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[3,3] SIGMATROPIC REARRANGEMENT OF ALLYLIC ALCOHOLS WITH ETHYL β,β-DIETHOXYACRYLATE: REGIOSPECIFIC SYNTHESIS OF SUBSTITUTED ALLYLMALONATES.[1]

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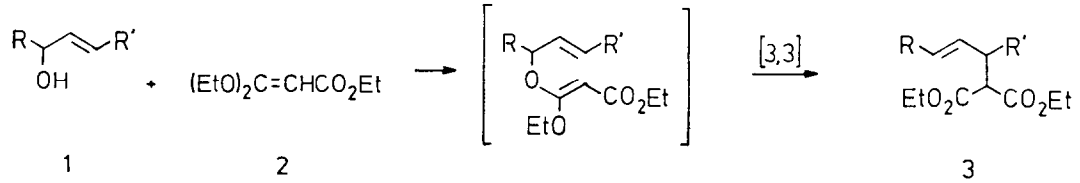
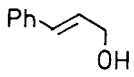
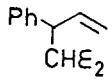
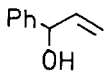
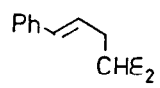
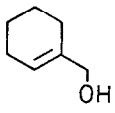
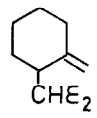
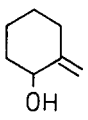
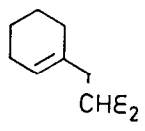
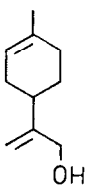
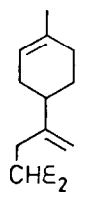
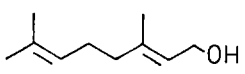
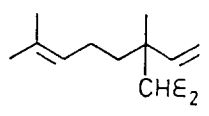
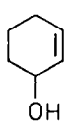
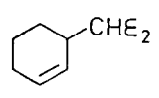
Abstract: [3,3] Sigmatropic rearrangement of allylic alcohols with ethyl β,β-diethoxyacrylate provides a convenient method for the regiospecific synthesis of substituted allylmalonates 3.

The [3,3] sigmatropic rearrangement of allyl vinyl ether derivatives to γ,δ-unsaturated carbonyl compounds provides an extremely useful and versatile method for the formation of new carbon-carbon bonds.[3] The Johnson ortho ester Claisen rearrangement[4] has proven to be quite useful, particularly for systems which are not compatible with the basic conditions[5] required for the ester enolate Claisen rearrangement.[6] The versatility of this process has been extended by the use of a variety of functionalized ortho esters in Claisen rearrangement.[7,8]

We now wish to report that the [3,3] sigmatropic rearrangement of allylic alcohols 1 with ethyl β,β-diethoxyacrylate (2)[9] provides a convenient method for the regiospecific synthesis of substituted allylmalonate esters 3. This method offers several attractive features over the previously reported[10] methods for the preparation of such systems. The procedure does not require the use of expensive or sensitive organometallic reagents. In addition, rather hindered systems which contain adjacent quaternary and tertiary carbons can be prepared by this procedure (entry f). The most important advantage, however, is the complete and unambiguous regiospecificity obtained for the rearrangement of isomeric allylic alcohols (entries a and b, c and d). This control of regiospecificity is in marked contrast to the results obtained by the alkylation of many of the π-allyl metal complexes.[11]



1 2 3

Entry	Allylic Alcohol 1	Malonate 3	Yield[a]	Method	Ref
a			92%[b]	A	10k,n
b			63%[b]	B	10k
c			74%[b]	B	13
d			75%[b]	B	10o
e			88%	A	10o
f			70%	A	13
g			70%	B	10b

E = $CO_2CH_2CH_3$

[a]Yields refer to isolated, chromatographically pure products. [b]>99% a single regioisomer by capillary GC (25 meter J&W DB-5).

