Autoassembling of cage structures
8.* α,ω-Bishydroxylation of alkylenebismalonates

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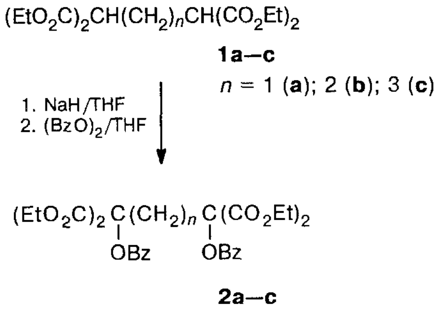
Treatment of alkylenebismalonates with NaH and benzoyl peroxide afforded dibenzoyloxy derivatives. Alkaline hydrolysis of the latter gave alkylenebistartronic acids. Tetramethyl and tetraethyl esters and tetraamides of these acids were synthesized.

Key words: alkylenebistartronic acids; synthesis.

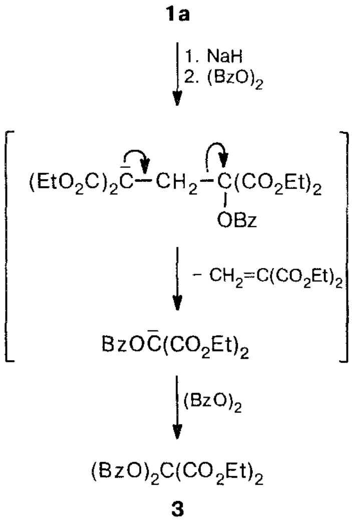
Alkylenebistartronates are key compounds for the complete autoassembling of bicyclic dilactones. We have shown previously[2] that they cannot be obtained from alkylenebisbromomalonates by nucleophilic substitution of the bromine atoms. In the present work, the α,ω-bisbenzoyloxylation of alkylenebismalonates (**1a—c**) was carried out, similarly to that of monoalkyl malonates,[3,4] by successive treatment with NaH and benzoyl peroxide ($(BzO)_2$) (Scheme 1).

Scheme 1



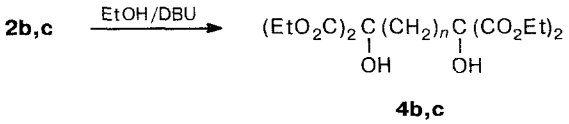
It was shown that the yields of benzoyloxylation products (**2a—c**) increased significantly if the reaction was carried out in THF rather than in C_6H_6 used previously.[4] For example, at the optimum molar ratio, $(BzO)_2$/**1** = 1.5, the yield of compound **2b** was 85 % with respect to $(BzO)_2$. When the above ratio was increased, the fraction of $(BzO)_2$ remained unchanged, and the reaction of compound **1a** resulted in bis(benzoyloxy)malonate **3** (Scheme 2), which has also been obtained by benzoyloxylation of diethyl malonate.[3]

Scheme 2



We succeeded in the selective debenzoylation of compounds **2b,c** by their alcoholysis in the presence of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU). However, dibenzoate **2a** does not react under these conditions (Scheme 3).

Scheme 3



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* For Part 7, see Ref. 1.

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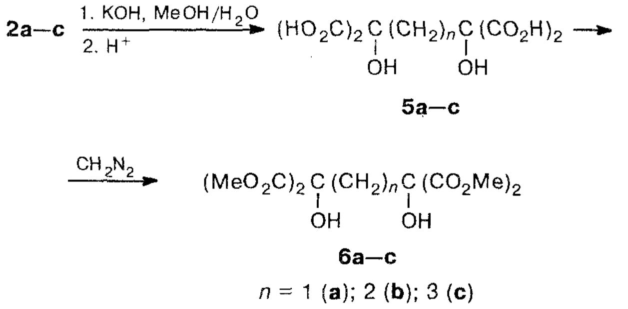
The exhaustive alkaline hydrolysis of dibenzoates **2a—c** affords alkylenebistartronic acids (**5a—c**). Acid **5b** was obtained in a pure state. The other acids were transformed to tetramethyl alkylenebistartronates (**6a—c**) by treatment with CH_2N_2 without isolation (Scheme 4).

