A facile synthesis of benzyl-α, β-unsaturated carboxylic esters

Alan R. Katritzky,* Suoming Zhang,§ Alessandro Soares, and Mingyi Wang

Center for Heterocyclic Compounds, Department of Chemistry, University of Florida,
Gainesville, Florida 32611-7200
E-mail: katritzky@chem.ufl.edu

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Abstract

A simple, convenient and practical method is reported for the preparation of benzyl α,β-unsaturated carboxylates using commercially available and inexpensive reagents under mild conditions.

Keywords: Benzyl α,β-unsaturated carboxylates, synthesis

Introduction

Although diverse benzyl esters of α,β-unsaturated acids are often required in organic synthesis, only 5 such compounds are commercially available. While numerous methods have been reported for the esterification of carboxylic acids, only relatively little has been documented on synthesis of α,β-unsaturated carboxylic esters. We now report a simple, convenient, high yielding preparation for benzyl α,β-unsaturated carboxylates from the corresponding acids and benzyl bromide.

Results and Discussion

In the present work, benzyl α,β-unsaturated carboxylates 3a–j were prepared from equimolar amounts of an α,β-unsaturated carboxylic acid 1 and benzyl bromide 2 using sodium bicarbonate as a base (Scheme 1). The results are summarized in Table 1. Benzyl esters have been prepared previously by the following methods: i) reaction of carboxylate anions with alkyl halides, ii) condensations of carboxylic acids or derivatives with benzyl alcohol, and iii) the use of alkyl or aryl triflates. The yields obtained in the present study compare favorably to those reported in the literature (see Table 1).
Table 1. Benzyl α,β-unsaturated-carboxylates (3)

<table>
<thead>
<tr>
<th>Entry</th>
<th>R</th>
<th>Present work</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>Mp (°C)</td>
<td>Yield (%)</td>
</tr>
<tr>
<td>a</td>
<td>Phenyl</td>
<td>33-34</td>
<td>92</td>
</tr>
<tr>
<td>b</td>
<td>m-Nitrophenyl</td>
<td>68-69</td>
<td>87</td>
</tr>
<tr>
<td>c</td>
<td>3,4-Methylenedioxyphenyl</td>
<td>85-86</td>
<td>95</td>
</tr>
<tr>
<td>d</td>
<td>p-Nitrophenyl</td>
<td>109-111</td>
<td>86</td>
</tr>
<tr>
<td>e</td>
<td>p-Chlorophenyl</td>
<td>239-241</td>
<td>82</td>
</tr>
<tr>
<td>f</td>
<td>3,4,5-Trimethoxypyphenyl</td>
<td>85-86</td>
<td>88</td>
</tr>
<tr>
<td>g</td>
<td>2-Furyl</td>
<td>oil</td>
<td>78</td>
</tr>
<tr>
<td>h</td>
<td>2-Thienyl</td>
<td>51-53</td>
<td>93</td>
</tr>
<tr>
<td>i</td>
<td>Methyl</td>
<td>oil</td>
<td>90</td>
</tr>
<tr>
<td>j</td>
<td>n-Propyl</td>
<td>oil</td>
<td>87</td>
</tr>
</tbody>
</table>

- 3b-c, e, h are novel compounds.

Products 3a-j were characterized spectroscopically: they show $^1$H NMR signals in the 5.16–5.28 ppm range for the benzyl protons, at 7.74–7.82 ppm (d, $J = 16.0$ Hz) and 6.30–6.90 ppm (d, $J = 16.0$ Hz) for the aryl or heteroaryl trans double bond proton, and at 5.80–5.90 ppm (d, $J = 14.0–16.0$ Hz) for the alkyl trans double bond proton. These spectra data are consistent with those reported. $^{2a,3a,3b,4}$

In conclusion, an economical and practical method for the synthesis of benzyl α,β-unsaturated carboxylates has been developed using commercially available and inexpensive reagents under mild conditions.

**Experimental Section**

**General Procedures.** Melting points were determined on a MEL-TEMP capillary melting point apparatus equipped with a Fluke 51 digital thermometer. NMR spectra were recorded in CDCl$_3$ (unless stated otherwise) with tetramethylsilane as the internal standard for $^1$H (300 MHz) and
the solvent for $^{13}$C (75 MHz).

