The Birch Reduction of Heterocyclic Compounds V [1] Birch Reduction of 2- and 5-Acylfuran-3-carboxylic Acids and Reductive Elimination of 2-(Arylmethoxymethyl)furan-3-carboxylic Acids

Yasuo Ohta, Matsumi Doe, Yoshiki Morimoto and Takamasa Kinoshita*

Department of Chemistry, Graduate School of Science, Osaka City University, Sumiyoshi-ku, Osaka
558-8585, Japan
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The Birch reduction of 2- and 5-acylfuran-3-carboxylic acid 1 and 4 gave 2-acyl-2,3-dihydrofuran-3-carboxylic acid 2 and 5-acyltetrahydrofuran-3-carboxylic acid 5, respectively. Further examination of the reductive elimination was also studied on 2-(arylmethoxymethyl)furan-3-carboxylic acids 7.

In a previous paper [1], we discussed whether carbonyl reduction or ring reduction took place in the metal-ammonia reduction of 3-acylfurans. As a part of our study on the Birch reduction of heterocyclic compounds, we now describe the Birch reduction of 2-(1-pentanoyl)furan-3-carboxylic acid 1, 5-acetylfuran-3-carboxylic acid 4, and 2-(arylmethoxymethyl)-furan-3-carboxylic acid 7.

The Birch reduction of 1 with two equivalent atoms of sodium in liquid ammonia at -70° gave, after esterification with diazomethane, methyl 2-(1-pentanoyl)-2,3-dihydrofuran-3-carboxylate 2 (68% yield) and methyl ester 3 (25% yield) of the starting material (Scheme 1). No isomer or side products attributable to carbonyl reduction were observed. The ^{1}H nmr coupling constant (J = 5.9 Hz) between H-2 (δ 5.23) and H-3 (δ 3.97) is presumed to be a *trans*-configuration [2].
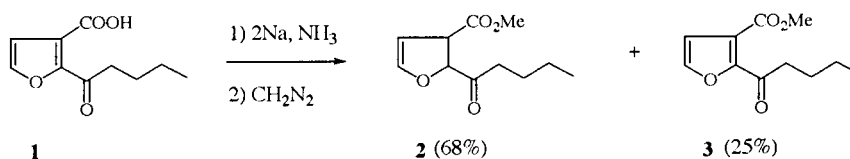
A similar reaction of 4 afforded a tetrahydrofuran derivative 5 (5a : 5b = 1:1; by nmr and hplc) in 40% yield, and a large amount of the starting material was recovered. In the reduction with four equivalent atoms of sodium, the yield of 5 increased (Scheme 2). The stereochemistry of 5 was deduced from comparison of the ^{1}H nmr chemical shifts and NOE in 5a and 5b (Figure). The H_b-4 of 5a should be deshielded more strongly than the H_b-4 of 5b

Figure

NMR (NOE) of 5.

2.45 Hb   H 3.15   2.18 Hb   H 3.12
2.30 Ha•••   •••CO₂Me   2.50 Ha•••   •••CO₂Me

anti-5a   *syn*-5b
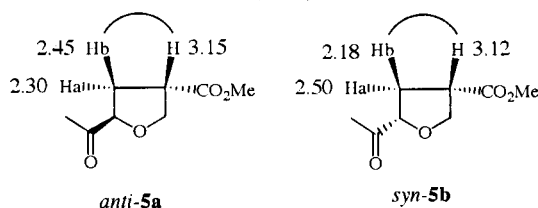
Scheme 1

Birch Reduction of 2-Acylfuran-3-carboxylic Acid 1

1) 2Na, NH₃

2) CH₂N₂

1   2 (68%)   +   3 (25%)

Scheme 2

Birch Reduction of 5-Acylfuran-3-carboxylic Acid 4

1) Na, NH₃, *t*-BuOH

2) CH₂N₂

4   5   +   6

	5	6
2 Na	40 %	52 %
4 Na	61 %	26 %
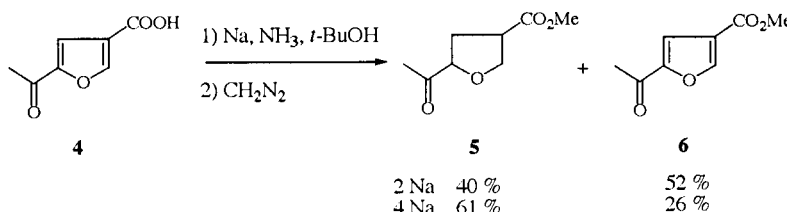
Scheme 3