Scheme 4



$$\mathbf{2a{-}c} \xrightarrow[2.\ H^+]{1.\ KOH,\ MeOH/H_2O} (HO_2C)_2\underset{OH}{C}(CH_2)_n\underset{OH}{C}(CO_2H)_2 \longrightarrow$$

5a—c

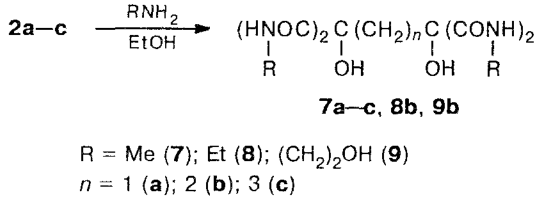
$$\xrightarrow{CH_2N_2} (MeO_2C)_2\underset{OH}{C}(CH_2)_n\underset{OH}{C}(CO_2Me)_2$$

6a—c

n = 1 (**a**); 2 (**b**); 3 (**c**)

The reaction of dibenzoates **2a—c** with primary amines in ethanol at ~20 °C results in debenzoylation and exhaustive amidation to give tetraamides (**7a—c**, **8b**, and **9b**) (Scheme 5).

Scheme 5



$$\mathbf{2a{-}c} \xrightarrow[EtOH]{RNH_2} (\underset{R}{HN}OC)_2\underset{OH}{C}(CH_2)_n\underset{OH}{C}(CO\underset{R}{NH})_2$$

7a—c, 8b, 9b

R = Me (**7**); Et (**8**); $(CH_2)_2OH$ (**9**)
n = 1 (**a**); 2 (**b**); 3 (**c**)

Experimental

NMR spectra were recorded on a Bruker WM-400 spectrometer (^1H 400.13; ^{13}C 100.62 MHz) in $CDCl_3$, using Me_4Si as the internal standard. Mass spectra (EI) were obtained on Hitachi-M-80-A and VG 7070E instruments with direct introduction of samples into the ion source. IR spectra were obtained for solutions in $CHCl_3$ and for KBr pellets on a UR-20 spectrophotometer. Melting points were measured on a Boetius PHMK-0.5 hot stage at a heating rate of 4—5 °C min^{-1}.

Alkylenebismalonates **1a—c** were obtained by the known procedure.[2] Benzoyl peroxide was purified by recrystallization from an $EtOH—H_2O$ mixture (4 : 1).

Benzoyloxylation of alkylenebismalonates (1a—c). General procedure. Ethyl alkylenebisbenzoyloxymalonates (2a—c). A solution of a bismalonate (32 mmol) in dry THF (30 mL) was added dropwise to a suspension of NaH (64 mmol) in dry THF (200 mL). Intense gas evolution was observed and the mixture warmed to 35—45 °C. After the reaction ceased, a solution of $(BzO)_2$ (48 mmol) in THF (120 mL) was added dropwise with stirring at 5—9 °C (20 min). Stirring was continued for 1 h at ~20 °C and then the mixture was poured into a saturated solution of Na_2SO_4 (800 mL). The organic layer was separated and the aqueous layer was extracted with ether (3×600 mL). The organic layer was combined with the ethereal extract, washed with water (3×100 mL), dried with $MgSO_4$, and evaporated *in vacuo*. The oily residue was triturated with hexane, and the resulting solid malonates **2a—c** were recrystallized from EtOH. In the case of **1a**, the solution in hexane was evaporated to give ester **3**.

