Toward the Synthesis of Modified Carbohydrates by Conjugate Addition of Propane-1,3-dithiol to α,β-Unsaturated Ketones

by **Stig Valdersnes**, **Ingrid Apeland**, **Guri Flemmen**, and **Leiv K. Sydnes***

Department of Chemistry, University of Bergen, Allégt. 41, NO-5007 Bergen

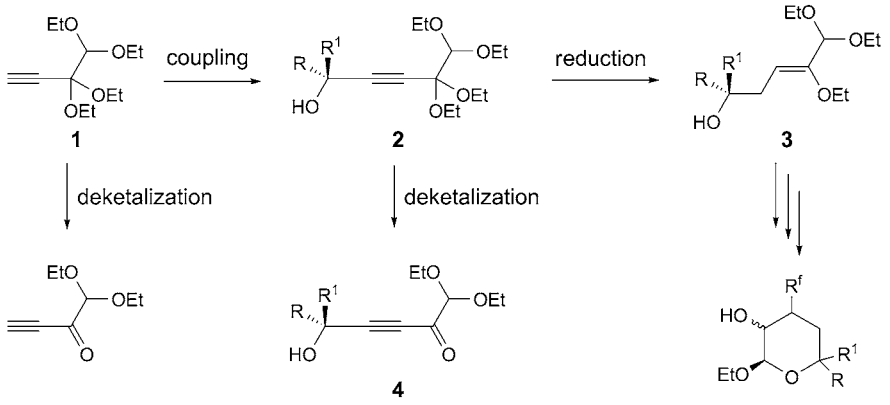
Dedicated to Prof. *Dieter Seebach* on the occasion of his 75th birthday

Selected 5-substituted derivatives **4** of 1,1-diethoxy-5-hydroxypent-3-yn-2-one were treated with propane-1,3-dithiol under various conditions. The unprotected hydroxy ketones underwent cyclization during the dithiol addition and gave the corresponding 3-(diethoxymethyl)-2-oxa-6,10-dithiaspiro[4.5]-decan-3-ols **5** in 80–90% yield as the only products (*Scheme 3* and *Table 1*). These products can be regarded as partly modified carbohydrates in the furanose form. When the benzyl-protected analogues **10-Bn** of the 1,1-diethoxy-5-hydroxypent-3-yn-2-one derivatives were treated with the same dithiol, however, no cyclization occurred; instead the corresponding 3-{2-[(benzyloxy)methyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one derivatives **11-Bn** were formed in good yield (up to 99%; *Table 4*). These 1,3-dithianes were and are in the process of being converted to a number of new carbohydrate analogues, and here are reported high-yield syntheses of functionalized molecules **17** belonging to the 5,5-diethoxy-1,4-dihydroxypentan-2-one family of compounds (*Table 7*), *via* **15-Bn** (*Table 5*) and **16-Bn** (*Table 6* and *Scheme 8*).

Introduction. – Some time ago, we published a simple and efficient synthesis of 3,3,4,4-tetraethoxybut-1-yne (**1**) [1] which is called TEB and has a significant chemical potential that has been exploited to synthesize a large variety of compounds [2–7]. The first step in several of these syntheses involves generation of the TEB-derived acetylide followed by aldehyde or ketone addition and hydrolysis, the result of which is chain elongation and formation of propargyl alcohols, *viz.* 4,4,5,5-tetraethoxypent-2-yn-1-ol derivatives **2** (*Scheme 1*). These alcohols show a range of chemical reactivities, and two transformations have been particularly useful in the application of **2** in syntheses, *viz.* conversion of **2** to the corresponding (*E*)-4,5,5-triethoxypent-3-en-1-ol derivatives **3** by treatment with $LiAlH_4$ [3][5], and specific removal of the ketal protection over the acetal protection to furnish 1,1-diethoxy-5-hydroxypent-3-yn-2-one derivatives **4**, generally in excellent yield (*Scheme 1*) [2][4]. From **3**, a number of 3-perfluoroalkylated carbohydrate analogues deoxygenated at C(3), C(4), and C(6) have been prepared [3][5], and when subjected to N-nucleophiles, **4** underwent *Michael* addition and appeared to be an excellent substrate for regiospecific synthesis of furan derivatives and other heterocyclic compounds [6][7].

The reason for the furan formation in the latter case was basically that the primary product from the first *Michael* addition was consumed by an intramolecular reaction before a second *Michael* addition could occur [6][7]. Therefore it was envisaged that if a better nucleophile was applied, a double *Michael* addition would take place and

Scheme 1

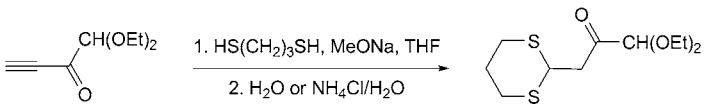


prevent cyclization from occurring. Studies by *Ley* and co-workers clearly indicated that propane-1,3-dithiol could be such a nucleophile [8], and indeed, when **4** was treated with this dithiol, thiolate addition occurred twice, and 1,3-dithiane formation took place (*vide infra*). This is definitely an interesting reaction if the aim is to synthesize modified carbohydrates, because when this bis-addition of thiolate to **4** takes place, the C(α)-atom is reduced, whereas the C(β)-atom is oxidized to a ketone equivalent. In a carbohydrate context, this dithiane formation has, therefore, resulted in deoxygenation at C(3) and ketone formation (oxidation) at C(4), and this latter transformation paves the way for subsequent selective alkylation at C(4).

Carbohydrates modified at both C(3) and C(4) are found as substructures in natural and pharmaceutical products, and the activity of such products can be synthetically modified by replacing the natural carbohydrate analogues with synthetic ones [9][10]. On this basis, a study of the conversion of **4** to modified carbohydrate was initiated, and some of the results obtained are reported here.

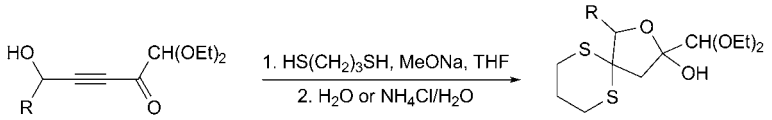
Results and Discussion. – 1. *Reactions with 1,1-Diethoxy-5-hydroxypent-3-yn-2-one Derivatives.* Before the investigation with **4** started, a series of exploratory experiments were performed with 1,1-diethoxybut-3-yn-2-one, the simple ketone derived in 96% by deketalization of TEB [1][2]. This compound turned out to react smoothly with propane-1,3-dithiol under a variety of conditions and gave in most cases the corresponding 1,3-dithiane, *i.e.*, 3-(1,3-dithian-2-yl)-1,1-diethoxypropan-2-one, in good to excellent yield (*Scheme 2*). The best outcome (91%) was achieved when moderate cooling ($-10°$) and fairly high dilution (*ca.* 0.05M in ketone) were applied.

Scheme 2



With the execution of this double conjugate addition under control, the reaction with the simplest hydroxy ketone, 1,1-diethoxy-5-hydroxypent-3-yn-2-one (**4a**), was carried out under the conditions that worked the best for 1,1-diethoxybut-3-yn-2-one. To prevent unintentional cyclization which is a potential risk, the reaction was quenched with H_2O so that the hydrolyzate and the extract remained basic, but this measure was apparently inadequate because the expected product, 1,1-diethoxy-3-[2-hydroxymethyl-1,3-dithian-2-yl]propan-2-one, was not isolated at all; instead 3-(diethoxymethyl)-2-oxa-6,10-dithiaspiro[4.5]decan-3-ol (**5a**) was obtained (*Scheme 3*, R = H). The product was isolated in 48% yield only, which is ascribed to extraction problems caused by emulsion formation during the workup. It was therefore decided to quench the reaction with aqueous NH_4Cl solution until the hydrolyzate was slightly acidic, and when the reaction was repeated and worked up in this way, **5a** was isolated pure in 85% yield (*Table 1*, *Entry 1*). Similar results were obtained with 1,1-diethoxy-5-hydroxyhex-3-yn-2-one (**4b**) and 1,1-diethoxy-5-hydroxyundec-3-yn-2-one (**4c**), but when 1,1-diethoxy-5-hydroxy-5-phenylpent-3-yn-2-one (**4d**) was treated under the same conditions, the product 3-(diethoxymethyl)-1-phenyl-2-oxa-6,10-dithiaspiro[4.5]-decan-3-ol (**5d**) was obtained in moderate yield only (*Table 1*, *Entry 4*). Why the introduction of a phenyl group results in such a low yield remains a puzzle. Except for **5a**, all the spiro compounds can be formed as mixtures of the *cis* and *trans* isomers, and this was indeed the case. The isomer composition was in all cases close to 1 : 1 as judged from ^{1}H-NMR spectra of the product mixtures, but the isomers could not be separated.

Scheme 3



4[a]) **5**[a])

[a]) For R, see *Table 1*.

