84 mmol, 3 equiv.). A single milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Saturated aq. NH₄Cl (2 mL) was added to the resulting crude reaction mixture followed by extraction of aqueous layer with CDCl₃ (2×1 mL). The obtained CDCl₃ solution was washed with water (1–1.5 mL), dried (Na₂SO₄) and analyzed by quantitative ¹H NMR.

NB! The competition experiments have been performed with 1:1:1 initial ratio of the starting materials at deficiency of aldehyde 1. Therefore, only approximate relative reaction rates can be derived from the ratios of products. The reaction rate of the less reactive bromide in a pair is exaggerated due to concentration factor, caused by faster consumption of more reactive bromide. Order of reactivity: Allyl-Br > EtBr > PhBr > PhCH₂CH₂Br.

Allyl bromide vs 2-phenylethyl bromide.

Allyl bromide vs phenyl bromide.

Phenyl bromide vs 2-phenylethyl bromide.

Phenyl bromide vs ethyl bromide.
2.8 The Barbier-Grignard reactions of 2-acetylnaphthalene

Scheme S3. The mechanochemical Barbier-Grignard reaction of allyl chloride with 2-acetylnaphthalene. Suppression of the enolization side process by quenching of alkoxide 6a-Mg with solid ammonium chloride.

Table S7. Selected optimization experiments for the Barbier-Grignard reaction of 2-acetylnaphthalene (7) with allyl halides.

<table>
<thead>
<tr>
<th>Entry</th>
<th>allyl halide (equiv.)</th>
<th>Magnesium powder (equiv.)</th>
<th>THF (equiv.)</th>
<th>Additive (equiv.)</th>
<th>Yield, a %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7c</td>
</tr>
<tr>
<td>1</td>
<td>1.0</td>
<td>2.0</td>
<td>1.5</td>
<td>–</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
<td>5.0</td>
<td>2.0</td>
<td>–</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>1.1</td>
<td>5.0</td>
<td>4.0</td>
<td>MgCl₂ (1.0)</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>1.5</td>
<td>2.0</td>
<td>3.0</td>
<td>NH₄Cl (1.0)</td>
<td>~2</td>
</tr>
<tr>
<td>6</td>
<td>1.5c</td>
<td>2.0</td>
<td>3.0</td>
<td>NH₄Cl (1.0)</td>
<td>~2</td>
</tr>
</tbody>
</table>

The reactions in Entries 1–5 were performed in accordance with the procedure A. The reactions in Entries 6 and 7 were performed in accordance with the procedure B. Allyl chloride was used as an allylation reagent unless stated otherwise.

a Yields were determined by ¹H NMR in CDCl₃ using triphenylmethane as an internal standard (signals of CH₃ protons of alcohol 6a at δ 1.65 ppm, CH₃ protons of 8 at δ 1.76 ppm, were integrated).

b Non-activated powder (form b).

c Yield of unreacted ketone 7.

d Pinacol coupling of 7 was also observed as side process (3% yield).

e Allyl bromide was used instead of allyl chloride.
**Table S8.** The Barbier-Grignard reactions of ketone 7 with other halides and additional optimization studies.

![Chemical structure of compounds](image)

<table>
<thead>
<tr>
<th>Entry</th>
<th>R–X</th>
<th>additive, form of Mg</th>
<th>Yields,(^{a}) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7b</td>
</tr>
<tr>
<td>1</td>
<td>EtBr</td>
<td>no additive, Mg (form b)</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>no additive, Mg (form c)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NH(_4)Cl, Mg (form b)</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NH(_4)Cl, Mg (form c)</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>PhBr</td>
<td>no additive, Mg (form b)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NH(_4)Cl, Mg (form b)</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>PhCH(_2)CH(_2)Br</td>
<td>no additive, Mg (form b)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NH(_4)Cl, Mg (form b)</td>
<td>13</td>
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<tr>
<td>4</td>
<td>PhCH(_3)Br</td>
<td>no additive, Mg (form b)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NH(_4)Cl, Mg (form b)</td>
<td>2</td>
</tr>
</tbody>
</table>

All the reactions without additive were performed in accordance with the procedure A and the reactions with NH\(_4\)Cl were performed in accordance with the procedure B.

\(^{a}\) Yields were determined by \(^1\)H NMR in CDCl\(_3\) using triphenylmethane as an internal standard.

\(^{b}\) Yield of unreacted ketone 7.

Although no significant difference was observed for the reactions with non-activated and activated Mg (Entry 1), the activated metal was used in the preparative runs (section 5) because of its generally better reactivity profile.
3. Tolerance of the mechanochemical Barbier-Grignard reaction to proton sources

3.1 The Barbier-Grignard reaction of 2-naphthaldehyde with 2-phenylethyl bromide in the presence of various proton sources

A 14 mL milling jar was loaded under air with 1 (200 mg, 1.28 mmol), 2-phenylethyl bromide (237 mg, 1.28 mmol, 1 equiv.), magnesium powder (form b, 62 mg, 2.56 mmol, 2 equiv.), triphenylmethane (ca. 30 mg, internal standard), a proton source (1.28 mmol, 1 equiv.) and THF (310 µL, 3.84 mmol, 3 equiv.). A single 10 mm ZrO₂ ball (weight ca. 3 g) was added, and the mixture of reactants was milled at 30 Hz for 60 min. To the resulting crude reaction mixture acid-free anhydrous CDCl₃ (1 mL) was added. An aliquot (ca. 200 µL) was taken and diluted with acid-free anhydrous CDCl₃ (0.6 mL), filtered through a celite pad and subjected to ¹H NMR analysis (see Table S9). ¹H NMR analysis of the samples obtained by aqueous work-up (std. NH₄Cl) of the remained reaction mixture showed a very similar outcome.

Table S9. Comparison of protonating efficacy of different proton sources.

<table>
<thead>
<tr>
<th>Entry</th>
<th>H⁺ source</th>
<th>pKₐᵇ</th>
<th>Yields, %</th>
<th>2d</th>
<th>9</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–</td>
<td>–</td>
<td>88ᶜ</td>
<td>8</td>
<td>0</td>
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<td>7</td>
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<td>2</td>
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<td>10.5</td>
<td>50</td>
<td>39</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>H₂O</td>
<td>31.4</td>
<td>46</td>
<td>28</td>
<td>0</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>phenol</td>
<td>18.0</td>
<td>0</td>
<td>traces</td>
<td>&gt;95ᵈ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>i-PrOH</td>
<td>30.3</td>
<td>0</td>
<td>traces</td>
<td>~12ᵈ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>MeNH₂·HCl</td>
<td>11.0</td>
<td>41</td>
<td>39</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Me₂NH·HCl</td>
<td>10.3</td>
<td>51</td>
<td>38</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Me₃N·HCl</td>
<td>8.4</td>
<td>68</td>
<td>23</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>benzidine·2HCl (0.5 equiv.)</td>
<td>~3.8ᶜ</td>
<td>43</td>
<td>41</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>K₂HPO₄</td>
<td>no data</td>
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<td>7</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>carbazole</td>
<td>19.9</td>
<td>44</td>
<td>50</td>
<td>34</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>benzamide</td>
<td>23.3</td>
<td>36</td>
<td>47</td>
<td>43</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

ᵃ Yields were determined by ¹H NMR with triphenylmethane as an internal standard.
ᵇ pKₐ values in DMSO.[²,³]
ᶜ After aqueous work-up (aq. NH₄Cl).
ᵈ Starting bromide remained unreacted.
ᵉ Estimation based on pKₐ value of PhNH₃⁺.
3.2 The Barbier-Grignard reaction of 2-naphthaldehyde with other halides in the presence of NH₄Cl and H₂O

![Chemical structure and reaction scheme]

A 14 mL milling jar was loaded under air with 1 (200 mg, 1.28 mmol), organic halide (1.28 mmol, 1.0 equiv.), magnesium powder (form b, 62 mg, 2.56 mmol, 2 equiv.), triphenylmethane (ca. 30 mg, internal standard), a proton source (1.28 mmol, 1 equiv.) and THF (310 µL, 3.84 mmol, 3 equiv.). A single 10 mm ZrO₂ ball (weight ca. 3 g) was added, and the mixture of reactants was milled at 30 Hz for 60 min. Saturated aq. NH₄Cl (2 mL) was added to the resulting crude reaction mixture followed by extraction of aqueous layer with CDCl₃ (2×1 mL). The obtained CDCl₃ solution was washed with water (1–1.5 mL), dried (Na₂SO₄) and analyzed by quantitative ¹H NMR.

**Table S10.** The Barbier-Grignard reaction of 1 with other organic halides in the presence of NH₄Cl and H₂O.

<table>
<thead>
<tr>
<th>Entry</th>
<th>R-Br</th>
<th>H⁺ source</th>
<th>Yields, %</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1ᵇ</td>
<td>2a-2c</td>
</tr>
<tr>
<td>1</td>
<td>Br</td>
<td>NH₄Cl</td>
<td>22</td>
<td>62</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>H₂O</td>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>6</td>
<td>EtBr</td>
<td>NH₄Cl</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>H₂O</td>
<td>2</td>
<td>61</td>
</tr>
<tr>
<td>9</td>
<td>PhBr</td>
<td>NH₄Cl</td>
<td>6</td>
<td>53</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>H₂O</td>
<td>2</td>
<td>46</td>
</tr>
</tbody>
</table>

ᵃ Yields were determined by ¹H NMR in CDCl₃ using triphenylmethane as an internal standard.
ᵇ Yield of unreacted aldehyde 1.

By contrast, no proton transfer to Mg alkoxide 2a-Mg from NH₄Cl was observed for the allylation reaction in THF solution. This result highlights the importance of mechanochemical activation in revealing the reactivity of solid NH₄Cl. Upon treatment with ethyl acetate, magnesium alkoxide 2a-Mg afforded the corresponding acetate ester 2a-Ac:

![Chemical structure and reaction scheme]

Mg powder (form b, 62 mg, 2.56 mmol, 2 equiv.) and triphenylmethane (30 mg, internal standard) were placed in a dry, argon-flushed 10 mL round-bottom flask equipped with a magnetic stirrer. Then, anhydrous THF (1 mL), allyl chloride (117 mg, 1.52 mmol, 1.2 equiv.), a solution of 1 (200 mg in 1 mL THF), and solid NH₄Cl (68 mg, 1.27 mmol, 1 equiv.) were added at stirring under inert atmosphere (argon). The reaction mixture was stirred for 2 hours at room temperature. Two different work-up protocols were applied:
(a) The crude reaction mixture was transferred with solvent (ethyl acetate) into a beaker and treated with ethyl acetate (total volume ca. 30 mL). The solution was filtered through a celite pad, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative $^1$H NMR, showing the formation of 2a-Ac (42%) and 3 (5%) as the main by-product. 1-(Naphthalen-2-yl)but-3-en-1-yl acetate (2a-Ac), characteristic signals in $^1$H NMR (400 MHz, CDCl$_3$): δ 5.98 (dd, $J = 6.4$ Hz, 1H, benzylic CH), 2.10 (s, 3H, CH$_3$). $^{13}$C NMR (100.6 MHz, CDCl$_3$): δ 75.4 (benzylic CH), δ 21.4 (CH$_3$).[4]

(b) The crude reaction mixture was quenched with saturated aqueous solution of NH$_4$Cl (10 mL) and extracted with ethyl acetate (2×20 mL). The combined organic layers were dried over Na$_2$SO$_4$, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative $^1$H NMR, showing the formation of 2a (48%) and 3 (7%) as the main by-product.
4. Mechanistic studies

4.1 Trapping of organomagnesium intermediate in a deuterium quenching experiment

A 14 mL milling jar was loaded under air with 1 (200 mg, 1.28 mmol), 2-phenylethyl bromide (237 mg, 1.28 mmol), magnesium powder (form b, 62 mg, 2.56 mmol, 2 equiv.), triphenylmethane (31.3 mg, internal standard), ND₄Cl (74 mg, 1.28 mmol, 1 equiv.) and THF (310 µL, 3.84 mmol, 3 equiv.). A single 10 mm ZrO₂ milling ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes.

Two different work-up protocols were applied:

(a) Acid-free and anhydrous CDCl₃ (2 mL) was added to the resulting crude reaction mixture and a 200 µL aliquot was sampled. The aliquot was diluted with CDCl₃ (0.8 mL) and filtered through a pad of celite. The resulting solution was analyzed by quantitative ¹H NMR to determine the 40% yield of deuterated ethylbenzene.

(b) Pentane (ca. 10 mL) was added to the crude reaction mixture followed by filtration through a pad of celite. After evaporation of the solvent, the residue was analyzed by ¹H and ¹³C NMR. Incorporation of deuterium was determined as 90% (see Figures S5 and S6).