Tetraethyl methylenebisbenzoyloxymalonate (2a). White fluffy crystals, yield 26 %, m.p. 108 °C. IR ($CHCl_3$), ν/cm^{-1}: 1605 (Ph); 1740 and 1760 (C=O); 2980—3030 (CH). ^1H NMR, δ: 1.16 (t, 12 H, 4 Me, ^3J = 7.0 Hz); 3.69 (s, 2 H, CH_2); 4.00 (m, ABX_3, 8 H, 4 CH_2O, Δν = 64.0, $^2J_{AB}$ = −10.7 Hz, $^3J_{AX}$ = $^3J_{BX}$ = 7.0 Hz); 7.44 (t, 4 H, Ph, H-3, ^3J = 8.2 Hz); 7.57 (t, 2 H, H-4, ^4J = 1.0 Hz); 8.06 (dd, 4 H, H-2, ^3J = 8.2 Hz, ^4J = 1.0 Hz). ^{13}C NMR, δ: 13.64 (qt, Me, ^1J = 127.5 Hz, ^2J = 2.5 Hz); 36.0 (t, CH_2, ^1J = 137.3 Hz); 62.48 (tq, CH_2O, ^1J = 148.6 Hz, ^2J = 4.4 Hz); 80.3 (t, C—O, ^2J = 4.4 Hz); 128.3 (dd, C-2, ^1J = 162.4 Hz, ^2J = 8.0 Hz); 128.9 (t, Ph, C-1, ^2J = 8.0 Hz); 130.13 (dt, C-3, ^1J = 162.4, ^2J = 8.0 Hz); 133.52 (dt, C-4, ^1J = 161.7 Hz, ^2J = 8.0 Hz); 164.53 (t, $Ph\underline{C}{=}O$, ^3J = 4.0 Hz); 165.65 (tt, C=O, ^3J = 3.3 Hz). MS (EI, 70 eV), *m/z* (I_{rel} (%)): 527 (1.8), 499 (17), 105 (100), 77 (77.2). MS (CI, CH_4), *m/z* (I_{rel} (%)): 601 $[M+29]^+$ (16.1), 573 $[M+H]^+$ (70.9).

Tetraethyl ethylenebisbenzoyloxymalonate (2b). White crystals, yield 85 %, m.p. 116—117 °C. Found (%): C, 60.85; H, 5.90. $C_{30}H_{34}O_{12}$. Calculated (%): C, 61.42; H, 5.84. IR ($CHCl_3$), ν/cm^{-1}: 1610 (Ph); 1740 and 1760 (C=O); 2995 (CH). ^1H NMR, δ: 1.26 (t, 12 H, 4 Me, ^3J = 7.0 Hz); 2.48 (s, 4 H, 2 CH_2); 4.27 (m, ABX_3, 8 H, 4 CH_2O); 7.45 (t, 4 H, H-3, ^3J = 7.5 Hz); 7.59 (t, 2 H, H-4, ^3J = 7.5 Hz, ^4J ~ 1.0 Hz); 8.06 (dd, 4 H, H-2, ^3J = 7.5 Hz, ^4J = 1.0 Hz). ^{13}C NMR, δ: 13.68 (q, Me, ^1J = 127.9 Hz); 28.2 (t, CH_2, ^1J = 135.2 Hz, ^2J = 5.8 Hz); 62.3 (tq, CH_2O, ^1J = 148.2 Hz, ^2J = 4.4 Hz); 82.1 (s, C—O); 128.27 (dd, C-2, ^1J = 162.8 Hz, ^2J = 7.3 Hz); 128.53 (t, C-1, ^2J = 7.3 Hz); 129.72 (dt, C-3, ^1J = 162.8 Hz, ^2J = 7.3 Hz); 133.47 (dt, C-4, ^1J = 162.8 Hz, ^2J = 7.3 Hz); 164.34 (t, $Ph\underline{C}{=}O$, ^3J = 4.4 Hz); 165.85 (s, C=O).

