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Hexafluoroacetone as a Protecting and Activating Reagent. Regioselective Esterification of Aspartic, Malic, and Thiomalic Acid

Ksenia Pumpor[1], **Elisabeth Windeisen**[1], **Jan Spengler**[1,2], **Fernando Albericio**[2,*], and **Klaus Burger**[1,*]

[1] Department of Chemistry, University of Leipzig, D-04103 Leipzig, Germany
[2] Barcelona Biomedical Research Institute, Barcelona Science Parc, University of Barcelona, 08028 Barcelona, Spain

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Summary. Hexafluoroacetone reacts with α-functionalized α,β-dicarboxy acids like aspartic, malic, and thiomalic acid to give exclusively five-membered lactones. The β-carboxylic groups remain unaffected and can be derivatized separately. They can be linked *i.a.* to orthogonal protecting groups or multivalent alcohols like pentaerythritol to give synthetically valuable building blocks.

Keywords. Branched depsipeptides; Branched peptides; Hexafluoroacetone; Peptidomimetics; Polyester.

Introduction

Regioselective functionalization of multifunctional compounds requires a sophisticated combination of protection and activation strategies [1, 2]. Nevertheless, the synthesis of supposedly simple target molecules like aspartic and glutamic acid α-esters [3], aspartic and glutamic acid α-amides (isoasparagine, isoglutamine) [4] as well as of the corresponding β-isomers are surprisingly laborious more-step procedures [5]. The development of new methodology for the construction of peptides, depsipeptides, and peptidomimetics with a minimum of steps is a great challenge for preparative chemists.

Multifunctional systems can serve as scaffolds if there is an orthogonal protective group concept available. In general, the α-carboxylic and the α-amino group of aspartic acid are incorporated into the backbone of peptides or peptidomimetics.

* Corresponding authors. E-mails: burger@chemie.uni-leipzig.de, albericio@pcb.ub.es

However, for post-synthetic transformations of the β-carboxylic group there exist several options [6], including glycosylation, lipidation, phosphorylation as well as attachment to transport systems and pharmacophors or rearrangement to give isopeptides [7].

We demonstrated that the ''hexafluoroacetone route'' offers a new, efficient approach to regioselective derivatization of multifunctional compounds of type HOOC–$(CH_2)_n$–CH(*X*H)–COOH. Hexafluoroacetone reacts selectively with α-functionalized dicarboxylic acids like aspartic [8], malic [9], thiomalic acids [10], and homologues to give exclusively five-membered lactones. With the formation of the five-membered ring the α-functionality is protected. Furthermore, the adjacent carboxylic group is protected and activated. With nucleophiles, *e.g.* amines or amino acid esters, amides or peptides are formed, while the α-placed functional group is deprotected. Since the β-carboxylic groups remain unaffected, separate derivatizations at both carboxylic groups are possible.

Recently we reported on synthetic aspects of the selective α-activation [3]. In this paper we focus on the regioselective β-esterification using the potential of the ''hexafluoroacetone route''. Esterification offers structural diversity. Furthermore, esters are the most common protecting groups for carboxylic acids [11]. Therefore, we studied the stability of the lactone moiety under different conditions applied for side chain esterification.

Results and Discussion

Lactones **2a**–**2c** are formed in excellent yields on treatment of a solution of commercially available acids **1a**–**1c** in *DMSO* or *DMF* with two equivalents of hexafluoroacetone (*HFA*) (Scheme 1).

Direct Esterification of the β-Carboxylic Group

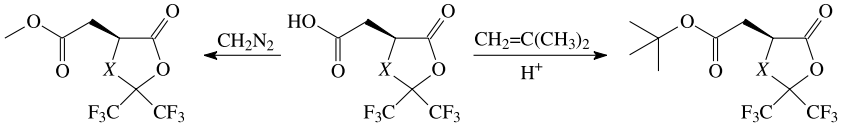
β-Methylesters of the hexafluoroacetone protected dicarboxylic acids **2a**–**2c** and homologues are obtained quantitatively on reaction with diazomethane in diethyl ether at 0°C within minutes (**2** → **3**, Scheme 2). The progress of the reaction can be monitored by ^{19}F NMR spectroscopy. Noteworthy, in the case of **2a** a large excess of diazomethane, long reaction times, and elevated temperatures result in a base-induced fragmentation reaction [12].

Isobutylene on acid catalysis reacts with compounds **2a**–**2c** at room temperature to give the corresponding β-*tert*-butylesters **4a**–**4c** in very good yields (Scheme 2). *Tert*-Butyl esters are orthogonal to *Fmoc*, which is one of the most

1a *X* = NH
1b *X* = O
1c *X* = S

2a *X* = NH
2b *X* = O
2c *X* = S

Scheme 1

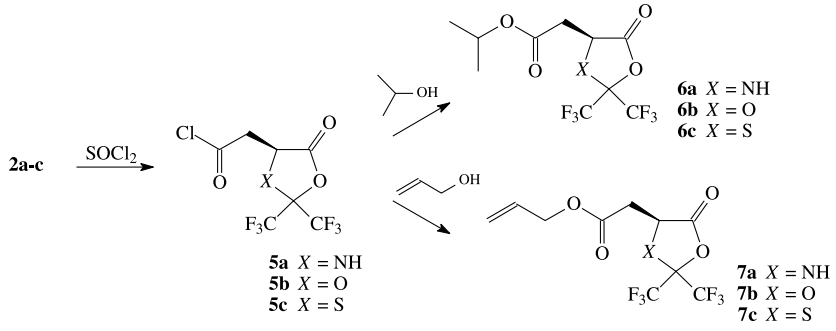


3a *X* = NH
3b *X* = O
3c *X* = S

2a *X* = NH
2b *X* = O
2c *X* = S

4a *X* = NH
4b *X* = O
4c *X* = S

Scheme 2



5a *X* = NH
5b *X* = O
5c *X* = S

6a *X* = NH
6b *X* = O
6c *X* = S

7a *X* = NH
7b *X* = O
7c *X* = S

Scheme 3

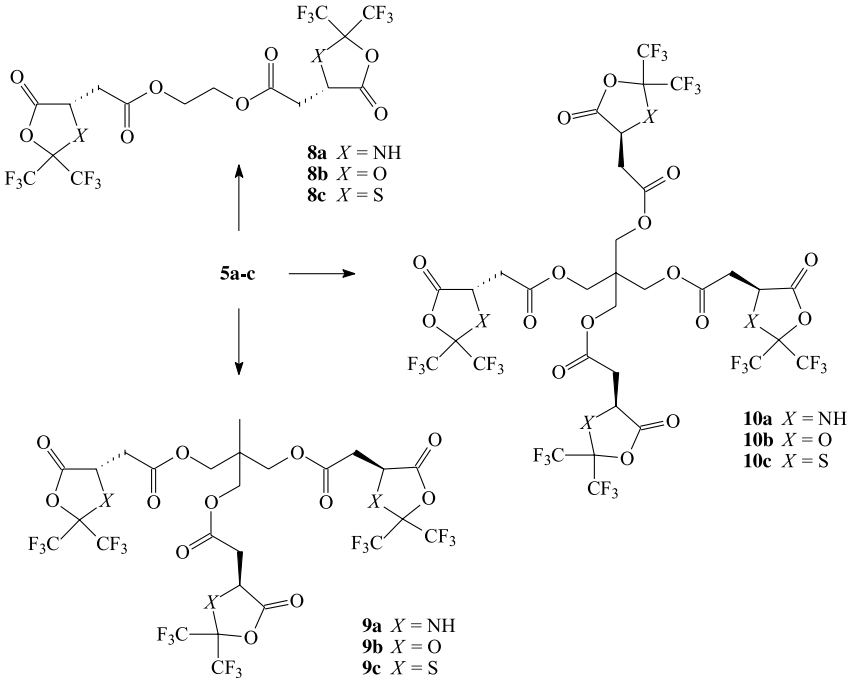
popular amino protecting groups in peptide synthesis. Surprisingly, compounds **4** on standing at room temperature undergo the retro reaction.

Esterification via β-Carboxylic Acid Chlorides

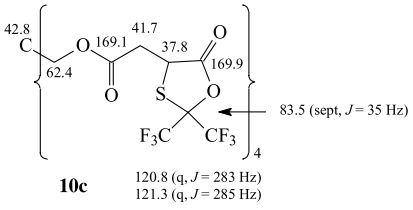
Alternatively, β-esters of compounds **2** can be obtained *via* the corresponding acid chlorides and acid fluorides, respectively. A preparatively simple way to activate the β-carboxy group in **2a**–**2c** is the conversion into the acid chloride on treatment with thionyl chloride or phosphorus pentachloride [13]. The conversion **2** → **5** is nearly quantitative (Scheme 3) [8–10]. However, this activation strategy is not applicable to hexafluoroacetone-protected *Glu* and *Aad* (aminoadipic acid), because the ω-acid chlorides formed first, spontaneously undergo cyclocondensation to give the corresponding five- and six-membered lactams [14].

Compounds **5** are dielectrophiles, readily capable for two consecutive acylation steps [15]. The acid chloride moiety is the more reactive center. Compounds **5** react with equimolar amounts of alcohols, *e.g.* isopropanol and allyl alcohol in diethyl ether to give esters **6** and **7** (Scheme 3). Under these conditions the lactone moiety remains unaffected. Allyl protection of carboxylic groups is orthogonal to *^{t}Bu* and *Fmoc* [16]. The allyl esters **7a**–**7c** are accessible in good yields (65–90%), orthogonally protected, and activated, ready for incorporation into peptides and peptidomimetics. β-Derivatization with alcohols or amines having long alkyl side-chains is an elegant route to incorporate lipophilic anchors.