(Ethyl-2-d)benzene (9-d), characteristic signals in ¹H NMR (400 MHz, CDCl₃): δ 2.64 (t, J = 7.5 Hz, 2H, CH₃CH₂D), 1.22 (tt, J_HH = 7.5 Hz, J_HD = 1.9 Hz, 2H, CH₂CH₂D). ¹³C NMR (100.6 MHz, CDCl₃): δ 28.94 (CH₂-CH₂D), 15.46 (t, J_CD = 19.4 Hz, CH₂-CH₂D).

Ethylbenzene (9), characteristic signals in ¹H NMR (400 MHz, CDCl₃): δ 2.64 (q, J = 7.5 Hz, 2H, CH₂CH₃), 1.23 (t, J = 7.5 Hz, 3H, CH₂CH₃). ¹³C NMR (100.6 MHz, CDCl₃) δ 29.02 (CH₂), 15.76 (CH₃).

The deuterium quenching reaction in the absence of 2-naphthaldehyde:

A 14 mL milling jar was loaded under air with 2-phenylethyl bromide (237 mg, 1.28 mmol), magnesium powder (form b, 62 mg, 2.56 mmol, 2 equiv.), ND₄Cl (74 mg, 1.28 mmol, 1 equiv.), triphenylmethane (31.3 mg, internal standard) and THF (310 µL, 3.84 mmol, 3 equiv.). A single 10 mm ZrO₂ milling ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes. D₂O (100 µL) was added to the formed reaction mixture, and the jar was milled at 30 Hz for additional 30 minutes. The resulting crude reaction mixture was diluted with CDCl₃ (3 mL), filtered through a pad of celite and analyzed by ¹H NMR. The yields of products are shown in the reaction Scheme above.
Figure S5. $^1$H NMR spectrum of the crude (ethyl-2-$d$)benzene (9-$d$).

Figure S6. $^{13}$C NMR spectrum of the crude (ethyl-2-$d$)benzene (9-$d$).
4.2 Mechanism of Side Products Formation

4.2.1 Preparation of 2-naphthalenecarboxaldehyde-d (1-d)

The title compound was prepared by following the known method.\[5\] N-(methoxy)methylammonium chloride (0.90 g, 9.2 mmol), DMAP (0.112 g, 0.92 mmol, 0.1 equiv.), dichloromethane (20 mL), triethylamine (3.0 mL, 22 mmol, 2.1 equiv.) and 2-naphthoyl chloride (1.7 g, 9.2 mmol, 1 equiv.) were added sequentially to a 250 mL round bottom flask. The solution was stirred for 20 min and then the solvent was evaporated under reduced pressure. EtOAc was added and the solution was washed twice with saturated aqueous NH₄Cl and aqueous NaHCO₃ solutions. The organic layer was dried over Na₂SO₄, filtered and evaporated under reduced pressure to give a Weinreb amide intermediate as a clear light-yellow oil (1.4 g, 75% yield) which was used without further purification. The obtained Weinreb amide (1.0 g, 4.6 mmol) was transferred to another round bottom flask and dissolved in THF (25 mL). The flask was cooled with an ice bath and then LiAlD₄ (214 mg, 5.09 mmol, 97% D) was added portion-wise. After 15 minutes, the reaction was quenched slowly by adding water (20 mL) and then 20% aq. NaOH (20 mL) in an ice bath. Then, the reaction mixture was allowed to room temperature and extracted with EtOAc (2×20 mL), the organic layer was evaporated under reduced pressure. The title compound was isolated by silica gel column chromatography (5% EtOAc/petroleum ether). White solid (620 mg, 85% yield, ca. 96% D). \(^1\)H NMR (400 MHz, CDCl₃) δ 10.15 (s, 0.04H, the residual CHO), 8.34 (s, 1H), 8.03–7.87 (m, 4H), 7.68–7.55 (m, 2H). \(^1\)C NMR (100 MHz, CDCl₃) δ 192.1 (t, \(J_{CD} = 27\) Hz), 136.5, 134.6, 134.2 (t, \(J_{CD} = 3\) Hz), 132.8, 129.7, 129.2, 129.2, 128.2, 127.2, 127.2, 129.9. Spectral data are in agreement with previously reported.\[5\]

4.2.2 Elucidation of mechanism of formation of 2-naphthalenemethanol (3) by-product

**Mechanistic hypotheses:**

1. **Bouveault–Blanc-type reduction**
   
   \[ \text{ArH} + 2e^- \rightarrow \text{ArOMgBr} \rightarrow \text{ArOH} \]

2. **SET**
   
   \[ \text{ArH} + e^- \rightarrow \text{ArOMgBr} \rightarrow \text{ArH} \]

3. **H-donor**
   
   \[ \text{ArOMgBr} \rightarrow \text{ArCHO} \]

4. **β-H reduction**
   
   \[ \text{ArCHO} \rightarrow \text{ArMgBr} \]

5. **MPV reduction**
   
   \[ \text{ArOMgBr} \rightarrow \text{ArCHO} \]

**Scheme S4.** Mechanistic hypotheses explaining the formation of the side products 3 and 5b.

Five mechanistic hypotheses (eqs. I–V) explaining the generation of the main side products 3 and 5b were proposed based on literature precedents. The formation of ethyl ketone 5b alongside with alcohol 3 pointed out on Meerwein-Ponndorf-Verley (MPV) reaction of alkoxide 2a-Mg and aldehyde 1 as the most probable mechanism (eq. V). The following alternative pathways en route to 3 have been also considered: (eq. I), Bouveault-Blanc-type reduction of 1 with metallic Mg\[^6\]; (eq. II), hydrogen atom transfer (HAT) from THF or 1.
to the ketyl radical anion \( A \) or (eq. III) via addition of transient magnesium hydride \( B \)\(^7\) to the carbonyl group of \( 1 \); (eq. IV), \( \beta \)-hydride transfer from ethyl Grignard reagent.

The pathways shown in eq. I–V were distinguished experimentally by tracking the origin of \( \alpha \)-hydrogen in alcohol \( 3 \) by means of deuterium-labelled reagents:

**Scheme S5.** Elucidation of mechanistic pathways accounting for generation of side products \( 3 \) and \( 5b \) in the Barbier-Grignard reaction of EtBr with 2-naphthaldehyde (I). Standard conditions: \( 1 \) (200 mg, 1.28 mmol), EtBr (1.1 equiv.), Mg powder (form b, 2 equiv.), THF (3 equiv.), 30 Hz, 1 h followed by quenching (H\( _2 \)O or D\( _2 \)O) and hydrolytic workup (aq. NH\( _4 \)Cl). Yields are determined by \(^1\)H NMR with internal standard.

First, no deuterium incorporation into \( 3 \) was noted when the reaction was quenched with D\( _2 \)O (eq. a), performed with THF-d\(_8\) (eq. b) or with EtBr-d\(_5\) (eq. c). These results allow to exclude the operation of the pathways (I) and (IV) or HAT from THF in the pathways (II) and (III). The absence of pinacols 4 among the by-products additionally indicated that the ketyl radical-anion \( A \) were unlikely generated. Second, the reaction of deuterated aldehyde \( 1-d \) produced double deuterated alcohol \( 3-d_2 \) hence evidencing that \( \alpha \)-hydrogens of \( 3 \) originate from the aldehyde hydrogen of \( 1 \) (eq. d). This result pointed out on operation of either HAT from aldehyde \( 1 \) (pathways II and III) or MPV reaction (V). The last option stays in better agreement with the observed by-products and explains the origin of \( 5b \). In support, the MPV reaction of solid alkoxide \( 2a-Mg \) and aldehyde \( 1 \) was attempted and indeed occurred in a control experiment (eq. e). The same reaction also occurred in THF solution. Mechanochemical reduction of \( 1 \) with Mg powder was also tested (eq. f) but delivered Tischenko-type ester SI-2 as major product (29% yield) along with low 6% yield of \( 3 \). While the reduction could be an addition source of \( 3 \), the accompanying ester SI-2 has not been observed among the by-products under the “standard” reaction conditions. Overall, the results of the mechanistic experiments suggest the MPV reaction of Mg alkoxides \( 2-Mg \) with aldehyde \( 1 \) as the
dominant pathway responsible for generation of by-products in the Barbier-Grignard reactions of aldehydes, which operate in the case of EtBr and likewise for similar halides.

Experimental protocols for the mechanistic experiments are described below.

(a) \( \text{D}_2\text{O quenching of the reaction mixture:} \)

A 14 mL milling jar was loaded under air with 1 (200 mg, 1.28 mmol), bromoethane (153 mg, 1.4 mmol, 1.1 equiv.), Mg powder (form b, 62 mg, 2.56 mmol, ca. 2 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF (310 \( \mu \)L, ca. 3 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then, \( \text{D}_2\text{O} \) (150 \( \mu \)L, 8 mmol) was added and the reaction mixture was milled for additional 20 min. Saturated aq. NH\(_4\)Cl (10 mL) was added and extracted with ethyl acetate (20 mL). The organic layer was dried over Na\(_2\)SO\(_4\), and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative \(^1\text{H} \) NMR, showing the formation of secondary alcohol \( 2\text{b} \) (72\% yield) and 2-naphthalenemethanol by-product 3 (9\% yield). No deuterium incorporation into 3 was observed as evidenced by \(^1\text{H} \) and \(^{13}\text{C} \) NMR data.

(b) The reaction in the presence of THF-\( \text{d}_8 \):

A 14 mL milling jar was loaded under air with 1 (200 mg, 1.28 mmol), bromoethane (153 mg, 1.4 mmol, 1.1 equiv.), Mg powder (form b, 62 mg, 2.56 mmol, ca. 2 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF-\( \text{d}_8 \) (310 \( \mu \)L, ca. 3 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then reaction was quenched with saturated aq. NH\(_4\)Cl (10 mL) and extracted with ethyl acetate (20 mL). The residue was analyzed by quantitative \(^1\text{H} \) NMR, showing the formation of secondary alcohol \( 2\text{b} \) (62\% yield) and 2-naphthalenemethanol by-product 3 (12\% yield). No deuterium incorporation into 3 was observed as evidenced by \(^1\text{H} \) and \(^{13}\text{C} \) NMR data.

(c) The reaction with bromoethane-\( \text{d}_5 \):

A 14 mL milling jar was loaded under air with 1 (200 mg, 1.28 mmol), bromoethane-\( \text{d}_5 \) (161 mg, 1.41 mmol, 1.1 equiv.), Mg powder (form b, 62 mg, 2.56 mmol, ca. 2 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF (310 \( \mu \)L, ca. 3 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then reaction was quenched with saturated aq. NH\(_4\)Cl (10 mL) and extracted with ethyl acetate (20 mL). The residue was analyzed by quantitative \(^1\text{H} \) NMR, showing the formation of secondary alcohol
2b-d$_5$ (81% yield) and 2-naphtalenemethanol by-product 3 (6% yield). No deuterium incorporation into 3 was observed as evidenced by $^1$H and $^{13}$C NMR data.

(d) The reaction of 2-naphthaldehyde-d:

A 14 mL milling jar was loaded under air with 2-naphthalene-carboxaldehyde-d (200 mg, 1.27 mmol), bromoethane (153 mg, 1.4 mmol, 1.1 equiv.), Mg powder (form b, 62 mg, 2.8 mmol, ca. 2 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF (310 µL, ca. 3 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then reaction was quenched with saturated aq. NH$_4$Cl (10 mL) and extracted with ethyl acetate (20 mL). The organic layer was dried over Na$_2$SO$_4$, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative $^1$H NMR, showing the formation of secondary alcohol 2b-d (ca. 70% yield) and 2-naphtalenemethanol-d$_2$ by-product 3-d$_2$ (ca. 10% yield). No intense signals CH$_2$OH or CHDOH protons of 3 at around δ 4.84 ppm were observed (see Figure S7). The formation of alcohol 3-d$_2$ was confirmed by TLC analysis ($R_f = 0.33$, 20% EtOAc/petroleum ether) and additional NMR$^{[8]}$ and MS data. HRMS (AJS-ESI) calcd. for C$_{11}$H$_7$D$_2$+ [M-H$_2$O+H]$^+$ 143.0824, found $m/z$ 143.0820.

Figure S7. $^1$H NMR spectra of crude reaction mixtures (region δ 4.5–5.0 ppm) obtained in the experiments a–d.
(e) Confirmation of MPV reaction:

Magnesium alkoxide 2b-Mg was prepared in a Schlenk tube under argon by the reaction of EtMgBr with aldehyde 1 in THF solution. Solid alkoxide 2b-Mg was obtained by evaporation of the solvent under reduced pressure in a Schlenk line.