**Typical procedure for the preparation of benzyl α, β-unsaturated carboxylates.** To a solution of an α,β-unsaturated carboxylic acid (10 mmol) and benzyl bromide (1.88 g, 11 mmol) in 30 mL of DMF/1,4-dioxane (1:1), NaHCO$_3$ (0.84 g, 10 mmol) was added at room temperature. The reaction mixture was heated and stirred at 90 °C for 24 h. Cooled to room temperature, the reaction mixture was diluted with EtOAc and washed with saturated NaCl and H$_2$O. The organic layer was dried over MgSO$_4$. Evaporation in vacuo provided crude product, which was recrystallized from the appropriate solvents to give the pure benzyl carboxylate in good to excellent yield.

**Benzyl (E)-cinnamate (3a).** White needles from hexane-ethyl acetate (92%), mp 33–34 °C (lit.$^{3a}$ 33–33.5 °C); $^1$H NMR δ 7.78 (d, $J = 16.1$ Hz, 1H), 7.46–7.33 (m, 10 H), 6.46 (d, $J = 16.1$ Hz, 1H), 5.23 (s, 2H); $^{13}$C NMR δ166.6, 144.9, 135.9, 134.2, 130.2, 128.7, 128.4, 128.2, 128.1, 127.9, 117.7, 66.2.

**Benzyl (E)-m-nitrocinnamate (3b).** White prisms from hexane-ethyl acetate (87%), mp 68–69 °C. $^1$H NMR δ 8.34 (d, $J = 2.2$ Hz, 1H), 8.21 (dd, $J = 1.0$, 8.3 Hz, 1H), 7.80 (d, $J = 8.3$ Hz, 1H), 7.74 (d, $J = 16.1$ Hz, 1H), 7.56 (t, $J = 8.1$ Hz, 1H), 7.25–7.43 (m, 5H), 6.60 (d, $J = 16.1$ Hz, 1H), 5.27 (s, 2H); $^{13}$C NMR δ 165.8, 148.5, 142.1, 135.9, 135.6, 133.5, 129.9, 128.5, 128.3, 128.2, 124.4, 122.3, 120.9, 66.6. Anal. Calcd for C$_{16}$H$_{13}$NO$_4$: C, 67.84; H, 4.63; N, 4.94. Found: C, 67.60; H, 4.95; N, 4.94.

**Benzyl (E)-3-(3,4-methoxylidenephenyl)acrylate (3c).** White microcrystals from hexane-ethyl acetate (95%), mp 85–86 °C; $^1$H NMR δ 7.61 (d, $J = 16.0$ Hz, 1H), 7.40–7.30 (m, 5H), 6.99–6.94 (m, 1H), 6.76 (d, $J = 7.9$ Hz, 1H), 6.29 (d, $J = 16.0$ Hz, 1H), 5.94 (s, 2H), 5.22 (s, 2H); $^{13}$C NMR δ 166.8, 149.5, 148.0, 144.7, 136.1, 128.6, 128.4, 128.0, 128.1, 124.4, 122.3, 120.9, 66.1. Anal. Calcd for C$_{17}$H$_{14}$O$_4$: C, 72.33; H, 5.00. Found: C, 72.08; H, 4.95; N, 4.94.

**Benzyl (E)-p-nitrocinnamate (3d).** Yellow needles from hexane-ethyl acetate (86%), mp 109–111 °C (lit.$^{4b}$ 112–113 °C); $^1$H NMR (DMSO-d$_6$) δ 8.20 (d, $J = 8.7$ Hz, 2H), 7.99 (d, $J = 8.6$ Hz, 2H), 7.80 (d, $J = 16.1$ Hz, 1H), 7.53–7.28 (m, 5H), 6.91 (d, $J = 16.1$ Hz, 1H), 5.28 (s, 2H); $^{13}$C NMR (DMSO-d$_6$) δ 165.5, 148.0, 142.2, 140.4, 136.0, 129.4, 128.5, 128.2, 128.1, 123.8, 122.1, 66.0. Anal. Calcd for C$_{16}$H$_{13}$NO$_4$: C, 67.84; H, 4.63; N, 4.94. Found: C, 67.60; H, 4.95; N, 4.94.

