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# Prototropic Isomerization of 1-Oxaspiro[2.3]hexane-5-carbonitrile and Methyl 1-Oxaspiro[2.3]hexane-5-carboxylate into the Corresponding 3-Hydroxymethylbicyclo[1.1.0]butane-1-carboxylic Acid Derivatives*

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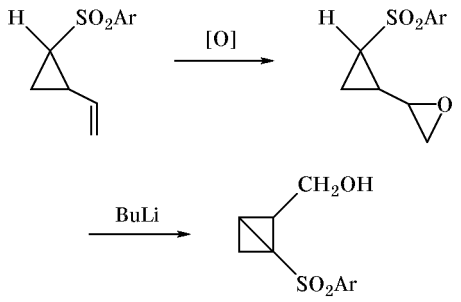
**Abstract**—Epoxy derivatives of 3-methylenecyclobutane-1-carbonitrile and methyl 3-methylenecyclobutane-1-carboxylate undergo isomerization into the corresponding 3-hydroxymethylbicyclobutane-1-carboxylic acid derivatives on treatment with lithium diisopropylamide in aprotic medium.

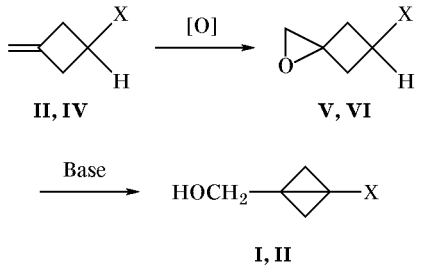
γ,δ-Epoxy sulfones, ketones, esters, and nitriles are known [2] to undergo rearrangement into the corresponding substituted cyclopropylcarbinols by the action of bases. Gaoni [3] used this method of construction of a three-membered carbon ring for the synthesis of functionally substituted bicyclobutylcarbinols, starting from vinylcyclopropane derivatives (Scheme 1).

**Scheme 1.**




Following an analogous approach, in the present work we made an attempt to synthesize bicyclobutylcarbinols with a different substitution pattern, namely compounds **I** and **II**, on the basis of the methylenecyclobutane system (Scheme 2). As starting compounds we used known 3-methylenecyclobutane-1-carbonitrile (**III**) and methyl 3-methylenecyclobutane-1-carboxylate (**IV**). Unlike Gaoni's scheme, in our case the central rather than the side bicyclobutane C–C bond is built up, so that the hydroxymethyl group appears at the bridgehead position rather than at the bridging carbon atom.

**Scheme 2.**




**I**, **III**, **V**, X = CN; **II**, **IV**, **VI**, X = $CO_2Me$.

Let us consider each of the two steps of synthesis of bicyclobutylmethanols **I** and **II** according to Scheme 2. Initial methylenecyclobutanes **III** and **IV** were converted into the corresponding spirooxiranes **V** and **VI** in two ways (Scheme 3): (1) by successive bromohydroxylation and dehydrobromination and (2) by direct epoxidation. Bromohydroxylation of **III** and **IV** was effected by the action of *N*-bromosuccinimide (NBS) in aqueous dioxane. In both cases, the addition was highly regioselective (according to the Markownikoff rule), and bromomethyl(hydroxy)cyclobutanes **VII** and **VIII** were obtained, respectively. Each product was formed as an approximately equimolar mixture of two diastereoisomers: **VIIa**:**VIIb** = 1.28, **VIIIa**:**VIIIb** = 1.15. All diastereoisomers were

* For preliminary communication, see [1].