Reaction Mechanism of 4

4   →(e)   A   →(e, H)   B   →(2e, H)   5
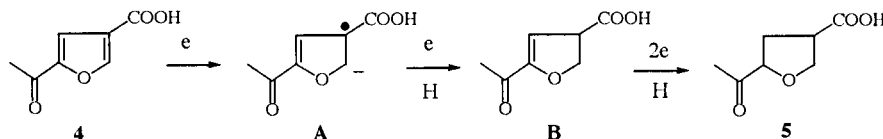
Scheme 4
Birch Reduction-Elimination of 7

7 a R=R₁=R₂=R₃=R₄=H
 b R=R₂=R₃=R₄=H, R₁=OMe
 c R=R₁=R₃=R₄=H, R₂=OMe
 d R=R₁=R₂=R₃=H, R₄=OMe
 e R=R₂=R₃=R₄=H, R₁=CH₃
 f R=R₁=R₂=H, R₃=R₄=OMe
 g R=COCH₃, R₁=R₂=R₃=R₄=H
 h R=COCH₃, R₂=R₃=R₄=H, R₁=CH₃
 i R=COCH₃, R₁=R₃=R₄=H, R₂=OMe

8 a R=R₁=R₂=R₃=R₄=H
 b R=R₂=R₃=R₄=H, R₁=OMe
 c R=R₁=R₃=R₄=H, R₂=OMe
 d R=R₁=R₂=R₃=H, R₄=OMe
 e R=R₂=R₃=R₄=H, R₁=CH₃
 f R=R₁=R₂=H, R₃=R₄=OMe
 g R=COCH₃, R₁=R₂=R₃=R₄=H
 h R=COCH₃, R₂=R₃=R₄=H, R₁=CH₃
 i R=COCH₃, R₁=R₃=R₄=H, R₂=OMe
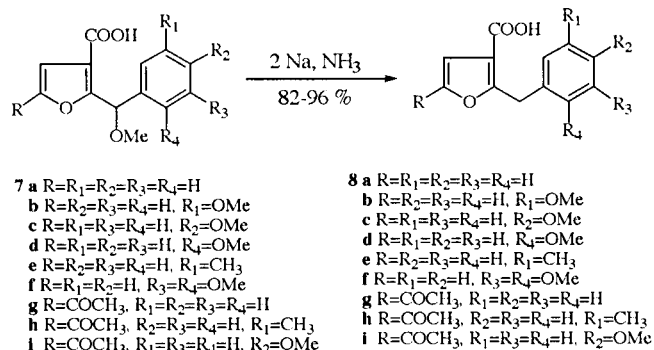
by the carbonyl of the 5-acetyl group. In **5a**, an NOE was observed between the H-3 and a lower-field hydrogen (H_b-4, δ 2.45), whereas in **5b**, an NOE was observed between the H-3 and a higher hydrogen (H_b-4, δ 2.18). These results indicate that the acetyl group at C-5 and the methoxycarbonyl group at C-3 of **5a** were bonded in the opposite configuration as compared with **5b**. From these considerations, it was found that the stereochemistry of **5a** was *anti*-configuration and **5b** was *syn*-configuration. The formation of the tetrahydrofuran **5** resulting from a further reduction shows that the reaction (**B** → **5**) is faster than the reaction (**4** → **B**) (Scheme 3). Since four electrons are consumed in the reduction of **4** to **5**, the starting material **4** is recovered in some amount.

Scheme 5
Reaction Mechanism of 7
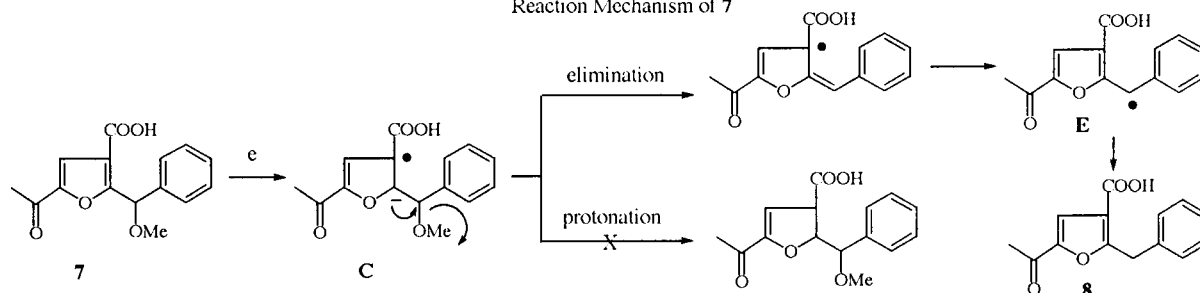
Table 1
Physical Data and Infrared Spectral Data of 7 and 8