A 14 mL milling jar was loaded with a single 10 mm ZrO₂ ball (weight ca. 3 g), 1 (0.74 mmol, 115 mg), triphenylmethane (20.0 mg, internal standard) and THF (100 µL). Then magnesium alkoxide 2b-Mg (ca. 500 mg, ca. 2 equiv.) was poured into the jar which was then immediately closed and set to mill at 30 Hz for 60 min. The obtained reaction mixture was hydrolyzed with saturated aqueous NH₄Cl (15 mL) and extracted with ethyl acetate (3×15 mL). The combined organic layers were dried (Na₂SO₄), filtered and concentrated under reduced pressure. The residue was analyzed by quantitative ¹H NMR. The formation of alcohol 3 (18%), ethyl ketone 5b (9%) and aldol SI-3 (3%) as major products was detected, along with unreacted aldehyde 1 (5%) and excess of alcohol 2b.

MPV reaction in THF solution:

An equimolecular mixture of aldehyde 1 and alkoxide 2b-Mg was generated by dropwise addition of EtMgBr (0.5 mL, 0.52 mmol, 1.05 M solution in THF) to a solution of 1 (1 mmol, 160 mg) in THF (1.5 mL). The reaction mixture was stirred for 2 h and then hydrolyzed with saturated aqueous NH₄Cl (5 mL) followed by extraction with ethyl acetate (2×10 mL). The combined organic layers were dried (Na₂SO₄), filtered and concentrated under reduced pressure. The residue was analyzed by quantitative ¹H NMR with triphenylmethane as an internal standard. The formation of alcohol 3 (29%), ethyl ketone 5b (19%) and aldol SI-3 (3%) as major products was detected, along with unreacted aldehyde 1 (6%) and alcohol 5 (25%).

(f) Reaction of 2-naphthaldehyde with Mg:

A 14 mL milling jar was loaded with 2-naphthaldehyde (200 mg, 1.28 mmol), Mg powder (62 mg, 2.8 mmol, ca. 2 equiv.), triphenylmethane as an internal standard (ca. 30 mg), and THF (310 µL, ca. 3 equiv.). A single 10 mm milling ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then reaction was quenched with saturated aqueous solution of NH₄Cl (10 mL) and extracted with ethyl acetate (20 mL). The organic layer was dried over Na₂SO₄, and the solvent was evaporated under reduced pressure. The residue was analyzed by quantitative ¹H NMR, showing the formation of SI-2 (ca. 29% yield) and 2-naphtalenemethanol (3).
(ca. 6% yield). Diagnostic signals of SI-2: $^1$H NMR (CDCl$_3$), δ 5.59 ppm (CH$_2$O); $^{13}$C NMR (CDCl$_3$), δ 166.8 (CO), 67.2 (CH$_2$O).[9]

4.3 Radical clock experiments with cyclopropylmethyl bromide

The formation of Grignard reagent from cyclopropylmethyl bromide (35) has been previously investigated in ethereal solvents. Thus, Roberts and co-workers demonstrated[10] that in situ acidolysis of the Grignard reagent derived from 35 in refluxed Me$_2$O (−24 °C) produced ~50% of methylcyclopropane along with ~50% of 1-butene because of substantial ring opening during the formation of Grignard reagent. The isomerization was more intense in refluxed Et$_2$O (35 °C) in which the proton quenching produced already ~70% of 1-butene. The ring opening occurred presumably via a radical mechanism, since cyclopropylmethyl radical A undergoes extremely fast ($k$ ~ $10^8$ s$^{-1}$) ring-opening rearrangement.[11] Küngid and Perret showed that once formed at low temperature (−75 °C), cyclopropylmethyl Grignard reagent C can be efficiently trapped by electrophiles without rearrangement.[12] Consequently, the ring opening in the reaction with magnesium occurs exclusively during the formation of Grignard reagent. The results indicated that transformation of the radical intermediate into the Grignard reagent had a slightly lower activation barrier than the ring opening reaction. The rearrangement of C into D also takes place but is relatively slow process ($k$ = 2.9·$10^{-5}$ s$^{-1}$ at 10 °C in THF).[12] Since the rate of addition of Grignard reagents to aldehydes is usually much higher, it can be assumed that both C and D are trapped with an aldehyde prior the rearrangement of C occurs to a notable extent.

(a) No additive:

A 14 mL milling jar was loaded under air with 1 (1.28 mmol, 200 mg), 35 (1.41 mmol, 190 mg, 1.1 equiv.), Mg powder (form b, 2.56 mmol, 62 mg, 2 equiv.) and THF (3.84 mmol, 312 µL, 3 equiv). A single 10 mm ZrO$_2$ ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aq. NH$_4$Cl (200 µL) was added to the jar and milling was continued for additional 20 minutes. The quenched reaction mixture was transferred with solvent (ethyl acetate) into a beaker and diluted with ethyl acetate (total volume ca. 40 mL). The solution was filtered through a celite pad, and the solvent was evaporated under reduced pressure and analyzed by quantitative $^1$H NMR. Alcohols 2m and 2n were isolated by column chromatography on silica gel (4% EtOAc/petroleum ether). Colorless oil which solidifies upon standing (220 mg, 1:1 mixture, 81% yield). R$_f$ = 0.63 and 0.59 (4:1 petroleum ether/ethyl acetate, UV 254 nm). $^1$H NMR (CDCl$_3$, 400 MHz): δ 7.87−7.81 (m, 6H), 7.78−7.75 (m, 1H), 7.53−7.45 (m, 6H), 5.87 (ddt, $J$ = 17.1, 10.2, 6.6 Hz, 1H, 2n), 5.07 (dq, $J$ = 17.1, 1.7 Hz,
1H, 2n), 5.04–4.99 (m, 1H, 2n), 4.93 (t, J = 6.6 Hz, 1H, 2m), 4.84 (dd, J = 7.5, 5.7 Hz, 1H, 2n), 2.40 (br s, OH), 2.30 (br s, OH), 2.25–2.08 (m, 2H, 2n), 2.05–1.84 (m, 2H, 2n), 1.82–1.68 (m, 2H, 2m), 0.80–0.66 (m, 1H, 2m), 0.57–0.37 (m, 2H, 2m), 0.19–0.12 (m, 1H, 2m), 0.09–0.02 (m, 1H, 2m). 13C NMR (100.6 MHz, CDCl3) δ 142.13, 142.06, 138.94, 138.27, 133.37, 133.36, 133.07, 133.04, 128.38, 128.20, 128.02, 127.78, 126.23, 126.15, 125.90, 125.82, 124.74, 124.66, 124.28, 124.16, 115.10, 75.18 (2m), 74.16 (2m), 44.07 (2m), 38.01 (2n), 30.15 (2n), 7.75 (2m), 4.60 (2n), 4.10 (2n). HRMS (AJS-ESI) calcd. for C15H15+ [M−H2O+H]+ 195.1168, found m/z 195.1166. Spectral data are in agreement with previously reported (2n).[13]

(b) with NH4Cl:

A 14 mL milling jar was loaded under air with 1 (150 mg, 0.96 mmol), 35 (0.96 mmol, 130 mg, 1.0 equiv.), Mg powder (form b, 47 mg, 1.93 mmol, 2 equiv.), triphenylmethane (ca. 30 mg, internal standard), NH4Cl (51 mg, 0.96 mmol, 1 equiv.) and THF (234 µL, 2.88 mmol, 3 equiv.). A single 10 mm ZrO2 ball (weight ca. 3 g) was added, and the mixture of reactants was milled at 30 Hz for 60 min. Then reaction was quenched with saturated aq. NH4Cl (10 mL) and extracted with CDCl3 (2×1 mL). The obtained CDCl3 solution was dried over (Na2SO4) and analyzed by quantitative 1H NMR. The formation of alcohols 2m (26%) and 2n (27%) was detected, along with unreacted aldehyde 1 (3%) and alcohol 3 (3%). No pinacols 4 was formed.

c) with H2O:

A 14 mL milling jar was loaded under air with 1 (150 mg, 0.96 mmol), 35 (0.96 mmol, 130 mg, 1.0 equiv.), Mg powder (form b, 47 mg, 1.93 mmol, 2 equiv.), triphenylmethane (ca. 30 mg, internal standard), H2O (17 µL, 0.96 mmol, 1 equiv.) and THF (234 µL, 2.88 mmol, 3 equiv.). A single 10 mm ZrO2 ball (weight ca. 3 g) was added, and the mixture of reactants was milled at 30 Hz for 60 min. Then reaction was quenched with saturated aqueous solution of NH4Cl (10 mL) and extracted with CDCl3 (2×1 mL). The obtained CDCl3 solution was dried over (Na2SO4) and analyzed by quantitative 1H NMR. The formation of alcohols 2m (15%) and 2n (15%) was detected, along with unreacted aldehyde 1 (27%), bromide 35 (32%), and alcohol 3 (10%). No pinacols 4 was formed.

4.4 Effect of milling frequency on the rate of Grignard reagent formation

A 14 mL milling jar was loaded under air with 2-phenethylbromide (200 mg, 1.08 mmol), magnesium powder (form b, 53 mg, 2.18 mmol, 2 equiv.), triphenylmethane (ca. 30 mg, internal standard), and THF (263 µL, 3.23 mmol, 3 equiv.). A single 10 mm ZrO2 ball (weight ca. 3 g) was added, and the mixture of reactants was milled for 3 min at two different frequencies (3 Hz and 30 Hz). Then reaction was quenched with saturated aqueous solution of NH4Cl (10 mL) and extracted with CDCl3 (2×1 mL). The obtained CDCl3 solution was dried over (Na2SO4) and analyzed by quantitative 1H NMR. The yields of products are shown in the reaction Scheme above.
4.5 Competitive allylation of \( p \)-MeO and \( p \)-Cl benzaldehydes

To detect the presence of ketyl-anion mediated pathway and distinguish its contribution from the organometallic pathway, a series of competition experiments have been performed for the allylation of \( p \)-methoxy and \( p \)-chloro-substituted benzaldehydes, which serve as representative aldehydes with \( p \)-substituents possessing distinct electronic properties (Hammett constants \( \sigma_p = \{-0.27 \) and \( +0.23 \), respectively). It is known that allyl Grignard reagents react with aldehydes with rate approaching the diffusion limit and therefore their addition reactions are non-selective.\(^{[14]}\)

By contrast, for the Mg-mediated Barbier allylation of benzaldehydes in aqueous media,\(^{[15]}\) the respective Hammett plot had a positive slope \( (\rho = 3.13) \) indicating a build-up of negative charge in the selectivity-determining step, which was attributed to generation of ketyl radical anion \( \text{A} \). In other words, the reaction rate is highly sensitive to the electron-donating properties of \( p \)-substituents and the reaction should be substrate-selective. Hence, \( p \)-Cl-substituted alcohol \( \text{11} \) must be generated at a much higher rate than \( \text{10} \) \( (k_{Cl}/k_{OMe} = 37, \) based on the Hammett equation\(^{[15]}\)\) in the case of operation of the ketyl-mediated pathway.

\( \text{(a)} \) Reaction with allylmagnesium chloride in THF solution: A solution of allylmagnesium chloride (320 \( \mu \)L, 0.85 M in THF, 0.28 mmol) was added dropwise at stirring under argon atmosphere to a solution of \( p \)-chlorobenzaldehyde (200 mg, 1.42 mmol, 5-fold excess) and \( p \)-methoxybenzaldehyde (194 mg, 1.42 mmol, 5-fold excess) in THF (1.5 mL). The reaction mixture was stirred for 10 minutes at room temperature, quenched with saturated aq. \( \text{NH}_4\text{Cl} \) (10 mL) and extracted with \( \text{CDCl}_3 \) (2×1 mL). The obtained \( \text{CDCl}_3 \) solution was dried over \( (\text{Na}_2\text{SO}_4) \) and analyzed by \( ^1\text{H} \) NMR. Alcohols \( \text{10} \) and \( \text{11} \) were formed in 1:1 ratio (ca. 10\% combined yield), and the ratio of unreacted aldehydes (10\% total conversion) was 1:1 thus confirming their consumption at equal rates.

\( \text{(b)} \) The Barbier reaction with allyl bromide in 0.1 M aq. \( \text{NH}_4\text{Cl} / \text{THF} \)\(^{[16]}\)
A mixture of \( p \)-chlorobenzaldehyde (200 mg, 1.42 mmol), \( p \)-methoxybenzaldehyde (194 mg, 1.42 mmol) and allyl bromide (516 mg, 4.26 mmol, 3.0 equiv.) was added to a vigorously stirred suspension of magnesium powder (350 mg, 2.8 mmol, 10 equiv.) in 0.1 M aq. NH4Cl (10 mL) and THF (2 mL). [NB! In line with a previous report\(^{[15]}\) we found that the reaction is hard to initiate and might involve an unpredictable long induction period.]