Tetraethyl 1,3-propylenebisbenzoyloxymalonate (2c). White transparent crystals, yield 40 %, m.p. 102—103 °C. IR ($CHCl_3$), ν/cm^{-1}: 1610 (Ph); 1730 and 1750 (C=O); 3000 (CH). ^1H NMR, δ: 1.23 (t, 12 H, 4 Me, ^3J = 7.0 Hz); 1.57 (m, 2 H, $CH_2\underline{CH_2}CH_2$); 2.42 (m, 4 H, $\underline{CH_2}CH_2\underline{CH_2}$); 4.25 (m, ABX_3, 8 H, 4 CH_2O, Δν ~ 2.0 Hz); 7.4 (t, 4 H, H-3, ^3J = 8.0 Hz); 7.58 (tt, 2 H, H-4, ^3J = 8.0 Hz, ^4J ~ 1.0 Hz); 8.04 (dd, 4 H, H-2, ^3J = 8.0 Hz, ^4J ~ 1.0 Hz). ^{13}C NMR, δ: 13.65 (qt, Me, ^1J = 127.5 Hz, ^2J = 2.5 Hz); 17.81 (tp, $CH_2\underline{C}H_2CH_2$, ^1J = 127.9 Hz, ^2J = 4.4 Hz); 33.71 (tt, $\underline{C}H_2CH_2\underline{C}H_2$, ^1J = 133.0 Hz, ^2J = 3.7 Hz); 62.04 (tq, CH_2O, ^1J = 149.0 Hz, ^2J = 4.4 Hz); 82.63 (s, C=O); 128.19 (dd, C-2, ^1J = 162.8 Hz, ^2J = 7.3 Hz); 128.68 (t, C-1, ^2J = 7.3 Hz); 129.59 (dt, C-3, ^1J = 163.5 Hz, ^2J = 7.3 Hz); 133.33 (dt, C-4, ^1J = 162.8, ^2J ~ 8.0 Hz); 164.37 (t, $Ph\underline{C}{=}O$, ^3J = 3.7 Hz); 166.09 (t, C=O, ^3J = 2.9 Hz).

Diethyl bisbenzoyloxymalonate (3). White lustrous crystals, yield 4 %, m.p. 117 °C (*n*-hexane) (*cf.* Ref. 3). Found (%): C, 63.2; H, 5.5. $C_{21}H_{20}O_8$. Calculated (%): C, 63.0; H, 5.0. ^1H NMR, δ: 1.35 (t, 6 H, 2 Me, ^3J = 7.0 Hz); 4.4 (q, 4 H, 2 CH_2O); 7.47 (t, 4 H, H-3, ^3J = 8.0 Hz); 7.6 (tt, 2 H, H-4, ^3J = 8.0 Hz, ^4J = 2.2 Hz); 8.15 (dd, 4 H, H-2, ^3J = 8.0 Hz, ^4J = 2.2 Hz). ^{13}C NMR, δ: 13.88 (qt, Me, ^1J = 127.2 Hz, ^2J = 2.9 Hz); 62.98 (tq, CH_2O, ^1J = 148.9 Hz, ^2J = 4.4 Hz); 96.16 (s, O—C—O); 128.37 (dd, C-2, ^1J = 162.0 Hz, ^2J = 7.3 Hz); 128.41 (t, C-1, ^2J = 8.0 Hz); 130.54 (dt, C-3, ^1J = 164.2

Hz, ^2J = 7.3 Hz); 133.83 (dt, C-4, ^1J = 161.3 Hz, ^2J = 7.3 Hz); 162.44 (t, $Ph\underline{C}=O$, ^3J = 3.6 Hz); 163.39 (t, C=O, ^3J = 4.4 Hz). MS (CI, CH_4), *m/z* (I_{rel} (%)): 429 $[M+29]^+$ (7.1), 401 $[M+H]^+$ (4.6), 105 (100). MS (EI, 70 eV), *m/z* (I_{rel} (%)): 400 $[M]^+$ (0.4), 328 (3.2), 327 (12), 106 (28), 105 (100), 77 (35.3).

