

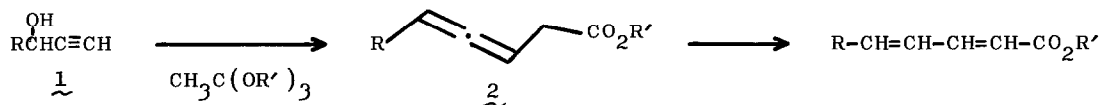
HIGHLY STEREOCONTROLLED SYNTHESIS OF (2E,4Z)-DIENOIC  
 ESTERS BY ALUMINA CATALYST<sup>1</sup>

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Summary: Thermal treatment of  $\beta$ -allenic esters (2) with alumina catalyst in aprotic solvents yielded (2E,4Z)-dienoic esters (3) in 57-87% yields with 91-100% stereoselectivity.

$\beta$ -Allenic esters 2, which are readily obtained from trialkyl orthoacetate and propargylic alcohols (1)<sup>2</sup>, can be converted to 2,4-dienoic esters by the prototropic rearrangement with basic or acidic catalysts.<sup>3,4</sup> However, these procedures hitherto reported are not satisfactory in the stereoselectivity.<sup>4</sup>

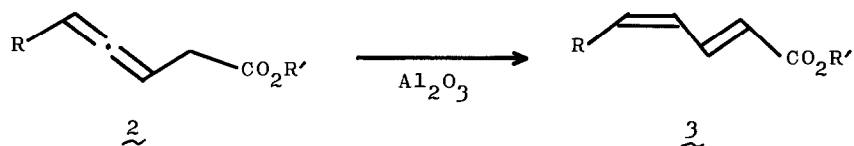


In this communication we wish to report a novel, stereoselective synthesis of (2E,4Z)-dienoic esters (3), which we found out recently and are both experimentally simple and economically feasible. The method merely involves the thermal treatment of 2 with alumina catalyst<sup>5</sup> in aprotic solvent, which caused a prototropic rearrangement to give 3 in good yields. Eight examples of this rearrangement were investigated, and the results are summarized in Table I. Although in several cases (2E,4E)-isomers<sup>6</sup> were produced as a minor component, this procedure of the transformation of  $\beta$ -allenic esters to (2E,4Z)-dienoates excels others<sup>4</sup> in its high stereoselectivity (91-100%).

Best results were obtained when the allenic esters were heated in non-polar solvents such as benzene and xylene with alumina<sup>5</sup> (5-10 equiv) at 80-138°C. The reaction, being monitored by IR or NMR spectrum, was terminated as soon as the starting material disappeared. Usually it took 2-6 h. After cooling, the alumina catalyst was removed by filtration and the evaporation of the solvent gave the <sup>1</sup>H NMR pure (2E,4Z)-diene 3<sup>7</sup> as a clean oil.

This synthetic method of (2E,4Z)-dienoate was adapted to the total syntheses of several natural products, which are outlined in Scheme I. Ethyl (2E,4Z)-decadienoate (3e), a component of the odoriferous principle of Bartlett

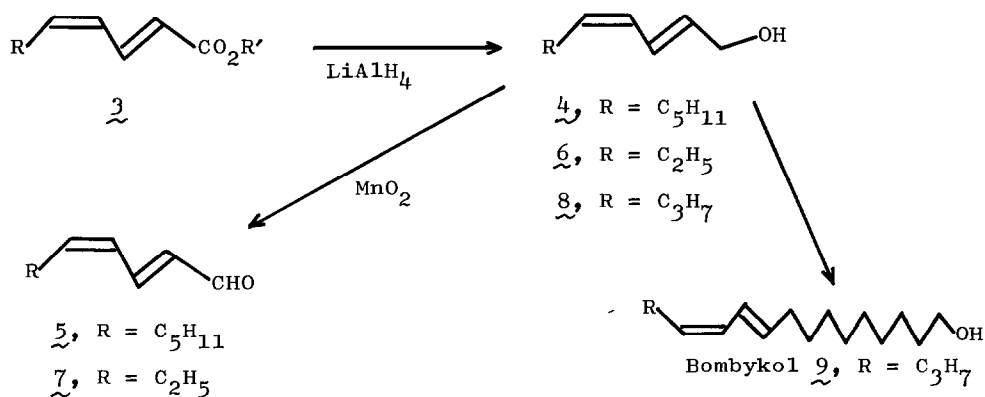
Table I. The Rearrangement of Allenic Esters 2 to (2E,4Z)-Dienoic Esters (3) with Alumina Catalyst



Compounds	R	R'	Yield <sup>a</sup> (%)	Purity <sup>b</sup> ((2E,4Z), %) ((2E,4E), %)	
<u>3a</u>	CH <sub>3</sub>	CH <sub>3</sub>	57 <sup>c</sup>	100	0
<u>3b</u>	C <sub>2</sub> H <sub>5</sub>	CH <sub>3</sub>	82	96	4
<u>3c</u>	C <sub>3</sub> H <sub>7</sub>	CH <sub>3</sub>	80	96	4
<u>3d</u>	C <sub>3</sub> H <sub>7</sub>	C <sub>2</sub> H <sub>5</sub>	69	93	7
<u>3e</u>	C <sub>5</sub> H <sub>11</sub>	C <sub>2</sub> H <sub>5</sub>	82	100	0
<u>3f</u>	C <sub>6</sub> H <sub>13</sub>	CH <sub>3</sub>	82	99	1
<u>3g</u>	C <sub>8</sub> H <sub>17</sub>	CH <sub>3</sub>	87	91	9
<u>3h</u>	C <sub>9</sub> H <sub>19</sub>	CH <sub>3</sub>	70	96	4

(a) Isolated yield. (b) Determined by GLPC. (c) Lower yield probably due to higher volatility of the product.