TLC analysis soon after initiation of the reaction showed alcohol 11 as a kinetic product. After 3 h, the reaction mixture was extracted with CDCl\(_3\) (2×1 mL). The obtained CDCl\(_3\) solution was dried over (Na\(_2\)SO\(_4\)) and analyzed by \(^1\)H NMR. Alcohols 10 and 11 were formed in 1:4 ratio and low yield (~5%), and the ratio of unreacted aldehydes (ca. 30% total conversion) was \( p \)-Cl/\( p \)-OMe = 8:92 thus showing much faster consumption of \( p \)-chlorobenzaldehyde. The faster consumption of the latter could account for the observed 1:4 ratio of alcohols, which is different from the value 1:37 calculated based on Hammett equation\(^{[15]}\). Hence, the ratio of products was also controlled by the relative concentrations of the aldehydes and therefore tended to overemphasize the reactivity of the less reactive \( p \)-OMe-substituted aldehyde. Despite its rough nature, this estimation of selectivity is adequate for the purposes of this study.

\((c)\) Mechanochemical Barbier-Grignard reactions:

A 14 mL milling jar was loaded with \( p \)-chlorobenzaldehyde (200 mg, 1.42 mmol), \( p \)-methoxybenzaldehyde (194 mg, 1.42 mmol), allyl chloride (109 mg, 1.42 mmol, 1 equiv.), activated magnesium powder (69 mg, 2.8 mmol, 2 equiv.), and THF (~350 µL, 3 equiv.). Additives (either NH\(_4\)Cl or H\(_2\)O, 1 equiv.) were added in two other experiments. A single milling ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 10 minutes. Then reaction was quenched with saturated aqueous solution of NH\(_4\)Cl (10 mL) and extracted with CDCl\(_3\) (2×1 mL). The obtained CDCl\(_3\) solution was dried over (Na\(_2\)SO\(_4\)) and analyzed by \(^1\)H NMR. The following outcomes were obtained:

without protic additives: alcohols 10 and 11 were formed in 1:1.5 ratio and ca. 10% combined yield, the ratio of unreacted aldehydes (ca. 25% total conversion) was \( p \)-Cl/\( p \)-OMe = 40:60 thus showing incomplete reaction and nearly equal consumption rate. Pinacols SI-4 (characteristic signals in \(^1\)H NMR: meso-CH δ 4.84 ppm, \( dl \)-CH δ 4.60 ppm)\(^{[17]}\) and alcohol SI-5 (characteristic signal in \(^1\)H NMR: benzylic CH\(_2\) δ 4.65 ppm)\(^{[18]}\) were also formed as by-products.

with NH\(_4\)Cl and H\(_2\)O (1 equiv.): alcohols 10 and 11 were formed in 1:1.7 ratio and ca. 10–13% combined yield, the ratio of unreacted aldehydes (ca. 25% total conversion) was \( p \)-Cl/\( p \)-OMe = 40:60 thus showing incomplete reaction and nearly equal consumption rate. Pinacols SI-4 (characteristic signals in \(^1\)H NMR: meso-CH δ 4.84 ppm, \( dl \)-CH δ 4.60 ppm)\(^{[17]}\) and alcohol SI-5 (characteristic signal in \(^1\)H NMR: benzylic CH\(_2\) δ 4.65 ppm)\(^{[18]}\) were also formed as by-products.
5. Preparative protocols and characterization of products

5.1 General procedures and characterization of products

The preparative reactions were performed by following the general protocols A and B described below. Any deviations from the general procedures are specified for each product.

Mechanochemical Barbier-Grignard reaction followed by a hydrolytic work-up (procedure A): A 14 mL milling jar was loaded under air with an electrophile (e.g., a carbonyl compound), an organic halide (1.1–1.5 equiv.), activated Mg powder (2 equiv.) and THF (3 equiv.). A single 10 mm ZrO₂ ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aqueous solution of NH₄Cl (200 µL) was added to the jar and milling was continued for additional 20 minutes. The quenched reaction mixture was transferred with solvent (ethyl acetate) into a beaker and diluted with ethyl acetate (total volume ca. 40 mL). The solution was filtered through a celite pad, and the solvent was evaporated under reduced pressure. If required, the product was purified by silica gel column chromatography (SiO₂, PE/ethyl acetate).

Mechanochemical Barbier-Grignard reaction with protonation of magnesium alkoxides in situ (procedure B): A 14 mL milling jar was loaded under air with an electrophile (e.g., a carbonyl compound), an organic halide (1.1–1.5 equiv.), activated Mg powder (2 equiv.), ammonium chloride (1.0 equiv.) and THF (3 equiv.). A single 10 mm ZrO₂ ball (weight ca. 3 g) was added, and the mixture was milled at 30 Hz for 60 minutes. The resulting crude mixture was transferred with solvent (ethyl acetate) into a beaker and diluted with ethyl acetate (total volume ca. 40 mL). The solution was filtered through a celite pad, and the solvent was evaporated under reduced pressure. If required, the product was purified by silica gel column chromatography (SiO₂, PE/ethyl acetate).

CAUTION: the reactions are exothermic and may result in pressure build-up, especially in the case of starting materials with low boiling point (e.g., EtBr). Although no significant temperature increase, violent reaction, or other safety hazards have been disclosed during the preparation of the compounds shown below, additional safety investigations[19] are recommended for new substrates. The use of halides that may react explosively with Mg (e.g., CF₃-substituted aromatic bromides[20]) must be avoided. The use of less reactive Mg beads instead of powder is recommended for upscaled preparations (as shown in section 5.2 below).

1-(Naphthalen-2-yl)but-3-en-1-ol (2a)

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), allylchloride (117 mg, 1.53 mmol, 1.2 equiv.), activated Mg powder (62 mg, 2.56 mmol, 2 equiv.), and THF (310 µL, 3 equiv.). Pale-yellow oil (245 mg, 97%). Rᶠ = 0.53 (20% EtOAc/petroleum ether). ¹H NMR (400 MHz, CDCl₃) δ 7.88–7.79 (m, 4H), 7.52–7.43 (m, 3H), 5.91–5.77 (m, 1H), 5.25–5.11 (m, 2H), 4.92 (dd, J = 7.7, 5.2 Hz, 1H), 2.70–2.54 (m, 2H), 2.16 (br s, 1H, OH). ¹³C NMR (100.6 MHz, CDCl₃) δ 141.4, 134.5, 133.4, 133.1, 128.4, 128.1, 127.8, 126.3, 126.0, 124.6, 124.1, 118.7, 73.5, 43.9. HRMS (AJS-ESI) calcd. for C₁₄H₁₃⁺ [M–H₂O+H]⁺ 181.1012, found m/z 181.1007. Spectral data are in agreement with previously reported.[21]

1-(Naphthalen-2-yl)propan-1-ol (2b)
Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), bromoethane (153 mg, 1.40 mmol, 1.1 equiv.; CAUTION: internal pressure build-up is possible), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.), and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). Pale-yellow oil (202 mg, 85%). Rf = 0.43 (20% EtOAc/petroleum ether). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.88–7.76 (m, 4H), 7.52–7.44 (m, 3H), 4.77 (t, \(J = 6.6\) Hz, 1H), 1.99 (br s, 1H, OH), 1.96–1.79 (m, 2H), 0.95 (t, \(J = 7.4\) Hz, 3H). \(^1\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 142.1, 133.4, 133.1, 128.4, 128.1, 127.8, 126.2, 125.9, 124.9, 124.3, 76.3, 31.9, 10.3. HRMS (AJS-ESI) calcd. for C\(_{13}\)H\(_{15}\)\([\text{M}–\text{H}2\text{O}+\text{H}]^+\) 169.1012, found \(m/z\) 169.1006. Spectral data are in agreement with previously reported.\(^{[22]}\)

**Naphthalen-2-yl(phenyl)methanol (2c)**

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), bromobenzene (221 mg, 1.40 mmol, 1.1 equiv.), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.), and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). White solid (243 mg, 81%). Rf = 0.19 (20% EtOAc/petroleum ether). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.88 (s, 1H), 7.85–7.75 (m, 3H), 7.50–7.38 (m, 5H), 7.37–7.22 (m, 3H), 5.98 (d, \(J = 3.0\) Hz, 1H), 2.35 (d, \(J = 3.3\) Hz, 1H, OH). \(^1\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 143.8, 141.2, 133.4, 133.0, 128.7 (2C), 128.5, 128.2, 127.8 (2C), 126.9 (2C), 126.3, 126.1, 125.2, 124.9, 76.5. HRMS (AJS-ESI) calcd. for C\(_{17}\)H\(_{15}\)\([\text{M}–\text{H}2\text{O}+\text{H}]^+\) 217.1012, found \(m/z\) 217.1008. Spectral data are in agreement with previously reported.\(^{[23]}\)

**1-(Naphthalen-2-yl)-3-phenylpropan-1-ol (2d)**

Prepared by following the general procedure A, from 2-naphthaldehyde (1.28 mmol, 200 mg, 1 equiv.), 2-phenylethyl bromide (1.28 mmol, 237 mg, 1 equiv.), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.) and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (4% EtOAc/petroleum ether). Product was isolated as pale-yellow oil, which solidifies upon standing (271 mg, 81%). Rf = 0.61 (4:1 petroleum ether/ethyl acetate, UV 254 nm). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.87–7.79 (m, 3H), 7.79–7.75 (m, 1H), 7.51–7.42 (m, 3H), 7.31–7.25 (m, 2H), 7.22–7.15 (m, 3H), 4.85 (dd, \(J = 7.7, 5.4\) Hz, 1H), 2.84–2.62 (m, 2H), 2.29–2.05 (m, 2H), 1.97 (br s, 1H, OH). \(^1\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 142.0, 141.9, 133.4, 133.2, 128.6 (2C), 128.55 (2C), 128.5, 128.1, 127.8, 126.3, 126.0 (2C), 124.8, 124.2, 74.1, 40.5, 32.2. HRMS (AJS-ESI) calcd. for C\(_{19}\)H\(_{17}\)\([\text{M}–\text{H}2\text{O}+\text{H}]^+\) 245.1325, found \(m/z\) 245.1320. Spectral data are in agreement with previously reported.\(^{[24]}\)

**1-(Naphthalen-2-yl)-2-phenylbut-3-en-1-ol (2e)**

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), cinnamyl chloride (234 mg, 1.40 mmol, 1.1 equiv.), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.), and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Colourless oil (241 mg, 70%). Rf = 0.34 (20% EtOAc/petroleum ether). Obtained as a 2:1 mixture of ant/syn-diastereomers. \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.87–7.67 (m, 5H), 7.62 (s, 1H), 7.52–7.24 (m, 7H), 7.23–7.06 (m, 5H), 6.30 (ddd, \(J = 17.1, 10.3, 8.9\) Hz, 1H, anti), 5.94 (ddd, \(J = 17.1, 10.3, 7.8\) Hz, 0.5H, syn), 5.31–5.21 (m, 2H, anti), 5.09 (dd, \(J = 8.3, 3.0\) Hz, 0.5H, syn), 5.03 (dd, \(J = 7.6, 2.5\) Hz, 1H, anti), 4.98 (dt, \(J = 10.3, 1.3\) Hz, 0.5H, syn), 4.87 (dt, \(J = 17.1, 1.4\) Hz, 0.5H, syn), 3.76 (t, \(J = 8.0\) Hz, 0.5H, syn), 3.68 (t, \(J = 8.2\) Hz, 1H, anti), 2.41 (d, \(J = 2.5\) Hz, 1H, anti-OH), 2.05 (d, \(J = 3.0\) Hz, 0.5H, syn-OH). \(^1\)C NMR (100.6 MHz, CDCl\(_3\)) (peaks of minor syn-isomer are marked with asterisk) \(\delta\) 140.7, 140.4*, 139.5, 137.9, 137.7*, 133.3*, 133.2*, 133.18, 133.0, 128.9*(2C), 128.6 (2C), 128.5 (2C), 128.2*, 128.10, 128.07*, 127.8*, 127.7, 127.3*, 126.8, 126.4*, 126.2*, 126.0*, 126.0, 125.8,
125.0*, 124.8, 118.7, 117.5*, 77.8*, 77.4, 59.2, 58.5*. HRMS (AJS-ESI) calcd. for C_{20}H_{17}^+ [M–H_2O+H]^+ 257.1325, found m/z 257.1322. Spectral data are in agreement with previously reported. [25]

1-(Naphthalen-2-yl)-2-phenylethan-1-ol (2f)

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), benzyl bromide (240 mg, 1.40 mmol, 1.1 equiv.), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.), and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). Off-white solid (222 mg, 69%). R_f = 0.48 (20% EtOAc/petroleum ether). ^1H NMR (400 MHz, CDCl_3) δ 7.87–7.76 (m, 4H), 7.52–7.43 (m, 3H), 7.33–7.18 (m, 5H), 5.06 (dd, J = 8.5, 4.8 Hz, 1H), 3.13 (dd, J = 13.7, 4.8 Hz, 1H), 3.06 (dd, J = 13.7, 8.5 Hz, 1H), 2.07 (br s, 1H, OH). ^13C NMR (100.6 MHz, CDCl_3) δ 141.3, 138.1, 133.4, 133.1, 129.7 (2C), 128.7 (2C), 128.3, 128.1, 127.8, 126.8, 126.3, 126.0, 124.7, 124.2, 75.6, 46.2. HRMS (AJS-ESI) calcd. for C_{18}H_{15}+ [M–H_2O+H]^+ 231.1168, found m/z 231.1166. Spectral data are in agreement with previously reported. [26]