Compound No.	Yield (%)	Mp(°) (lit. mp)	Molecular Formula	Elemental Analyses Calcd./Found		IR (cm⁻¹)
7a	66	116-117 [4]				
7b	75	116-117	C₁₄H₁₄O₅	64.12	5.38	[a] 2920, 1660, 1580, 1320, 1280,
				64.03	5.35	1220, 1040, 960
7c	79	100-100.5	C₁₄H₁₄O₅	64.12	5.38	[a] 1680, 1590, 1100, 790
				64.13	5.51	
7d	60	135-136	C₁₄H₁₄O₅	64.12	5.38	[a] 1680, 1590, 1280, 1240, 1180, 1080
				63.81	5.46	
7e	82	78.5-79.5	C₁₄H₁₄O₄	68.28	5.73	[b] 3000, 1680, 1590, 1520, 1460,
				68.18	5.67	1090, 970, 770
7f	80	92-95	C₁₅H₁₆O₆	61.64	5.52	[a] 1670, 1580, 1060, 730
				61.52	5.52	
7g	61	112-113	C₁₅H₁₄O₅	65.69	5.14	[b] 1740, 1440, 1360, 1180, 1080,
				65.66	5.09	1020, 930
7h	82	150-151	C₁₆H₁₆O₅	66.66	5.59	[b] 2830, 1670, 1580, 1430, 1260,
				66.47	5.62	1070, 960
7i	79	126-127	C₁₆H₁₆O₆	63.15	5.30	[b] 2930, 2560, 1670, 1590, 1510,
				62.90	5.28	1440, 1250, 1070
8a	96	104-105 [4]				
8b	92	95-96 (80-82) [6]	C₁₃H₁₂O₄	67.23	5.21	[a] 1670, 1580, 1300, 1260, 1140, 1040,
				67.03	5.21	910
8c	88	119 (114) [6]	C₁₃H₁₂O₄	67.23	5.21	[a] 1680, 1600, 1330, 1250, 760
				67.08	5.10	
8d	86	131-132 (121-123) [6]	C₁₃H₁₂O₄	67.23	5.21	[a] 1670, 1590, 1300, 1240, 1060, 840
				67.23	5.17	
8e	90	89-90	C₁₃H₁₂O₃	72.21	5.59	[a] 1680, 1590, 1320, 1050, 760
				72.22	5.62	
8f	92	111-112 (104-106) [6]	C₁₄H₁₄O₅	64.12	5.38	[a] 1680, 1580, 1300, 1080, 1000
				63.95	5.46	
8g	83	144-145	C₁₄H₁₂O₄	68.85	4.95	[a] 1620, 1450, 710
				68.93	4.69	
8h	85	150-151	C₁₅H₁₄O₄	69.76	5.46	[b] 1695, 1680, 1650, 1590, 1270, 750
				69.52	5.38	
8i	82	153-154	C₁₅H₁₄O₅	65.69	5.14	[a] 1680, 1580, 1500, 1240
				65.29	5.14	