Esterification with multivalent alcohols is a preparatively valuable reaction. Acid chlorides **5** react with polyalcohols (1 equivalent per HO group) like glycol, 1,1,1-tris(hydroxymethyl)ethane and pentaerythritol in boiling toluene to give the



Scheme 4



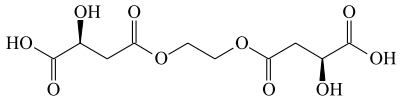
Scheme 5

corresponding polyesters **8**–**10** (Scheme 4) in good to excellent yields (61–100%). Again the lactone moiety remains unaffected under carefully controlled conditions. The high symmetry of compounds **10** can be easily proved by ^{1}H and ^{13}C NMR spectroscopy (Scheme 5).

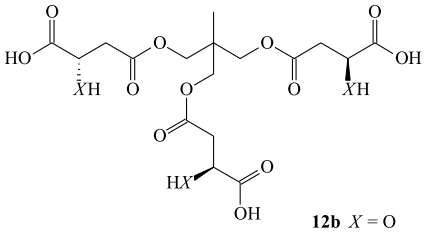
1,1,1-Tris(hydroxymethyl)ethane and pentaerythritol serve as core for dendrimers [17]. Dendrimers, a type of branched macromolecules, are a relatively new class of materials with many applications [18]. One of the major advantages of dendrimers is their globular structure and relatively small size which facilitates cell uptake more efficiently than larger carriers. Another advantage of dendrimers is that their synthesis results in monodisperse molecules. In addition, dendrimers should exhibit a high drug-carrying capacity because of their multivalency [19].

Under carefully controlled conditions the lactone moiety serves in the first step as protective group. In the second step, compounds **6**–**10** act as activated esters and therefore can be readily cleaved by *O*- and *N*-nucleophiles.

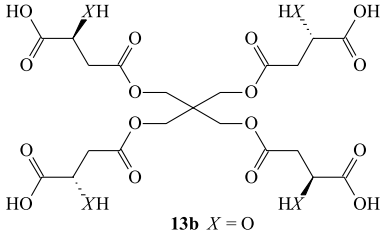
Hydrolysis of compounds **8**–**10** can be achieved on heating in water/THF or water/acetonitrile mixtures. Reaction times can be reduced considerably when



11b

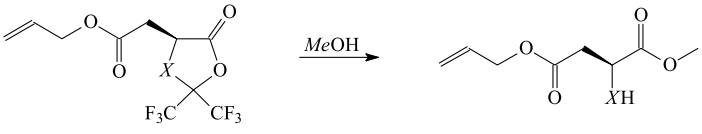


12b $X = O$
12c $X = S$



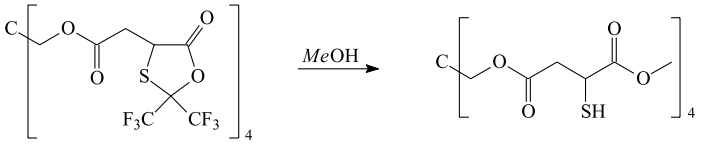
13b $X = O$
13c $X = S$

Scheme 6



7b $X = O$
7c $X = S$

14b $X = O$
14c $X = S$



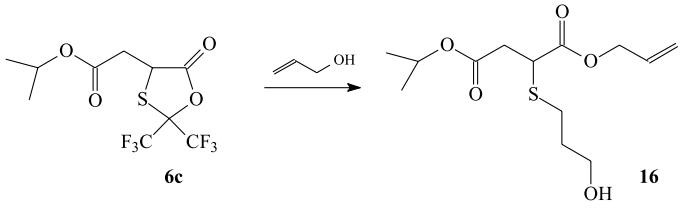
10c

15

Scheme 7

hydrolysis is performed with diluted HCl. Compounds **11**–**13** (Scheme 6) are interesting ligands for metal ion transport [20].

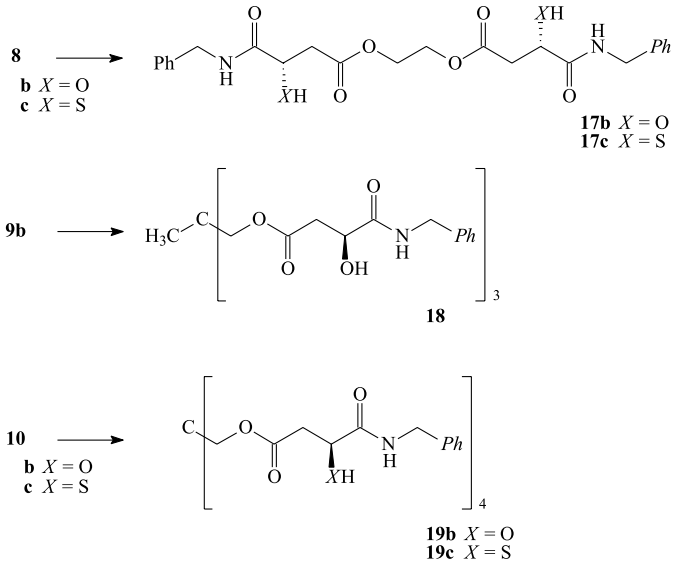
Methanolysis of compounds **7b**, **7c**, and **10c** can be achieved quantitatively in boiling methanol (Scheme 7). When **6c** was treated with an excess of allyl alcohol, the expected diester could not be isolated. Instead, the mercapto group formed during lactone ring cleavage adds to a second equivalent of the allyl acohol to give thioether **16** (Scheme 8).



6c

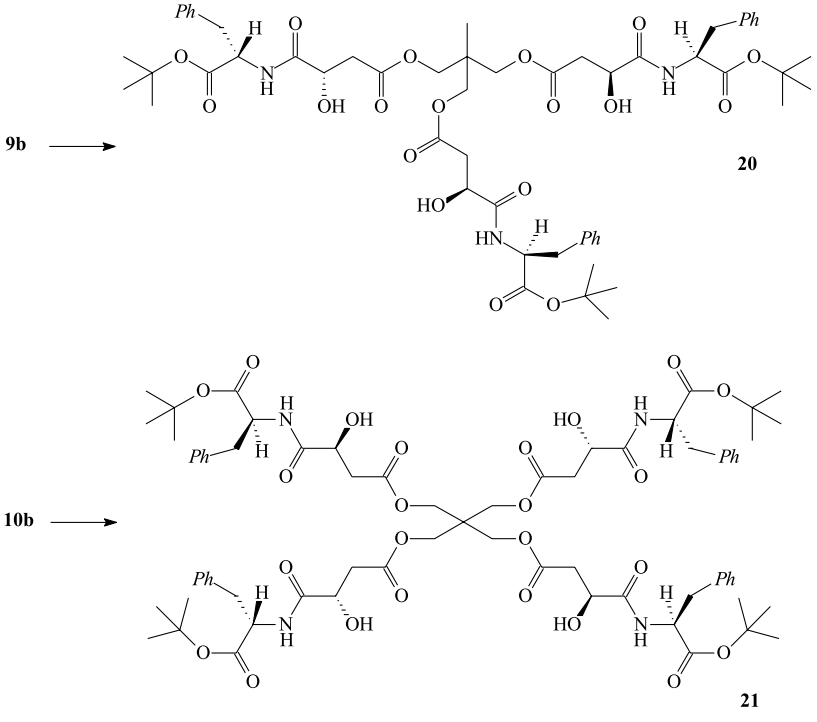
16

Scheme 8



Scheme 9

Aminolytic cleavage of the lactone moiety of compounds **8–10** with benzylamine occurs below 0°C in very good yields (Scheme 9). The readily precipitating compounds **17–19** are analytically pure after careful trituration with ice-cold diethyl ether. At room temperature aminolytic cleavage of the lactone moiety



Scheme 10

competes with the cleavage of the ester function to give product mixtures, which are difficult to separate.

Reaction of **9b** and **10b** with amino acid esters provides branched peptide and depsipeptide fragments **20–21** (Scheme 10). After deprotection the chain-elongation can be continued by conventional methods.

Conclusion

It was demonstrated that the ''hexafluoroacetone route'' offers a preparatively simple access to β-esters of aspartic, malic, and thiomalic acid, which can serve as versatile intermediates for post-synthetic transformations. Esterification of polyalcohols and consecutive aminolysis of the polylactones obtained can serve as various start reaction for the synthesis of branched peptides and depsipeptides and for divergent syntheses of dendrimers.

Experimental

General

Solvents were purified and dried prior to use. Reagents were used as purchased. Melting points (uncorrected) were determined on a Boetius heating table. Mass spectra were recorded on a VG 12-250 and a MAT 212 (Masslab) electron ionization spectrometer (EI-MS, EI = 70 eV). IR spectra were obtained with a FTIR spectrometer (Genesis ATI Mattson/Unicam) and a Specord M 80 (Fa. Carl Zeiss, Jena). ^{1}H (200 MHz, 300 MHz), ^{13}C (50 MHz, 75 MHz), and ^{19}F (188 MHz) NMR spectra were recorded on a Varian Gemini spectrometer. *TMS* was used as reference of ^{1}H and ^{13}C NMR spectra (internal), and CF_3COOH for ^{19}F NMR spectra (external). Flash chromatography was performed using silica gel (32–63 μm) with solvent systems given in the text. Elemental analyses were performed with a CHNO-S Rapid apparatus (Fa. Heraeus); their results were in agreement with calculated values.

*Reaction of **2a–2c** with Diazomethane*

To a solution of **2** (10 mmol) in diethyl ether (20 cm^3) an excess of diazomethane in diethyl ether (30 mmol) was added at 0°C. After stirring for 10 min, the solvent and the excess of diazomethane was removed *in vacuo*.