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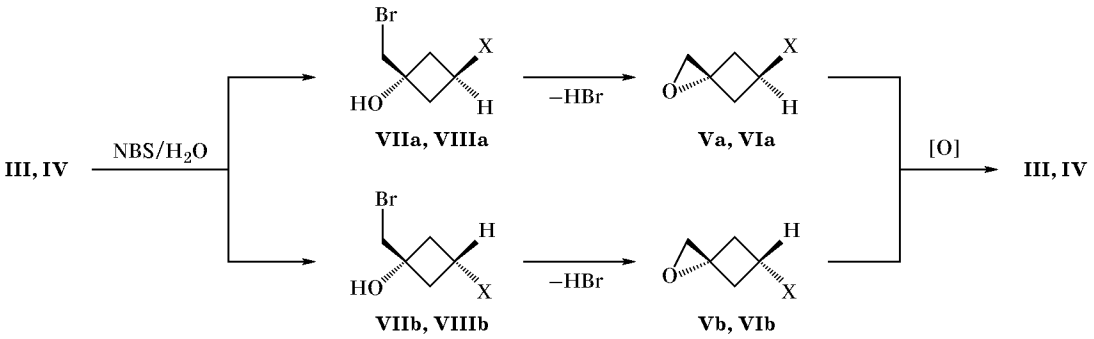
**Scheme 3.**




**V**, **VII**, X = CN; **VI**, **VIII**, X = $CO_2Me$.

isolated in the pure state by column chromatography on silica gel.

Table 1 contains the $^1H$ and $^{13}C$ NMR spectral data of compounds **VIIa**, **VIIb**, **VIIIa**, and **VIIIb**. For comparison, the corresponding data are given for two diastereoisomers of 3-hydroxy-3-methylcyclobutane-1-carbonitrile (**IXa** and **IXb**) which were obtained by hydroxymercuration–hydrodemercuration of nitrile **III**. These data ensure unambiguous assignment of the structures of **VII** and **VIII**. Their configuration was determined by comparing the $^1H$ NMR spectra of stereoisomers according to the recommendations of [4]: compounds **VIIa**, **VIIIa**, and **IXa** were assigned *trans* configuration, for their 1-H signal appears in a weaker field, $\Delta\delta_{1\text{-H}}$(*trans*, *cis*) ~ 0.4 ppm.

Nitriles **VII** were converted into spirooxiranes **V** by treatment with potassium *tert*-butoxide, and analogous transformation of esters **VIII** into epoxy derivatives **VI** was effected by the action of sodium hydride. The results of experiments with pure diastereoisomers of **VII** and **VIII** showed that the configuration of substituted cyclobutane fragment does not change during the dehydrobromination process.

Direct epoxidation of methylenecyclobutanes **III** and **IV** was performed in methylene chloride with the system $H_2O_2$–$CCl_3CN$, following the procedure described in [5]. As a result, stereoisomeric mixtures of spirooxiranes **V** and **VI** were obtained. The direct epoxidation is characterized by higher diastereoselectivity, as compared with the bromohydroxylation reaction: the *trans*/*cis* ratio of the products was 19.0 for nitrile **V** and 3.2 for ester **VI**. It should be noted that epoxidation of cyclobutane **III** with *m*-chloroperoxybenzoic acid was less selective: the ratio of the *trans* and *cis* isomers of nitrile **V** was 2.9. The $^1H$ and $^{13}C$ NMR spectra of compounds **Va**, **Vb**, and **VIa**, **VIb** are given in Table 2. Here, the same arguments as those underlying structure assignment of **VII** and **VIII** are less convincing: $\Delta\delta_{1\text{-H}}$(*trans*, *cis*) ≈ 0.2 ppm.