[a] Nujol, [b] Potassium bromide

Table 2
^{1}H- and ^{13}C NMR Spectral Data of **7** and **8**

Compound No.	^{1}H NMR (δ, ppm)	^{13}C NMR (δ, ppm)
7a [4]		
7b	3.44(s, 3H), 3.81 (s, 3H), 6.14 (s, 3H), 6.74 (d, 1H, J = 1.8), 6.84 (dd, 1H, J = 1.8, 8.0), 7.07 (d, 1H, J = 7.9), 7.09 (d, 1H, J = 2.0), 7.27 (t, 1H, J = 7.9), 7.38 (d, 1H, J = 1.8)	55.2, 57.3, 76.3, 110.8, 112.3, 113.8, 115.3, 119.3, 129.5, 139.7, 142.6, 159.7, 168.8
7c	3.42 (s, 3H), 3.79 (s, 3H), 6.07 (s, 1H), 6.74 (d, 1H, J = 2.0), 6.89 (d, 2H, J = 8.6), 7.37 (d, 1H, J = 2.0), 7.43 (d, 2H, J = 8.6)	55.2, 57.1, 76.6, 111.0, 113.9, 115.0, 128.4, 130.2, 142.4, 159.6, 159.9, 168.3
7d	3.47 (s, 3H), 3.78 (s, 3H), 6.39 (s, 1H), 6.76 (d, 1H, J = 1.8), 6.87 (d, 1H, J = 8.0), 7.02 (t, 1H, J = 7.5), 7.31 (d, 1H, J = 1.8), 7.31 (dt, 1H, J = 1.5, 8.0), 7.58 (dd, 1H, J = 1.5, 7.7)	55.5, 57.4, 71.6, 110.6, 111.3, 115.6, 120.7, 126.0, 127.9, 129.4, 140.1, 156.8, 158.5, 167.7
7e	2.36 (s, 3H), 3.44 (s, 3H), 6.08 (s, 1H), 6.75 (d, 1H, J = 1.8), 7.12 (d, 1H, J = 7.0), 7.24 (t, 1H, J = 7.5), 7.26 (d, 1H, J = 7.1), 7.30 (s, 1H), 7.38 (d, 1H, J = 1.8)	21.4, 57.3, 76.7, 110.9, 115.3, 124.1, 127.5, 128.4, 129.0, 138.0, 138.3, 142.6, 159.7, 168.5
7f	3.46 (s, 3H), 3.75 (s, 3H), 3.85 (s, 3H), 6.40 (s, 3H), 6.77 (d, 1H, J = 2.0), 6.90 (dd, 1H, J = 1.5, 7.9), 7.10 (t, 1H, J = 7.9), 7.19 (dd, 1H, J = 1.5, 7.9), 7.32 (d, 1H, J = 2.0)	55.8, 57.3, 60.7, 71.7, 111.4, 112.5, 115.6, 119.6, 124.1, 131.5, 142.2, 146.9, 152.6, 158.4, 167.0
7g	2.48 (s, 3H), 3.46 (s, 3H), 6.15 (s, 1H), 7.32-7.41 (m, 3H), 7.46 (s, 1H), 7.52-7.56 (m, 2H)	26.2, 57.6, 76.9, 116.9, 117.3, 127.2, 128.8, 128.9, 137.2, 151.7, 162.6, 166.9, 186.7
7h	2.36 (s, 3H), 2.48 (s, 3H), 3.46 (s, 3H), 6.10 (s, 1H), 7.14 (d, 1H, J = 7.5), 7.26 (t, 1H, J = 7.5), 7.33 (d, 1H, J = 7.5), 7.34 (br s, 1H), 7.47 (s, 1H)	21.4, 26.1, 57.5, 77.1, 116.8, 117.3, 124.3, 127.8, 128.7, 129.5, 137.0, 138.5, 151.5, 162.5, 166.7, 186.6
7i	2.48 (s, 3H), 3.43 (s, 3H), 3.80 (s, 3H), 6.06 (s, 1H), 6.91 (d, 2H, J = 8.6), 7.46 (s, 1H), 7.46 (d, 2H, J = 8.8)	26.1, 55.3, 57.3, 76.8, 114.2, 116.4, 117.5, 128.6, 129.0, 151.4, 160.0, 162.6, 166.4, 186.5
8a [4]		
8b [6]	3.78 (s, 3H), 4.36 (s, 2H), 6.72 (d, 1H, J = 2.0), 6.77 (dd, 1H, J = 2.3, 8.3), 6.84 (br s, 1H), 6.88 (d, 1H, J = 7.5), 7.21 (t, 1H, J = 7.9), 7.29 (d, 1H, J = 2.0)	33.6, 55.1, 110.9, 112.1, 113.1, 114.6, 121.2, 129.5, 138.5, 141.4, 159.7, 161.8, 169.1
8c [6]	3.77 (s, 3H), 4.31 (s, 2H), 6.70 (d, 1H, J = 2.0), 6.83 (d, 2H, J = 8.6), 7.22 (d, 2H, J = 8.6), 7.29 (d, 1H, J = 2.0)	32.7, 55.2, 110.9, 112.8, 114.0, 129.1, 129.8, 141.3, 158.4, 162.5, 169.3
8d [6]	3.82 (s, 3H), 4.46 (s, 2H), 6.72 (d, 1H, J = 1.5), 6.87 (d, 1H, J = 5.9), 6.88 (t, 1H, J = 5.0), 7.06 (dd, 1H, J = 1.7, 7.8), 7.21 (dt, 1H, J = 1.7, 8.0), 7.26 (d, 1H, J = 1.5)	27.9, 55.5, 110.5, 110.9, 113.4, 120.5, 125.5, 128.0, 129.9, 141.2, 157.3, 162.1, 169.5
8e	2.33 (s, 3H), 4.35 (s, 2H), 6.71 (d, 1H, J = 2.0), 7.06 (m, 2H), 7.10 (s, 1H), 7.19 (m, 1H), 7.29 (d, 1H, J = 2.0)	21.4, 33.5, 110.9, 113.0, 125.8, 127.5, 128.5, 129.5, 136.9, 138.2, 141.4, 162.1, 169.4
8f [6]	3.82, (s, 3H), 3.85 (s, 3H), 4.43 (s, 2H), 6.71 (d, 1H, J = 1.8), 6.76 (dd, 1H, J = 1.0, 6.6), 6.81 (dd, 1H, J = 1.4, 8.3), 6.97 (t, 1H, J = 7.9), 7.26 (d, 1H, J = 1.8)	27.7, 55.7, 60.5, 110.9, 111.2, 113.3, 122.1, 123.9, 130.8, 141.2, 147.2, 152.8, 162.0, 169.5
8g	2.45 (s, 3H), 4.44 (s, 2H), 7.19-7.25 (m, 5H), 7.46 (s, 1H)	25.9, 33.3, 115.2, 118.3, 127.1, 128.7, 128.8, 135.8, 150.9, 165.4, 168.0, 186.2
8h	2.33 (s, 3H), 2.45 (s, 3H), 4.41 (s, 2H), 7.05-7.22 (m, 4H), 7.46 (s, 1H)	21.4, 26.0, 33.8, 115.1, 118.2, 125.9, 127.9, 128.6, 129.5, 135.7, 138.5, 150.8, 165.5, 167.8, 186.1
8i	2.45 (s, 3H), 3.78 (s, 3H), 4.38 (s, 2H), 6.48 (d, 2H, J = 8.6), 7.26 (d, 2H, J = 8.6), 7.45 (s, 1H)	26.0, 33.1, 55.3, 114.3, 114.9, 118.4, 127.9, 130.0, 150.9, 158.8, 166.0, 168.0, 186.2