Methyl [(4S)-2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate (**3a**, $C_8H_7F_6NO_4$)

2a (2.80 g, 10 mmol) was converted into **3a** (2.95 g, 100%); mp 50°C; $[\alpha]_D = -24.0°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.0$, $CHCl_3$); IR (KBr): $\bar{\nu} = 3375, 1830, 1720\ cm^{-1}$; ^{1}H NMR ($CDCl_3$): $\delta = 2.63$ (dd, $J = 17.5$, 10.0 Hz, 1H), 2.92 (dd, $J = 17.5$, 3.0 Hz, 1H), 3.56 (d, $J = 7.0$ Hz, 1H, NH), 3.70 (s, 3H) 4.32 (ddd, $J = 10.0$, 7.0, 3.0 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 37.6$, 51.6, 52.5, 88.6 (sept, $J = 35.0$ Hz), 120.3 (q, $J = 286.0$ Hz), 121.4 (q, $J = 289.0$ Hz), 170.1, 170.8 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -2.5$ (q, $J = 9.0$ Hz, 3F, CF_3), -1.5 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 295$ $[M]^+$, 263 $[M–CH_3OH]^+$, 235 $[M–CH_3OH, –CO]^+$, 166 $[(CF_3)_2CO]^+$, 69 $[CF_3]^+$, 43 $[C_2H_5N]^+$.

Methyl [(5S)-2,2-Bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate (**3b**, $C_8H_6F_6O_5$)

2b (2.82 g, 10 mmol) was converted into **3b** (2.96 g, 100%); bp 38–40°C (0.2 torr); $[\alpha]_D = -16.1°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.0$, $CHCl_3$); IR (film): $\bar{\nu} = 1840, 1735\ cm^{-1}$; ^{1}H NMR ($CDCl_3$): $\delta = 2.91$

(dd, $J = 17.5$, 7.0 Hz, 1H), 3.04 (dd, $J = 17.5$, 4.0 Hz, 1H), 3.77 (s, 3H), 5.09 (dd, $J = 7.0$, 4.0 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 35.7$, 52.5, 71.8, 97.7 (sept, $J = 36.0$ Hz), 118.7 (q, $J = 286.0$ Hz), 119.7 (q, $J = 289.0$ Hz), 166.9, 167.9 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -2.21$ (q, $J = 7.0$ Hz, 3F, CF_3), -1.94 (q, $J = 7.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 296$ $[M]^+$, 264 $[M–CH_3OH]^+$, 236 $[M–CH_3OH, –CO]^+$, 45 $[COOH]^+$, 32 $[CH_3OH]^+$.

Methyl [2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate (**3c**, $C_8H_6F_6O_4S$)

2c (2.98 g, 10 mmol) was converted into **3c** (3.12 g, 100%); bp 140°C (2 torr); oil; IR ($CHCl_3$): $\bar{\nu} = 2960$, 1805, 1725 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 2.92$ (dd, $J = 18.0$, 10.0 Hz, 1H), 3.30 (dd, $J = 18.0$, 3.5 Hz, 1H), 3.77 (s, 3H), 4.53 (dd, $J = 10.0$, 3.5 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 38.1$, 42.0, 52.9, 83.6 (sept, $J = 35.0$ Hz), 120.9 (q, $J = 283.0$ Hz), 121.5 (q, $J = 285.0$ Hz), 170.1, 170.1 ppm; ^{19}F NMR ($CDCl_3$): $\delta = 0.68$ (q, $J = 9.0$ Hz, 3F, CF_3), 1.52 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 312$ $[M]^+$, 280 $[M–CH_3OH]^+$, 252 $[M–CH_3OH, –CO]^+$, 87 $[COCH_2CSH]^+$, 59 $[CH_2CSH]^+$, 45 $[CSH]^+$.

*Reaction of **2a–2c** with Isobutene/conc. H_2SO_4*

A vigorously stirred solution of **2** (20 mmol) in *DCM* (40 cm^3) was treated with an excess of isobutene in the presence of 4 drops of conc. H_2SO_4 for 6 h. *DCM* (75 cm^3) was added, the organic phase was extracted with ice-cold water, with $NaHCO_3$ solution, again with water (30 cm^3), and dried with $MgSO_4$.

tert-Butyl [(4S)-2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate
(**4a**, $C_{11}H_{13}F_6NO_4$)

2a (5.62 g, 20 mmol) was converted into **4a** (5.40 g, 80%); mp 73°C; $[\alpha]_D = -9.0°$ cm^3 g^{-1} dm^{-1} ($c = 1.0$, $CHCl_3$); IR (KBr): $\bar{\nu} = 3345$, 1815, 1725 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 1.45$ (s, 9H), 2.60 (dd, $J = 17.0$, 10.0 Hz, 1H), 2.89 (dd, $J = 17.0$, 3.0 Hz, 1H), 3.66 (d, $J = 7.0$ Hz, 1H, NH), 4.32 (ddd, $J = 10.0$, 7.0, 3.0 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 28.0$, 38.6, 51.4, 82.7, 88.3 (sept, $J = 35.0$ Hz), 120.1 (q, $J = 285.0$ Hz), 121.3 (q, $J = 288.0$ Hz), 169.4, 170.0 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -3.1$ (q, $J = 9.0$ Hz, 3F, CF_3), -2.2 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 281$ $[M–(CH_3)_2C{=}CH_2]^+$, 236 $[M–(CH_3)_3COCO]^+$, 57 $[(CH_3)_3C]^+$.

tert-Butyl [(5S)-2,2-Bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate (**4b**, $C_{11}H_{12}F_6O_5$)

2b (2.80 g, 10 mmol) was converted into **4b** (2.58 g, 80%); mp 49°C; IR (KBr): $\bar{\nu} = 1860$, 1735 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 1.48$ (s, 9H), 2.80 (dd, $J = 17.0$, 7.0 Hz, 1H), 2.92 (dd, $J = 17.0$, 4.0 Hz, 1H), 5.00 (dd, $J = 7.0$, 4.0 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 28.0$, 37.2, 72.1, 83.2, 97.8 (sept, $J = 36.0$ Hz), 118.9 (q, $J = 287.0$ Hz), 119.8 (q, $J = 290.0$ Hz), 166.7, 167.3 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -3.03$ (q, $J = 6.0$ Hz, 3F, CF_3), -2.61 (q, $J = 6.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 323$ $[M–CH_3]^+$, 265 $[M–(CH_3)_3CO]^+$, 99 $[265–HFA]^+$, 69 $[CF_3]^+$.

tert-Butyl [2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate (**4c**, $C_{11}H_{12}F_6O_4S$)

2c (2.98 g, 10 mmol) was converted into **4c** (2.27 g, 64%); mp 60°C; IR (KBr): $\bar{\nu} = 1815$, 1715 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 1.47$ (s, 9H), 2.80 (dd, $J = 17.5$, 11.0 Hz, 1H), 3.22 (dd, $J = 17.5$, 3.5 Hz, 1H), 4.45 (dd, $J = 11.0$, 3.5 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 28.1$, 39.7, 42.3, 83.4, 83.6 (sept, $J = 35.0$ Hz), 120.9 (q, $J = 283.0$ Hz), 121.5 (q, $J = 282.0$ Hz), 168.7, 170.2 ppm; ^{19}F NMR ($CDCl_3$):

$\delta = 0.81$ (q, $J = 9.0$ Hz, 3F, CF_3), 1.69 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 354$ $[M]^+$, 339 $[M–CH_3]^+$, 281 $[M–(CH_3)_3CO]^+$, 252 $[M–(CH_3)_3COH, –CO]^+$, 69 $[CF_3]^+$, 57 $[C(CH_3)_3]^+$.

*Reaction of **5a–5c** with Alcohols*

To a solution of **5** (10 mmol) in dry diethyl ether (100 cm^3) the corresponding alcohol (10 mmol) was added dropwise at room temperature. After stirring the reaction mixture for 12 h at room temperature, it was heated 3–12 h under reflux (^{19}F NMR control). After removal of the solvent the residue was purified by distillation (Büchi Kugelrohr oven) or recrystallization.

Isopropyl [(4S)-2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate
(**6a**, $C_{10}H_{11}F_6NO_4$)

5a (2.99 g, 10 mmol) was reacted with isopropanol (0.60 g, 0.83 cm^3, 10 mmol) in dry diethyl ether to give **6a** (3.23 g, 100%); mp 65–66°C; $[\alpha]_D = -23.3°$ $cm^3\,g^{-1}\,dm^{-1}$ ($c = 1.2$, $CHCl_3$); IR (KBr): $\bar{\nu} = 3320$, 1810, 1720 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 1.26$ (d, $J = 6.0$ Hz, 6H), 2.62 (dd, $J = 17.5$, 9.5 Hz, 1H), 2.92 (dd, $J = 17.5$, 3.0 Hz, 1H), 3.64 (d, $J = 6.5$ Hz, 1H, NH), 4.35 (ddd, $J = 9.5$, 6.5, 3.0 Hz, 1H), 5.05 (sept, $J = 6.0$ Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 21.9$, 38.1, 51.6, 69.9, 89.1 (sept, $J = 34.0$ Hz), 120.3 (q, $J = 283.0$ Hz), 121.5 (q, $J = 286.0$ Hz), 170.1, 170.2 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -4.45$ (q, $J = 9.0$ Hz, 3F, CF_3), -3.59 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 323$ $[M]^+$, 308 $[M–CH_3]^+$, 281 $[M–C_3H_6]^+$, 264 $[M–C_3H_7O]^+$, 235 $[M–C_3H_7O, –CHO]^+$, 191 $[M–C_3H_7O, –CHO, –CO_2]^+$, 43 $[C_3H_7]^+$.