Isomerization of spiro epoxides **Va**, **Vb**, **VIa**, and **VIb** into target bicyclobutylmethanols **I** and **II** was effected by the action of 1.3 equiv of lithium diiso-

**Table 1.** $^1H$ and $^{13}C$ NMR spectra of substituted cyclobutanols **VII**–**IX**

| Comp. no. | $^1H$ NMR spectrum, δ, ppm (*J*, Hz) | | | | | $^{13}C$ NMR spectrum, $\delta_C$, ppm | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1-H | 2-H, 4-H | $CH_2Br$ [$CH_3$] | OH | $OCH_3$ | $C^1$ | $C^2$, $C^4$ | $C^3$ | $CH_2Br$ [$CH_3$] | CN [$CO_2CH_3$] |
| **VIIa** | 3.16 quint (8) | 2.37–2.57 | 3.60 s | 3.10 br.s | – | 13.9 | 37.7 | 72.2 | 42.4 | 122.0 |
| **VIIb** | 2.65–2.80 | 2.47–2.65 | 3.51 s | 3.17 br.s | – | 12.9 | 38.4 | 70.8 | 40.9 | 121.2 |
| **VIIIa** | 3.17 quint (8) | 2.39 d (8) | 3.64 s | 2.67 br.s | 3.69 s | 28.8 | 36.4 | 71.8 | 44.1 | [175.7] [51.9] |
| **VIIIb** | 2.59–2.78 | 2.33–2.45 | 3.55 s | 3.35 br.s | 3.67 s | 28.4 | 37.4 | 70.0 | 42.2 | [175.0] [51.9] |
| **IXa** | 3.05–3.19 | 2.34–2.56 | [1.53 s] | 2.25 br.s | – | 14.1 | 40.8 | 71.9 | [28.5] | 122.9 |
| **IXb** | 2.59–2.71 | 2.34–2.56 | [1.38 s] | 2.25 br.s | – | 12.7 | 42.2 | 69.7 | [26.0] | 121.9 |

**Table 2.** $^1$H and $^{13}$C NMR spectra of substituted 1-oxaspiro[2.3]hexanes **Va**, **Vb**, **VIa**, and **VIb**

| Comp. no. | $^1$H NMR spectrum, δ, ppm (*J*, Hz) | | | | $^{13}$C NMR spectrum, $\delta_C$, ppm | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1-H | 2-H, 4-H | $CH_2O$ | $CH_3O$ | $C^1$ | $C^2$, $C^4$ | $C^3$ | $CH_2O$ | $CO_2CH_3$ [CN] |
| **Va** | 3.08–3.25 | 2.65–2.95 | 2.76 s | – | 15.0 | 35.6 | 57.6 | 51.6 | [122.1] |
| **Vb** | 2.85–3.02 (3H), | 2.67–2.83 (2H) | 2.74 s | – | 13.5 | 35.9 | 56.2 | 51.7 | [121.0] |
| **VIa** | 3.00–3.18 | 2.58–2.80 | 2.69 s | 3.66 s | 30.3 | 34.0 | 58.3 | 52.1 | 174.0<br>51.8 |
| **VIb** | 2.70–3.00 (3H), | 2.36–2.55 (2H) | 2.69 s | 3.66 s | 29.0 | 34.4 | 56.2 | 52.0 | 174.3<br>51.8 |

**Table 3.** $^1$H and $^{13}$C NMR spectra of substituted bicyclobutanes **I**, **II**, and **X**–**XIII**[a]

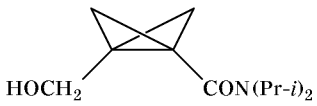
| Comp. no. | $^1$H NMR spectrum, δ, ppm (*J*, Hz) | | | | $^{13}$C NMR spectrum, $\delta_C$, ppm | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *endo*-2-H, *endo*-4-H[b] | *exo*-2-H, *exo*-4-H[b] | $CH_2O$ [$CH_3$] | OH [$OCH_3$] | $C^1$ | $C^2$, $C^4$ | $C^3$ | $CH_2O$ [$CH_3$] | CN [$CO_2CH_3$] |
| **I** | 1.36 | 2.27 | 4.22 s | 3.07 br.s | –4.4 | 38.1 | 26.8 | 58.8 | 119.6 |
| **II** | 1.25 | 2.35 | 3.98 s | 3.21 br.s<br>[3.65 s] | 12.8 | 36.3 | 29.9 | 60.0 | [51.8]<br>[172.2] |
| **X** | 1.08 | 2.18 | 4.13 s | 4.27 br.s | 13.3 | 35.5 | 22.5 | 59.3 | – |
| **XI** | 1.49 | 2.33 | 4.94 s | – | –2.8 | 38.9 | 22.9 | 61.3 | 118.5 |
| **XII** | 1.40 | 2.51 | 4.77 s | [3.65 s] | 13.5 | 36.8 | 26.2 | 62.2 | [171.1]<br>[51.9] |
| **XIII** | 1.28 | 1.98 | [1.72 s] | – | –3.6 | 40.2 | 22.8 | [12.4] | 120.0 |