Similar to the reduction-elimination of **7a-f** without an acyl group, the reduction of **7g-i** [3] having both a methoxyl group and an acyl group afforded **8g-i** in good yield, respectively (Scheme 4). As shown in Scheme 5, the methoxyl group would be predominantly eliminated from the initial anion radical intermediate **C** to give product **8** via the stable benzyl radical **E**, and no protonation at the C-2 carbanion occurred.

In this way, the ring reduction proceeded prior to the carbonyl reduction in the Birch reduction of the acyl-furan-3-carboxylic acids. This method is applied to the synthesis of 2-substituted furanonaphthoquinones [3].

EXPERIMENTAL

Melting points were measured with a Yanagimoto MP apparatus and are uncorrected. The ir spectra were taken on a JASCO A-102 IR spectrophotometer. ^{1}H and ^{13}C nmr (in deuterio-

chloroform) were recorded on JEOL LA-300 (300 MHz) and Varian U-500 (500 MHz). The mass spectra were recorded on a JEOL AX-500 spectrometer. Column chromatography was performed with silica gel (Merck NO. 7734; 63-200 μm), and thin layer chromatography (tlc) was performed on a glass plate coated with Kieselgel 60 GF$_{254}$ (Merck). All reagents were commercially available (reagent grade) and purified before use. Diisopropylamine and dimethylsulfoxide were distilled from calcium hydride. Tetrahydrofuran was dried by distillation from sodium benzophenone ketyl prior to use. Organic solutions were dried over anhydrous sodium sulfate. Ether refers to diethyl ether.

2-(1-Pentanoyl)furan-3-carboxylic acid (**1**).