Isopropyl [(5S)-2,2-Bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate (**6b**, $C_{10}H_{10}F_6O_5$)

5b (3.01 g, 10 mmol) was reacted with isopropanol (0.60 g, 10 mmol) in dry diethyl ether (20 cm^3) to give **6b** (1.73 g, 53%); bp 70°C (0.1 torr); colorless liquid; $[\alpha]_D = -11.1°$ $cm^3\,g^{-1}\,dm^{-1}$ ($c = 1.3$, $CHCl_3$); IR ($CDCl_3$): $\bar{\nu} = 1845$, 1725 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 1.27$ (d, $J = 6.5$ Hz, 6H), 2.86 (dd, $J = 17.0$, 7.5 Hz, 1H), 2.98 (dd, $J = 17.0$, 4.0 Hz, 1H), 5.08 (sept, $J = 6.5$ Hz, 1H), 5.09 (dd, $J = 7.5$, 4.0 Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 21.0$, 21.0, 36.0, 69.5, 71.8, 97.6 (sept, $J = 36.0$ Hz), 118.8 (q, $J = 288.0$ Hz), 119.7 (q, $J = 288.0$ Hz), 166.9, 167.0 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -2.34$ (q, $J = 7.0$ Hz, 3F, CF_3), -2.06 (q, $J = 7.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 309$ $[M–CH_3]^+$, 265 $[M–OCH(CH_3)_2]^+$.

Isopropyl [2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate (**6c**, $C_{10}H_{10}F_6O_4S$)

5c (3.17 g, 10 mmol) was reacted with isopropanol (0.60 g, 10 mmol) in dry diethyl ether (20 cm^3) to give **6c** (3.37 g, 99%); bp 67°C (1 torr); IR (KBr): $\bar{\nu} = 1820$, 1730 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 1.22$ (d, $J = 6.5$ Hz, 6H), 2.80 (dd, $J = 17.5$, 10.5 Hz, 1H), 3.22 (dd, $J = 17.5$, 3.5 Hz, 1H), 4.48 (dd, $J = 10.5$, 3.5 Hz, 1H), 5.02 (sept, $J = 6.5$ Hz, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 21.6$, 38.8, 42.1, 70.2, 83.6 (sept, $J = 35.0$ Hz), 121.1 (q, $J = 284.0$ Hz), 121.5 (q, $J = 284.0$ Hz), 169.0, 170.1 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -0.56$ (q, $J = 9.0$ Hz, 3F, CF_3), 0.26 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 340$ $[M]^+$, 325 $[M–CH_3]^+$, 298 $[M–(CH_3)_2]^+$, 281 $[M–(CH_3)_2CHO]^+$, 252 $[M–(CH_3)_2CHOCHO]^+$, 87 $[(CH_3)_2CHOCO]^+$, 59 $[(CH_3)_2CHO]^+$, 43 $[(CH_3)_2CH]^+$.

Allyl [(4S)-2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate (**7a**, $C_{10}H_9F_6NO_4$)

5a (2.99 g, 10 mmol) was reacted with allyl alcohol (0.58 g, 10 mmol) in dry diethyl ether to give **7c** (2.67 g, 83%); bp 62°C (5 torr); colorless liquid; $[\alpha]_D = -23.6°$ $cm^3\,g^{-1}\,dm^{-1}$ ($c = 1.4$, $CHCl_3$); IR (film): $\bar{\nu} = 1835$, 1735 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 2.65$ (dd, $J = 17.5$, 10.0 Hz, 1H), 2.95 (dd,

$J = 17.5$, 3.0 Hz, 1H), 3.56 (d, $J = 7.0$ Hz, 1H, NH), 4.33 (ddd, $J = 10.0$, 7.0, 3.0 Hz, 1H), 4.58–4.61 (m, 2H), 5.21–5.32 (m, 2H), 5.79–5.92 (m, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 37.8$, 51.5, 66.4, 88.4 (sept, $J = 34.0$ Hz), 119.3, 120.2 (q, $J = 283.0$ Hz), 121.4 (q, $J = 285.0$ Hz), 131.4, 169.9, 170.1 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -3.15$ (q, $J = 9.0$ Hz, 3F, CF_3), -2.23 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 321$ $[M]^+$, 280 $[M–CH_2{=}CHCH_2]^+$, 262 $[M–CH_2{=}CHCH_3, –OH]^+$, 236 $[280–CO_2]^+$, 222 $[236–CH_2]^+$, 220 $[262–CH_2CO]^+$, 166 $[(CF_3)_2CO]^+$, 99 $[C_5H_7O_2]^+$, 69 $[CF_3]^+$.

Allyl [(5S)-2,2-Bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate (**7b**, $C_{10}H_8F_6O_5$)

5b (3.01 g, 10 mmol) was reacted with allyl alcohol (0.58 g, 10 mmol) in dry diethyl ether (20 cm^3) to give **7b** (2.09 g, 65%); bp 50°C (5 torr); colorless liquid; $[\alpha]_D = -15.5°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.1$, $CHCl_3$); IR (film): $\bar{\nu} = 1855$, 1745 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 2.90$ (dd, $J = 17.5$, 7.5 Hz, 1H), 3.05 (dd, $J = 17.5$, 4.0 Hz, 1H), 4.65–4.68 (m, 2H), 5.08 (dd, $J = 7.5$, 4.0 Hz, 1H), 5.28 (dd, $J = 14.5$, 1.0 Hz, 1H), 5.34 (dd, $J = 14.5$, 1.0 Hz, 1H), 5.81–5.98 (m, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 36.2$, 66.6, 71.9, 97.8 (sept, $J = 36.0$ Hz), 118.8 (q, $J = 287.0$ Hz), 119.2, 119.7 (q, $J = 290.0$ Hz), 131.3, 167.1, 167.4 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -4.39$ (q, $J = 7.5$ Hz, 3F, CF_3), -4.10 (q, $J =$ 7.5 Hz, 3F, CF_3) ppm; MS (EI): $m/z = 322$ $[M]^+$, 294 $[M–CO]^+$, 265 $[M–CH_2{=}CHCH_2O]^+$, 253 $[M–CF_3]^+$, 224 $[C_5H_2F_6O_3]^+$, 167 $[(CF_3)_2COH]^+$, 115 $[M–CH_2{=}CHCH_2, –(CF_3)_2CO]^+$, 99 $[M–CH_2{=}CHCH_2O, –(CF_3)_2CO]^+$, 69 $[CF_3]^+$, 57 $[CH_2{=}CHCH_2O]^+$, 41 $[CH_2{=}CHCH_2]^+$.

Allyl [2,2-Bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate (**7c**, $C_{10}H_8F_6O_4S$)

5c (3.17 g, 10 mmol) was reacted with allyl alcohol (0.58 g, 10 mmol) in dry diethyl ether (20 cm^3) to give **7c** (3.04 g, 90%); bp 67°C (1.3 torr); colorless liquid; IR (film): $\bar{\nu} = 1820$, 1730 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 2.93$ (dd, $J = 17.5$, 10.5 Hz, 1H), 3.33 (dd, $J = 17.5$, 3.5 Hz, 1H), 4.51 (dd, $J = 10.5$, 3.5 Hz, 1H), 4.66 (m, 2H), 5.30 (dd, $J = 10.5$, 1.0 Hz, 1H), 5.35 (dd, $J = 18.5$, 1.0 Hz, 1H), 5.86–5.96 (m, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 38.4$, 42.0, 66.7, 83.6 (sept, $J = 35.0$ Hz), 119.5, 120.9 (q, $J = 283.0$ Hz), 121.4 (q, $J = 283.0$ Hz), 131.2, 169.3, 170.0 ppm; ^{19}F NMR ($CDCl_3$): $\delta = 0.86$ (q, $J = 9.0$ Hz, 3F, CF_3), 1.67 (q, $J = 9.0$ Hz, 3F, CF_3) ppm; MS (EI): $m/z = 338$ $[M]^+$, 297 $[M–CH_2{=}CHCH_2]^+$, 281 $[M–CH_2{=}CHCH_2O]^+$, 253 $[M–CH_2{=}CHCH_2O, –CO]^+$, 57 $[CH_2{=}CHCH_2O]^+$, 41 $[CH_2{=}CHCH_2]^+$.

Ethan-1,2-diyl Di[(4S)-bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate (**8a**, $C_{16}H_{12}F_{12}N_2O_8$)

5a (5.0 g, 17 mmol) and ethylene glycol (0.52 g, 8.5 mmol) were reacted in dry diethyl ether (30 cm^3). Yield: 3.15 g (63%) **8a**; mp 75°C; $[\alpha]_D = +4.0°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.0$, acetone); IR (KBr): $\bar{\nu} = 3400$, 3380, 1830, 1730 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 2.73$ (dd, $J = 17.5$, 9.5 Hz, 2H), 3.00 (dd, $J = 17.5$, 3.0 Hz, 2H), 3.66 (d, $J = 7.0$ Hz, 2H, NH), 4.34–4.45 (m, 6H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 37.5$, 51.4, 63.0, 88.4 (sept, $J = 35.0$ Hz), 120.1 (q, $J = 285.0$ Hz), 121.3 (q, $J = 288.0$ Hz), 169.8, 169.9 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -2.2$ (q, $J = 8.0$ Hz, 6F, $2CF_3$), -1.4 (q, $J = 8.0$ Hz, 6F, $2CF_3$) ppm; MS (EI): $m/z = 588$ $[M]^+$, 544 $[M–CO_2]^+$, 500 $[M–2CO_2]^+$, 308 $[M–C_7H_4F_6NO_4]^+$, 166 $[(CF_3)_2CO]^+$.