[a] Other signals: $^1$H NMR, δ, ppm: **X**: 1.20 d (6H), 1.36 d (6H), 3.43 sept (1H), 4.75 sept (1H), $CON[CH(CH_3)_2]_2$; **XI**: 7.40–7.65 (3H) and 8.05–8.15 (2H) (PhCO); **XII**: 7.40–7.65 (3H) and 8.0–8.10 (2H) (PhCO); $^{13}$C NMR, $\delta_C$, ppm: **X**: 20.3, 20.7, 46.0, 50.3, 170.2 ($CON[CH(CH_3)_2]_2$); **XI**: 128.3, 129.6, 133.2, 141.0, 165.8 (PhCO); **XII**: 128.2, 129.5, 133.0, 140.1, 165.8 (PhCO).

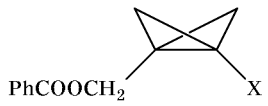
[b] All 2-H and 4-H signals are broadened singlets.

propylamide in THF at –80°C. These conditions ensured formation of compounds **I** and **II** as the only products, regardless of configuration of the initial epoxy derivative. With a larger excess of lithium diisopropylamide, amide **X** was formed as by-product in the two cases. The fraction of **X** was greater in the reaction with ester **VI**. Each bicyclobutylmethanol, **I** and **II**, was converted into the corresponding benzoyl derivative (**XI**, X = CN; **XII**, X = $CO_2CH_3$).

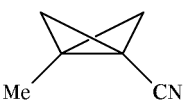
Table 3 contains the $^1$H and $^{13}$C NMR spectral data for bicyclobutane derivatives **I**, **II**, and **X**–**XII** and also the data reported in [6] for their known analog, bicyclobutane **XIII**. The $^1$H NMR spectra characteristically contain broadened singlets ($^2J_{HH} \approx 0$ Hz) from nonequivalent methylene protons of the bicyclobutane fragment; the corresponding difference in the chemical shifts is about 1 ppm. The $^{13}$C NMR spectra of substituted bicyclobutane-1-carboxylic acid derivatives **I**, **II**, **XI**–**XIII** are characterized by upfield shift of the $C^1$ signal by about 15 ppm relative to the $C^1$ signal in the spectra of respective cyclobutanecarboxylic acid derivatives **V**–**IX**. It should be emphasized that the chemical shifts of $C^1$ in nitriles **I**, **XI**, and **XIII** have negative values.




**X**



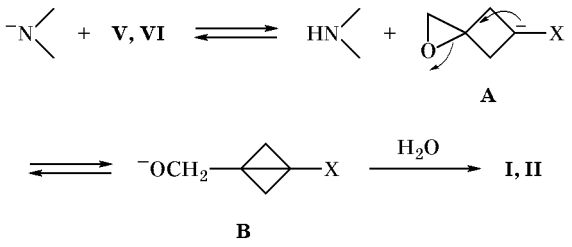

**XI, XII**




**XIII**

Taking into account the accessibility of nitrile **III** as the product of cycloaddition of acrylonitrile and allene [7], the proposed procedure for synthesizing bicyclobutylmethanols **I** and **II** on the basis of the corresponding methylenecyclobutanes **III** and **IV** according to Scheme 2 seems to be efficient and quite reasonable. The key stage in this procedure, prototropic isomerization of spirooxiranes **V** and **VI** into bicyclobutanes **I** and **II** is irreversible, despite the greater strain energy of the bicyclobutane system (62.6 kcal/mol [8]), as compared to the 1-oxaspirohexane system (56.7 kcal/mol [9]).