Scheme I. Total Syntheses of Several Natural Products



pears, <sup>8</sup> was stereospecifically prepared in 82% yield, as shown in Table I. Furthermore 3e was converted to (2E,4Z)-decadienal (5), a flavour component of groundnuts and carrot root.<sup>9</sup> Reduction of 3e with LiAlH<sub>4</sub> (ether, -40°C, 1 h) gave (2E,4Z)-decadien-1-ol (4)<sup>10</sup> in 84% yield. Oxidation of 4 with active MnO<sub>2</sub> (20 equiv, petroleum ether, 25°C, 1.5 h) afforded 5<sup>8</sup> (88% pure, 70% yield) together with the (2E,4E)-isomer (12%). Methyl (2E,4Z)-heptadienoate (3b) was similarly converted to (2E,4Z)-heptadienal (7), a flavour component of tomato.<sup>11</sup> Reduction of 3b with LiAlH<sub>4</sub> gave (2E,4Z)-heptadien-1-ol (6) (84%), which was subsequently oxidized with active MnO<sub>2</sub> to afford 7<sup>11</sup> (70%) along with 6% of the (2E,4E)-isomer. The current reaction was further applied to the preparation of a key intermediate for the synthesis of (10E,12Z)-hexadecadien-1-ol, which is the sex pheromone of *Bombyx mori*<sup>12,13</sup> named bombykol (9). Reduction of methyl (2E,4Z)-octadienoate (3c) with LiAlH<sub>4</sub> (ether, -50 — -30°C, 1 h) gave (2E,4Z)-octadienol (8) (73%)<sup>14,15</sup> which can be converted to bombykol (9) via two steps by the known method.<sup>14</sup>

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#### References and Notes

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- (5) Weakly basic alumina (200-300 mesh) for column chromatography, which was purchased from Katayama Chemical Industries Co., Ltd., was used

after drying at 200–250°C (10 mm).

- (6) The structure was identified by comparison of  $^1\text{H}$  NMR spectrum and the retention time of GLPC with those of an authentic sample prepared by the independent synthesis: T. Sakai, K. Seko, A. Tsuji, M. Utaka, and A. Takeda, to be published.
- (7) 3a: IR (neat) 1722, 1642, 1610  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR ( $\text{CCl}_4$ ) 1.88 (d,  $J = 6$  Hz,  $\text{CH}_3\text{CH=}$ ), 3.68 (s,  $\text{CO}_2\text{CH}_3$ ), 5.4–6.4 (m,  $-\text{CH}=\text{CHCH}=\text{CHCO}_2\text{CH}_3$ ), 7.55 (dd,  $J = 10$  and 15 Hz,  $\text{C}_3\text{-H}$ );  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  6.3 (q), 51.4 (q), 127.6 (d), 128.4 (d), 135.7 (d), 139.4 (d), 171.9 (s). 3c: IR (neat) 1720, 1635, 1605  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR ( $\text{CCl}_4$ )  $\delta$  0.93 (t,  $J = 6$  Hz,  $\text{CH}_3\text{CH}_2$ ), 1.40 (m,  $\text{CH}_3\text{CH}_2$ ), 2.22 (m,  $\text{CH}_2\text{CH=}$ ), 3.65 (s,  $\text{OCH}_3$ ), 5.74 (m,  $\text{C}_5\text{-H}$ ), 5.75 (d,  $J = 16$  Hz,  $\text{C}_2\text{-H}$ ), 6.12 (dd,  $J = 11.5, 11.5$  Hz,  $\text{C}_4\text{-H}$ ), 7.50 (dd,  $J = 11.5, 16$  Hz,  $\text{C}_3\text{-H}$ );  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  13.7 (q), 22.7 (t), 30.3 (t), 51.3 (q), 121.0 (d), 126.9 (d), 139.7 (d), 141.3 (d), 167.6 (s). 3f: IR (neat) 1720, 1635, 1605  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR ( $\text{CCl}_4$ )  $\delta$  0.92 (t,  $\text{CH}_3(\text{CH}_2)_5$ ), 1.32 (m,  $\text{CH}_3(\text{CH}_2)_4\text{CH}_2$ ), 2.30 (m,  $\text{CH}_2\text{CH=}$ ), 3.65 (s,  $\text{OCH}_3$ ), 5.50–6.30 (m,  $\text{C}_2\text{-H}$ ,  $\text{C}_4\text{-H}$ ,  $\text{C}_5\text{-H}$ ), 7.47 (dd,  $J = 11.5, 16$  Hz,  $\text{C}_3\text{-H}$ );  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  14.1 (q), 22.7 (t), 28.4 (t), 29.0 (t), 29.5 (t), 31.8 (t), 51.4 (q), 120.9 (d), 126.6 (d), 139.7 (d), 141.7 (d), 167.7 (s).
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- (15) The  $^1\text{H}$  NMR spectrum (100 MHz) of 8 was identical with that of the authentic sample. <sup>14a</sup>  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  13.7 (q), 22.9 (t), 29.9 (t), 63.6 (t), 127.0 (d), 127.9 (d), 131.7 (d), 132.9 (d).

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