**Benzyl (E)-4-chlorocinnamate (3e).** White needles from hexane-ethyl acetate (82%), mp 239–241 °C; $^1$H NMR δ 7.73–7.68 (m, 3H), 7.47–7.34 (m, 6H), 6.46 (d, $J = 16.1$ Hz, 1H), 5.25 (s, 2H); $^{13}$C NMR δ 166.8, 144.2, 137.5, 136.5, 134.3, 130.7, 129.9, 129.4, 129.1, 128.9, 119.8, 66.7. Anal. Calcd for C$_{16}$H$_{13}$ClO$_2$: C, 70.46; H, 4.80. Found: C, 70.81; H, 4.81.

**Benzyl (E)-3,4,5-trimethoxyphenylacrylate (3f).** Yellow microcrystals from hexane-ethyl acetate (88%), mp 85–86 °C (lit.$^{4a}$ 87–89 °C); $^1$H NMR δ 7.64 (d, $J = 15.9$ Hz, 1H), 7.41–7.37 (m, 5H), 6.75 (s, 2H), 6.40 (d, $J = 15.8$ Hz, 1H), 5.25 (s, 2H), 3.88 (s, 9H); $^{13}$C NMR δ 166.7, 153.4, 145.1, 136.0, 128.8, 128.6, 128.3, 117.0, 116.5, 105.4, 105.2, 66.3, 60.9, 56.1.

**Benzyl (E)-3-(furan-2-yl)acrylate (3g).** Dark brown oil (78%) (lit.$^{3f}$ 42 °C); $^1$H NMR
δ7.49–7.36 (m, 6H), 6.61 (t, J = 3.2 Hz, 1H), 6.47 (d, J = 1.6 Hz, 1H), 6.36 (d, J = 15.8 Hz, 1H), 5.23 (s, H); 13C NMR δ 166.8, 150.8, 144.8, 136.1, 131.4, 128.5, 128.1, 115.4, 114.9, 112.2, 66.2.

**Benzyl (E)-3-(thien-2-yl)acrylate (3h).** White needles from hexane-ethyl acetate (93%), mp 51–53 °C; 1H NMR δ 7.82 (d, J = 15.7 Hz, 1H), 7.47–7.30 (m, 6H), 7.25 (d, J = 3.3 Hz, 1H), 7.05 (t, J = 3.8 Hz, 1H), 6.29 (d, J = 15.7 Hz, 1H), 5.23 (s, 2H); 13C NMR δ 166.2, 139.1, 137.2, 135.8, 130.8, 128.3, 128.2, 128.0, 127.9, 127.8, 116.2, 66.0. Anal. Calcd for C14H12O2S: C, 68.83; H, 4.95. Found: C, 68.53; H, 5.12.

**Benzyl (E)-2-butenoate (3i).** Colorless oil (90%); 1H NMR δ 7.35–7.32 (m, 5H), 7.08–6.96 (m, 1H), 5.89 (d, J = 15.5 Hz, 1H), 5.16 (s, 2H), 1.85 (d, J = 5.9 Hz, 3H); 13C NMR δ 166.2, 145.1, 136.0, 128.4, 128.0, 122.3, 65.8, 17.9.

**Benzyl (E)-2-hexenoate (3j).** Colorless oil (87%); 1H NMR δ 7.41–7.34 (m, 5H), 7.06–6.97 (m, 1H), 5.87 (d, J = 14.1 Hz, 1H), 5.17 (s, 2H), 2.18–2.14 (m, 2H), 1.51–1.44 (m, 2H), 0.94 (t, J = 5.6 Hz, 3H); 13C NMR δ 166.4, 149.8, 136.1, 128.4, 128.1, 128.0, 121.0, 65.9, 34.1, 21.1, 13.6.

**References**

§ Current address: Neurogen Corporation, 35 Northeast Industrial Road, Branford, CT 06405.