**Scheme 4.**




Presumably, the observed isomerization direction (**V**, **VI** → **I**, **II**) is governed by the stage including transformation of carbanion **A** into alcoholate ion **B**; the latter is more stable due to high electronegativity of the oxygen atom. Aprotic medium and some excess of a strong base are necessary conditions for the process to be controlled by the transformation **A** → **B** (Scheme 4).

## EXPERIMENTAL

The $^1$H and $^{13}$C NMR spectra of solutions in $CDCl_3$ were recorded on a Bruker AM-200 spectrometer. GLC analysis was performed on a Tsvet-101 chromatograph equipped with a flame-ionization detector; carrier gas nitrogen, flow rate 30 ml/min; glass column, 2000 × 3 mm; stationary phase 3% of OV-17 on Inerton Super (0.16–0.2 mm). Silufol UV-254 plates were used for thin-layer chromatography; eluent hexane–ethyl acetate, 1 : 1. Column chromatography was performed on silica gel L 40/100 μm.

3-Methylenecyclobutane-1-carbonitrile (**III**), bp 65–66°C (21 mm), $n_D^{20}$ 1.4615 [7], methyl 3-methylenecyclobutane-1-carboxylate (**IV**), bp 57–60°C (20 mm), $n_D^{20}$ 1.4490 [10], and 3-methylbicyclobutane-1-carbonitrile (**XIII**) [6] were synthesized by known methods. Potassium *tert*-butoxide was prepared as described in [11], and butyllithium was obtained by the procedure reported in [12].

**Bromohydroxylation of 3-methylenecyclobutane-1-carbonitrile (III).** *N*-Bromosuccinimide, 2.7 g (15 mmol), was added in small portions over a period of 0.5 h to a solution of 1.4 g (15 mmol) of nitrile **III** in 10 ml of aqueous dioxane (1 : 1) under continuous stirring at 0°C. The cooling bath was removed, and the mixture was stirred for 2 h at room temperature. Diethyl ether, 30 ml, was added, and the organic layer was separated, washed with water (3 × 10 ml), dried over magnesium sulfate, and evaporated. The residue, 2.65 g, was a viscous liquid (yield 93%) consisting of four components (according to the GLC data, 180°C); below are given the retention time and the fraction of each component: **1**, 5.1 min, 50.0%; **2**, 6.3 min, 5.5%; **3** 9.0 min, 5.5%; **4** 10.4 min, 39%. Components **1** and **4** were identified as compounds **VIIa** and **VIIb**, respectively, and were separated by column chromatography on silica gel (the separation process was monitored by GLC). Minor components **2** and **3** were not isolated and identified. By analogy with the results of bromomethoxylation of **III** and **IV** [13], these products were tentatively assigned the structure of diastereoisomeric anti-Markownikoff adducts (with no regard to their configuration).

***trans*-3-Bromomethyl-3-hydroxycyclobutane-1-carbonitrile (VIIa)** (component **1**). Viscous liquid. Found, %: C 37.78, 37.93; H 4.39, 4.33; N 7.29, 7.24. $C_6H_8BrNO$. Calculated, %: C 37.92; H 4.24; N 7.37.

***cis*-3-Bromomethyl-3-hydroxycyclobutane-1-carbonitrile (VIIb)** (component **4**). mp 77°C. Found, %: C 37.88, 37.90; H 4.35, 4.28; N 7.20, 7.34. $C_6H_8BrNO$. Calculated, %: C 37.92; H 4.24; N 7.37.

The $^1$H and $^{13}$C NMR spectra of nitriles **VIIa** and **VIIb** are given in Table 1.