Debenzoylation of alkylenebisbenzoyloxymalonates (2b,c). A mixture of malonate **2b** or **2c** (6 mmol) and DBU (6 mmol) in dry EtOH (30 mL) was refluxed for 30 h (**2b**) or 60 h (**2c**) and then concentrated. The residue was extracted with Et_2O (100 mL) with trituration. The ethereal solution was passed through a column (2 m×5 cm) with 40/100 μm silica gel, the eluate was concentrated, and ethyl benzoate was extracted with hexane. The residue was crystallized by trituration, the crystals of bistartronate **4** were filtered off, and the mother liquor was concentrated by evaporation in air. The crystals that formed were combined with those isolated previously, and compounds **4b,c** were recrystallized from a suitable solvent.

Tetraethyl ethylenebistartronate (4b). White needle-shaped crystals, yield 70 %, m.p. 59—60 °C (C_6H_6). IR ($CHCl_3$), ν/cm^{-1}: 1740 (C=O); 2960 (CH); 3520 (br, OH). ^1H NMR, δ: 1.3 (t, 12 H, 4 Me, *J* = 7.0 Hz); 2.03 (s, 4 H, 2 CH_2); 3.72 (s, 2 H, 2 OH); 4.26 (q, 8 H, 4 CH_2O). ^{13}C NMR, δ: 13.85 (q, Me, ^1J = 126.4 Hz); 28.41 (tt, CH_2, ^1J = 132.2 Hz, ^2J = 4.4 Hz); 62.31 (tq, CH_2O, ^1J = 148.5 Hz, ^2J = 4.0 Hz); 78.24 (s, C—OH); 170.03 (s, C=O). MS (CI, CH_4), *m/z* (I_{rel} (%)): 407 $[M+29]^+$ (2.5), 379 $[M+H]^+$ (29.8), 361 (55.7), 287 (100).

Tetraethyl propylenebistartronate (4c). White crystals, yield 41 %, m.p. 84—85 °C (C_6H_6). IR ($CHCl_3$), ν/cm^{-1}: 1740 (CO); 3000 (CH); 3540 (OH). ^1H NMR, δ: 1.27 (t, 12 H, 4 Me, ^3J = 7.0 Hz); 1.35 (m, 2 H, $CH_2\underline{H_2}CH_2$); 2.05 (m, 4 H, 2 $C\underline{H_2}COH$); 3.73 (s, 2 H, 2 OH); 4.24 (q, 8 H, 4 CH_2O, ^3J = 7.0 Hz). ^{13}C NMR, δ: 13.68 (qt, Me, ^1J = 127.2 Hz, ^2J = 2.1 Hz); 16.77 (t.quint, $CH_2\underline{C}H_2CH_2$, ^1J = 127.9 Hz, ^2J = 4.4 Hz); 34.11 (tt, $\underline{C}H_2COH$, ^1J = 130.8 Hz, ^2J = 3.7 Hz); 62.04 (tq, CH_2O, ^1J = 149.0 Hz, ^2J = 4.4 Hz); 78.46 (dt, COH, ^2J = 2.9 Hz); 170.04 (tt, C=O, ^2J = 3.7 Hz); 62.04 (tq, CH_2O, ^1J = 149.0 Hz, ^2J = 4.4 Hz); 78.46 (dt, COH, ^3J = 2.9 Hz). MS (EI, 70 eV), *m/z* (I_{rel} (%)): 393 $[M+H]^+$ (3.5), 302 (15.6), 301 (100), 255 (11.4), 228 (11.3), 227 (54.2), 198 (10.5), 172 (12.8), 171 (16.2), 143 (26.8), 116 (14.1), 115 (22.6), 99 (12.6), 88 (14.2), 87 (12.9), 69 (16.8), 55 (61.8).