Ethan-1,2-diyl Di[(5S)-bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate (**8b**, $C_{16}H_{10}F_{12}O_{10}$)

To a solution of **5b** (4.51 g, 15 mmol) in dry diethyl ether (25 cm^3), a solution of ethylene glycol (0.42 cm^3, 7.5 mmol) in dry diethyl ether (25 cm^3) was dropped slowly with stirring. After stirring for several days at room temperature (^{19}F NMR control) the solvent was removed. The residue was recrystallized from $CHCl_3$/*n*-hexane. Yield: 2.70 g (61%) **8b**; mp 66°C; $[\alpha]_D = -4.9°\ cm^3\ g^{-1}\ dm^{-1}$

($c = 1.3$, $CHCl_3$); IR (KBr): $\bar{\nu} = 1860$, 1740 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 2.95$ (dd, $J = 17.5$, 7.0 Hz, 2H), 3.06 (dd, $J = 17.5$, 4.0 Hz, 2H), 4.40 (d, $J = 14.5$ Hz, 2H), 4.42 (d, $J = 14.5$ Hz, 2H), 5.09 (dd, $J = 7.0$, 4.0 Hz, 2H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 35.5$, 62.8, 71.6, 97.7 (sept, $J = 36.0$ Hz), 118.7 (q, $J = 287.0$ Hz), 119.6 (q, $J = 287.0$ Hz), 166.8, 167.3 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -2.31$ (q, $J = 7.0$ Hz, 6F, $2CF_3$), -2.01 (q, $J = 7.0$ Hz, 6F, $2CF_3$) ppm; MS (EI): $m/z = 591$ $[M + H]^+$, 309 $[M–C_7H_4F_6O_5]^+$, 265 $[C_7H_3F_6O_4]^+$, 71 $[C_3H_3O_2]^+$, 69 $[CF_3]^+$, 43 $[C_2H_3O]^+$.

Ethan-1,2-diyl Di[2,2-bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate
(**8c**, $C_{16}H_{10}F_{12}O_8S_2$)

To a solution of **5c** (4.75 g, 15 mmol) in dry diethyl ether (25 cm^3), a solution of dry ethylene glycol (0.42 cm^3, 7.5 mmol) in diethyl ether (25 cm^3) was added slowly with stirring. After stirring for several days at room temperature the solvent was removed and the residue was distilled *in vacuo*. Yield: 3.69 g (79%) **9c**; bp 169°C (0.3 torr); IR (film): $\bar{\nu} = 1810$, 1730 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 2.95$ (dd, $J = 17.5$, 10.0 Hz, 2H), 3.32 (dd, $J = 17.5$, 4.0 Hz, 2H), 4.41 (s, 4H), 4.53 (dd, $J = 10.0$, 4.0 Hz, 2H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 38.0$, 41.8, 63.3, 83.5 (sept, $J = 35.0$ Hz), 120.9 (q, $J = 283.0$ Hz), 121.4 (q, $J = 284.0$ Hz), 169.4, 170.0 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -0.46$ (q, $J = 9.0$ Hz, 6F, $2CF_3$), 0.40 (q, $J = 9.0$ Hz, 6F, $2CF_3$) ppm; MS (EI): $m/z = 622$ $[M]^+$, 325 $[M–C_7H_3F_6O_4S]^+$, 281 $[M–C_7H_3F_6O_4S, –C_2H_4O]^+$, 87 $[COCH_2CSH]^+$, 69 $[CF_3]^+$, 59 $[CH_2CSH]^+$, 45 $[CSH]^+$.

*Reaction of **5a–5c** with 1,1,1-Tris(hydroxymethyl)ethane and Pentaerythritol*

In dry toluene (100 cm^3) **5** (10 mmol) and the corresponding alcohol (1,1,1-tris(hydroxymethyl)ethane: 0.40 g, 3.3 mmol; pentaerythritol: 0.34 g, 2.5 mmol) were dissolved. The mixture was heated for 3 days under reflux (^{19}F NMR control). The solvent was removed *in vacuo*.

1,1,1-Ethyltrismethyl Tris[(5S)-2,2-bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate
(**9a**, $C_{26}H_{21}F_{18}N_3O_{12}$)

5a (2.99 g, 10 mmol) gave according to the general procedure 2.39 g (79%) of **9a**, oil; IR (film): $\bar{\nu} = 1835$, 1735 cm^{-1}; ^1H NMR (acetone-d_6): $\delta = 1.09$ (s, 3H), 2.94 (dd, $J = 17.0$, 6.5 Hz, 3H), 3.04 (dd, $J = 17.0$, 4.5 Hz, 3H), 4.10 (d, $J = 11.5$ Hz, 3H), 4.21 (d, $J = 11.5$ Hz, 3H), 4.61 (m, 3H), 5.37 (d, $J = 7.0$ Hz, 3H, NH) ppm; ^{13}C NMR (acetone-d_6): $\delta = 17.6$, 38.4, 40.1, 53.0, 67.4, 90.2 (sept, $J = 35.0$ Hz), 122.0 (q, $J = 284.0$ Hz), 123.2 (q, $J = 290.0$ Hz), 170.4, 172.1 ppm; ^{19}F NMR (acetone-d_6): $\delta = -3.32$ (q, $J = 9.0$ Hz, 9F, $3CF_3$), -2.83 (q, $J = 9.0$ Hz, 9F, $3CF_3$) ppm; MS (FAB): $m/z = 910$ $[M + H]^+$, 629 $[M–C_7H_4F_6NO_4]^+$, 366 $[M–C_7H_4F_6NO_4, –C_6H_5F_6O_2, –CO]^+$.

1,1,1-Ethyltrismethyl Tris[(5S)-2,2-bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate
(**9b**, $C_{26}H_{18}F_{18}O_{15}$)

5b (3.01 g, 10 mmol) was reacted according to the general procedure. After removal of the solvent *in vacuo* the residue was triturated with dry diethyl ether and recrystallized from acetone. Yield: 2.55 g (84%) **9b**; mp 116°C; $[\alpha]_D = -17.1°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.1$, acetone); IR (KBr): $\bar{\nu} = 1850$, 1755, 1730 cm^{-1}; ^1H NMR (acetone-d_6): $\delta = 1.08$ (s, 3H), 3.19 (dd, $J = 17.5$, 6.0 Hz, 3H), 3.30 (dd, $J = 17.5$, 4.0 Hz, 3H), 4.14 (d, $J = 11.0$ Hz, 3H), 4.22 (d, $J = 11.0$ Hz, 3H), 5.46 (dd, $J = 6.0$, 4.0 Hz, 3H) ppm; ^{13}C NMR (acetone-d_6): $\delta = 16.8$, 36.0, 39.5, 67.2, 72.9, 98.2 (sept, $J = 36.0$ Hz), 119.9 (q, $J = 285.0$ Hz), 120.9 (q, $J = 285.0$ Hz), 167.7, 168.4 ppm; ^{19}F NMR (acetone-d_6): $\delta = -2.84$ (q, $J = 8.0$ Hz, 9F, $3CF_3$), -2.17 (q, $J = 8.0$ Hz, 9F, $3CF_3$) ppm; MS (FAB): $m/z = 913$ $[M + H]^+$, 631 $[M–C_7H_3F_6O_5]^+$, 265 $[C_7H_3F_6O_4]^+$.

1,1,1-Ethyltrismethyl Tris[2,2-bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate
(**9c**, $C_{26}H_{18}F_{18}O_{12}S_3$)

5c (3.17 g, 10 mmol) was transformed into **9c**. Yield: 3.20 g (100%); oil; IR (film): $\bar{\nu} = 1815$, 1740 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 1.17$ (s, 3H), 2.98 (dd, $J = 17.5$, 10.0 Hz, 3H), 3.34 (dd, $J = 17.5$, 3.5 Hz, 3H), 4.09 (d, $J = 11.0$ Hz, 3H), 4.18 (d, $J = 11.0$ Hz, 3H), 4.55 (dd, $J = 10.0$, 3.5 Hz, 3H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 17.2$, 38.1, 39.0, 41.8, 66.5, 83.7 (sept, $J = 35.0$ Hz), 120.9 (q, $J = 283.0$ Hz), 121.4 (q, $J = 284.0$ Hz), 169.2, 169.8 ppm; ^{19}F NMR ($CDCl_3$): $\delta = -0.49$ (q, $J = 9.0$ Hz, 9F, $3CF_3$), 0.42 (q, $J = 9.0$ Hz, 9F, $3CF_3$) ppm; MS (EI): $m/z = 960$ $[M]^+$, 663 $[M–C_7H_3F_6O_4S]^+$, 410 $[M–C_7H_3F_6O_4S, –C_6H_3F_6O_2S]^+$, 352 $[M–C_7H_3F_6O_4S, –C_8H_5F_6O_4S]^+$, 299 $[M–C_7H_3F_6O_4S, –2(CF_3)_2CS]^+$, 281 $[C_7H_3F_6O_3S]^+$, 182 $[(CF_3)_2CS]^+$.

Pentaerythrityl Tetrakis[(4S)-2,2-bis(trifluoromethyl)-5-oxo-1,3-oxazolidin-4-yl]acetate
(**10a**, $C_{33}H_{24}F_{24}N_4O_{16}$)

5a (2.99 g, 10.0 mmol) was reacted with pentaerythritol (0.34 g, 2.5 mmol) according to the general procedure. After removal of the solvent *in vacuo*, the residue was carefully triturated with dry diethyl ether and recrystallized from acetone. Yield: 2.64 g (89%) **10a**; mp 138°C; $[\alpha]_D = +19.75°$ $cm^3\,g^{-1}\,dm^{-1}$ ($c = 1.0$, acetone); IR (KBr): $\bar{\nu} = 3380$, 2980, 1830, 1735 cm^{-1}; ^1H NMR (acetone-d_6): $\delta = 2.91$ (dd, $J = 17.0$, 6.5 Hz, 4H), 3.00 (dd, $J = 17.0$, 4.5 Hz, 4H), 4.22 (d, $J = 11.5$ Hz, 4H), 4.32 (d, $J = 11.5$ Hz, 4H), 4.58 (m, 4H), 5.31 (d, $J = 7.0$ Hz, 4H, NH) ppm; ^{13}C NMR (acetone-d_6): $\delta = 37.7$, 43.2, 52.2, 63.4, 89.3 (sept, $J = 34.0$ Hz), 121.7 (q, $J = 285.0$ Hz), 122.5 (q, $J = 289.0$ Hz), 169.7, 171.4 ppm; ^{19}F NMR (acetone-d_6): $\delta = -3.32$ (q, $J = 9.0$ Hz, 12F, $4CF_3$), -2.83 (q, $J = 9.0$ Hz, 12F, $4CF_3$) ppm; MS (EI): $m/z = 600$ $[C_{17}H_{12}F_{12}N_2O_8]^+$, 200 $[C_5F_6NO_2]^+$.