**Bromohydroxylation of methyl 3-methylenecyclobutane-1-carboxylate (IV).** *N*-Bromosuccinimide, 1.78 g (10 mmol), was added in small portions over a period of 0.5 h to a solution of 1.26 g (10 mmol) of ester **IV** in 8 ml of aqueous dioxane (1 : 1) under continuous stirring at 0°C. The cooling bath was removed, and the mixture was stirred for 1 h at 20°C, diluted with 20 ml of water, and extracted with diethyl ether (3 × 15 ml). The combined extracts were washed with water (2 × 10 ml) and dried over $MgSO_4$. Removal of the solvent gave 2.1 g (94%) of a product which, according to the GLC data (160°C), was a mixture of four substances. Below are given their retention times and fractions in the mixture: **1**, 4.1 min, 50%; **2**, 5.0 min, 3.0%; **3**, 6.0 min, 3.5%; **4**, 6.7 min, 43.5%. By column chromatography on silica gel (under GLC monitoring), components **1**

(**VIIIa**) and **4** (**VIIIb**) were separated from minor products **2** and **3**.

**Methyl *trans*-3-bromomethyl-3-hydroxycyclobutane-1-carboxylate (VIIIa)** (component **1**). Viscous liquid. Found, %: C 37.91, 37.63; H 5.03, 5.15. $C_7H_{11}BrO_3$. Calculated, %: C 37.69; H 4.97.

**Methyl *cis*-3-bromomethyl-3-hydroxycyclobutane-1-carboxylate (VIIIb)** (component **4**). mp 58°C. Found, %: C 37.65, 37.85; H 4.91, 5.09. $C_7H_{11}BrO_3$. Calculated, %: C 37.69; H 4.97.

The $^1$H and $^{13}$C NMR spectra of esters **VIIIa** and **VIIIb** are given in Table 1.

**3-Hydroxy-3-methylcyclobutane-1-carbonitrile (IXa/IXb).** A solution of 4.15 g (13 mmol) of mercury acetate in 30 ml of aqueous tetrahydrofuran (1:1) was added with stirring to a solution of 1.2 g (13 mmol) of nitrile **III** in 20 ml of a 2:1 THF–$H_2O$ mixture. The mixture was stirred for 18 h at room temperature, 30 ml of a 6 M aqueous solution of NaOH and 0.75 g (20 mmol) of $NaBH_4$ were added in succession, and the mixture was stirred for 1 h. It was then filtered, and the filtrate was extracted with diethyl ether (3 × 30 ml). The combined extracts were dried over $MgSO_4$ and evaporated, and the residue was distilled under reduced pressure. Yield 0.54 g (38%). bp 85°C (2 mm). The product was a mixture of diastereoisomers **IXa** and **IXb** at a ratio of 1.7:1 (according to the $^1$H NMR data). Found, %: C 64.68, 64.77; H 8.08, 8.21; N 12.45, 12.67. $C_6H_9NO$. Calculated, %: C 64.84; H 8.15; N 12.60.

The $^1$H and $^{13}$C NMR spectra of nitriles **IXa** and **IXb**, given in Table 1, were derived from the spectra of their mixture.

**Epoxidation of nitrile (III). *trans*- and *cis*-1-Oxaspiro[2.3]hexane-5-carbonitriles Va and Vb.** *a.* To a solution of 0.93 g (10 mmol) of nitrile **III** and 2.9 g (20 mmol) of trichloroacetonitrile in 15 ml of $CH_2Cl_2$, while stirring at 20°C, we added dropwise 2 ml of 30% hydrogen peroxide preliminarily adjusted to pH 7 by addition of potassium hydrogen phosphate. The mixture was stirred for 2 h, and the disappearance of initial nitrile **III** was monitored by GLC. Usually, it was necessary to add 0.5 ml more of $H_2O_2$ to complete the reaction. The mixture was diluted with hexane (15 ml), and the precipitate of trichloroacetamide was filtered off and washed with hexane. The filtrate was washed with water, a 3% solution of $Na_2SO_3$, and water again. It was then dried over $MgSO_4$ and evaporated, and the residue was distilled under reduced pressure to obtain 0.67 g (61%) of a mixture of epoxy derivatives **Va** and **Vb** at a ratio of 95:5 (GLC). bp 69–72°C (8 mm). Found, %: C 66.29, 65.95; H 6.31, 6.52; N 12.71, 12.65. $C_6H_7NO$. Calculated, %: C 66.04; H 6.47; N 12.84.