1-(Naphthalen-2-yl)pentan-1-ol (2g)

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), bromobutane (193 mg, 1.40 mmol, 1.1 equiv.), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.), and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). White solid (226 mg, 83%). R_f = 0.23 (20% EtOAc/petroleum ether). ^1H NMR (400 MHz, CDCl_3) δ 7.87–7.80 (m, 3H), 7.77 (s, 1H), 7.53–7.44 (m, 3H), 4.82 (t, J = 6.6 Hz, 1H), 2.11 (br s, 1H, OH), 1.96–1.74 (m, 2H), 1.49–1.22 (m, 4H), 0.90 (t, J = 7.1 Hz, 3H). ^13C NMR (100.6 MHz, CDCl_3) δ 142.3, 133.3, 133.0, 128.3, 128.0, 127.7, 126.1, 125.8, 124.7, 124.2, 74.8, 38.7, 28.0, 22.7, 14.1. HRMS (AJS-ESI) calcd. for C_{19}H_{17}+ [M–H_2O+H]^+ 197.1320, found m/z 197.1320. Spectral data are in agreement with previously reported. [27]

1-(naphthalen-2-yl)ethan-1-ol (2h)

Prepared by following the general procedure A, from 2-naphthaldehyde (1.28 mmol, 200 mg), iodomethane (200 mg, 1.41 mmol, 1.1 equiv.), activated Mg powder (373 mg, 15.4 mmol, 12 equiv.) and THF (420 µL, 4 equiv.). Purification was performed by column chromatography on silica gel (9% EtOAc/petroleum ether). Product was isolated as pale-yellow oil, which solidifies upon standing (111 mg, 50%). R_f = 0.72 (2:1 petroleum ether/EtOAc, UV 254 nm). ^1H NMR (CDCl_3, 400 MHz): δ 7.88–7.78 (m, 4H), 7.54–7.44 (m, 3H), 5.07 (q, J = 6.5 Hz, 1H), 1.89 (br s, 1H, OH), 1.59 (d, J = 6.5 Hz, 3H). ^13C NMR (100.6 MHz, CDCl_3) δ 143.3, 133.5, 133.1, 128.5, 128.1, 127.8, 126.3, 125.9, 123.9 (2C), 70.7, 25.3. HRMS (AJS-ESI) calcd. for C_{12}H_{11}+ [M–H_2O+H]^+ 155.0855, found m/z 155.0851. Spectral data are in agreement with previously reported. [28]

Cyclohexyl(naphthalen-2-yl) methanol (2i)

Prepared by following the general procedure A, from 2-naphthaldehyde (1.28 mmol, 200 mg), cyclohexyl bromide (230 mg, 1.41 mmol, 1.1 equiv.), activated Mg powder (373 mg, 15.4 mmol, 12 equiv.) and THF (420 µL, 4 equiv.). Purification was performed by column chromatography on silica gel (4% EtOAc/petroleum ether). Product was isolated as pale-yellow oil, which solidifies upon standing (152 mg, 50%). R_f = 0.57 (4:1 petroleum ether/EtOAc, UV 254 nm). ^1H NMR (CDCl_3, 400 MHz): δ 7.87–7.79 (m, 3H), 7.76–7.71 (s, 1H), 7.52–7.41 (m, 3H), 4.54 (d, J = 7.1 Hz, 1H), 2.09–1.93 (m, 2H), 1.82–1.60 (m, 4H), 1.46–1.36 (m, 1H), 1.30–1.06 (m, 4H), 1.06–0.93 (m, 1H). ^13C NMR (100.6 MHz, CDCl_3) δ 141.2, 133.3, 133.1, 128.1, 128.0, 127.8, 126.2, 125.9, 125.6, 124.8, 79.6, 45.0,
29.5, 29.0, 26.6, 26.2, 26.15. HRMS (AJS-ESI) calcd. for C_{17}H_{19}^+ [M–H_2O+H]^+ 223.1481, found m/z 223.1478. Spectral data are in agreement with previously reported.\(^{[29]}\)

2-Methyl-1-(naphthalen-2-yl)prop-2-en-1-ol (2j)

Prepared by following the general procedure A, from 2-naphthaldehyde (1.28 mmol, 200 mg), 2-bromoprop-1-ene (170 mg, 1.41 mmol, 1.1 equiv.), activated Mg powder (62 mg, 2.6 mmol, 2 equiv.) and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (4% EtOAc/petroleum ether). Product was isolated as pale-yellow oil (186 mg, 73%). \(R_f = 0.75\) (4:1 petroleum ether/EtOAc, UV 254 nm). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.89–7.78 (m, 4H), 7.53–7.43 (m, 3H), 5.31 (d, \(J = 3.5\) Hz, 1H), 5.28 (br s, 1H), 5.02 (br s, 1H), 2.03 (d, \(J = 3.5\) Hz, 1H, OH), 1.66–1.61 (br s, 3H). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 142.2, 141.8, 133.5, 133.3, 133.1, 128.8 (2C), 128.7, 128.2 (3C), 127.8, 126.5, 126.3, 125.3, 124.7, 75.9. HRMS (AJS-ESI) calcd. for C\(_{17}\)H\(_{18}\)O\(_2\) [M+H]^+ 251.0622, found \(m/z\) 251.0622. Spectral data are in agreement with previously reported.\(^{[30]}\)

(4-Chlorophenyl)(naphthalen-2-yl)methanol (2k)

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), 1-bromo-4-chloro benzene (270 mg, 1.41 mmol, 1.1 equiv.), activated Mg powder (160 mg, 6.4 mmol, 5 equiv.), iodine as an activator (a small crystal) and THF (310 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Off-white solid (220 mg, 64\%). \(R_f = 0.54\) (20% EtOAc/petroleum ether). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.87–7.77 (m, 4H), 7.53–7.45 (m, 2H), 7.41–7.28 (m, 5H), 5.97 (s, 1H), 2.40 (br s, 1H, OH). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 142.2, 141.8, 133.5, 133.3, 133.1, 128.8 (2C), 128.7, 128.2 (3C), 127.8, 126.5, 126.3, 125.3, 124.7, 75.9. HRMS (AJS-ESI) calcd. for C\(_{19}\)H\(_{17}\)Cl\(_2\) [M+H]^+ 223.1478, found \(m/z\) 223.1481. Spectral data are in agreement with previously reported.\(^{[30]}\)

(4-Methoxyphenyl)(naphthalen-2-yl)methanol (2l)

Prepared by following the general procedure A, from 2-naphthaldehyde (1.28 mmol, 200 mg, 1 equiv.), 1-bromo-4-methoxybenzene (269 mg, 1.41 mmol, 1.1 equiv.), activated Mg powder (190 mg, 7.7 mmol, 6 equiv.), THF (520 µL, 5 equiv.) and iodine as an activator (a small crystal). Purification was performed by column chromatography on silica gel (7% EtOAc/petroleum ether) followed by recrystallization (petroleum ether/ethyl acetate = 1:4). Product was isolated as off-white solid (130 mg, 38\%). \(R_f = 0.66\) (2:1 petroleum ether/EtOAc, UV 254 nm). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta\) 7.92–7.88 (m, 1H), 7.86–7.78 (m, 3H), 7.50–7.45 (m, 2H), 7.42 (dd, \(J = 8.5, 1.8\) Hz, 1H), 7.36–7.30 (m, 2H), 6.90–6.84 (m, 2H), 5.97 (s, 1H), 3.79 (s, 3H), 2.34 (br s, 1H, OH). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 159.3, 141.5, 136.1, 133.4, 133.0, 128.4, 128.23 (2C), 128.20, 127.8, 126.3, 126.0, 124.9 (2C), 114.0 (2C), 76.0, 55.4. HRMS (AJS-ESI) calcd. for C\(_{18}\)H\(_{15}\)O\(_2\) [M+H]^+ 247.1114, found \(m/z\) 247.1117. Spectral data are in agreement with previously reported.\(^{[31]}\)

1-(4-Methoxyphenyl)but-3-en-1-ol (10)

Prepared by following the general procedure A, from 4-anisaldehyde (200 mg, 1.46 mmol), allylchloride (123 mg, 1.60 mmol, 1.1 equiv.), activated Mg powder (71 mg, 2.9 mmol, 2 equiv.), sodium chloride as solid grinding additive (170 mg) and THF (360 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). Yellow oil (221 mg, 87\%). \(R_f = 0.38\) (20% EtOAc/petroleum ether). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.3–7.22 (m, 2H), 6.91–6.84 (m, 2H), 5.79 (m, 1H), 5.19–5.07 (m, 2H), 4.66 (t, \(J = 6.6\) Hz, 1H), 3.79 (s, 3H), 2.53–2.45 (m, 2H), 2.09 (br s, 1H, OH). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta\) 159.1, 136.2, 134.8, 127.2 (2C), 118.3, 113.9
(2C), 73.1, 55.4, 43.8. HRMS (AJ-S-ESI) calcd. for C_{11}H_{15}O^+ [M–H_2O+H]^+ 161.0961, found m/z 161.0955. Spectral data are in agreement with previously reported.[21]

1-(4-Chlorophenyl)but-3-en-1-ol (11)

Prepared by following the general procedure A, from 4-chlorobenzaldehyde (200 mg, 1.42 mmol), allylchloride (120 mg, 1.56 mmol, 1.1 equiv.), activated Mg powder (69 mg, 2.8 mmol, 2 equiv.), and THF (350 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Pale yellow oil (166 mg, 64%). Rf = 0.52 (20% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 7.33–7.24 (m, 4H), 5.83–5.70 (m, 1H), 5.19–5.10 (m, 2H), 4.69 (dd, J = 7.6, 5.2 Hz, 1H), 2.55–2.37 (m, 2H), 2.19 (br s, 1H, OH). 13C NMR (100.6 MHz, CDCl3) δ 142.4, 134.1, 133.3, 128.6 (2C), 127.3 (2C), 119.0, 72.7, 44.0. HRMS (AJ-S-ESI) calcd. for C_{10}H_{16}Cl^+ [M–H_2O+H]^+ 165.0466, found m/z 165.0462. Spectral data are in agreement with previously reported.[33]

4-(1-Hydroxybut-3-en-1-yl)benzonitrile (12)

Prepared by following the general procedure B, from 4-cyanobenzaldehyde (200 mg, 1.52 mmol.), allylchloride (128 mg, 1.67 mmol, 1.1 equiv.), activated Mg powder (74 mg, 3 mmol, 2 equiv.), ammonium chloride (81 mg, 1.5 mmol, 1 equiv.) and THF (370 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (5% EtOAc/petroleum ether). Pale yellow oil (47 mg, 18%). Rf = 0.22 (20% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 7.66–7.61 (m, 2H), 7.50–7.45 (m, 2H), 5.84–5.70 (m, 1H), 5.23–5.13 (m, 2H), 5.83–5.76 (m, 1H), 2.58–2.49 (m, 1H), 2.43 (m, 1H), 2.24 (br s, 1H, OH). 13C NMR (100.6 MHz, CDCl3) δ 149.2, 133.5, 132.4 (2C), 126.6 (2C), 119.7, 119.0, 111.3, 72.5. HRMS (AJ-S-ESI) calcd. for C_{11}H_{12}NO^+ [M+H]^+ 174.0913, found m/z 174.0909. Spectral data are in agreement with previously reported.[33]

1-(4-(Trifluoromethyl)phenyl)but-3-en-1-ol (13)

Prepared by following the general procedure A, from 4-trifluoromethylbenzaldehyde (200 mg, 1.14 mmol), allylchloride (97 mg, 1.3 mmol, 1.1 equiv.), activated Mg powder (56 mg, 2.3 mmol, 2 equiv.), sodium chloride as grinding additive (130 mg) and THF (280 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Colourless oil (138 mg, 55%). Rf = 0.51 (20% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 7.60 (d, J = 8.2 Hz, 2H), 7.47 (d, J = 8.2 Hz, 2H), 5.85–5.72 (m, 1H), 5.22–5.13 (m, 2H), 4.79 (dd, J = 8.0, 4.8 Hz, 1H), 2.59–2.41 (m, 2H), 2.26 (br s, 1H, OH). 13C NMR (100.6 MHz, CDCl3) δ 147.9, 133.8, 129.8 (q, J_{CF} = 32.4 Hz), 126.2 (2C), 125.5 (2C, q, J_{CF} = 3.8 Hz), 124.2 (q, J_{CF} = 273 Hz, CF3), 119.3, 72.7, 44.0. HRMS (AJ-S-ESI) calcd. for C_{11}H_{15}F_{3}^+ [M–H_2O+H]^+ 199.0729, found m/z 199.0723. Spectral data are in agreement with previously reported.[33]