A solution of oxalyl chloride (0.6 ml, 7.2 mmoles) in dichloromethane (50 ml) was cooled to -60°; then a solution of dry dimethylsulfoxide (0.6 ml, 7.8 mmoles) in dichloromethane (5 ml) was added dropwise and stirring was continued for 2 minutes. A solution of methyl 2-(1-hydroxypentyl)furan-3-carboxylate [4] (1.20 g, 5.5 mmoles) in dichloromethane (10 ml)

was added over 5 minutes and the resulting slurry stirred 15 minutes at -60°. After this period, triethylamine (3.9 ml, 28 mmoles) was added and the slurry stirred an additional 5 minutes. The mixture was warmed to room temperature, water (20 ml) was added, and the mixture was extracted with dichloromethane (3 x 50 ml). The organic phase was washed with water and dried. The solvent was removed *in vacuo* and the residual product was hydrolyzed with sodium hydroxide in aqueous methanol to give 1 (944 mg, 85%) as a colorless oil, ir (film): 1720, 1620 cm⁻¹; ¹H nmr: δ 0.98 (t, 3H, J = 5.5 Hz), 1.44 (sext, 2H, J = 5.5 Hz), 1.76 (quint, 2H, J = 5.5 Hz), 3.08 (t, 2H, J = 5.5 Hz), 7.18 (d, 1H, J = 1.3 Hz), 7.62 (d, 1H, J = 1.3 Hz); ¹³C nmr: δ 13.7 (q), 22.2 (t), 25.7 (t), 38.3 (t), 116.6 (d), 127.7 (s), 146.0 (d), 149.2 (s), 160.4 (s), 196.4 (s). hrms (CI): Calcd. for $C_{10}H_{13}O_4$: (M+H)⁺ 197.0814. Found: m/z 197.0835.

Birch reduction of 1.

Sodium (265 mg, 2.3 equivalents) was added to a stirred liquid ammonia (30 ml) in small pieces at -70°. 2-(1-Penta-noyl)furan-3-carboxylic acid 1 (980 mg, 5 mmoles) in tetra-hydrofuran (10 ml) was added to the blue solution, and the mixture was stirred for 1 hour. After addition of solid ammo-nium chloride, the mixture was warmed slowly to room temper-ature while the ammonia was removed with a stream of nitr-ogen. The resulting residue was acidified with 3 *M* hydrochloric acid, and extracted with ether. The ether solution was esterified with diazomethane, and washed with water and dried. The resi-dual oil was purified by chromatography (*n*-hexane-ethyl acetate; 7:1) to afford methyl 2-(1-pentanoyl)-2,3-dihydrofuran-3-carboxylate 2 (721 mg, 68%) and methyl ester 3 of the starting material (229 mg, 25%). 2: colorless oil; ir (film): 2960, 1740, 1620, 1440, 1140, 1080 cm⁻¹; ¹H nmr: δ 0.91 (t, 3H, J = 7.3 Hz), 1.33 (sext, 2H, J = 7.3 Hz), 1.58 (m, 2H), 2.62 (dt, 2H, J = 2.4 Hz, J = 7.1 Hz), 3.75 (s, 3H), 3.97 (dt, 1H, J = 2.7 Hz, J = 5.9 Hz), 5.05 (t, 1H, J = 2.7 Hz), 5.23 (d, 1H, J = 5.9 Hz), 6.42 (t, 1H, J = 2.7 Hz); ¹³C nmr: δ 13.8 (q), 22.3 (t), 25.2 (t), 38.5 (t), 49.6 (d), 52.6 (q), 86.2 (d), 99.0 (d), 146.4 (d), 172.2 (s), 208.9 (s). hrms: Calcd. for $C_{11}H_{16}O_4$: (M)⁺ 212.1048. Found: m/z 212.1050.

Birch Reduction of 5-Acetylfuran-3-carboxylic acid (4).

To a stirred solution of 4 (300 mg, 1.95 mmoles), and *tert*-butanol (1.44 ml) in liquid ammonia (20 ml) was added 2 equiv-alent atoms of sodium little by little under reflux, and the mix-ture was stirred for 1 hour. After addition of solid ammonium chloride, the usual work-up was carried out as mentioned above. Silica gel chromatography (*n*-hexane-ethyl acetate; 4:1) of the crude product gave methyl 5-acetyltetrahydrofuran-3-carb-oxylate 5 (134 mg, 40%) and methyl ester 6 of the starting mate-rial (170 mg, 52%). In the case of 4 equivalent atoms of sodium, compound 5 was obtained in 61% yield and the starting material was recovered in 26% yield. The isomeric mixture 5 was sepa-rated by hplc [Nippon Bunseki Kogyo LC-908; column: JAIGEL-H (silicon); chloroform; 3.5 ml/min] to afford *anti*-5a and *syn*-5b (1:1). *Anti*-5a: colorless oil; ir (film): 2960, 1730, 1440, 1360, 1180, 1080, 930 cm⁻¹; ¹H nmr (500 MHz): δ 2.21 (s, 3H), 2.30 (dt, 1H, J = 6.9 Hz, J = 13.2 Hz), 2.45 (dt, 1H, J = 8.5 Hz, J = 13.2 Hz), 3.15 (ddt, 1H, J = 6.3 Hz, J = 7.6 Hz, J = 8.5 Hz), 3.73 (s, 3H), 4.08 (dd, 1H, J = 7.8 Hz, J = 9.0 Hz), 4.15 (dd, 1H, J = 6.1 Hz, J = 9.0 Hz), 4.33 (dd, 1H, J = 6.9 Hz, J = 8.3 Hz); ¹³C nmr: δ 25.7 (q), 32.1 (t), 43.6 (d), 52.2 (q), 71.1