Pentaerythrityl Tetrakis[(5S)-2,2-bis(trifluoromethyl)-4-oxo-1,3-dioxolan-5-yl]acetate
(**10b**, $C_{33}H_{20}F_{24}O_{20}$)

5b (3.01 g, 10 mmol) was reacted with pentaerythritol (0.34 g, 2.5 mmol) according to the general procedure. After removal of the solvent *in vacuo*, the residue was carefully triturated with dry diethyl ether and recrystallized from acetone. Yield: 2.62 g (88%) **10b**; mp 148°C; $[\alpha]_D = -16.4°$ $cm^3\,g^{-1}\,dm^{-1}$ ($c = 1.0$, acetone); IR (KBr): $\bar{\nu} = 1840$, 1750 cm^{-1}; ^1H NMR (acetone-d_6): $\delta = 3.25$ (dd, $J = 17.5$, 6.5 Hz, 4H), 3.36 (dd, $J = 17.5$, 4.0 Hz, 4H), 4.35 (d, $J = 11.5$ Hz, 4H), 4.41 (d, $J = 11.5$ Hz, 4H), 5.51 (dd, $J = 6.5$, 4.0 Hz, 4H) ppm; ^{13}C NMR (acetone-d_6): $\delta = 35.8$, 43.0, 63.8, 72.7, 98.1 (sept, $J = 36.0$ Hz), 119.8 (q, $J = 289.0$ Hz), 120.7 (q, $J = 285.0$ Hz), 167.6, 168.2 ppm; ^{19}F NMR (acetone-d_6): $\delta = -2.82$ (q, $J = 9.0$ Hz, 12F, $4CF_3$), -2.18 (q, $J = 9.0$ Hz, 12F, $4CF_3$) ppm; MS (EI): $m/z = 1192$ $[M]^+$, 911 $[M–C_7H_3F_6O_5]^+$, 688 $[M–C_7H_3F_6O_5, –C_5HF_6O_3]^+$, 616 $[M–C_7H_3F_6O_4, –C_5HF_6O_3, –CF_3, –F]^+$, 364 $[M–C_7H_3F_6O_5, –C_7H_4F_6O_5, –C_7H_3F_6O_4]^+$, 265 $[C_7H_3F_6O_4]^+$, 98 $[M–2C_7H_4F_6O_5, –2C_7H_3F_6O_4]^+$.

Pentaerythrityl Tetrakis[2,2-bis(trifluoromethyl)-5-oxo-1,3-oxathiolan-4-yl]acetate
(**10c**, $C_{33}H_{20}F_{24}O_{16}S_4$)

3c (3.17 g, 10 mmol) gave according to the general procedure **10c** (3.14 g, 100%); mp 39°C; IR (KBr): $\bar{\nu} = 1815$, 1740 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 2.93$ (dd, $J = 18.0$, 9.5 Hz, 4H), 3.26 (dd, $J = 18.0$, 4.0 Hz, 4H), 4.14 (d, $J = 12.0$ Hz, 4H), 4.25 (d, $J = 12.0$ Hz, 4H), 4.50 (dd, $J = 9.5$, 4.0 Hz, 4H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 37.8$, 41.7, 42.8, 62.4, 83.5 (sept, $J = 35.0$ Hz), 120.8 (q, $J = 283.0$ Hz), 121.3 (q, $J = 285.0$ Hz), 169.1, 169.9 ppm; ^{19}F NMR ($CDCl_3$): $\delta = 0.82$ (q, $J = 9.0$ Hz, 12F, $4CF_3$), 1.78 (q, $J = 9.0$ Hz, 12F, $4CF_3$) ppm; MS (EI): $m/z = 959$ $[M–C_7H_3F_6O_4S]^+$, 281 $[C_7H_3F_6O_3S]^+$, 182 $[(CF_3)_2CS]^+$, 132 $[M–4C_7H_3F_6O_3S]^+$, 113 $[CF_3CS]^+$.

Ethan-1,2-diyl Di[(2S)-malate] (**11b**, $C_{10}H_{14}O_{10}$)

9b (1.48 g, 2.5 mmol) was heated in water/*THF* (bath temperature: 65°C) for 3 h. After removal of the solvent the residue was extracted with *DCM* ($5\times10\,cm^3$). The combined organic layer was dried with $MgSO_4$, then the solvent was removed *in vacuo*. Yield: 0.34 g (52%) **11b**; oil; IR (film): $\bar{\nu}=3600$–2800, 1725 cm^{-1}; ^1H NMR (*DMSO*-d_6): $\delta=2.41$ (dd, $J=15.5$, 8.0 Hz, 2H), 2.57 (dd, $J=15.5$, 5.0 Hz, 2H), 4.06 (s, 4H), 4.15 (dd, $J=8.0$, 5.0 Hz, 2H) ppm; ^{13}C NMR (*DMSO*-d_6): $\delta=39.3$, 62.3, 67.1, 170.6, 174.7 ppm.

4-(1,1,1-Ethyltrismethyl) Tris[(2S)-malate] (**12b**, $C_{17}H_{24}O_{15}$)

9b (0.46 g, 0.5 mmol) was hydrolyzed. Yield: 0.18 g (78%) **12b**; oil; IR (film): $\bar{\nu}=3535$–3230, 1730 cm^{-1}; ^1H NMR (acetone-d_6): $\delta=0.93$ (s, 3H), 2.57 (dd, $J=15.5$, 7.5 Hz, 3H), 2.73 (dd, $J=15.5$, 5.0 Hz, 3H), 3.98 (s, 6H), 4.29 (dd, $J=7.5$, 5.0 Hz, 3H), 5.49 (s, br, 3H, OH) ppm; ^{13}C NMR (acetone-d_6): $\delta=16.5$, 38.8, 39.2, 65.9, 67.3, 170.0, 174.1 ppm; MS (FAB): $m/z=469$ $[M+H]^+$, 451 $[M–H_2O]^+$.

4-(1,1,1-Ethyltrismethyl) Tris[thiomalate] (**12c**, $C_{17}H_{24}O_{12}S_3$)

9c (0.96 g, 1.0 mmol) was heated (65°C, bath temperature) in 25 cm^3 of an acetonitrile/water mixture for 6 h. After evaporation of the solvent, the residue was extracted with ethyl acetate ($3\times20\,cm^3$). The organic layer was extracted with water, dried with $MgSO_4$, and evaporated to dryness. Yield: 0.25 g (48%) **12c**; oil; IR (film): $\bar{\nu}=3435$–2925, 1735, 1715 cm^{-1}; ^1H NMR (acetone-d_6): $\delta=1.03$ (s, 3H), 2.69 (d, $J=9.0$ Hz, 3H), 2.80 (dd, $J=17.0$, 6.0 Hz, 3H), 3.02 (dd, $J=17.0$, 9.0 Hz, 3H), 3.79 (ddd, $J=9.0$, 6.0, 6.0 Hz, 3H), 4.04 (d, $J=10.0$ Hz, 3H), 4.09 (d, $J=10.0$ Hz, 3H) ppm; ^{13}C NMR (acetone-d_6): $\delta=16.5$, 35.8, 38.8, 39.9, 66.0, 170.0, 173.2 ppm; MS (EI): $m/z=517$ $[M]^+$, 500 $[M–OH]^+$, 410 $[M–2CO_2H]^+$, 335 $[M–3CO_2H, –CH_3]^+$, 251 $[M–2COCH_2CH(SH)CO_2H]^+$, 42 $[C_2H_2O]^+$.

4-Pentaerythrityl Tetrakis[(2S)-malate] (**13b**, $C_{21}H_{28}O_{20}$)

10b (1.19 g, 1.0 mmol) was heated in acetonitrile/water mixture (100 cm^3, 4:1) at 65°C for 3 h. The reaction mixture was concentrated *in vacuo* and afterwards extracted with *DCM* ($5\times15\,cm^3$). The combined organic layer was washed with water and dried with $MgSO_4$. Yield: 0.32 g (53%) **13b**; oil; IR (film): $\bar{\nu}=3600$–2800, 1720 cm^{-1}; ^1H NMR (acetone-d_6): $\delta=2.76$ (dd, $J=16.0$, 7.0 Hz, 4H), 2.87 (dd, $J=16.0$, 4.5 Hz, 4H), 4.22 (s, 8H), 4.52 (dd, $J=7.0$, 4.5 Hz, 4H) ppm; ^{13}C NMR (acetone-d_6): $\delta=39.7$, 43.0, 63.3, 67.8, 170.6, 174.8 ppm.