Saponification of alkylenebisbenzoyloxymalonates 2a—c to alkylenebistartronic acids (5a—c) (general procedure). A solution of KOH (54 mmol for **2a** or 36 mmol for **2b,c**) in a mixture of MeOH (40 mL) and H_2O (10 mL) was added at 40 °C to a solution of ester **2** (6 mmol) in MeOH (150 mL). The mixture was kept for 18 h at 20 °C, concentrated to dryness, and extracted with Et_2O (2×150 mL) to remove methyl benzoate. Concentrated HCl (15 mL) was cautiously added to the residue suspended in 100 mL of Et_2O, the ethereal layer was removed, and the aqueous layer was extracted with Et_2O (2×200 mL) to remove benzoic acid. MeCN (300 mL) was then added to the aqueous layer, the precipitate of KCl was filtered off, and the filtrate was concentrated to give acid **5** as an oil (compound **5b** crystallizes when triturated in dry MeCN). Compounds **5a,c** were characterized in the form of tetramethyl esters **6a,c**.

Methylenebistartronic acid (5a). ^1H NMR (CD_3OD), δ: 2.97 (s, CH_2).

Ethylenebistartronic acid (5b). White lamellar crystals, yield 62.5 %, m.p. 195—198 °C (dec.). Found (%): C, 35.86; H, 3.65. $C_8H_{10}O_{10}$. Calculated (%): C, 36.09; H, 3.76. ^1H NMR (CD_3OD), δ: 2.06 (s, CH_2).

Propylenebistartronic acid (5c). ^1H NMR (CD_3OD), δ: 1.31 (m, 2 H, $CH_2C\underline{H_2}CH_2$); 2.04 (m, 4 H, 2 $C\underline{H_2}COH$).

Tetramethyl alkylenebistartronates (6a—c). Acids **5a—c** were dissolved in MeOH (20 mL), then Et_2O (40 mL) was added. The mixtures were filtered and treated with an ethereal solution of diazomethane until the yellow coloring no longer disappeared. The solvent was evaporated and the residue was kept for 1 h *in vacuo* (2 Torr) and recrystallized from benzene or ether.

Tetramethyl methylenebistartronate (6a). White lamellar crystals, yield 22 %, m.p. 141 °C (C_6H_6). IR ($CHCl_3$), ν/cm^{-1}: 1750 (C=O); 2950—3030 (CH); 3480 (OH). ^1H NMR, δ: 3.02 (s, 2 H, CH_2); 3.81 (s, 12 H, 4 Me); 3.93 (s, 2 H, 2 OH). ^{13}C NMR, δ: 40.67 (t, CH_2, ^1J = 133.7 Hz); 53.54 (q, Me, ^1J = 148.2); 77.47 (t, C—O, ^2J = 4.0 Hz); 171.9 (dq, C=O, ^3J = 3.5 Hz). MS (EI, 70 eV), *m/z* (I_{rel} (%)): 309 $[M+H]^+$ (1.0), 308 $[M]^+$ (1.1), 291 (7.3), 250 (87.9), 233 (32.5), 232 (87.1), 218 (43.7), 206 (52.7), 199 (52.5), 189 (75.6), 171 (68), 162 (51.4), 161 (69.2), 129 (87.3), 117 (62.8), 113 (77.6), 103 (34.5), 102 (67.3), 101 (100), 85 (15.8), 69 (44.2), 59 (71.9).

Tetramethyl 1,2-ethylenebistartronate (6b). White needle-shaped crystals, yield 80 %, m.p. 163—164 °C (C_6H_6). Found (%): C, 44.66; H, 5.63. $C_{12}H_{18}O_{10}$. Calculated (%): C, 44.72; H, 5.59. IR ($CHCl_3$), ν/cm^{-1}: 1745 (C=O); 2970—3050 (CH); 3560 (OH). ^1H NMR (CD_3OD), δ: 2.03 (s, 4 H, 2 CH_2); 3.74 (s, 12 H, 4 Me). ^{13}C NMR (C_6D_6), δ: 28.79 (t, CH_2, ^1J = 133.7 Hz); 53.56 (q, Me, ^1J = 148.2 Hz); 78.3 (s, C—O); 170.5 (s, C=O).