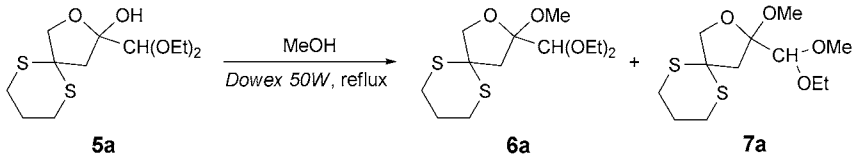
Table 1. *Conversion of α,β-Unsaturated γ-Hydroxy Ketones* **4** *to Spiro-Linked 1,3-Dithianes* **5**

Ketone	R	Product	Yield [%] after isolation
4a	H	**5a**	85
4b	Me	**5b**	87
4c	Hex	**5c**	84
4d	Ph	**5d**	44

Storage of **5** even at refrigerator temperature resulted in decomposition; it was therefore necessary to stabilize the compounds before further studies could be carried out. Such a stabilization is usually done by converting the compounds to the corresponding ketals by reaction with an alcohol in the presence of an acid. Many procedures are available for this purpose, and the first one explored, with **5a** as a model compound, was to reflux a dilute solution in dry MeOH in the presence of *Dowex 50W* [11]. Regrettably the reaction was very slow, and even after a reaction time of 20 h, only low yields of two products were obtained, *viz*. 3-(diethoxymethyl)-3-methoxy-2-

oxa-6,10-dithiaspiro[4.5]decane (**6a**) obtained in 41% yield and 3-[ethoxy(methoxy)-methyl]-3-methoxy-2-oxa-6,10-dithiaspiro[4.5]decane (**7a**) isolated in a 7% yield (*Scheme 4*). Replacing *Dowex* with *p*-toluenesulfonic acid (TsOH) was of no help, and addition of various dehydrating agents, such as $CuSO_4$ [12] and 4-Å molecular sieve, did not shift the equilibrium in the right direction either. Small improvements were observed when **5a** was refluxed in a mixture of trimethyl orthoformate, dry MeOH, and a catalytic amount of TsOH acid [13], but under these conditions, unfortunately, additional products were formed, and the method was therefore abandoned.

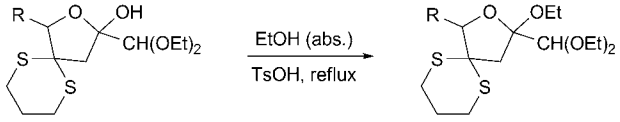
Scheme 4



5a **6a** **7a**

The results from the reactions in MeOH were not encouraging, and it was therefore decided to use dry EtOH instead. Explorative experiments with **5a** in EtOH containing a little TsOH revealed that the ketalization was much faster than in MeOH but very sensitive to the reaction temperature. Without warming, very little happened, but when the reaction was performed at close to 100°, product formation followed by decomposition of the primary product(s) took place and gave a black, intractable reaction mixture of a large number of compounds. However, when the reaction was run at 80°, no decomposition occurred and 3-(diethoxymethyl)-3-ethoxy-2-oxa-6,10-dithiaspiro[4.5]decane (**8a**) was isolated as the only product in 78% yield (*Table 2*, *Entry 1*). Hemiketals **5b**–**5d** were then treated under the best conditions developed for **5a**, and the corresponding ketals were formed and isolated in good yield (*Table 2*, *Entries 2–4*). It is also noteworthy that the isomer composition of the spiro ketones changed during the ketalization; whereas the hemiketals showed an approximate 1:1 isomer composition, the ratio was *ca.* 3:2 for the ketals based on NMR data. Such a change is not surprising considering the reaction mechanism for the ketalization which

Table 2. *Protection of the Hydroxy Group of Spiro Compounds* **5**



5 **8**

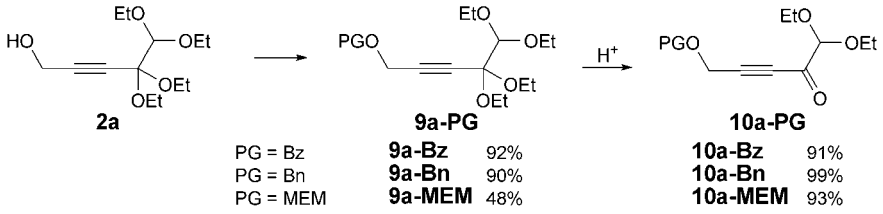
Entry	Substrate	R	Product	Yield [%] after isolation	
				> 95°	80°
1	**5a**	H	**8a**	45	78
2	**5b**	Me	**8b**	42	82
3	**5c**	Hex	**8c**	38	71
4	**5d**	Ph	**8d**	13	74

involves a cationic intermediate that can be attacked by EtOH from two sides which are sterically different. What is surprising, however, is that the (*E*)/(*Z*) ratio is rather insensitive to the steric crowding of R.

2. *Synthesis of OH-Protected 1,1-Diethoxy-5-hydroxypent-3-yn-2-one Derivatives.* Most carbohydrate analogues in nature are pyranose derivatives, which are, therefore, more attractive targets than the furanose derivatives obtained from **4**. To avoid generation of five-membered rings and facilitate six-membered ring formation, three additional steps had to be introduced. Firstly, the OH group of **4** has to be protected to prevent cyclization during the *Michael* reaction; secondly, after 1,3-dithiane formation, the keto function has to be converted to a moiety that is unable to react with the OH group which will be regenerated by deprotection in the third step to make cyclization at C(1) feasible.

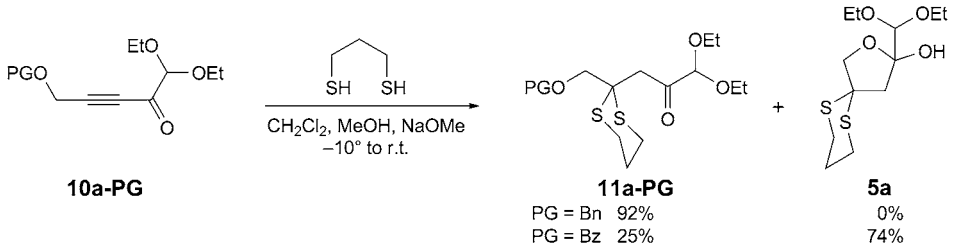
Many protecting groups (PGs) are available for alcohols [14], but after a literature survey, we decided to screen how effective the benzyl (Bn), benzoyl (Bz), and (2-methoxyethoxy)methyl (MEM = $MeOCH_2CH_2OCH_2$) groups were as protecting groups for our purpose. Screening experiments were carried out with 4,4,5,5-tetraethoxypent-2-yn-1-ol (**2a**) as the test compound, and as the results in *Scheme 5* show, the key findings are that its benzyl ether **9a-Bn** and benzoate **9a-Bz** were obtained in much higher yield than the corresponding MEM ether **9a-MEM**, whereas deprotection of the ketals gave all the corresponding ketones **10a-Bn**, **10a-Bz**, and **10a-MEM**, respectively, in excellent yield. Due to the moderate overall yield of **10a-MEM** from **2a** (45%), MEM protection was deemed unsuitable for our purpose, and the ability to prevent cyclization in the reaction with propane-1,3-dithiol was therefore tested for **10a-Bn** and **10a-Bz** only.

Scheme 5



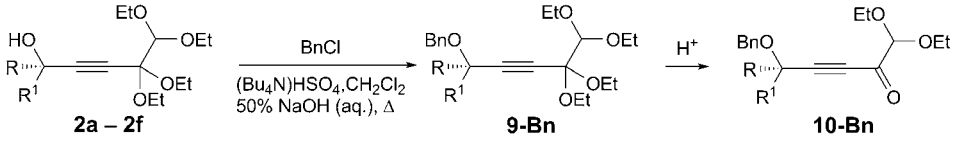
Ether **10a-Bn** and ester **10a-Bz** turned out to behave rather differently when treated with propane-1,3-dithiol. Whereas the former compound gave one product, *viz*. the desired compound 3-{2-[(benzyloxy)methyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one (**11a-Bn**) in excellent yield, the ester-protected analogue 5,5-diethoxy-4-oxopent-2-yn-1-yl benzoate (**10a-Bz**) afforded a 1:3 mixture of two products, the desired analogue to **11a-Bn**, *i.e.*, [2-(3,3-diethoxy-2-oxopropyl)-1,3-dithian-2-yl]methyl benzoate (**11a-Bz**), and 3-(diethoxymethyl)-2-oxa-6,10-dithiaspiro[4.5]decan-3-ol (**5a**) (*Scheme 6*). The major product was identical to the furan derivative obtained from **4a**, which is the unprotected analogue of **11a-Bn**, and this means that the benzoate protection is useless under the conditions prevailing during the reaction with propane-1,3-dithiol. That is not really surprising; esters undergo after all transesterification when exposed to alcohols under the right conditions.

Scheme 6



With benzoate protection obviously out of the question, Bn protection of the propargyl alcohol moiety appeared to be the best alternative of those investigated. Thus, the 4,4,5,5-tetraethoxypent-2-yn-1-ol derivatives **2b**–**2f** were treated as outlined in *Scheme 5* for **2a** to obtain **10-Bn**, the benzylated α,β-unsaturated acetylenic hydroxy ketones required to make pyran derivatives. The results (*Table 3*) show that all the syntheses, except for one (*Entry 4*), were successful and gave the corresponding ketones **10-Bn** *via* **9-Bn** in excellent overall yield.

Table 3. *Conversion of Propargyl Alcohol* **2** *to γ-(Benzyloxy)-Substituted α,β-Unsaturated Acetylenic Ketones* **10-Bn**



Entry	**2**	R	R^1	Yield [%] of **9-Bn**[a])	Yield [%] of **10-Bn**[a])
1	**a**	H	H	72	99
2	**b**	H	Me	96	82
3	**c**	H	Hex	88	99
4	**d**	H	Ph	0	–
5	**e**	Me	Me	85	94
6	**f**	$-(CH_2)_5-$		75	86

[a]) After isolation.