4-Pentaerythrityl Tetrakis[thiomalate] (**13c**, $C_{21}H_{28}O_{16}S_4$)

9c (0.96 g, 1.0 mmol) was heated in an acetonitrile/water mixture (25 cm^3, 4:1) to 65°C for 6 h. Yield: 0.51 g (77%) **13c**; oil; IR (film): $\bar{\nu}=3395$–2930, 1730, 1700 cm^{-1}; ^1H NMR (acetone-d_6): $\delta=2.76$ (d, $J=9.5$ Hz, 4H), 2.88 (dd, $J=17.0$, 5.5 Hz, 4H), 3.07 (dd, $J=17.0$, 9.5 Hz, 4H), 3.85 (ddd, $J=9.0$, 6.0, 6.0 Hz, 4H), 4.24 (d, $J=10.0$ Hz, 4H), 4.28 (d, $J=11.0$ Hz, 4H) ppm; ^{13}C NMR (acetone-d_6): $\delta=37.1$, 41.2, 43.8, 64.1, 171.1, 174.3 ppm; MS (EI): $m/z=664$ $[M]^+$, 501 $[M–C_5H_7O_4S]^+$, 133 $[C_4H_5O_3S]^+$.

4-Allyl 1-Methyl (2S)-Malate (**14b**, $C_8H_{12}O_5$)

7b (1.61 g, 5.0 mmol) was heated in dry methanol (10 cm^3) under reflux. After the reaction was complete (^{19}F NMR analysis) the solvent was evaporated, the residue was dissolved in $CHCl_3$, and extracted with water. The organic phase was dried with $MgSO_4$ and evaporated to dryness. Yield: 0.76 g (81%) **14b**; oil;

$[\alpha]_D = -7.3°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.1$, $CHCl_3$); IR (film): $\bar{\nu} = 1740\ cm^{-1}$; ^1H NMR ($CDCl_3$): $\delta = 2.83$ (dd, $J = 16.0$, 9.0 Hz, 1H), 2.87 (dd, $J = 16.0$, 3.5 Hz, 1H), 3.79 (s, 3H), 4.52 (m, 1H), 4.60 (dd, $J = 5.5$, 1.5 Hz, 1H), 4.61 (dd, $J = 5.5$, 1.5 Hz, 1H), 5.23 (m, 1H), 5.30 (m, 1H), 5.88 (m, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 38.7$, 53.0, 65.8, 67.4, 118.8, 131.7, 170.4, 173.8 ppm; MS (EI): $m/z = 188$ $[M]^+$, 129 $[M–CO_2CH_3]^+$, 103 $[M–CO_2CH_2CH{=}CH_2]^+$, 87 $[M–CO_2CH_3, –CH_2CH{=}CH_2]^+$.

4-Allyl 1-Methyl Thiomalate (**14c**, $C_8H_{12}O_4S$)

7c (1.02 g, 5.0 mmol) was heated in dry methanol (10 cm^3) under reflux. After the reaction was complete (^{19}F NMR analysis) the solvent was evaporated and the residue was dissolved in $CHCl_3$. The organic phase was dried with $MgSO_4$ and the solvent distilled off *in vacuo*. The residue was distilled in a Büchi Kugelrohr oven. Yield: 0.71 g (70%) **8c**; bp 101°C ($2.6 \cdot 10^{-1}$ torr); IR (film): $\bar{\nu} = 1735\ cm^{-1}$; ^1H NMR ($CDCl_3$): $\delta = 2.22$ (d, $J = 9.5$ Hz, 1H), 2.80 (dd, $J = 17.0$, 6.0 Hz, 1H), 3.06 (dd, $J = 17.0$, 9.0 Hz, 1H), 3.73 (dd, $J = 9.0$, 6.0 Hz, 1H), 3.77 (s, 3H), 4.60 (m, 2H), 5.25 (dd, $J = 10.5$, 1.5 Hz, 1H), 5.32 (dd, $J = 17.5$, 1.5 Hz, 1H), 5.89 (m, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 36.2$, 40.0, 52.9, 65.7, 118.6, 131.8, 170.2, 172.8 ppm; MS (EI): $m/z = 204$ $[M]^+$, 172 $[M–CH_3OH]^+$, 163 $[M–CH_2{=}CHCH_2]^+$, 146 $[M–CH_2CH{=}CH_2OH]^+$, 132 $[M–CH_2{=}CHCH_2, –CH_3O]^+$, 119 $[M–CH_2{=}CHCH_2, –CO_2]^+$, 59 $[CH_3CO_2]^+$, 41 $[CH_2CH{=}CH_2]^+$.

4-Pentaerythrityl 1-Methyl Tetrakis(thiomalate) (**15**, $C_{25}H_{36}O_{16}S_4$)

10c (0.63 g, 0.5 mmol) was heated in methanol (10 cm^3) for 24 h under reflux. After evaporation of the solvent the residue was redissolved in $CHCl_3$. The organic layer was washed with citric acid (10% solution) and water. After drying the organic layer with $MgSO_4$ the solvent was removed *in vacuo*. The remaining oil was analytically pure. Yield: 0.32 g (89%) **15c**; oil; IR (film): $\bar{\nu} = 1745$, $1725\ cm^{-1}$; ^1H NMR ($CDCl_3$): $\delta = 2.24$ (d, $J = 9.5$ Hz, 4H), 2.79 (dd, $J = 17.0$, 6.0 Hz, 4H), 3.03 (dd, $J = 17.0$, 9.0 Hz, 4H), 3.73 (dd, $J = 9.0$, 6.0 Hz, 4H), 3.77 (s, 12H), 4.12 (s, 8H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 35.7$, 39.5, 42.0, 52.9, 62.3, 169.7, 172.5 ppm; MS (EI): $m/z = 720$ $[M]^+$, 688 $[M–CH_3OH]^+$, 656 $[M–2CH_3OH]^+$, 377 $[M–2CH_2CH(SH)CO_2CH_3, –CH(SH)CO_2CH_3]^+$, 230 $[M–3CH_2CH(SH)–CO_2CH_3, –CH(SH)CO_2CH_3, –CO]^+$, 147 $[COCH_2CH(SH)CO_2CH_3]^+$, 119 $[CH_2CH(SH)CO_2CH_3]^+$, 59 $[CO_2CH_3]^+$.

1-Allyl 4-Isopropyl 2-(3-Hydroxypropylthio)succinate (**16**, $C_{13}H_{22}O_5S$)

6c (1.70 g, 5.0 mmol) was heated in allyl alcohol (10 cm^3) under reflux until the starting material was consumed (^{19}F NMR analysis). The solvent was removed *in vacuo* and the residue distilled in a Büchi Kugelrohr oven. Yield: 0.97 g (67%) **16**; oil; bp 171°C (0.2 torr); IR (film): $\bar{\nu} = 3530$–3395, 2980, 1730, $1160\ cm^{-1}$; ^1H NMR ($CDCl_3$): $\delta = 1.21$ (d, $J = 6.0$ Hz, 6H), 1.83 (m, 2H), 2.64 (dd, $J = 17.0$, 6.0 Hz, 1H), 2.78 (dt, $J = 7.0$, 2.0 Hz, 2H), 2.95 (dd, $J = 17.0$, 9.5 Hz, 1H), 3.68 (dd, $J = 9.5$, 6.0 Hz, 1H), 3.71 (t, $J = 6.0$ Hz, 2H), 4.63 (dd, $J = 5.5$, 1.0 Hz, 1H), 5.24 (dd, $J = 10.0$, 1.0 Hz, 1H), 5.35 (dd, $J = 17.0$, 1.0 Hz, 1H), 5.90 (m, 1H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 21.6$, 27.9, 31.7, 36.6, 41.5, 60.8, 65.8, 68.6, 118.5, 131.6, 170.1, 171.4 ppm; MS (EI): $m/z = 290$ $[M]^+$, 272 $[M–H_2]^+$, 231 $[M–CH_2CH_2CH_2OH]^+$, 214 $[M–(CH_3)_2CHO, –OH]^+$, 200 $[M–CH_2]^+$, $[M–CH_2CH_2CH_2OH, –CH_2CH{=}CH_2]^+$, 173 $[M–(CH_3)_2CHO, –OH, –CH_2CH{=}CH_2]^+$, 158 $[M–SCH_2CH_2CH_2SH, –CH_2CH{=}CH]^+$, 145 $[M–(CH_3)_2CHO, –OH, –CH_2CH{=}CH_2, –CO]^+$, 115 $[M–SCH_2CH_2CH_2SH, –CH_2CH{=}CH, –(CH_3)_2CH]^+$.

Aminolysis with Benzylamine

To a solution of **8**–**10** (0.5 mmol) in *THF* (20 cm^3) benzylamine (1.5 equiv.) was added slowly with stirring at 0°C. The mixture was allowed to warm up to room temperature and stirring was continued

until the starting material was consumed (^{19}F NMR analysis). The precipitate was filtered off, washed carefully with ice-cold ether, and dried *in vacuo*.

Ethan-1,2-diyl Di[(2S)-1-(N-benzylmalamide)] (**17b**, $C_{24}H_{28}N_2O_8$)

8b (1.77 g, 3.0 mmol) was reacted with benzylamine (0.16 g, 1.5 mmol) according to the general procedure to give **16b** (0.75 g, 53%); mp 150°C; IR (KBr): $\bar{\nu} = 3390$, 3330, 1725, 1620 cm^{-1}; ^{1}H NMR (*DMSO*-d$_6$): $\delta = 2.51$ (dd, $J = 15.5$, 8.5 Hz, 2H), 2.75 (dd, $J = 15.5$, 4.0 Hz, 2H), 4.22 (s, 4H), 4.29 (d, $J = 6.0$ Hz, 4H), 4.31 (m, 2H), 5.97 (d, $J = 5.5$ Hz, 2H), 7.27 (m, 10H), 8.39 (t, $J = 6.0$ Hz, 2H, NH) ppm; ^{13}C NMR (*DMSO*-d$_6$): $\delta = 39.6$, 41.9, 62.0, 68.3, 126.7, 127.2, 128.2, 139.5, 170.6, 172.6 ppm; MS (EI): $m/z = 267$ $[C_{13}H_{17}NO_5]^+$, 205 $[M–C_{13}H_{17}NO_5]^+$, 106 $[C_7H_7NH]^+$, 91 $[C_7H_7]^+$.