1-(2,6-Dimethylphenyl)but-3-en-1-ol (14)

Prepared by following the general procedure A, from 2-naphthaldehyde (200 mg, 1.28 mmol), allylchloride (125 mg, 1.63 mmol, 1.1 equiv.), activated Mg powder (72 mg, 3.0 mmol, 2 equiv.), and THF (360 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). Colourless oil (201 mg, 76%). Rf = 0.70 (20% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 7.10–6.97 (m, 3H), 5.86 (dddd, J = 17.1, 10.1, 8.0, 6.4 Hz, 1H), 5.25–5.11 (m, 3H), 2.73 (dddt, J = 14.1, 9.1, 8.0, 1.0 Hz, 1H), 2.51 (dddt, J = 14.1, 6.4, 5.1, 1.4 Hz, 1H), 2.46 (s, 6H), 1.95 (br s, 1H, OH). 13C NMR (100.6 MHz, CDCl3) δ 139.0, 136.2, 135.3, 129.5, 127.2, 118.0, 71.0, 40.3, 21.0. HRMS (AJ-S-ESI) calcd. for C_{12}H_{15}^+ [M–H_2O+H]^+ 159.1168, found m/z 159.1164.
1-(Pyridin-2-yl)but-3-en-1-ol (15)

Prepared by following the general procedure A, from pyridine-2-carbaldehyde (200 mg, 1.86 mmol), allylchloride (157 mg, 2.05 mmol, 1.1 equiv.), activated Mg powder (90 mg, 3.7 mmol, 2 equiv.), sodium chloride as grinding additive (220 mg) and THF (460 µL, 3 equiv.). Pale-yellow oil (174 mg, 62%). Rf = 0.09 (20% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 8.56–8.49 (m, 1H), 7.71–7.62 (m, 1H), 7.28 (d, J = 7.9 Hz, 1H), 7.21–7.15 (m, 1H), 5.89–5.75 (m, 1H), 5.14–5.03 (m, 2H), 4.83–4.77 (m, 1H). 13C NMR (100.6 MHz, CDCl3) δ 136.7, 133.7, 132.4, 128.3, 128.1, 127.6, 126.2, 125.9, 123.7, 123.4, 119.8, 73.9, 48.4, 30.1. HRMS (AJS-ESI) calcd. for C9H10ON+ [M–H2O+H]+ 132.0805. Spectral data are in agreement with previously reported.34

5,5,5-Trifluoro-1-(pyridin-2-yl)pentan-1-ol (16)

A 14 mL milling jar was loaded under air with freshly distilled picolinaldehyde (100 mg, 0.93 mmol), 4-bromo-1,1,1-trifluorobutane (1.02 mmol, 131 µL, 1.1 equiv.), activated Mg powder (46 mg, 1.9 mmol, 2.0 equiv.) and THF (230 µL, 3 equiv.). A single 10 mm ZrO2 ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aqueous solution of NH4Cl (10 mL) was added to the jar and extracted twice with EtOAc (2×20 mL). The combined organic solvent was washed with brine and was dried over Na2SO4. Removal of the solvent afforded crude product as a yellow oil. Yield (189 mg, 92%). Analytically pure sample obtained after chromatographic purification (silica gel, CH2Cl2/MeOH 99:1 to 20:1) as yellowish solid. Rf = 0.30 (CH2Cl2/MeOH 20:1). 1H NMR (400 MHz, CDCl3): δ 8.55 (d, J = 4.8 Hz, 1H), 7.70 (td, J = 7.7, 1.7 Hz, 1H), 7.25–7.20 (m, 2H), 4.79–4.74 (m, 1H), 4.30 (br s, 1H, OH), 2.20–2.03 (m, 2H), 1.99–1.85 (m, 1H), 1.79–1.65 (m, 3H). 13C NMR (100.6 MHz, CDCl3) δ 161.4, 148.4, 137.0, 127.3 (q, JCF = 276.4 Hz), 122.7, 120.3, 72.1, 37.5, 33.8 (q, JCF = 28.5 Hz), 18.0 (q, JCF = 3.0 Hz). HRMS (AJS-ESI) calcd. for C10H13F3NO+ [M+H]+ 220.0944, found m/z 220.0941.

1-(Thiophen-2-yl)propan-1-ol (17)

Prepared by following the general procedure A, from thiophene-2-carbaldehye (200 mg, 1.78 mmol), bromoethane (213 mg, 1.95 mmol, 1.1 equiv.; CAUTION: internal pressure build-up is possible), activated Mg powder (86 mg, 3.5 mmol, 2 equiv.), sodium chloride as grinding additive (210 mg) and THF (430 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (3% EtOAc/petroleum ether). Pale yellow oil (189 mg, 75%). Rf = 0.48 (20% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 7.26 (d, J = 7.4 Hz, 3H), 7.22 (m, 1H), 6.96 (m, 2H), 4.82 (t, J = 6.6 Hz, 1H), 2.18 (br s, 1H, OH), 1.96–1.77 (m, 2H), 0.96 (t, J = 7.4 Hz, 3H). 13C NMR (100.6 MHz, CDCl3) δ 148.7, 126.7, 124.6, 123.9, 71.9, 32.3, 10.3. HRMS (AJS-ESI) calcd. for C10H13S+ [M–H2O+H]+ 125.0419, found m/z 125.0417. Spectral data are in agreement with previously reported.35

2-(Naphthalen-2-yl)pent-4-en-2-ol (6a)

Prepared by following the general procedure B, from 2-acetyl naphthalene (200 mg, 1.18 mmol), allylbromide (213 mg, 1.76 mmol, 1.5 equiv.), activated Mg powder (58 mg, 2.4 mmol, 2 equiv.), ammonium chloride (63 mg, 1.2 mmol, 1 equiv.) and THF (290 µL, 3 equiv.). Pale-yellow oil (247 mg, 92% yield, 94% purity by 1H NMR). Rf = 0.27 (10% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 7.94–7.91 (m, 1H), 7.88–7.80 (m, 3H), 7.55 (dd, J = 8.7, 1.9 Hz, 1H), 7.52–7.43 (m, 2H), 5.63 (dddd, J = 17.1, 10.1, 8.4, 6.3 Hz, 1H), 5.21–5.09 (m, 2H), 2.81 (dd, J = 13.7, 6.3 Hz, 1H), 2.60 (dd, J = 13.7, 8.4 Hz, 1H), 2.19 (s, 1H, OH), 1.65 (s, 3H). 13C NMR (100.6 MHz, CDCl3) δ 145.1, 133.7, 133.3, 132.4, 128.3, 128.1, 127.6, 126.2, 125.9, 123.7, 123.4, 119.8, 73.9, 48.4, 30.1. HRMS
2-(Naphthalen-2-yl)butan-2-ol (6b)

Prepared by following the general procedure B, from 2-acetylnaphthalene (200 mg, 1.18 mmol), bromoethane (192 mg, 1.76 mmol, 1.5 equiv.; CAUTION: internal pressure build-up is possible), activated Mg powder (58 mg, 2.4 mmol, 2 equiv.), ammonium chloride (63 mg, 1.2 mmol, 1 equiv.) and THF (290 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Pale-yellow oil (167 mg, 71%; 78% yield by $^1$H NMR). $R_f = 0.29$ (10% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.92 (d, $J = 1.9$ Hz, 1H), 7.86–7.77 (m, 3H), 7.54 (dd, $J = 8.6$, 1.9 Hz, 1H), 7.51–7.43 (m, 2H), 2.06–1.87 (m, 2H), 1.85 (s, 1H, OH), 1.65 (s, 3H), 0.83 (t, $J = 7.4$ Hz, 3H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 145.2, 133.3, 132.4, 128.3, 128.0, 127.6, 126.1, 125.8, 123.9, 123.4, 75.6, 36.6, 29.9, 8.5. HRMS (AJES-ESI) calcd. for C$_{14}$H$_{15}^+$ [M–H$_2$O+H]$^+$ 183.1168, found m/z 183.1163. Spectral data are in agreement with previously reported.[$^{[37]}$]

1-(Naphthalen-2-yl)-1-phenylethan-1-ol (6c)

Prepared by following the general procedure B, from 2-acetylnaphthalene (200 mg, 1.18 mmol), bromobenzene (276 mg, 1.76 mmol, 1.5 equiv.), activated Mg powder (58 mg, 2.4 mmol, 2 equiv.), ammonium chloride (63 mg, 1.2 mmol, 1 equiv.) and THF (290 µL, 3 equiv). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Pale-yellow oil (172 mg, 59%; 68% yield by $^1$H NMR). $R_f = 0.22$ (10% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.92 (d, $J = 1.9$ Hz, 1H), 7.86–7.77 (m, 3H), 7.51–7.37 (m, 5H), 7.34–7.28 (m, 2H), 7.27–7.21 (m, 1H), 2.28 (s, 1H, OH), 2.04 (s, 3H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 147.9, 145.4, 133.1, 132.5, 128.4 (3C), 128.1, 127.6, 127.2, 126.3, 126.1 (3C), 125.1, 123.9, 76.5, 30.9. HRMS (AJES-ESI) calcd. for C$_{19}$H$_{19}^+$ [M–H$_2$O+H]$^+$ 231.1168, found m/z 231.1164. Spectral data are in agreement with previously reported.[$^{[37]}$]

2-(Naphthalen-2-yl)-4-phenylbutan-2-ol (6d)

Prepared by following the general procedure B, from 2-acetonaphthone (200 mg, 1.18 mmol), 2-phenylethyl bromide (326 mg, 1.76 mmol, 1 equiv.), activated Mg powder (57 mg, 2.4 mmol, 2 equiv.), ammonium chloride (63 mg, 1.2 mmol, 1 equiv.) and THF (290 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (4% EtOAc/petroleum ether). Product was isolated as pale-yellow oil (137.4 mg, 42%; 49% yield by $^1$H NMR). $R_f = 0.54$ (5:1 petroleum ether/EtOAc, UV 254 nm). $^1$H NMR (CDCl$_3$, 400 MHz): 7.97–7.93 (m, 1H), 7.91–7.76 (m, 3H), 7.55 (dd, $J = 8.6$, 1.9 Hz, 1H), 7.51–7.41 (m, 2H), 7.26–7.19 (m, 2H), 7.18–7.06 (m, 3H), 2.64 (ddd, $J = 13.6$, 11.3, 6.0 Hz, 1H), 2.46 (ddd, $J = 13.6$, 11.3, 5.2 Hz, 1H), 2.32–2.10 (m, 2H), 1.91 (br s, 1H, OH), 1.68 (s, 3H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 145.0, 142.3, 133.3, 132.4, 128.5 (2C), 128.4 (2C), 128.3, 128.2, 127.6, 126.3, 125.9 (2C), 123.7, 123.4, 75.0, 45.9, 30.8, 30.6. HRMS (AJES-ESI) calcd. for C$_{20}$H$_{19}^+$ [M–H$_2$O+H]$^+$ 259.1481, found m/z 259.1478. Spectral data are in agreement with previously reported.[$^{[38]}$]

2-(Naphthalen-2-yl)-1-phenylpropan-2-ol (6e)

Prepared by following the general procedure B, from 2-acetylnaphthalene (200 mg, 1.18 mmol), benzyl bromide (300 mg, 1.76 mmol, 1.5 equiv.), activated Mg powder (58 mg, 2.4 mmol, 2 equiv.), ammonium chloride (63 mg, 1.2 mmol, 1.0 equiv.) and THF (290 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2%
EtOAc/petroleum ether). Pale-white oil (242 mg, 78%; 82% yield by $^1$H NMR). $R_f = 0.32$ (10% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.88–7.78 (m, 4H), 7.59 (dd, $J = 8.5$, 2.0 Hz, 1H), 7.49 (m, 2H), 7.24–7.18 (m, 3H), 7.07–7.00 (m, 2H), 3.27 (d, $J = 13.4$ Hz, 1H), 3.14 (d, $J = 13.4$ Hz, 1H), 2.01 (s, 1H, OH), 1.67 (s, 3H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 145.1, 136.8, 133.3, 132.4, 130.7 (2C), 128.33, 128.27 (2C), 127.9, 127.6, 126.8, 126.1, 125.8, 124.0, 123.6, 74.8, 50.3, 29.7. HRMS (AJS-ESI) calcd. for C$_{19}$H$_{17}$+ [M–H$_2$O+H]$^+$ 245.1325, found $m/z$ 245.1321.