The compound deviating from the general trend was 4,4,5,5-tetraethoxy-1-phenylpent-2-yn-1-ol (**2d**) which was completely consumed but gave a very complex product mixture, from which no compound could be isolated pure by chromatography. Thorough spectroscopic and spectrometric analyses of some fractions collected after repeated fractionations indicated that two of the products obtained were 4,5,5-triethoxy-1-phenylpenta-2,3-dien-1-one (**12**) and 1-(benzyloxy)-4,5,5-triethoxy-1-phenylpenta-1,2,3-triene (**13**) (see *Scheme 7* for **12** and **13**). A ^{13}C-NMR spectrum of one such fraction is shown in *Fig. 1* and exhibits two peaks at δ(C) 197 and 191 which correlate well with a central allene C-atom and the C=O C-atom of a conjugated ketone moiety. DEPT-135 ^{13}C-NMR Spectra of this mixture indicated that the two C-atoms were quaternary. Furthermore, a number of signals between δ(C) 150 and 100, in addition to those expected for the phenyl groups, are compatible with the cumulene

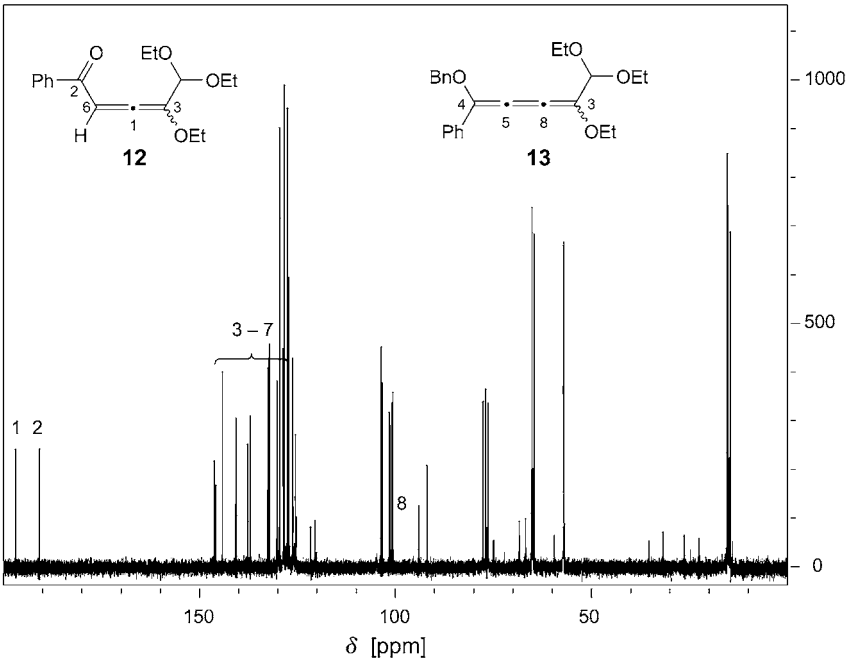


Fig. 1. *^{13}C-NMR Spectrum of an impure fraction of two of the products obtained from benzylation of* **2d**. Arbitrary atom numbering.

structures of **12** and **13**. It is also noteworthy that some of the peaks in the δ(C) 150–135 region appear as pairs which might indicate that penta-1,2,3-triene derivative **13** was formed as a mixture of isomers. The IR spectra of the same fractions were also compatible with the proposed structures, as indicated by the spectrum shown in *Fig. 2*; the allene moiety is supported by a peak at 1959 cm^{-1}, the absorption at 1674 cm^{-1} is indicative of an α,β-unsaturated C=O group, signals from the phenyl groups appear in the expected regions (>3000, <2000, and <1000 cm^{-1}), and the strong, broad absorption stretching from *ca.* 1000 to 1300 cm^{-1} is indicative of ether C–O bonds, of which there are quite a few in each compound.

The conversion of **2d** to cumulenes **12** and **13** can be rationalized by invoking the formation of the corresponding alkoxide which can form the corresponding benzyl ether **9d-Bn** (*Route a*) or undergo rearrangement by hydride migration to benzylic carbanion **14** (*Route b*; *Scheme 7*). The former reaction is supported by the successful synthesis of a number of other benzyl ethers from **2** (see below *Table 4*), whereas the latter is substantiated by a number of similar transformations well documented in the literature [15]. Subsequent 1,4-elimination of EtOH or ethoxide, a base-promoted reaction with significant literature precedence [16], then gives **13** from **9d-Bn** and **12** from carbanion intermediate **14**. Why only **2d** and not the other 5-hydroxypent-3-yn-2-one derivatives behave like this is not clear, but it is well established that the phenyl group is capable of stabilizing a carbanion in α-position to the ring.

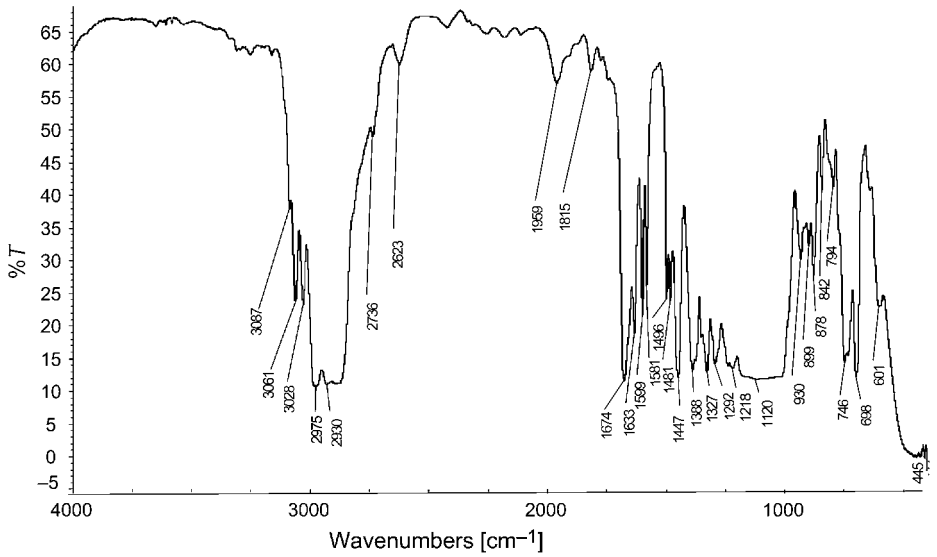
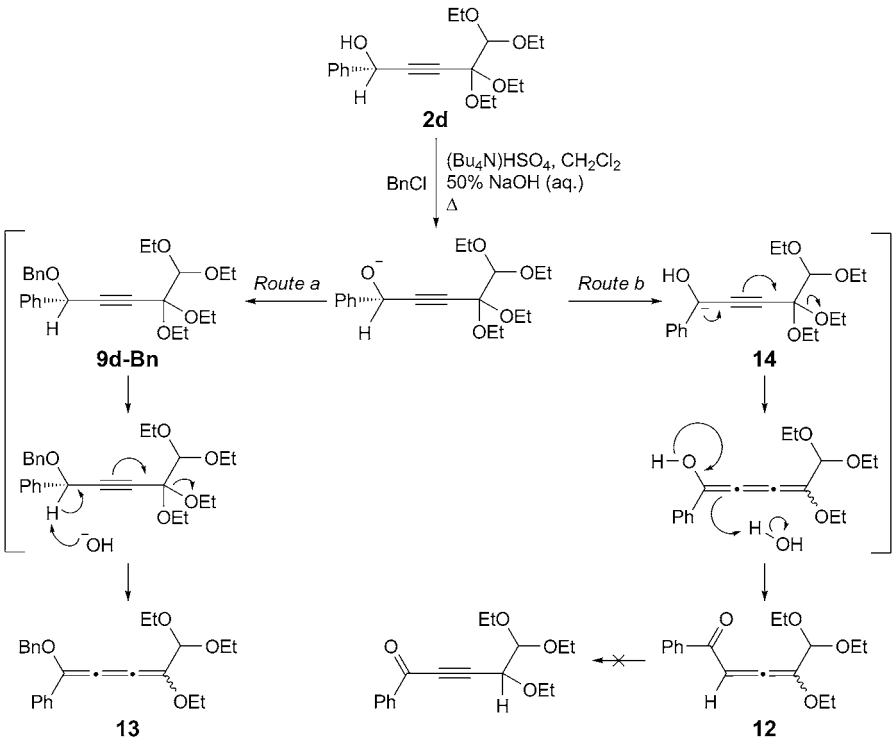


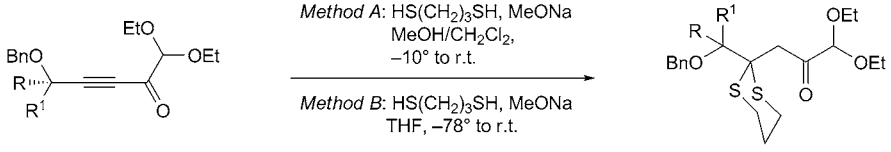
Fig. 2. *IR Spectrum of an impure fraction of two of the products obtained from benzylation of* **2d**

Scheme 7



3. *Reactions of 5-(Benzyloxy)-1,1-diethoxypent-3-yn-2-one Derivatives with Propane-1,3-dithiol and Subsequent Transformations.* With the adequately protected γ-hydroxy-substituted α,β-unsaturated acetylenic ketones **10-Bn** at hand, *Michael* addition of propane-1,3-dithiol could be carried out. The conditions that gave the best results in the reactions with 1,1-diethoxybut-3-yn-2-one were applied (*cf. Scheme 2*), and consistently the corresponding 1,3-dithiane **11-Bn** was formed in good to excellent yield (*Table 4*). When *Method A* ($MeOH/CH_2Cl_2$, MeONa, $-10°$ to r.t.) was applied, small amounts of some vinyl sulfide(s) (*ca.* 5% yield at the most) were also formed as judged from the presence of olefinic H-atom signals in the region δ(C) 5.8–6.7 in the ^{1}H-NMR spectrum of the crude product, but this by-product formation was avoided by using *Method B* (THF, MeONa, $-78°$ to r.t.).