Ethan-1,2-diyl Di[(2S)-1-(N-benzylthiomalamide)] (**17c**, $C_{24}H_{28}N_2O_6S_2$)

8c (062 g, 1.0 mmol) was reacted with benzylamine (0.32 g, 3.0 mmol) in dry diethyl ether (15 cm^3). Yield: 0.32 g (64%) **17c**; mp 115°C; IR (KBr): $\bar{\nu} = 3515$–3365, 1735, 1645 cm^{-1}; ^{1}H NMR (*DMSO*-d$_6$): $\delta = 2.67$ (dd, $J = 17.0$, 6.5 Hz, 2H), 2.93 (dd, $J = 17.0$, 9.0 Hz, 2H), 3.69 (dd, $J = 9.0$, 6.5 Hz, 2H), 4.17 (s, 4H), 4.25 (d, $J = 5.0$ Hz, 2H), 4.28 (d, $J = 5.5$ Hz, 2H), 7.25 (s, 5H), 7.26 (s, 5H), 8.60 (t, $J = 5.5$ Hz, 2H, NH) ppm; ^{13}C NMR (*DMSO*-d$_6$): $\delta = 37.1$, 40.3, 42.9, 62.7, 127.5, 127.7, 129.0, 139.8, 171.0, 172.1 ppm; MS (EI): $m/z = 505$ $[M]^+$, 472 $[M–SH]^+$, 366 [M–SH, $–NHC_6H_7]^+$, 232 [M–SH, $–NHC_6H_7$, $–NHC_7H_7$, $–CO]^+$, 106 $[NHC_7H_7]^+$, 91 $[C_7H_7]^+$, 77 $[C_6H_5]^+$.

4-(1,1,1-Ethyltrismethyl) Tris[(2S)-1-(N-benzylmalamide)] (**18**, $C_{38}H_{45}N_3O_{12}$)

9b (0.46 g, 0.5 mmol) was reacted with benzylamine (0.16 g, 1.5 mmol) according to the general procedure to give **18** (0.35 g, 95%); mp 100°C; $[\alpha]_D = -33.9°$ cm^3 g^{-1} dm^{-1} ($c = 1.0$, *DMSO*); IR (KBr): $\bar{\nu} = 3600$–3100, 1730, 1650, 1530 cm^{-1}; ^{1}H NMR (*DMSO*-d$_6$): $\delta = 0.95$ (s, 3H), 2.53 (dd, $J = 15.5$, 8.5 Hz, 3H), 2.78 (dd, $J = 15.5$, 4.0 Hz, 3H), 3.99 (d, $J = 11.0$ Hz, 3H), 4.03 (d, $J = 7.0$ Hz, 3H), 4.28–4.31 (m, 9H), 5.94 (d, $J = 6.0$ Hz, 3H), 7.19–7.32 (m, 15H), 8.38 (t, $J = 6.0$ Hz, 3H, NH) ppm; ^{13}C NMR (*DMSO*-d$_6$): $\delta = 16.5$, 38.4, 39.7, 42.0, 65.5, 68.5, 126.8, 127.3, 128.3, 139.6, 170.4, 172.7 ppm; MS (EI): $m/z = 106$ $[C_7H_7NH]^+$, 91 $[C_7H_7]^+$, 44 $[CO_2]^+$.

4-Pentaerythrityl Tetrakis[(2S)-1-(N-benzylmalamide)] (**19b**, $C_{49}H_{56}N_4O_{16}$)

10b (0.60 g, 0.5 mmol) was reacted with benzylamine (0.20 g, 2.0 mmol) according to the general procedure to give **19b** (0.39 g, 82%); mp 120°C; IR (KBr): $\bar{\nu} = 3600$–3100, 1740, 1655, 1535 cm^{-1}; ^{1}H NMR (*DMSO*-d$_6$): $\delta = 2.52$ (dd, $J = 15.5$, 8.5 Hz, 4H), 2.79 (dd, $J = 15.5$, 4.0 Hz, 4H), 4.11 (d, $J = 11.5$ Hz, 4H), 4.17 (d, $J = 11.5$ Hz, 4H), 4.23–4.32 (m, 12H), 5.97 (d, $J = 6.0$ Hz, 4H), 7.26 (m, 20H), 8.41 (t, $J = 6.0$ Hz, 4H, NH) ppm; ^{13}C NMR (*DMSO*-d$_6$): $\delta = 39.6$, 40.2, 41.9, 62.3, 68.4, 126.7, 127.2, 128.2, 139.5, 170.3, 172.6 ppm; MS (EI): $m/z = 106$ $[C_7H_7NH]^+$, 91 $[C_7H_7]^+$, 44 $[CO_2]^+$.

4-Pentaerythrityl Tetrakis[1-(N-benzylthiomalamide)] (**19c**, $C_{49}H_{56}N_4O_{12}S_4$)

10c (0.63 g, 0.5 mmol) was reacted with benzylamine (0.21 g, 2.0 mmol) in dry diethyl ether (15 cm^3). When the reaction was complete, the solvent was removed *in vacuo*. The residue was extracted with *DCM*, washed with diluted HCl and water, dried with $MgSO_4$, then the solvent was removed *in vacuo*. Yield: 0.44 g (87%) **19c**; oil; IR (film): $\bar{\nu} = 3370$–3300, 1745, 1650, 1550 cm^{-1}; ^{1}H NMR ($CDCl_3$): $\delta = 2.52$ (dd, $J = 18.5$, 4.5 Hz, 4H), 3.11 (dd, $J = 18.5$, 9.0 Hz, 4H), 3.84 (m, 4H), 4.12 (d, $J = 11.5$ Hz, 4H), 4.36 [d, $J = 11.5$ Hz, 4H), 4.65 (s, 8H), 7.25–7.34 (m, 24H) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 34.2$,

37.7, 40.2, 43.0, 62.3, 127.7, 128.2, 128.4, 128.8, 170.4, 173.9 ppm; MS (FAB): $m/z = 1021$ $[M]^+$, 222 $[C_{11}H_{12}NO_2S]^+$, 106 $[NHC_7H_7]^+$.

4-(1,1,1-Ethyltrismethyl) Tris[((2S)-malo-1-yl)phenylalanine tert-butylester]
(**20**, $C_{56}H_{75}N_3O_{18}$)

A solution of **9b** (0.46 g, 0.5 mmol) in *THF* (50 cm^3) was stirred with *L*-phenylalanine *tert*-butylester (0.44 g, 2.0 mmol) at room temperature for 4 d. The progress of the reaction was monitored by ^{19}F NMR. For work-up see general procedure. Purification by column chromatography (eluent: ethyl acetate/hexanes). Yield: 0.44 g (85%) **20**; oil; IR (film): $\bar{\nu} = 3600$–3100, 2980, 1720, 1660, 1515 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 1.01$ (s, 3H), 1.39 (s, 27H), 2.55 (dd, $J = 16.5$, 8.5 Hz, 3H), 2.87 (dd, $J = 16.5$, 3.5 Hz, 3H), 3.07 (m, 6H), 4.01 (d, $J = 11.0$ Hz, 3H), 4.09 (d, $J = 11.0$ Hz, 3H), 4.47 (dd, $J = 8.5$, 3.5 Hz, 3H), 4.72 (m, 3H), 7.23 (m, 15H), 7.39 (d, $J = 8.5$ Hz, 3H, NH) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 17.2$, 27.9, 38.2, 38.6, 39.1, 53.4, 66.0, 68.6, 82.4, 127.0, 128.4, 129.5, 136.0, 170.4, 171.5, 172.0 ppm; MS (FAB in glycerol/thioglycerol): $m/z = 1078$ $[M]^+$, 120 $[C_5H_{12}O_3]^+$.

4-Pentaerythrityl Tetrakis[((2S)-malo-1-yl)-phenylalanine tert-butylester]
(**21**, $C_{73}H_{96}N_4O_{24}$)

A solution of **10b** (1.19 g, 1.0 mmol) in dry *THF* (50 cm^3) was stirred with *L*-phenylalanine *tert*-butyester (0.88 g, 4.0 mmol) at room temperature until ^{19}F NMR analysis showed complete consumption of compound **10b**. For work-up see general procedure. Recrystallization from $CHCl_3$/hexanes. Yield: 1.21 g (93%) **21**; mp 62°C; $[\alpha]_D = +24°\ cm^3\ g^{-1}\ dm^{-1}$ ($c = 1.0$, $CHCl_3$); IR (KBr): $\bar{\nu} = 3600$–3100, 2980, 1735, 1660, 1525 cm^{-1}; ^1H NMR ($CDCl_3$): $\delta = 1.38$ (s, 36H), 2.52 (dd, $J = 16.0$, 9.0 Hz, 4H), 2.85 (dd, $J = 16.0$, 3.0 Hz, 4H), 3.05 (dd, $J = 14.0$, 6.5 Hz, 4H), 3.09 (dd, $J = 14.0$, 6.0 Hz, 4H), 4.11 (d, $J = 11.5$ Hz, 4H), 4.22 (d, $J = 11.5$ Hz, 4H), 4.48 (dd, $J = 9.0$, 3.0 Hz, 4H), 4.72 (ddd, $J = 8.0$, 6.5, 6.0 Hz, 4H), 7.22 (m, 20H), 7.45 (d, $J = 8.0$ Hz, 4H, NH) ppm; ^{13}C NMR ($CDCl_3$): $\delta = 27.8$, 38.0, 39.1, 42.0, 53.2, 62.2, 68.4, 82.3, 126.9, 128.3, 129.4, 135.9, 170.2, 171.0, 172.0 ppm; MS (FAB in *NBA*): $m/z = 1436$ $[M + Na]^+$.

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