(d), 83.9 (t), 173.1 (s), 209.5 (s). hrms (CI): Calcd. for $C_8H_{13}O_4$: (M+H)⁺ 173.0814. Found: m/z 173.0822. *Syn*-5b: colorless oil; ir (film): 2900, 1740, 1440, 1360, 1200, 1080, 930 cm⁻¹; ¹H nmr (500 MHz): δ 2.18 (dt, 1H, J = 8.8 Hz, J = 13.2 Hz), 2.21 (s, 3H), 2.50 (ddd, 1H, J = 6.8 Hz, J = 8.8 Hz, J = 13.2 Hz), 3.12 (ddt, 1H, J = 5.9 Hz, J = 7.3 Hz, J = 8.8 Hz), 3.73 (s, 3H), 4.07 (dd, 1H, J = 5.9 Hz, J = 8.8 Hz), 4.15 (dd, 1H, J = 7.3 Hz, J = 8.8 Hz), 4.46 (dd, 1H, J = 6.8 Hz, J = 8.8 Hz); ¹³C nmr: δ 26.1 (q), 31.6 (t), 43.4 (d), 52.3 (q), 71.1 (t), 83.4 (d), 173.3 (s), 208.9 (s). hrms (CI): Calcd. for $C_8H_{13}O_4$: (M+H)⁺ 173.0814. Found: m/z 173.0800.

Preparation of 2-(Arylmethoxymethyl)furan-3-carboxylic Acids 7a-i.

General Procedure.

The reaction was carried out using a modification of the procedure reported by Knight and Nott [5]. A solution of lithium diisopropylamide was prepared by the addition of *n*-butyllithium (1.6 *N* in *n*-hexane, 12.8 ml) to a stirred and cooled solution of diisopropylamine (3.0 ml) in dry tetrahydrofuran (20 ml) at -78° under nitrogen. To this was added a solution of 3-furancarb-oxylic acid or 5-(1,1-ethylenedioxyethyl)furan-3-carboxylic acid (10.0 mmoles) in tetrahydrofuran (5 ml), and the mixture was stirred for 30 minutes. Then an appropriate benzaldehyde (12.0 mmoles) was added dropwise during 5 minutes. After stirring for 30 minutes followed by warming to room temperature, the mixture was concentrated *in vacuo*, and diluted with dry dimethylsulfoxide (75 ml). To the reaction mixture was added powdered potassium hydroxide (4.6 g) and iodomethane (30 mmoles) at 0°, and the mixture was stirred at room tempera-ture for 12 hours. The reaction mixture was quenched by addi-tion of water (100 ml), and extracted with dichloromethane (3 x 100 ml). The organic phase was washed with water, saturated sodium thiosulphate and brine, and concentrated *in vacuo*. The resulting ester was hydrolyzed with sodium hydroxide to give methoxy acid 7 (60-82% yield).

Birch Reduction-Elimination of 7.

General Procedure.

To a stirred solution of methoxy furan-3-carboxylic acid 7 (5 mmoles in tetrahydrofuran 5 ml) in liquid ammonia (50 ml) was added 2 equivalent atoms of sodium little by little with constant stirring under reflux. The mixture was stirred for an additional hour and an excess of ammonium chloride was added. After evaporation of the liquid ammonia at room temperature, the residue was acidified with hydrochloric acid and extracted with ether (3 x 40 ml). The combined organic extracts were washed with water and brine, and dried. Removal of solvent *in vacuo* afforded the product 8 (82-96% yield).

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