Table 4. *Formation of 1,3-Dithiane Derivatives* **11-Bn** *by Double* Michael *Addition of Propane-1,3-dithiol to Conjugated Acetylenic Ketones* **10-Bn**



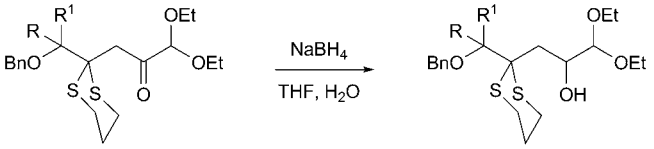
10-Bn **11-Bn**

	R	R^1	Product	Yield [%] after isolation *Method A*	*Method B*
10a-Bn	H	H	**11a-Bn**	92	99
10b-Bn	H	Me	**11b-Bn**	92	99
10c-Bn	H	Hex	**11c-Bn**	–	71
10e-Bn	Me	Me	**11e-Bn**	84	–
10f-Bn	$-(CH_2)_5-$		**11f-Bn**	85	93

Ketones **11-Bn** constitute a versatile platform for the synthesis of a large variety of modified carbohydrates. Compared to ordinary carbohydrates, these ketones are modified by deoxygenation at C(3) and, with the exception of **11a-Bn**, at C(6), by aldehyde protection at C(1), by oxidation at C(2), by oxidation and protection at C(4), and by alcohol protection at C(5), and all these functionalities make it possible to modify **11-Bn** further before the alcohol protection is removed and cyclization to pyranose analogues is carried out. We are studying a number of approaches to reach this goal and here one such strategy is reported.

To avoid formation of furan derivatives during or after removal of the benzyl protection, the C=O group has to be chemically modified and to ensure that the reaction is regiospecific, the modification has to be carried out before dethioketalization is performed. Several transformations are under investigation, and a variety of derivatives have been prepared, but so far, reduction to the corresponding alcohols **15-Bn** with $NaBH_4$ in wet THF has been most successful. All the ketones were essentially reduced quantitatively under these conditions (*Table 5*), and as expected, the two chiral ketones 3-{2-[1-(benzyloxy)ethyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one (**11b-Bn**) and 3-{2-[1-(benzyloxy)heptyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one

Table 5. *$NaBH_4$ Reduction of (1,3-Dithian-2-yl)methyl Ketones* **11-Bn** *to the Corresponding Alcohols* **15-Bn**



11-Bn **15-Bn**

	R	R^1	Product	Yield [%] after isolation
11a-Bn	H	H	**15a-Bn**	99
11b-Bn	H	Me	**15b-Bn**	99[a])
11c-Bn	H	Hex	**15c-Bn**	99[a])
11e-Bn	Me	Me	**15e-Bn**	96
11f-Bn	$-(CH_2)_5-$		**15f-Bn**	95

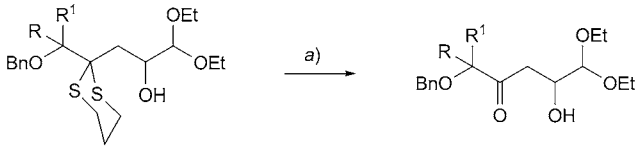
[a]) Essentially pure crude product.

(**11c-Bn**) were formed as mixtures of diastereoisomers. The diastereoisomer ratio was *ca.* 1:1, and the isomers were easily separated by flash chromatography.

Cyclization and formation of modified pyranoses require removal of the benzyl protection, and we wanted to do that with the 1,3-dithiane moiety intact. However, when hydrogenolysis of 3-{2-[(benzyloxy)methyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-ol (**15a-Bn**) was attempted in the presence of Pd/C as catalyst under atmospheric pressure of H_2, no reaction took place, even with prolonged reaction time and increased catalyst loading. This was probably due to the presence of sulfur [17], and it was therefore decided to convert the thioketal group into a C=O group before the Bn group was removed. A large number of methods are available for the conversion of the 1,3-dithiane moiety to the corresponding ketones. The reaction has traditionally been carried out with heavy-metal reagents [14], but since they appear quite unattractive due to their health and environmental hazards, we tried four other methods that have been developed in recent years, using **15a-Bn** as model compound (*Scheme 8*; $R^1 = R^2 = H$).

The four methods appeared to give rather different results. *Method 1* furnished no ketone at all, and the crude product consisted mainly of unreacted starting material. *Method 2* was more successful, but in spite of extensive heating, a large excess of MeI (150 times), and a long reaction time, the corresponding ketone, 1-(benzyloxy)-5,5-diethoxy-4-hydroxypentan-2-one (**16a-Bn**) was obtained in 28% yield only (*Table 6*, *Entry 1*). However, *Method 3*, a simple modification of *Method 2*, gave a much better result: when the reaction was performed at r.t. with less MeI (40 times excess) **16a-Bn** was isolated in 84% yield. An acceptable result, 54% yield (*Table 6*, *Entry 3*), was also obtained with the *Method 4* which is a redox process based on iodine under basic conditions, but when 1,3-dithianes more substituted and congested than **15a-Bn** were subjected to the conditions of *Method 4*, the yield increased significantly and reached 91% in the best cases (*Table 6*, *Entries 8* and *9*).

Scheme 8. *Methods Tried to Perform Dethioketalization.* For R and R^1, see *Table 6*.



15-Bn **16-Bn**

a) Dithiane hydrolysis: *Method 1*) $NaNO_2$, AcCl, CH_2Cl_2 [18]. *Method 2*) MeI (enormous excess), $CaCO_3$, MeCN, THF, H_2O [19]. *Method 3*) MeI, $CaCO_3$, MeCN, H_2O [20]. *Method 4*) I_2, $NaHCO_3$ (aq.), MeCN [8].

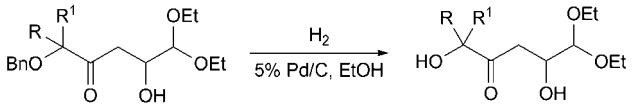
Table 6. *Preparation of Ketones* **16-Bn** *by Dethioketalization of* **15-Bn** (see *Scheme 8*)

Entry	Substrate	R	R^1	*Method*	Product	Yield [%] after isolation
1	**15a-Bn**	H	H	*2*	**16a-Bn**	28
2	**15a-Bn**	H	H	*3*	**16a-Bn**	84
3	**15a-Bn**	H	H	*4*	**16a-Bn**	54
4	**15b-Bn-I**[a])	H	Me	*4*	**16b-Bn-I**[a])	39
5	**15b-Bn-II**[a])	H	Me	*4*	**16b-Bn-II**[a])	59
6	**15c-Bn-I**[a])	H	Hex	*4*	**16c-Bn-I**[a])	83
7	**15c-Bn-II**[a])	H	Hex	*4*	**16c-Bn-II**[a])	75
8	**15e-Bn**	Me	Me	*4*	**16e-Bn**	91
9	**15f-Bn**	$-(CH_2)_5-$		*4*	**16f-Bn**	91

[a]) **I** and **II** denote diastereoisomers of **15-Bn** and **16-Bn**.

After dethioketalization of **15-Bn**, removal of the Bn protection from **16-Bn** should be straightforward, and this turned indeed out to be the case. When subjected to catalytic hydrogenation in EtOH with 5% Pd/C as catalyst, the corresponding 1,4-dihydroxypentan-2-ones **17** were obtained in essentially quantitative yield (*Table 7*).

Table 7. *Conversion of Benzyloxy Ketones* **16-Bn** *to Hydroxy Ketones* **17**



16-Bn **17**

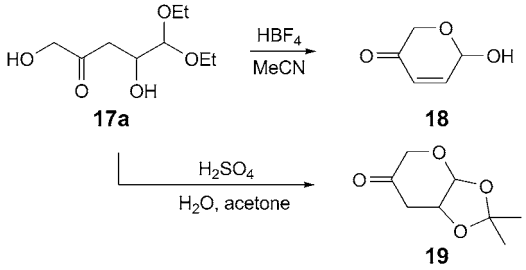
	R	R^1	Product	Yield [%] after isolation
16a-Bn	H	H	**17a**	99
16b-Bn-I[a])	H	Me	**17b-I**[a])	91
16b-Bn-II[a])	H	Me	**17b-II**[a])	89
16c-Bn-I[a])	H	Hex	**17c-I**[a])	99
16c-Bn-II[a])	H	Hex	**17c-II**[a])	95
16e-Bn	Me	Me	**17e**	99
16f-Bn	$-(CH_2)_5-$		**17f**	99

[a]) **I** and **II** denote diastereoisomers of **16-Bn** and **17**.

The reactions were in fact so clean that the crude products could be used in subsequent reactions without purification.