1,1,1-Trifluoro-2-phenylpent-4-en-2-ol (18)

Prepared by following the general procedure A, from trifluoroacetophenone (200 mg, 1.15 mmol), allyl chloride (131 mg, 1.72 mmol, 1.5 equiv.), activated Mg powder (56 mg, 2.3 mmol, 2 equiv.), sodium chloride as grinding additive (134 mg), and THF (280 $\mu$L, 3 equiv.). Pale yellow oil (219 mg, 87%). Similar yield was obtained under conditions of procedure B, with ammonium chloride ammonium chloride (61 mg, 1.1 mmol, 1 equiv.). $R_f = 0.58$ (20% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.61–7.56 (m, 2H), 7.46–7.34 (m, 3H), 5.64–5.51 (m, 1H), 5.31–5.20 (m, 2H), 3.00 (dd, $J = 14.4$, 6.6 Hz, 1H), 2.86 (dd, $J = 14.4$, 8.0 Hz, 1H), 2.60 (s, 1H, OH). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 137.0, 130.5, 128.7, 128.5, 126.6, 125.5 (q, $J_{CF} = 284$ Hz, CF$_3$), 122.2, 75.9 (q, $J_{CF} = 28.2$ Hz), 40.5. HRMS (AJS-ESI) calcd. for C$_{11}$H$_{10}$F$_3$+ [M–H$_2$O+H]$^+$ 199.0729, found $m/z$ 199.0726. Spectral data are in agreement with previously reported. [33]

1,1-Diphenylbut-3-en-1-ol (19)

Prepared by following the general procedure A, from benzophenone (200 mg, 1.10 mmol), allyl chloride (126 mg, 1.64 mmol, 1.5 equiv.), activated Mg powder (53 mg, 2.2 mmol, 2 equiv.), and THF (270 $\mu$L, 3 equiv.). Colourless oil (241 mg, 98%). Similar yield was obtained under conditions of procedure B, with ammonium chloride (58 mg, 1.1 mmol, 1 equiv.). $R_f = 0.47$ (10% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.50–7.45 (m, 4H), 7.37–7.31 (m, 4H), 7.27–7.22 (m, 2H), 5.69 (ddt, $J = 17.3$, 10.1, 7.2 Hz, 1H), 5.31–5.17 (m, 2H), 3.11 (d, $J = 7.2$ Hz, 2H), 2.58 (s, 1H, OH). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 146.6, 133.6, 128.3, 127.0, 126.1, 120.7, 77.0, 46.8. HRMS (AJS-ESI) calcd. for C$_{16}$H$_{15}$O$^+$ [M–H$_2$O+H]$^+$ 207.1168, found $m/z$ 207.1167. Spectral data are in agreement with previously reported.[39]

1-(2-Aminophenyl)-1-phenylbut-3-en-1-ol (20)

A 14 mL milling jar was loaded under air with 2-aminobenzophenone (200 mg, 1.01 mmol), allylchloride (155 mg, 2.02 mmol, 1.5 equiv.), Mg powder (50 mg, 2.1 mmol, 2 equiv.), and THF (250 $\mu$L, 3 equiv.). A single 10 mm ZrO$_2$ ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes. Then, reaction mixture was quenched with aqueous solution of NaHCO$_3$ (20 mL) and was extracted with ethyl acetate (40 mL). The organic layer was separated and the solvent was evaporated under reduced pressure. Crude was purified by using column chromatography on silica gel (2% EtOAc/petroleum ether). The product obtained as a brown liquid (176 mg, 73%). $R_f = 0.40$ (20% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.41–7.33 (m, 3H), 7.33–7.26 (m, 2H), 7.26–7.19 (m, 1H), 7.11 (td, $J = 7.6$, 1.5 Hz, 1H), 6.81 (td, $J = 7.6$, 1.3 Hz, 1H), 6.61 (dd, $J = 7.9$, 1.3 Hz, 1H), 5.80 (ddt, $J = 17.3$, 10.2, 7.1 Hz, 1H), 5.24–5.14 (m, 2H), 3.96 (br s, 2H, NH$_2$), 3.63 (br s, 1H, OH), 3.25 (ddt, $J = 14.0$, 7.0, 1.2 Hz, 1H), 2.86 (ddt, $J = 14.0$, 7.3, 1.3 Hz, 1H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 145.9, 145.2, 133.7, 130.2, 128.8, 128.2, 127.1, 127.0, 125.8, 120.1, 118.5, 118.3, 77.8, 47.1. HRMS (AJS-ESI) calcd. for C$_{16}$H$_{16}$N$^+$ [M–H$_2$O+H]$^+$ 222.1277, found $m/z$ 222.1277. Spectral data are in agreement with previously reported. [40]

3-Methyl-1-phenylhexa-1,5-dien-3-ol (23)

S39
1,3-Diphenylhexa-1,5-dien-3-ol (24)

Prepared by following the general procedure B, from trans-chalcone (200 mg, 0.96 mmol), allylchloride (110 mg, 1.43 mmol, 1.5 equiv.), activated Mg powder (B, 47 mg, 1.9 mmol, 2 equiv.), ammonium chloride (51 mg, 1.01 mmol, 1 equiv.), and THF (230 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (2% EtOAc/petroleum ether). Product was isolated as colourless oil (208 mg, 79% yield). Rf = 0.45 (10% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 5.88 (ddt, J = 16.9, 10.2, 7.5 Hz, 1H), 5.17–5.04 (m, 2H), 2.17 (d, J = 7.5 Hz, 2H), 1.71–1.53 (m, 5H), 1.40–1.26 (m, 5H), 0.86 (s, 9H). 13C NMR (100.6 MHz, CDCl3) δ 134.0, 118.7, 70.4, 48.7, 48.1, 37.6, 32.6, 27.7, 22.6. HRMS (AJS-ESI) calcd. for C18H17O+ [M–H2O]+ 233.1325, found m/z 233.1325. Spectral data are in agreement with previously reported.

1-Allyl-4-(tert-butyl)cyclohexan-1-ol (25)

Prepared by following the general procedure B, from 4-tert-butylcyclohexanone (200 mg, 1.29 mmol), allylchloride (148 mg, 1.94 mmol, 1.5 equiv.), activated Mg powder (63 mg, 2.6 mmol, 2 equiv.), ammonium chloride (69 mg, 1.3 mmol, 1 equiv.) and THF (320 µL, 3 equiv.). Yield (by 1H NMR): 72% (dr 1:1), ax-leq-OH diastereomers were separated by column chromatography on silica gel (3% EtOAc/petroleum ether). First eluted diastereomer, ax-OH, colourless oil (71 mg, 28% yield). Rf = 0.45 (10% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 5.88 (ddt, J = 16.9, 10.2, 7.5 Hz, 1H), 5.17–5.04 (m, 2H), 2.17 (d, J = 7.5 Hz, 2H), 1.71–1.53 (m, 5H), 1.40–1.26 (m, 5H), 0.86 (s, 9H). 13C NMR (100.6 MHz, CDCl3) δ 134.0, 118.7, 70.4, 48.7, 48.1, 37.6, 32.6, 27.7, 22.6. HRMS (AJS-ESI) calcd. for C18H23Na+ [M–H2O]+ 219.1719, found m/z 219.1715. Second eluted diastereomer, eq-OH, white solid (103 mg, 40% yield). Rf = 0.22 (10% EtOAc/petroleum ether). 1H NMR (400 MHz, CDCl3) δ 5.88 (ddt, J = 17.6, 10.2, 7.5 Hz, 1H), 5.21–5.09 (m, 2H), 2.29 (d, J = 7.5 Hz, 2H), 1.82–1.64 (m, 4H), 1.58 (br s, 1H, OH), 1.39 (m, 2H), 1.16–1.01 (m, 3H), 0.86 (s, 9H). 13C NMR (100.6 MHz, CDCl3) δ 133.9, 119.0, 71.9, 47.6, 41.1, 38.6, 32.4, 27.8, 24.4. HRMS (AJS-ESI) calcd. for C18H23O+ [M–H2O]+ 179.1794, found m/z 179.1790. Spectral data are in agreement with previously reported.

4-(Naphthalen-2-yl) hepta-1,6-dien-4-ol (26)

Prepared by following the general procedure B, from methyl 2-naphthoate (200 mg, 1.1 mmol), allylchloride (206 mg, 2.69 mmol, 2.5 equiv.), activated Mg powder (104 mg, 4.30 mmol, 4.0 equiv.), ammonium chloride (2.15 mmol, 115 mg, 2.0 equiv.) and THF (350 µL, 4.0 equiv.). Product was isolated as pale-yellow oil (244 mg, 95%, purity 97% by 1H NMR). Rf = 0.71 (3:1 petroleum ether/EtOAc, UV 254 nm). 1H NMR (400 MHz, CDCl3) δ 7.94–7.89 (m, 1H), 7.89–7.80 (m, 3H), 7.54–7.43 (m, 3H), 5.63 (dd, J = 17.1, 10.1, 8.4, 6.1 Hz, 2H), 5.18–5.11 (m,
2H), 5.11–5.06 (m, 2H), 2.81 (ddt, J = 13.9, 6.1, 1.4 Hz, 2H), 2.62 (ddt, J = 13.9, 8.4, 0.9 Hz, 2H), 2.34 (s, 1H, OH). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 143.3, 133.5, 133.3, 132.4, 128.3, 128.0, 127.6, 126.2, 125.9, 124.3, 123.9, 119.4, 75.4, 46.9. HRMS (AJS-ESI) calcd. for C$_{17}$H$_{27}^+ [M–H$_2$O$^+$] 221.1325, found m/z 221.1323. Spectral data are in agreement with previously reported.$^{[43]}$

3-(Naphthalen-2-yl)propan-3-ol (27)

Prepared by following the general procedure A, from methyl 2-naphthoate (200 mg, 1.1 mmol), ethyl bromide (470 mg, 4.3 mmol, 4.0 equiv.; CAUTION: internal pressure build-up is possible), activated Mg powder (131 mg, 5.37 mmol, 5.0 equiv.) and THF (350 µL, 4.0 equiv.). Purification was performed by column chromatography on silica gel (5% EtOAc/petroleum ether). Product was isolated as a colorless oil (161 mg, 70%). $R_f$ = 0.63 (4:1 petroleum ether/EtOAc, UV 254 nm). $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 7.92–7.88 (s, 1H), 7.88–7.78 (m, 3H), 7.54–7.38 (m, 3H), 2.06–1.83 (m, 4H), 1.77 (br s, OH), 0.79 (t, J = 7.4 Hz, 6H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 143.3, 133.3, 132.3, 128.3, 127.8, 127.6, 126.1, 125.7, 124.4, 124.1, 77.8, 35.1, 8.0. HRMS (AJS-ESI) calcd. for C$_{15}$H$_{27}^+$ [M–H$_2$O$^+$] 197.1325, found m/z 197.1320.

((4R,5R)-2-phenyl-1,3-dioxolane-4,5-diyl)bis(diphenylmethanol) (28)

Prepared by following the general procedure A, from dimethyl (4R,5R)-2-phenyl-1,3-dioxolane-4,5-dicarboxylate (200 mg, 0.75 mmol), bromobenzene (708 mg, 4.50 mmol, 6.0 equiv.), activated Mg powder (183 mg, 7.50 mmol, 10 equiv.) and THF (370 µL, 6 equiv.). Purification was performed by column chromatography on silica gel (5% EtOAc/petroleum ether) followed by recrystallization (toluene:hexane = 1:2). Additional portion of the product was crystallized as a clathrate with ethanol (diethyl ether:ethanol = 1:4), followed by co-evaporation with toluene.$^{[44]}$ White solid (201 mg, 52%). $R_f$ = 0.62 (4:1 petroleum ether/ethyl acetate, UV 254 nm). $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ 7.61–7.00 (m, 25H), 5.32 (d, J = 5.0 Hz, 1H), 5.16 (s, 1H), 5.13 (d, J = 5.0 Hz, 1H), 3.27 (s, 1H, OH), 2.05 (s, 1H, OH). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 146.3, 144.5, 144.3, 143.1, 137.1, 129.5, 128.4, 128.3, 128.02, 127.98, 127.7, 127.5, 127.4, 127.3, 127.2, 127.0, 126.9, 105.1, 81.7, 80.9, 78.73, 78.65. HRMS (AJS-ESI) calcd. for C$_{53}$H$_{36}$O$_5$Na$^+$ [M+Na$^+$] 537.2036, found m/z 537.2032. Spectral data are in agreement with previously reported.$^{[45]}$

1-(Naphthalen-2-yl)propan-1-one (5b)