General Experimental Method A. Diethyl (1-phenyl)allylmalonate (3a). A solution of 3-phenyl-2-propenol (1a) (450 mg, 3.35 mmol), ethyl β,β-diethoxyacrylate (2) (1.26 g, 6.70 mmol), 2,4,6-trimethylbenzoic acid (55 mg, 0.33 mmol), and 1,2-dichlorobenzene (25 mL) was heated at 110 °C for one hour under an argon atmosphere in a 50 mL flask fitted with a short path distillation head. The oil bath temperature was then gradually increased to 200 °C, and approximately 1 mL of 1,2-dichlorobenzene distilled out. The short path distillation head was then replaced by a reflux condenser and the reaction solution was heated at reflux for 16 hours. The 1,2-dichlorobenzene was removed in vacuo, and the residue was purified by flash chromatography[12] to give 3a as a colorless liquid (849 mg, 3.07 mmol) in 92% yield.[13]

Method B. The reaction was conducted exactly as above except that the oil bath temperature was increased to only 150 °C, and the distillation head was not replaced.

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(11) For example, although Fe-catalyzed alkylation of 3-phenyl-2-propenyl acetate with diethyl sodiomalonate gave 3a, the analogous reaction of 1-phenyl-2-propenyl acetate gave a 66:34 ratio of 3b and 3a.[10k] Reaction of di-μ-chlorobis(1,2-tetramethylene-π-allyl)dipalladium with dimethyl sodiomalonate gave either a 21:79 or 74:26 ratio of the dimethyl esters corresponding to 3c and 3d, depending on the ligand utilized.[10d,e] The Mo-catalyzed allylic alkylation of geranyl acetate with dimethyl sodiomalonate gave an 85:15 mixture of regioisomers.[10f]

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(13) All compounds gave spectra (^{1}H NMR, IR, HREIMS) in accord with their proposed structures. ^{1}H NMR ($CDCl_3$): 3a δ 0.97 (t, J=7, 3H), 1.26 (t, J=7, 3H), 3.7-4.4 (m, 6H), 5.10 (m, 2H), 6.03 (m, 1H), 7.33 (m, 5H); 3b δ 1.23 (t, J=7, 6H), 2.80 (m, 2H), 3.52 (t, J=7, 1H), 4.20 (q, J=7, 4H), 5.9-6.8 (m, 2H), 7.37 (m, 5H); 3c δ 1.22 (t, J=7, 3H), 1.26 (t, J=7, 3H), 1.3-1.8 (m, 6H), 2.0-3.2 (m, 3H), 3.69 (d, J=10, 1H), 4.13 (q, J=7, 2H), 4.20 (q, J=7, 2H), 4.64 (d, J=5, 2H); 3d δ 1.25 (t, J=7, 6H), 1.2-2.2 (m, 8H), 2.50 (d, J=8, 2H), 3.52 (t, J=8, 1H), 4.16 (q, J=7, 4H), 5.47 (m, 1H); 3e δ 1.23 (t, J=7, 6H), 1.5-2.4 (m, 10H), 2.67 (d, J=8, 2H), 3.59 (t, J=8, 1H), 4.17 (q, J=7, 4H), 4.80 (m, 2H), 5.40 (m, 1H); 3f δ 1.23 (t, J=7, 6H), 1.26 (s, 3H), 1.5-2.3 (m, 10H), 3.40 (s, 1H), 4.17 (q, J=7, 4H), 4.8-5.3 (m, 3H), 6.03 (m, 1H); 3g δ 1.25 (t, J=7, 6H), 1.5-2.3 (m, 6H), 2.90 (m, 1H), 3.23 (d, J=10, 1H), 4.18 (q, J=7, 4H), 5.4-6.0 (m, 2H). HREIMS: 3a calcd $C_{16}H_{20}O_4$ 276.1362, found 276.1365; 3b calcd $C_{16}H_{20}O_4$ 276.1362, found 276.1362; 3c calcd $C_{14}H_{22}O_4$ 254.1518, found 254.1522; 3d calcd $C_{14}H_{22}O_4$ 254.1518, found 254.1525; 3e calcd $C_{17}H_{26}O_4$ 294.1831, found 294.1837; 3f calcd $C_{17}H_{28}O_4$ 296.1988, found 296.1988; 3g calcd $C_{13}H_{20}O_4$ 240.1362, found 240.1360.

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