With the successful debenzylation of **16-Bn**, we have given access to a number of modified carbohydrates with the general structure **17**. To be applicable as modifiers of biologically active compounds, cyclization of **17** to pyranose derivatives has to be achieved, and this transformation is currently under investigation. So far, explorative experiments revealed that the ultimate outcome in a given case depends on the substrate structure as well as the reaction conditions. The importance of the reaction conditions is illustrated by two reactions with 5,5-diethoxy-1,4-dihydroxypentan-2-one (**17a**). When treated with HBF_4 in acetonitrile, cyclization and dehydration took place and gave 6-hydroxy-2*H*-pyran-3(6*H*)-one (**18**) as the only product in 90% yield, but when exposed to wet acetone at 0°, with concentrated sulfuric acid as catalyst, dehydration was avoided, and dihydro-2,2-dimethyl-5*H*-1,3-dioxolo[4,5-*b*]pyran-6(3a*H*)-one (**19**) was obtained in 60% yield (*Scheme 9*). Results of studies under way will be published in due course.

Scheme 9



Financial support from the *Research Council of Norway,* the University of Bergen, and the *Munin Foundation* is gratefully acknowledged. Thanks are also due to Dr. *Bjarte Holmelid* for recording mass spectra.

Experimental Part

1. *General.* See [5]. FC = Flash chromatography. DART-MS = Direct analysis in real time mass spectrometry.

2. *Starting Materials.* The 3,3,4,4-tetraethoxybut-1-yne (TEB; **1**) was synthesized from ethyl vinyl ether in a four-step synthesis in 50% total yield following published procedures [1]. Treatment of TEB with *Dowex 50W* in moist acetone gave 1,1-diethoxybut-3-yn-2-one which showed spectroscopic data in accordance with [1].

3. *3-(1,3-Dithian-2-yl)-1,1-diethoxypropan-2-one.* A mixture of 1,1-diethoxybut-3-yn-2-one (11.83 g, 75.8 mmol), CH_2Cl_2 (1.20 l), MeOH (300 ml), MeONa (54 g, 100 mmol), and propane-1,3-dithiol (9.5 g, 88 mmol) was stirred in an dry ice/acetone bath (−10°) under N_2. After 16.5 h, the mixture was concentrated, and most of the solvent was evaporated. The resulting slush was diluted with H_2O and extracted with CH_2Cl_2 and the combined extract dried ($MgSO_4$) and concentrated to give 20.31 g of an orange liquid, from which 18.1 g (91%) of the title compound was isolated as a yellow liquid by FC (hexanes/AcOEt 95 : 5). IR (film): 2973*s*, 2943*s*, 2904*s*, 1732*s*, 1420*m*, 1327*m*, 1278*m*, 1156*m*, 1068*s*, 949*w*, 910*w*, 871*w*, 810*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.57 (*s*, 1 H); 4.51 (*t*, *J* = 7.0, 1 H); 3.78–2.49 (*m*, 4 H); 3.05 (*d*, *J* = 7.0, 2 H); 2.93–2.79 (*m*, 4 H); 2.16–1.80 (*m*, 2 H); 1.25 (*t*, *J* = 7.1, 6 H). ^{13}C-NMR (50 MHz,

$CDCl_3$): 201.2 (C); 102.2 (CH); 63.2 (2 CH_2); 42.0 (CH_2); 40.1 (CH); 29.5 (2 CH_2); 25.1 (CH_2); 14.9 (2 Me). EI-MS: 264 (9, M^+), 219 (14), 189 (11), 119 (17), 103 (63), 84 (13), 75 (55), 59 (27), 49 (7). HR-MS: 264.085320 (M^+, $C_{11}H_{20}O_3S_2^+$; calc. 264.085388).

4. *Reaction of* **4** *with Propane-1,3-dithiol. 3-(Diethoxymethyl)-2-oxa-6,10-dithiaspiro[4.5]decan-3-ol* (**5a**). Propane-1,3-dithiol (0.90 ml, 8.9 mmol) and MeONa (0.48 g, 8.9 mmol) were dissolved in dry THF (200 ml) under N_2. The mixture was cooled to $-78°$, and 1,1-diethoxy-5-hydroxypent-3-yn-2-one (**4a**; 1.50 g, 8.1 mmol) was dissolved in dry THF (50 ml) and added dropwise during 30 min. The mixture was stirred overnight and allowed to reach r.t. The reaction was quenched with sat. aq. NH_4Cl soln. (150 ml), the mixture extracted with CH_2Cl_2 (3×150 ml), the combined org. extract dried ($MgSO_4$) and concentrated and the product isolated by FC (hexanes/AcOEt 3:2): **5a** (2.02 g, 85%). Yellow liquid. IR (film): 3466*s*, 2977*s*, 2931*s*, 2987*s*, 1778*w*, 1423*m*, 1366*m*, 1324*m*, 1278*m*, 1114*s*, 1071*s*, 967*m*, 912*m*, 839*w*, 808*w*, 736*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.45 (*s*, 1 H); 4.35 (*d*, $J = 9.1$, 1 H); 4.21 (*d*, $J = 9.1$, 1 H); 3.93–3.46 (*m*, 5 H); 3.05–2.72 (*m*, 4 H); 2.59 (*d*, $J = 14.5$, 1 H); 2.39 (*d*, $J = 14.5$, 1 H); 2.16–1.90 (*m*, 2 H); 1.25 (*m*, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 106.5 (C); 103.8 (CH); 79.0 (CH_2); 65.2 (CH_2); 64.4 (CH_2); 52.6 (C); 48.6 (CH_2); 28.8 (CH_2); 28.7 (CH_2); 25.1 (CH_2); 15.4 (Me). DART-MS: 312 (40, $[M + H_2O]^+$), 294 (35, M^+), 277 (95, $[M - OH]^+$), 231 (100), 203 (40), 189 (15). HR-MS: 277.0937 ($[M - OH]^+$, $C_{12}H_{21}O_3S_2^+$; calc. 277.0932).

3-(Diethoxymethyl)-1-methyl-2-oxa-6,10-dithiaspiro[4.5]decan-3-ol (**5b**). As described for **5a**, with propane-1,3-dithiol (1.15 ml, 11 mmol), MeONa (0.61 g, 11 mmol), and 1,1-diethoxy-5-hydroxyhex-3-yn-2-one (**4b**; 2.02 g, 10 mmol). The product was isolated by FC (hexanes/AcOEt 7:3): **5b** (2.70 g, 87%). Yellow liquid. IR (film): 3479*s*, 2983*s*, 2939*s*, 1766*w*, 1449*m*, 1433*m*, 1373*m*, 1328*m*, 1113*s*, 1069*s*, 917*m*, 824*w*, 797*w*, 724*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.50, 4.38 (2*s*, ratio 5:4, 1 H); 4.39, 4.03 (2*q* ratio 5:4, $J =$ 6.4 and 6.5, resp., 1 H); 4.11 (*s*, 0.5 H); 3.86–3.54 (*m*, 4.5 H); 3.12–2.76 (*m*, 5.5 H); 2.59 (*d*, *B* part of *AB* system, $J = 14.3$, 0.5 H); 2.18–2.09, 2.00–1.84 (2*m*, ratio 4:5, 2 H); 1.45, 1.40 (2*d*, ratio 4:5, $J = 6.5$ and 6.4, resp., 3 H); 1.32–1.18 (*m*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 105.4, 104.9 (2 C); 104.4, 103.8 (2 CH); 83.9, 83.2 (2 CH); 65.6, 65.4 (2 CH_2); 64.8, 64.1 (2 CH_2); 57.2, 57.1 (2 C); 49.9, 47.9 (2 CH_2); 28.6, 28.6 (2 CH_2); 27.4, 27.0 (2 CH_2); 25.8, 25.7 (2 CH_2); 16.5, 16.3 (2 Me); 15.6, 15.5 (2 Me); 15.4, 15.3 (2 Me). DART-MS: 308 (5, M^+), 291 (70, $[M - OH]^+$), 245 (100), 217 (10), 113 (15). HR-MS: 291.1093 ($[M - OH]^+$, $C_{13}H_{23}O_3S_2^+$; calc. 291.1087).

3-(Diethoxymethyl)-1-hexyl-2-oxa-6,10-dithiaspiro[4.5]decan-3-ol (**5c**). As described for **5a**, with propane-1,3-dithiol (0.55 ml, 5.5 mmol), MeONa (0.32 g, 5.9 mmol), and 1,1-diethoxy-5-hydroxyundec-3-yn-2-one (**4c**; 1.02 g, 3.7 mmol). The product was isolated by FC (hexane/AcOEt 8:2): **5c** (1.20 g, 84%). Yellow liquid. IR (film): 3483*s*, 2923*s*, 2985*s*, 1736*w*, 1445*m*, 1429*m*, 1370*m*, 1332*m*, 1285*m*, 1217*m*, 1069*s*, 913*m*, 812*w*, 721*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.49, 4.37 (2*s*, ratio 1:1, 1 H); 4.20–4.05 (*m*, 0.5 H); 4.14 (*s*, 0.5 H); 3.86 (*m*, 5 H); 3.21–2.73 (*m*, 5.5 H); 2.63 (*d*, *B* part of *AB* system, $J = 14.3$, 0.5 H); 2.25–2.09, 2.00–1.83 (2*m*, ratio 1:1, 2 H); 1.84–1.64 (*m*, 2 H); 1.60–1.51 (*m*, 1 H); 1.47–1.16 (*m*, 13 H); 0.88 (*t*, $J = 6.8$, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 105.4, 104.9 (2 C); 104.4, 104.0 (2 CH); 87.9, 87.0 (2 CH), 65.9, 65.8 (2 CH_2); 64.6, 63.9 (2 CH_2); 57.4, 57.0 (2 C); 50.1, 47.8 (2 CH_2); 31.9 (CH_2); 31.2, 30.9 (2 CH_2); 29.3, 29.3 (2 CH_2); 28.8, 28.6 (2 CH_2); 27.4, 27.1 (2 CH_2); 27.0 (CH_2); 26.0 (CH_2); 22.8 (CH_2); 15.6 (Me); 15.4, 15.3 (2 Me); 14.2 (Me). DART-MS: 378 (10, M^+), 361 (30, $[M - OH]^+$), 315 (100), 275 (10), 183 (5). HR-MS: 361.1845 ($[M - OH]^+$, $C_{18}H_{33}O_3S_2^+$; 361.1871).