Prepared by following the general procedure A, from N-methoxy-N-methyl-2-naphthamide (200 mg, 0.93 mmol), bromoethane (152 mg, 1.4 mmol, 2 equiv.; CAUTION: internal pressure build-up is possible), activated Mg powder (112 mg, 4.60 mmol, 5 equiv.), sodium chloride as grinding additive (106 mg) and THF (230 µL, 3 equiv.). Purification was performed by column chromatography on silica gel (1% EtOAc/petroleum ether). White solid (84 mg, 48%). $R_f$ = 0.66 (20% EtOAc/petroleum ether). $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.51–8.45 (s, 1H), 8.05 (dd, J = 8.7, 1.8 Hz, 1H), 7.97 (dd, J = 7.9, 0.8 Hz, 1H), 7.93–7.85 (m, 2H), 7.57 (dddd, J = 18.5, 8.1, 6.9, 1.4 Hz, 2H), 3.15 (q, J = 7.2 Hz, 2H), 1.29 (t, J = 7.3 Hz, 3H). $^{13}$C NMR (100.6 MHz, CDCl$_3$) $\delta$ 201.0, 135.7, 134.4, 132.7, 129.7 (2C), 128.53, 128.45, 127.9, 126.9, 124.1, 32.0, 8.6. HRMS (AJS-ESI) calcd. for C$_{13}$H$_{13}$O$^+$ [M+H$^+$] 185.0961, found m/z 185.0956. Spectral data are in agreement with previously reported.$^{[46]}$

tert-Butyl (R)-(2,6-dimethyl-3-oxohept-1-en-4-yl) carbamate (29)

Prepared by following the general procedure A, from t-butyl (R)-(4-methyl-1-morpholino-1-oxopentan-2-yl) carbamate (76.5 mg, 0.255 mmol), 2-bromoprop-1-ene (92.4 mg, 0.764 mmol, 3 equiv.), activated Mg powder (50 mg, 2.0 mmol, 8 equiv.) and THF (210 µL, 10 equiv.), 120
min milling time. Purification was performed by column chromatography on silica gel (5% EtOAc/petroleum ether). Product was isolated as colourless oil (33 mg, 51%). R\_f = 0.85 (2:1 petroleum ether/acetone, PMA). \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta = 6.06\) (s, 1H), 5.92–5.82 (m, 1H), 5.14 (m, 1H), 5.05 (dt, \(J = 9.4, 3.6\) Hz, 1H), 1.88 (s, 3H), 1.77–1.66 (m, 1H), 1.50–1.38 (m, 1H), 1.41 (s, 9H), 1.31 (ddd, \(J = 14.1, 9.9, 4.5\), 1H), 0.99 (d, \(J = 6.5\) Hz, 3H), 0.89 (d, \(J = 6.5\) Hz, 3H). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta = 201.7, 155.7, 142.4, 126.2, 79.7, 52.7, 43.3, 28.5, 25.1, 23.5, 21.9, 18.0\). HRMS (AJS-ESI) calcd. for C\(_{14}H_{36}NO_3^+\) [M+H]\(^+\) 256.1907, found m/z 256.1903. Spectral data are in agreement with previously reported.\(^{[47]}\)

**Benzyltriethyilsilane (30)**

![Benzyltriethyilsilane](image)  

A 14 mL milling jar was loaded under air with chlorotriethylsilane (100 mg, 0.92 mmol), benzyl chloride (1.01 mmol, 116 \(\mu\)L, 1.1 equiv.) and THF (224 \(\mu\)L, 3 equiv.). A single 10 mm ZrO\(_2\) ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aqueous solution of NH\(_3\) \(2\) (10 mL) was added to the jar and extracted twice with EtOAc (2×20 mL). The combined organic solvent was washed with brine and was dried over Na\(_2\)SO\(_4\). Removal of the solvent afforded crude benzyltriethylsilane as colorless liquid (106 mg, 56%). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta = 7.22–7.17\) (m, 2H), 7.08–6.98 (m, 3H), 2.10 (s, 2H), 0.92 (t, \(J = 7.9\) Hz, 9H), 0.52 (q, \(J = 7.9\) Hz, 6H). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta = 140.8, 128.3, 128.2, 123.9, 21.8, 7.4, 3.1\). Spectral data are in agreement with previously reported.\(^{[48]}\)

**N-Benzyl-N-ethylethanamine (31)**

![N-Benzyl-N-ethylethanamine](image)  

A 14 mL milling jar was loaded under air with \(O\)-benzoyl-\(N,N\)-diethylhydroxylamine (100 mg, 0.52 mmol), benzyl chloride (0.57 mmol, 66.5 \(\mu\)L, 1.1 equiv.) and THF (127 \(\mu\)L, 3 equiv.). A single 10 mm ZrO\(_2\) ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aqueous solution of NaHCO\(_3\) (10 mL) was added to the jar and extracted twice with EtOAc (2×20 mL). The combined organic solvent was washed with brine and was dried over Na\(_2\)SO\(_4\). Removal of the solvent afforded crude amine as a colorless oil (78 mg, 92%). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta = 7.38–7.31\) (m, 5H), 3.60 (s, 2H), 1.88 (m, 1H), 1.41 (s, 9H), 1.31 (dt, \(J = 14.1, 9.9\), 1H), 0.99 (d, \(J = 6.5\) Hz, 3H), 0.89 (d, \(J = 6.5\) Hz, 3H). The analytically pure sample was obtained as hydrochloride salt. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta = 7.22–7.17\) (m, 2H), 7.08–6.98 (m, 3H), 2.10 (s, 2H), 0.92 (t, \(J = 7.9\) Hz, 9H), 0.52 (q, \(J = 7.9\) Hz, 6H). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta = 129.8, 129.0, 128.3, 128.30, 54.9, 45.8, 7.1\). Spectral data are in agreement with previously reported.\(^{[49]}\)

**2-Benzyl-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (32)**

![2-Benzyl-4,4,5,5-tetramethyl-1,3,2-dioxaborolane](image)  

A 14 mL milling jar was loaded under air with 2-methoxy-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (100 mg, 0.63 mmol), benzyl chloride (0.70 mmol, 80 \(\mu\)L, 1.1 equiv.) and THF (154 \(\mu\)L, 3 equiv.). A single 10 mm ZrO\(_2\) ball (weight ca. 3 g) was added and the mixture was milled at 30 Hz for 60 minutes. Then, saturated aqueous solution of NH\(_4\)Cl (10 mL) was added to the jar and extracted twice with EtOAc (2×20 mL). The combined organic solvent was washed with brine and was dried over Na\(_2\)SO\(_4\). Removal of the solvent afforded the crude reaction mixture and \(^1\)H NMR analysis showed 50% of conversion of the starting material. The product was isolated by column chromatography on silica gel (petroleum ether/diethyl ether, 9:1). Yield 57 mg (42%). \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta = 7.26–7.16\) (m, 4H), 7.14–7.08 (m, 1H), 2.29 (s, 2H), 1.23 (s, 12H). \(^{13}\)C NMR (100.6 MHz, CDCl\(_3\)) \(\delta = 138.8, 129.1, 128.4, 125.0, 83.6, 29.9, 24.9\). Spectral data are in agreement with previously reported.\(^{[50]}\)
5.2 Gram-scale preparation of alcohol 6a

(a) with Mg powder:

Two identical reactions were performed simultaneously in two milling jars. A 14 mL milling jar was loaded under air with a 10 mm ZrO$_2$ ball, ketone 7 (0.5 g, 2.93 mmol), allyl bromide (0.53 g, 4.4 mmol, 1.5 equiv.), Mg powder (0.14 g, 5.8 mmol, 2 equiv.), ammonium chloride (0.16 g, 3 mmol, 1equiv.) and THF (0.71 mL, 3 equiv.). The second jar was loaded with the same amount of chemicals and the two jars were set to mill at 30 Hz for 60 min. The resulting crude reaction mixtures (grey paste) from the two jars were combined and transferred into a beaker with ethyl acetate and diluted with ethyl acetate (total volume ca. 50 mL). The solution was filtered through a celite pad and the solvent was evaporated under reduced pressure. Tertiary alcohol 6a was obtained as pale yellow oil (1.20 g, 96% yield, 94% NMR purity; see Fig S8).

(b) with Mg beads:

Two identical reactions were performed simultaneously in two milling jars. A 14 mL milling jar was loaded under air with a 10 mm ZrO$_2$ ball, ketone 7 (0.5 g, 2.93 mmol), allyl bromide (0.53 g, 4.4 mmol, 1.5 equiv.), Mg beads (0.72 g, 29.6 mmol, 10 equiv.), ammonium chloride (0.16 g, 3 mmol, 1 equiv.), and THF (0.71 mL, 3 equiv.). The second jar was loaded with the same amount of chemicals and the two jars were set to mill at 30 Hz for 60 min. The resulting crude reaction mixtures from the two jars were combined and transferred into a beaker with ethyl acetate and diluted with ethyl acetate (total volume ca. 50 mL). The solution was filtered through a celite pad. The excess of Mg beads was collected and recovered (1.25 g, 8.7 equiv., Fig. S9). The solvent was evaporated under reduced pressure to get the crude product. The crude was analyzed by quantitative $^1$H NMR showing the formation of 6a (86%) and 12% of starting ketone 7 remained unreacted.

Figure S8. Appearance of reaction mixture and work-up procedure for the synthesis of 6a with Mg powder.
5.3 Gram-scale preparation of alcohol 2d

(a) Mechanochemical Barbier-Grignard reaction of 2-naphthaldehyde with 2-phenylethyl bromide:

Two identical reactions were performed simultaneously in two milling jars.

A 14 mL milling jar was loaded under air with a 10 mm ZrO$_2$ ball, 2-naphthaldehyde (0.5 g, 3.2 mmol), activated Mg powder (0.16 g, 6.4 mmol, 2 equiv.), 2-phenylethyl bromide (0.59 g, 3.2 mmol, 1 equiv.) and THF (0.78 mL, 9.6 mmol, 3 equiv.). The second jar was loaded with the same amount of chemicals and the two jars were set to mill at 30 Hz for 60 min. Black paste was produced (Fig. S10). Saturated aq. NH$_4$Cl (250 µL) was added to each jar and the jars were milled for additional 30 min at 30 Hz. The resulting crude reaction mixtures were combined and diluted with ethyl acetate (total volume 80 mL), filtered through a celite pad and concentrated under reduced pressure. The residue was analyzed by quantitative $^1$H NMR with triphenylmethane as internal standard (see Table S10; $^1$H NMR of the crude reaction mixture is shown in Figure S11, I). Further purification by silica gel column chromatography (4% EtOAc in petroleum ether) afforded product 2d as pale-yellow oil (1.27 g, 75%).
Two identical reactions were performed simultaneously in two milling jars.

A 14 mL milling jar was loaded under air with a 10 mm ZrO$_2$ ball, activated Mg powder (0.16 g, 6.4 mmol, 2 equiv.), 2-phenylethyl bromide (0.59 g, 3.2 mmol, 1 equiv.) and THF (0.78 mL, 9.6 mmol, 3 equiv.). The second jar was loaded with the same amount of chemicals and then two jars were set to mill at 30 Hz for 60 minutes. 2-Naphthaldehyde (500 mg, 3.2 mmol) was added to each jar (immediate start of the exothermic reaction was noticed upon the addition of aldehyde) and the jars were set to mill at 30 Hz for additional 60 min. Saturated aqueous NH$_4$Cl (250 µL) was added to each jar and the jars were milled for additional 30 min at 30 Hz. The resulting crude reaction mixtures were combined and diluted with ethyl acetate (total volume 80 mL), filtered through a celite pad and concentrated under reduced pressure. The residue was analyzed by quantitative $^1$H NMR with triphenylmethane as internal standard (see Table S11; $^1$H NMR of the crude reaction mixture is shown in Figure S11, II). Further purification by silica gel column chromatography (4% EtOAc in petroleum ether) afforded product 2d as pale-yellow oil (0.82 g, 49%).

<table>
<thead>
<tr>
<th>Table S11. Synthesis of alcohol 2d: comparison of yields.</th>
</tr>
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<tbody>
<tr>
<td><strong>Product</strong></td>
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<tr>
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<tr>
<td></td>
</tr>
<tr>
<td>2d:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>by-products:</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>5d</td>
</tr>
<tr>
<td>33 (oxidation)</td>
</tr>
<tr>
<td>SI-1 (Wurtz coupling)</td>
</tr>
<tr>
<td>unreacted I</td>
</tr>
<tr>
<td>PMI[$^a$]</td>
</tr>
</tbody>
</table>

[$^a$] PMI = process mass intensity, excluding work-up and purification
Figure S11. $^1$H NMR spectra of the crude reaction mixture obtained by using synthetic protocol I and II. Signals of product 2d are highlighted in blue color. Identified side products: 2-phenylethanol 33, product of Wurtz coupling SI-1 and 1-(2-naphthalenyl)-3-phenyl-1-propanone 5d.
6. References


7. Copies of $^1$H and $^{13}$C NMR spectra
25- eq-OH
25-ax-OH
31 x HCl
$\text{N}$

31

x HCl

13C (ppm)

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0