*b*. A solution of 2.60 g (12 mmol) of 80% *m*-chloroperoxybenzoic acid in 60 ml of $CH_2Cl_2$ was stirred for 30 min at –10°C. The precipitate of *m*-chlorobenzoic acid was filtered off, and the filtrate was added dropwise at 0°C to a solution of 0.93 g (10 mmol) of nitrile **III** in 20 ml of $CH_2Cl_2$. The mixture was stirred for 1 h at room temperature and cooled to –15°C, the precipitate was filtered off, and the filtrate was washed in succession with a 5% solution of sodium sulfite, a saturated solution of sodium hydrogen carbonate, and water. It was then dried over $MgSO_4$ and evaporated to obtain 0.73 g (67%) of epoxy nitrile **V**. According to the $^1$H NMR data, the product was a mixture of diastereoisomers **Va** and **Vb** at a ratio of 2.9:1.

**Epoxidation of ester (IV). Methyl *trans*- and *cis*-1-oxaspiro[2.3]hexane-5-carboxylates VIa and VIb.** Following the above procedure (method *a*), from 1.26 g (10 mmol) of ester **IV** and 2.9 g (20 mmol) of trichloroacetonitrile in 20 ml of $CH_2Cl_2$ and 2.5 ml of 30% hydrogen peroxide (pH 7–8) we obtained 1.10 g (77%) of a mixture of epoxy esters **VIa** and **VIb** at a ratio of 3.2:1 ($^1$H NMR). bp 71–74°C (12 mm). Found, %: C 59.20, 58.89; H 7.01, 6.95. $C_7H_{10}O_3$. Calculated, %: C 59.14; H 7.09.

**Dehydrobromination of compounds VIIa and VIIb.** Potassium *tert*-butoxide, 1.2 mmol, was added to a solution of 1 mmol of nitrile **VIIa** or **VIIb** in 5 ml of dry ether. The disappearance of the initial compound was monitored by GLC. As a rule, it was necessary to add ~0.5 mmol more of potassium *tert*-butoxide to complete the reaction. The reaction time was about ~3 h. The mixture was filtered through a layer of silica gel using 1:1 pentane–ether as eluent. The eluate was dried over magnesium sulfate and evaporated to obtain spectrally ($^1$H NMR) pure products **Va** (yield 85%) and **Vb** (89%). Their $^1$H and $^{13}$C NMR spectra are given in Table 2.

**Dehydrobromination of compounds VIIIa and VIIIb.** Sodium hydride, 40 mg (1.2 mmol), was added to a solution of 1 mmol of compound **VIIIa** or **VIIIb** in 10 ml of dry ether, and the mixture was stirred at 20°C until the initial compound disappeared completely. Usually, an additional amount of sodium hydride (15–20 mg) was necessary. The yields of epoxy esters **VIa** and **VIb** were 83 and 77%, respectively. Their $^1$H and $^{13}$C NMR spectra are given in Table 2.