3-(Diethoxymethyl)-1-phenyl-2-oxa-6,10-dithiaspiro[4.5]decan-3-ol (**5d**). As described for **5a**, with propane-1,3-dithiol (0.55 ml, 5.5 mmol), MeONa (0.30 g, 5.7 mmol), and 1,1-diethoxy-5-hydroxy-5-phenylpent-3-yn-2-one (**4d**; 0.95 g, 3.6 mmol). The crude product was purified by FC (hexanes/AcOEt 4:1): benzyl alcohol and **5d** in a ratio of *ca.* 1:1 (0.59 g, 44%). Yellow liquid. IR (film): 3459*s*, 3068*m*, 3030*m*, 1603*w*, 1499*m*, 1461*m*, 1419*m*, 1366*m*, 1325*m*, 1281*m*, 1209*m*, 1117*s*, 1069*s*, 945*m*, 921*m*, 877*m*, 805*w*, 756*s*, 700*s*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.65–7.47 (*m*, 2 H); 7.45–7.28 (*m*, 8 H); 5.36, 5.00 (2*s*, ratio *ca.* 1:1, 1 H); 4.69 (*s*, 2.5 H); 4.49 (*s*, 0.5 H); 4.35 (*s*, 0.5 H); 3.97–3.51 (*m*, 5.5 H); 3.07 (*d*, *A* part of *AB* system, $J = 14.6$, 0.5 H); 3.04–2.95 (*m*, 1 H); 2.91–2.77 (*m*, 2 H); 2.72 (*d*, *B* part of *AB* system, $J =$ 14.6, 0.5 H); 2.60–2.43 (*m*, 1 H); 2.16–2.11 (*m*, 0.5 H); 2.06–1.96 (*m*, 0.5 H); 1.95–1.84 (*m*, 0.5 H); 1.81–1.64 (*m*, 1.5 H); 1.34–1.19 (*m*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 136.4 (C); 136.3 (C); 128.8 (CH); 128.8 (CH); 128.1 (CH); 128.0 (CH); 127.9 (CH); 127.8 (CH); 127.4 (CH); 127.2 (CH); 105.8, 104.5 (2 C); 104.3, 104.2 (2 CH); 90.0, 89.1 (2 CH); 66.1, 65.9 (2 CH_2); 65.6, 65.0, 64.1 (3 CH_2); 57.5, 56.9

(2 C); 51.2, 48.0 (2 CH_2); 28.7, 28.5 (2 CH_2); 27.5, 27.2 (2 CH_2); 25.2, 24.9 (2 CH_2); 15.7 (CH_2); 15.5 (CH_2); 15.4 (CH_2). DART-MS: 370 (10, M^+), 353 (20, $[M-OH]^+$), 307 (100), 263 (10), 175 (10), 103 (5). HR-MS: 353.1211 ($[M-OH]^+$, $C_{18}H_{25}O_3S_2^+$; calc. 353.1245).

5. *Experiments Aiming at Stabilizing Hemiketal* **5**. 5.1. *3-(Diethoxymethyl)-2-oxa-6,10-dithiaspiro-[4.5]decan-3-ol* (**5a**) *in MeOH Containing Dowex 50W*. Dry MeOH (100 ml), **5a** (0.70 g, 2.4 mmol), and a spatula of *Dowex 50W-X8* (H) were mixed in a dry reaction flask under N_2. The mixture was heated to reflux and stirred for 22 h. After cooling to r.t., the *Dowex* was removed by filtration. H_2O (50 ml) was added, and 2/3 of the MeOH was evaporated. CH_2Cl_2 (3 × 75 ml) was used for extraction, the combined org. phase dried ($MgSO_4$) and concentrated, and the residue subjected to FC (hexanes/AcOEt 3:2): *3-(diethoxymethyl)-3-methoxy-2-oxa-6,10-dithiaspiro[4.5]decane* (**6a**; 0.30 g, 41%) and *3-[ethoxy(methoxy)methyl]-3-methoxy-2-oxa-6,10-dithiaspiro[4.5]decane* (**7a**; 0.047 g, 7%). Yellowish liquids. *Data of* **6a**: IR (film): 2973*s*, 2939*s*, 2904s, 1427*m*, 1366*m*, 1324*m*, 1274*m*, 1118*s*, 1072*s*, 954*m*, 912*m*, 873*m*, 801*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.55 (*s*, 1 H); 4.32 (*d*, *J* = 9.0, 1 H); 4.26 (*d*, *J* = 9.0, 1 H); 3.88–3.54 (*m*, 4 H); 3.37 (*s*, 3 H); 3.08–2.77 (*m*, 4 H); 2.69 (*d*, *J* = 14.5, 1 H); 2.25 (*d*, *J* = 14.5, 1 H); 2.17–1.88 (*m*, 2 H); 1.25 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 109.7 (C); 101.7 (CH); 80.0 (CH_2); 65.5 (CH_2); 63.9 (CH_2); 52.5 (C); 50.0 (CH_2); 47.6 (CH_2); 29.2 (CH_2); 29.1 (CH_2); 25.1 (CH_2); 15.5 (Me); 15.4 (Me). DART-MS: 277 ($[75\ M-MeO]^+$), 231 (100), 145 (5). HR-MS: 277.0945 ($C_{12}H_{21}O_3S_2^+$, $[M-MeO]^+$; calc. 277.0932).

Data of **7a**: IR (film): 2977*s*, 2931*s*, 2898*s*, 2828*s*, 1736*w*, 1423*m*, 1370*m*, 1320*m*, 1274*m*, 1110*s*, 1080*s*, 969*m*, 945*m*, 801*m*, 725*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.47 (*s*, 1 H); 4.33–4.23 (*m*, 2 H); 3.77–3.71 (*m*, 2 H); 3.50 (*s*, 1 H); 3.47 (*s*, 2 H); 3.37 (*s*, 2 H); 2.93–2.81 (*m*, 4 H); 2.67–2.63 (*m*, 1 H); 2.27–2.21 (*m*, 1 H); 2.12–1.89 (*m*, 2 H); 1.26 (*m*, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 109.7, 109.6 (2 C); 103.2, 103.0 (2 CH); 80.1, 79.93 (2 CH_2); 66.0, 64.4 (2 CH_2); 57.3, 55.9 (2 Me); 52.5, 52.4 (2 C); 50.0 (Me); 47.9, 47.4 (2 CH_2); 29.24, 29.16 (2 CH_2); 29.1 (CH_2); 25.07, 25.05 (2 CH_2); 15.49, 15.43 (2 Me).

5.2. *Ketal* **8** *from Hemiketal* **5** *in* EtOH *Containing TsOH*. *3-(Diethoxymethyl)-3-ethoxy-2-oxa-6,10-dithiaspiro[4.5]decane* (**8a**). Abs. EtOH (60 ml), **5a** (0.37 g, 1.3 mmol), and TsOH (0.048 g, 0.25 mmol, 20 mol-%) were mixed and heated to 80°. The mixture was left overnight (12 h). After cooling to r.t., H_2O (60 ml) was added. CH_2Cl_2 was used for extraction, the combined org. phase dried ($MgSO_4$) and concentrated, and the residue subjected to FC (hexanes/AcOEt 4:1): **8a** (0.32 g, 78%). Yellow liquid. IR (film): 2983*s*, 2935*s*, 2903*s*, 1433*m*, 1370*m*, 1316*m*, 1286*m*, 1232*m*, 1121*s*, 1077*s*, 965*m*, 904*m*, 866*w*, 816*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.52 (*s*, 1 H); 4.31 (*d*, *J* = 8.9, 1 H); 4.25 (*d*, *J* = 8.9, 1 H); 3.87–3.51 (*m*, 6 H); 3.03–2.76 (*m*, 4 H); 2.69 (*d*, *J* = 14.5, 1 H); 2.24 (*d*, *J* = 14.5, 1 H); 2.15–1.83 (*m*, 2 H); 1.24 (*td*, *J* = 2.1, 7.0, 6 H); 1.18 (*t*, *J* = 7.1, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 109.7 (C); 102.2 (CH); 79.8 (CH_2); 65.4 (CH_2); 64.0 (CH_2); 57.9 (C); 52.7 (CH_2); 48.0 (CH_2); 29.3 (CH_2); 29.2 (CH_2); 25.2 (CH_2); 16.0 (Me); 15.5 (Me); 15.4 (Me). DART-MS: 277 (95, $[M-EtO]^+$), 231 (100). HR-MS: 277.0952 ($[M-EtO]^+$, $C_{12}H_{21}O_3S_2^+$; calc. 277.0932).

