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

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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.

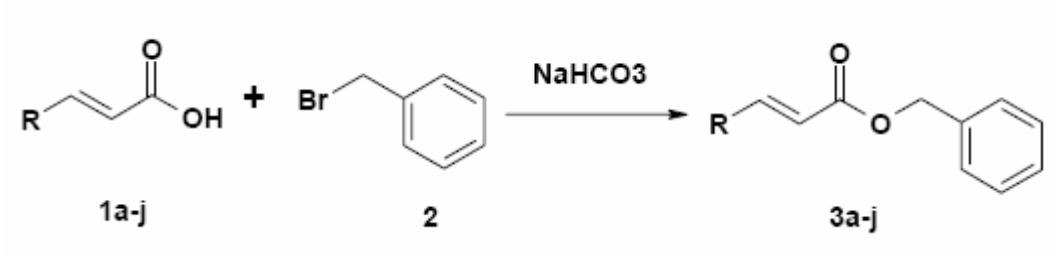
Keywords: Benzyl α,β-unsaturated carboxylates, synthesis

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,[1] 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,[2] ii) condensations of carboxylic acids or derivatives with benzyl alcohol,[3] and iii) the use of alkyl or aryl triflates.[4] The yields obtained in the present study compare favorably to those reported in the literature (see Table 1).



Scheme 1

Table 1. Benzyl α,β-unsaturated-carboxylates **(3)**

Entry	R	Present work		Literature		
		Mp (0C)	Yield (%)	Mp (0C)	Yield (%)	Ref.
a	Phenyl	33-34	92	33-33.5	89	3a
b	*m*-Nitrophenyl	68-69	87	–	-	-
c	3,4-Methylenedioxyphenyl	85-86	95	–	-	-
d	*p*-Nitrophenyl	109-111	86	112-113	82	4b
e	*p*-Chlorophenyl	239-241	82	–	-	-
f	3,4,5-Trimethoxyphenyl	85-86	88	87-89	85	4a
g	2-Furyl	oil	78	42-43	86	3f
h	2-Thienyl	51-53	93	-	-	-
i	Methyl	oil	90	oil	55	3b
j	*n*-Propyl	oil	87	oil	98	2b

- **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 (1.88g, 11 mmol) in 30 mL of DMF/1,4-dioxane (1:1), $NaHCO_3$ (0.84g, 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_2O. 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); ^1H 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. ^1H 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; ^1H NMR δ 7.61 (d, *J* =16.0 Hz, 1H), 7.40−7.30 (m, 5H), 6.99−6.94 (m, H), 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, 128.1, 128.0, 124.4, 115.6, 108.4, 106.3, 101.4, 66.1. Anal. Calcd for $C_{17}H_{14}O_4$: C, 72.33; H, 5.00. Found: C, 72.08; H, 5.15.

Benzyl (*E*)-*p*-nitrocinnamate (3d). Yellow needles from hexane-ethyl acetate (86%), mp 109−111 °C (lit.[4b] 112-113 °C); ^1H 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, 128.0, 123.8, 122.1, 66.0.

Benzyl (*E*)-4-chlorocinnamate (3e). White needles from hexane-ethyl acetate (82%), mp 239−241 °C; ^1H 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); ^1H 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); ^1H 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); ^{13}C 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 ^{o}C; ^{1}H 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); ^{13}C NMR δ166.2, 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 $C_{14}H_{12}O_2S$: C, 68.83; H, 4.95. Found: C, 68.53; H, 5.12.

Benzyl (*E*)-2-butenoate (3i). Colorless oil (90%); ^{1}H 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); ^{13}C 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%); ^{1}H 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); ^{13}C NMR δ 166.4, 149.8, 136.1, 128.4, 128.1, 128.0, 121.0, 65.9, 34.1, 21.1, 13.6.

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