**Methyl 3-hydroxymethylbicyclo[1.1.0]butane-1-carboxylate (II).** A 0.58 M solution of butyllithium in pentane (4 mmol, 6.8 ml) was added in small portions through a syringe to a solution of 0.43 g (4.2 mmol) of diisopropylamine (preliminarily distilled over NaH) in 5 ml of dry ether, stirred under dry nitrogen at –78°C. The mixture was stirred for 30 min, gradually raising the temperature to –20°C. A solution of 0.44 g (3.1 mmol) of epoxy derivative **VIa** in 3 ml of dry ether was added, the cooling bath was removed, and the mixture was stirred for 3 h. It was then treated with 10 ml of a saturated solution of ammonium chloride, the organic phase was separated, and the aqueous phase was extracted with ether ($2 \times 10$ ml). The extracts were combined with the organic phase, washed with a solution of sodium chloride, and dried over magnesium sulfate. Removal of the solvent left an oily residue, 0.37 g (84%), which (according to the TLC and $^1$H NMR data) contained alcohol **II**, $R_f$ 0.25, with an impurity (~5%) of amide **X**, $R_f$ 0.37. Following a similar procedure with the same reactant ratio, alcohol **II** was obtained from epoxy ester **VIb** in 80% yield. Chromatographically and spectrally pure alcohol **II** was obtained by purification of the crude product by column chromatography on silica gel; colorless liquid, $R_f$ 0.25. Using the standard technique [14], alcohol **II** was converted into benzoyl derivative **XII** which was purified by flash chromatography on silica gel.

**Methyl 3-benzoyloxymethylbicyclobutane-1-carboxylate (XII).** $R_f$ 0.63; viscous noncrystallizable liquid. Found, %: C 68.09, 68.37; H 5.59, 5.67. $C_{14}H_{14}O$. Calculated, %: C 68.28; H 5.73.

***N,N*-Diisopropyl-3-hydroxymethylbicyclobutane-1-carboxamide (X).** When the isomerization of epoxy esters **VIa** and **VIb** (see above) was carried out using a threefold excess of lithium diisopropylamide, the product, apart from alcohol **II** ($R_f$ 0.25), contained an appreciable amount (15%) of amide **X**, $R_f$ 0.37. The latter was isolated by column chromatography on silica gel. mp 71°C. Found, %: C 68.03, 68.18; H 9.89, 10.11; N 6.48, 6.51. $C_{12}H_{21}NO_2$. Calculated, %: C 68.21; H 10.02; N 6.63.

**3-Hydroxymethylbicyclo[1.1.0]butane-1-carbonitrile (I).** A 0.6 M solution of butyllithium in pentane (5 mmol, 0.85 ml) was added in small portions through a syringe to a solution of 0.51 g (5 mmol) of anhydrous diisopropylamine in 10 ml of dry ether, stirred at –78°C under dry nitrogen. The mixture was stirred for 30 min, gradually raising the temperature to –25°C. A solution of 0.43 g (3.7 mmol) of a mixture of compounds **Va** and **Vb** in 2 ml of dry ether was added, the cooling bath was removed, and the mixture was stirred for 10–15 min (TLC). Water, 10 ml, a saturated solution of ammonium chloride, 5 ml, and ether, 10 ml, were added, and the organic phase was separated, washed with a solution of sodium chloride, and dried over $MgSO_4$. Removal of the solvent left 0.35 g (86%) of an oily liquid which contained alcohol **I** and a small amount (less than 5%) of amide **X**. Chromatographically and spectrally pure alcohol **I** was obtained by purification of the crude product by column chromatography on silica gel. Colorless liquid, $R_f$ 0.23. Using standard technique [14], alcohol **I** was converted into benzoyl derivative **XI** which was purified by recrystallization from hexane–ether.

**3-Benzoyloxymethylbicyclobutane-1-carbonitrile (XI).** mp 69°C. Found, %: C 72.98, 73.08; N 5.17, 5.30; N 6.67, 6.77. $C_{13}H_{11}NO_2$. Calculated, %: C 73.22; H 5.20; N 6.57.

The $^1$H and $^{13}$C NMR spectra of compounds **I**, **II**, and **X**–**XIII** are given in Table 3.

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