3-(Diethoxymethyl)-3-ethoxy-1-methyl-2-oxa-6,10-dithiaspiro[4.5]decane (**8b**). As described for **8a**, with abs. EtOH (70 ml), **5b** (1.29 g, 4.2 mmol), and TsOH (0.160 g, 0.84 mmol, 20 mol-%). FC (hexanes/AcOEt 4:1) gave **8b** (0.84 g, 42%). Yellow liquid. IR (film): 2975*s*, 2935*s*, 2899*s*, 1425*m*, 1377*m*, 1305*m*, 1274*m*, 1213*m*, 1125*s*, 1069*s*, 909*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.52, 4.43 (2*s*, ratio 3:2, 1 H); 4.27 (*q*, *J* = 6.4, 1 H); 3.75–3.58 (*m*, 6 H); 3.07 (*d*, *A* part of *AB* system, *J* = 14.1, 1 H); 3.03–2.79 (*m*, 5 H); 2.66 (*d*, *B* part of *AB* system, *J* = 14.5, 1 H); 2.50 (*d*, *B* part of *AB* system, *J* = 14.1, 1 H); 2.14–2.02, 2.02–1.87 (2*m*, ratio 3:2, 2 H); 1.49–1.40 (*m*, 3 H); 1.26–1.21 (*m*, 6 H); 1.17 (*t*, *J* = 7.1, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 108.0, 107.6 (2 C); 103.8, 101.8 (2 CH); 85.0, 83.7 (2 CH); 65.5, 65.3 (2 CH_2); 64.5, 64.2 (2 CH_2); 58.2, 57.8 (2 CH_2); 57, 56.6 (2 C); 51.2, 47.8 (2 CH_2); 29.0, 28.9 (2 CH_2); 27.7, 27.5 (2 CH_2); 25.7, 25.6 (2 CH_2); 17.1, 16.3 (2 Me); 16.1, 15.8 (2 Me); 15.5, 15.4 (2 Me); 15.4, 15.4 (2 CH). DART-MS: 291 (65, $[M-EtO]^+$), 245 (100), 203 (10), 113 (20). HR-MS: 291.1099 ($[M-EtO]^+$, $C_{13}H_{23}O_{32}^+$; calc. 291.1089).

3-(Diethoxymethyl)-3-ethoxy-1-hexyl-2-oxa-6,10-dithiaspiro[4.5]decane (**8c**). As described for **8a**, with abs. EtOH (60 ml), **5c** (0.85 g, 2.20 mmol), and TsOH (0.085 g, 0.45 mmol, 20 mol-%). FC (hexanes/AcOEt 4:1) gave **8c** (0.65 g, 71%). Yellow liquid. IR (film): 2983*s*, 2931*s*, 2863*s*, 1689*w*, 1473*m*, 1375*m*, 1312*m*, 1270*m*, 1125*s*, 1077*s*, 942*m*, 908*m*, 797*w*, 721*w*. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.52, 4.42 (2*s*, ratio 3:2, 1 H); 4.07–3.96 (*m*, 1 H); 3.83–3.54 (*m*, 6 H); 3.14 (*d*, *A* part of *AB* system, *J* = 14.0, 0.5 H); 3.09–2.71 (*m*, 5 H); 2.54 (*d*, *B* part of *AB* system, *J* = 14.0, 0.5 H); 2.12–2.07 (*m*, 1 H); 2.01–1.85 (*m*, 1 H);

1.85 – 1.68 (*m*, 2 H); 1.57 – 1.53 (*m*, 1 H); 1.50 – 1.13 (*m*, 16 H); 0.90 (*t*, *J* = 9.2, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 108.1, 107.5 (2 C); 104.1, 102.0 (2 CH); 88.7, 87.2 (2 CH); 65.8, 65.2 (2 CH_2); 64.5, 64.4 (2 CH_2); 58.3, 57.8 (2 CH_2); 57.4, 56.8 (2 C); 51.7, 47.5 (2 CH_2); 31.9, 31.9 (2 CH_2); 31.5, 30.6 (2 CH_2); 29.4, 29.3 (2 CH_2); 29.2, 27.4 (2 CH_2); 27.3, 26.1 (2 CH_2); 26.0, 22.8 (2 CH_2); 22.8 (CH_2); 16.2 (Me); 15.9, 15.6 (2 Me); 15.4 (Me); 14.2 (Me). DART-MS: 361 (75, $[M - EtO]^+$), 315 (100), 183 (5). HR-MS: 361.1843 ($[M - EtO]^+$, $C_{18}H_{33}O_3S_2^+$; calc. 361.1871).

3-(Diethoxymethyl)-3-ethoxy-1-phenyl-2-oxa-6,10-dithiaspiro[4.5]decane (**8d**). As described for **8a**, with abs. EtOH (40 ml), **5d** (0.30 g, 0.0.81 mmol), and TsOH (0.0.031 g, 0.16 mmol, 20 mol-%). FC (hexanes/AcOEt 4 : 1) gave **8d** (0.24 g, 74%). Yellow liquid. IR (film): 3065*m*, 3034*m*, 2987*s*, 2935*s*, 2895*s*, 2254*w*, 1496*m*, 1457*m*, 1435*m*, 1381*m*, 1320*m*, 1278*m*, 1217*m*, 1121*s*, 1077*s*, 954*m*, 912*m*, 870*m*, 820*w*, 744*m*, 702*m*. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.66 – 7.61 (*m*, 2 H); 7.39 – 7.36 (*m*, 3 H); 5.24, 5.21 (2*s*, ratio 3 : 2, 1 H); 4.68, 4.53 (2*s*, 1 H); 4.00 – 3.56 (*m*, 6 H); 3.08 (*d*, *A* part of *AB* system, *J* = 14.2, 0.5 H); 3.00 (*d*, *A* part of *AB* system, *J* = 14.5, 0.5 H); 2.91 – 2.72 (*m*, 3 H); 2.68 (*d*, *B* part of *AB* system, *J* = 14.4, 0.5 H); 2.57 (*d*, *B* part of *AB* system, *J* = 14.3, 0.5 H); 2.52 – 2.35 (*m*, 1 H); 1.90 – 1.79, 1.79 – 1.65 (2*m*, ratio 3 : 2, 2 H); 1.35 – 1.22 (*m*, 6 H); 1.20 (*t*, *J* = 7.1, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 137.5, 136.7 (2 C); 128.8 (CH); 128.7 (CH); 128.1 (CH); 128.0 (CH); 127.9 (CH); 107.6, 107.4 (2 C); 103.8, 101.7 (2 CH); 91.4, 89.6 (2 CH); 65.9, 65.7 (2 CH_2); 64.6, 64.3 (2 CH_2); 58.2, 58.0 (2 CH_2); 56.6, 55.6 (2 C); 51.9, 47.9 (2 CH_2); 28.8, 28.5 (2 CH_2); 27.6, 27.2 (2 CH_2); 24.8 (CH_2); 16.1, 16.0 (2 Me); 15.7, 15.6 (2 Me); 15.5 (Me). DART-MS: 353 (30, $[M - EtO]^+$), 307 (100), 261 (5), 233 (5), 175 (10). HR-MS: 353.1215 ($[M - EtO]^+$, $C_{18}H_{25}O_3S_2^+$; calc. 353.1245).

6. *Exploratory Experiments with* **2a** *to Assess Protection of Hydroxy Ketone* **4**. 6.1. *Synthesis of* **9a-PG** (PG = Bz, Bn, MEM). *4,4,5,5-Tetraethoxypent-2-yn-1-yl Benzoate* (**9a-Bz**). To a mixture of **2a** (4.01 g, 15.38 mmol) and pyridine (30 ml) in CH_2Cl_2 (40 ml) kept at 0° under N_2 was added dropwise during 1.5 h a soln. of benzoyl chloride (2.8 g, 20 mmol) in CH_2Cl_2 (20 ml). After stirring for 16 h, H_2O was added and the hydrolyzate extracted by CH_2Cl_2 (4 × 30 ml). The combined org. extract was dried ($MgSO_4$) and concentrated and the residual orange liquid (6.69 g) of purified by FC (hexanes/AcOEt 4 : 1): 5.13 g (92%) of **9a-Bz**. Yellow liquid. IR (film): 3066*w*, 2977*s*, 2931*s*, 2892*s*, 1788*w*, 1728*s*, 1601*w*, 1480*m*, 1448*s*, 1373*s*, 1319*m*, 1264*s*, 1173*s*, 1074*s*, 1026*s*, 947*m*, 879*m*, 806*w*, 714*s*. ^{1}H-NMR (200 MHz, $CDCl_3$): 8.09 – 8.03 (*m*, 2 H); 7.57 – 7.40 (*m*, 3 H); 5.02 (*s*, 2 H); 4.42 (*s*, 1 H); 3.89 – 3.63 (*m*, 8 H); 1.25 (*t*, *J* = 7.0, 6 H); 1.22 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 165.5 (C); 133.0 (CH); 129.5 (2 CH); 129.3 (C); 128.2 (2 CH); 103.6 (CH); 98.4 (C); 81.4 (C); 80.6 (C); 64.7 (2 CH_2); 59.4 (2 CH_2); 52.6 (CH_2); 15.1 (2 Me); 15.0 (2 Me). EI-MS: 320 (12), 261 (10), 187 (17), 140 (10), 112 (10), 103 (100), 84 (8), 75 (58), 67 (8), 47 (51). HR-MS: 261.111519 ($[M - CH(OEt)_2]^+$, $C_{15}H_{17}O_4^+$; calc. 261.112684).