Tetramethyl 1,3-propylenebistartronate (6c). White needle-shaped crystals, yield 81 %, m.p. 68—69 °C (Et_2O). IR ($CHCl_3$, ν/cm^{-1}): 1750 (C=O); 2970—3000 (CH); 3525 (br, OH). ^1H NMR, δ: 1.3 (m, 2 H, $CH_2C\underline{H_2}CH_2$); 2.03 (m, 4 H, 2 $C\underline{H_2}COH$; 3.8 (s, 12 H, 4 Me). ^{13}C NMR, δ: 16.86 (tt, $CH_2\underline{C}H_2CH_2$, ^1J = 127.9 Hz, ^2J = 3.6 Hz); 34.28 (tt, $\underline{C}H_2COH$, ^1J = 130.8 Hz, ^2J = 2.9 Hz); 52.92 (q, Me, ^1J = 148.2 Hz); 78.53 (t, $\underline{C}OH$, ^2J = 2.9 Hz); 170.42 (q, C=O, ^3J = 3.6 Hz). MS (EI, 70 eV), *m/z* (I_{rel} (%)): 393 $[M+H]^+$ (3.5), 302 (15.6), 301 (100), 255 (11.4), 228 (11.3), 227 (54.2), 198 (10.5), 172 (12.8), 171 (16.2), 143 (26.8), 116 (14.1), 115 (22.6), 99 (12.7), 88 (14.2), 87 (12.9), 69 (16.8), 55 (61.8).

Tetraamides of alkylenebistartronic acids (7a—c). Compound **2a—c** (4 mmol) was heated until dissolution in a saturated solution of $MeNH_2$ in dry EtOH (15 mL) and the mixture was kept for 24 h at ~20 °C. The crystals of tetraamide **7a** that precipitated were filtered off, washed with cold EtOH, and dried *in vacuo*. Compound **7b** was isolated as a crystal hydrate after crystallization from H_2O. The crystals of amide **7c** were extracted with Et_2O (2×100 mL) to remove PhCONHMe and recrystallized from MeOH.

Tetramethylamide of methylenebistartronic acid (7a). White long needle-shaped crystals, yield 70 %, m.p. 228—230 °C. ^1H NMR (CD_3OD), δ: 2.69 (s, 2 H, CH_2); 2.73 (s, 12 H, 4 MeN). ^{13}C NMR, DMSO-d_6 at 100 °C, δ: 26.0 (q, ^1J = 138.1 Hz, MeN); 43.07 (t, CH_2, ^1J = 132.2 Hz); 76.16 (t, C—O, ^2J = 3.6 Hz); 171.16 (s, C=O).

Tetramethylamide of 1,2-ethylenebistartronic acid (7b) was isolated as a crystal hydrate, white lamellar crystals, yield ~100 %, m.p. 270 °C (H_2O). Found (%): C, 40.72; H, 7.15; N, 15.60. $C_{12}H_{22}N_4O_6 \cdot 2H_2O$. Calculated (%): C, 40.68; H, 7.35; N, 15.82. IR (KBr), ν/cm^{-1}: 1665 and 1740 (CONH); 2960 (CH); 3220, 3350, 3430 (NH); 3545 (OH). ^1H NMR (CD_3OD), δ: 1.87 (s, 4 H, 2 CH_2); 2.74 (s, 12 H, 4 MeN). ^{13}C NMR, DMSO-d_6, δ: 25.98 (q, MeN, ^1J = 138.1 Hz); 32.28 (tt, CH_2, ^1J = 131.0 Hz, ^2J = 2.9 Hz); 77.53 (s, C—O); 171.25 (s, C=O).

Tetramethylamide of 1,3-propylenebistartronic acid (7c). White crystals, yield ~100 %, m.p. 91 °C (MeOH). IR ($CHCl_3$), ν/cm^{-1}: 1660 and 1685 (C=O); 3010—3040 (CH); 3390, 3410, 3430 (NH). ^{1}H NMR (CD_3OD), δ: 1.26 (m, 2 H, $CH_2C\underline{H}_2CH_2$); 1.83 (m, 4 H, 2 $C\underline{H}_2COH$); 2.73 (s, 12 H, 4 MeN). ^{13}C NMR (CD_3OD), δ: 18.77 (t, $CH_2\underline{C}H_2CH_2$, ^1J = 127.9 Hz); 26.58 (q, MeN, ^1J = 138.1 Hz); 39.34 (s, $\underline{C}H_2COH$, ^1J = 126.4 Hz); 79.68 (br.s, COH); 173.66 (br.s, C=O).

Tetraethylamide of 1,2-ethylenebistartronic acid (8b). A mixture of ester **2b** (1.9 g, 3.24 mmol) and a saturated solution of $EtNH_2$ in MeOH (50 mL) was kept for 3 days at 20 °C and worked-up according to the procedure described for compound **7c** to give white needle-shaped crystals of amide **8b**, yield ~100 %, m.p. 166—167 °C (Et_2O). ^{1}H NMR (CD_3OD), δ: 1.1 (t, 12 H, 4 Me, ^3J = 7.3 Hz); 1.88 (s, 4 H, 2 CH_2); 3.22 (m, ABX_3, 8 H, 4 CH_2N, Δν ~ 2.0 Hz, $^2J_{AB}$ ~13 Hz, $^3J_{AX}$ = $^3J_{BX}$ = 7.3 Hz). ^{13}C NMR, δ: 14.3 (q, Me, ^1J = 126.4 Hz); 33.5 (tt, CH_2, ^1J = 132.2 Hz, ^2J = 5.8 Hz); 34.42 (t, CH_2N, ^1J = 139.5 Hz); 76.47 (s, C—O); 170.51 (s, C=O).

Tetra(2-hydroxyethyl)amide of 1,2-ethylenebistartronic acid (9b). A mixture of ester **2b** (1 g, 1.7 mmol) and monoethanolamine (0.625 g, 10.2 mmol) in dry EtOH (7 mL) was refluxed for 30 h and then filtered. The crystalline product was washed with cold EtOH and dried *in vacuo* to give 0.6 g of amide **9b** as white cubic crystals, yield 80 %, m.p. 175 °C. Found (%): C, 43.65; H, 7.6; N, 12.14. $C_{16}H_{30}O_{10}N_4$. Calculated (%): C, 43.84; H, 6.85; N, 12.79. ^{1}H NMR (D_2O), δ: 1.82 (s, 4 H, 2 CH_2); 3.2 (m, 8 H, 4 CH_2N); 3.47 (m, 8 H, 4 CH_2O). ^{13}C NMR (D_2O), δ: 32.96 (t, $\underline{C}H_2COH$, ^1J = 133.7 Hz); 43.82 (t, CH_2N, ^1J = 139.5 Hz); 62.1 (t, CH_2O, ^1J = 142.4 Hz); 80.89 (s, C—O); 174.44 (s, C=O).

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References

1. R. G. Kostyanovsky and Yu. I. El'natanov, *Izv. Akad. Nauk, Ser. Khim.*, 1994, 2002 [*Russ. Chem. Bull.*, 1994, **43**, 1889 (Engl. Transl.)].
2. R. G. Kostyanovsky, O. N. Krutius, and Yu. I. El'natanov, *Izv. Akad. Nauk, Ser. Khim.*, 1994, 2185 [*Russ. Chem. Bull.*, 1994, **43**, 2065 (Engl. Transl.)].
3. S.-O. Lawesson, T. Busch, and C. Rerglund, *Acta Chem. Scand.*, 1961, **15**, 260.
4. E. H. Larsen and S.-O. Lawesson, *Org. Synth.*, 1965, **45**, 37.

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