6.2. *1-(Benzyloxy)-4,4,5,5-tetraethoxypent-2-yne* (**9a-Bn**). Alcohol **2a** (26.0 g, 0.10 mol) was mixed with CH_2Cl_2 (80 ml), benzyl chloride (16.4 g, 130 mmol), and tetrabutylammonium hydrogensulfate ($(Bu_4N)HSO_4$; 1.0 g, 2.9 mmol), and to this mixture was added 50% aq. NaOH soln. (50 g, 0.125 mol). The mixture was refluxed, and extra benzyl chloride (5.0 g, 39.7 mmol) was added after 2.5 h (TLC monitoring). After a total of 5 h, the mixture was allowed to cool. H_2O was added followed by extraction with CH_2Cl_2. The combined org. extract was dried ($MgSO_4$) and concentrated and the crude product purified by FC (hexanes/AcOEt 95 : 5): 25.2 g (72%) of **9a-Bn**. Yellowish liquid. IR (film): 3030*m*, 2976*s*, 2934*s*, 2885*s*, 1448*m*, 1287*m*, 1351*m*, 1244*m*, 1080*s*, 884*w*, 811*w*, 743*m*, 700*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.38 – 7.27 (*m*, 5 H); 4.63 (*s*, 2 H); 4.41 (*s*, 1 H); 4.27 (*s*, 2 H); 3.89 – 3.63 (*m*, 8 H); 1.25 (*t*, *J* = 7.6, 6 H); 1.23 (*t*, *J* = 7.6, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 137.3 (C); 128.2 (2 CH); 128.0 (2 CH); 127.6 (CH); 103.8 (CH); 98.6 (C); 82.7 (C); 81.2 (C); 71.1 (CH_2); 64.6 (2 CH_2); 59.4 (2 CH_2); 57.1 (CH_2); 15.1 (2 Me); 15.0 (2 Me). EI-MS: 305 (5, $[M - EtO]^+$), 247 (13), 200 (18), 171 (17), 157 (6), 141 (7), 127 (6), 119 (13), 103 (100), 91 (75), 83(7), 75 (53), 55 (7), 47 (38). HR-MS: 305.174667 ($[M - EtO]^+$, $C_{18}H_{25}O_4^+$; calc. 305.175285).

6.3. *4,4,5,5-Tetraethoxy-1-[(2-methoxyethoxy)methoxy]pent-2-yne* (**9a-MEM**). To **2a** (1.00 g, 3.80 mmol) mixed with CH_2Cl_2 (10 ml) and $^iPr_2EtN$ (0.52 g, 4.00 mmol) at 0° under N_2 was added dropwise $MeOCH_2CH_2OCH_2Cl$ (0.52 g, 4.17 mmol). After stirring overnight, H_2O was added and the hydrolyzate worked up with CH_2Cl_2. The combined org. extract was dried ($MgSO_4$) and concentrated and the crude product (1.22 g) purified by FC (hexanes/AcOEt): 0.64 g (48%) of **9a-MEM**. Yellow liquid. IR (film): 2983*s*, 2885s, 2249*w*, 1702*w*, 1620*w*, 1449*m*, 1371*m*, 1341*m*, 1294*m*, 1083*s*, 929*m*, 902*m*,

849*m*, 756 *w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.81 (*s*, 2 H); 4.28 (*s*, 1 H); 4.34 (*s*, 2 H); 3.87–3.53 (*m*, 12 H); 3.40 (*s*, 3 H); 1.24 (*t*, *J* = 7.0, 6 H); 1.21 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 103.7 (CH); 98.5 (C); 93.5 (CH_2); 82.3 (C); 80.5 (C); 71.5 (CH_2); 66.9 (CH_2); 64.6 (2 CH_2); 59.3 (2 CH_2); 58.8 (Me); 54.2 (CH_2); 15.1 (2 Me); 15.0 (2 Me). EI-MS: 347 (22), 334 (100), 171 (10), 159 (35), 148 (10), 142 (12), 125 (15), 113 (17), 103 (88), 97 (24), 85 (53), 75 (64). HR-MS: 348.2137 (M^+, $C_{17}H_{32}O_7^+$; calc. 348.2148).

6.4. *Deketalization of* **9a-PG**, *Formation of* **10a-PG** (PG = Bz, Bn, MEM). *General Procedure.* Alkyne **9a-PG** (1.0 mmol) was refluxed in a mixture of acetone (10 ml), H_2O (0.5 ml), and *Dowex 50W* (0.35 g) (TLC monitoring). The reaction was stopped when it was finished according to TLC (3–6 h). The mixture was allowed to cool to r.t. and filtered to remove the *Dowex 50W*. Evaporation of the acetone gave a crude product which was purified by FC (hexanes/AcOEt): corresponding ketone **10a-PG**.

5,5-Diethoxy-4-oxopent-2-yn-1-yl Benzoate (**10a-Bz**): Yield 91%. Slightly yellow liquid. IR (film): 3067*w*, 2979*s*, 2934*s*, 2889*s*, 2222*s*, 1728*s*, 1694*s*, 1601*m*, 1480*m*, 1448*m*, 1369*m*, 1317*m*, 1261*s*, 1170*s*, 1105*s*, 957*m*, 911*m*, 832*w*, 809*w*, 714*s*. ^{1}H-NMR (200 MHz, $CDCl_3$): 8.10–8.04 (*m*, 2 H); 7.65–7.42 (*m*, 3 H); 5.12 (*m*, 2 H); 4.76 (*s*, 1 H); 3.81–3.56 (*m*, 4 H); 1.26 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.1 (C); 165.4 (C); 133.5 (CH); 129.7 (2 CH); 128.8 (C); 128.4 (2 CH); 101.3 (CH); 89.1 (C); 83.4 (C); 63.1 (2 CH_2); 51.9 (CH_2); 12.9 (2 Me). EI-MS: 245 (1), 217 (1), 187 (2), 143 (1), 122 (4), 103 (100), 75 (54), 66 (14), 58 (7), 47 (95). HR-MS: 290.1162 (M^+, $C_{16}H_{18}O_5^+$; calc. 290.1154).

5-(Benzyloxy)-1,1-diethoxypent-3-yn-2-one (**10a-Bn**): Yield 99%. Slightly yellow liquid. IR (film): 3031*m*, 2979*s*, 2934*s*, 2884*s*, 2211*m*, 1691*s*, 1450*m*, 1387*m*, 1351*s*, 1322*m*, 1246*s*, 1103*s*, 905*m*, 836*w*, 743*s*, 701*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.38–7.30 (*m*, 5 H); 4.80 (*s*, 1 H); 4.64 (*s*, 2 H); 4.35 (*s*, 2 H), 3.82–3.56 (*m*, 4 H); 1.27 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.2 (C); 136.6 (C); 128.3 (2 CH); 128.0 (2 CH); 127.9 (CH); 101.4 (CH); 91.6 (C); 83.6 (C); 71.6 (CH_2); 63.0 (2 CH_2); 56.8 (CH_2); 14.9 (2 Me). EI-MS: 185 (4), 173 (4), 149 (6), 129 (6), 115 (13), 103 (100), 91 (57), 83 (8), 75 (47), 83 (10), 75 (47), 65 (15), 55 (9), 47 (70). HR-MS: 276.133476 (M^+, $C_{16}H_{20}O_4^+$; calc. 276.136159).

5-[(2-Methoxyethoxy)methoxy]-1,1-diethoxypent-3-yn-2-one (**10a-MEM**). Yield 93%. Slightly yellow liquid. IR (film): 2978*s*, 2931*s*, 2890*s*, 2213*m*, 1693*s*, 1459*m*, 1366*m*, 1244*m*, 1122*s*, 1049*s*, 990*m*, 907*m*, 846*m*, 781*w*. ^{1}H-NMR: (200 MHz, $CDCl_3$): 4.83 (*s*, 2 H); 4.74 (*s*, 1 H); 4.46 (*s*, 2 H); 3.80–3.55 (*m*, 8 H); 3.40 (*s*, 3 H); 1.27 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.1 (C); 101.2 (CH); 93.8 (CH_2); 91.4 (C); 83.1 (C); 71.4 (CH_2); 67.1 (CH_2); 62.9 (2 CH_2); 58.7 (Me); 53.8 (CH_2); 14.8 (2 Me). EI-MS: 273 (1), 247 (1), 229 (1), 199 (1), 185 (1), 169 (1), 155 (1), 141 (5), 113 (5), 103 (100), 75 (57), 66 (11), 59 (22), 47 (97). HR-MS: 229.1075 ($[M - EtO]^+$, $C_{11}H_{17}O_5^+$; calc. 229.1076).

6.5. *Double Conjugate Addition of Propane-1,3-dithiol to* **10a-PG**, *Formation of* **11a-PG** (PG = Bz, Bn): *General Procedures. Method A*. Protected **10a-PG** (10 mmol) and propane-1,3-dithiol (1.2 g, 11 mmol) were dissolved in MeOH (170 ml) and CH_2Cl_2 (42 ml) and cooled to $-10°$ before MeONa (0.82 g, 15 mmol) was added. The mixture was stirred overnight and allowed to reach r.t. The reaction was quenched by adding sat. aq. NH_4Cl soln. followed by extraction with CH_2Cl_2 (3 × 40 ml). The combined extract was dried ($MgSO_4$) and concentrated crude **11a-PG**.

Method B. Propane-1,3-dithiol (1.51 ml, 15 mmol) and MeONa (0.81 g, 15 mmol) was dissolved in dry THF (200 ml) at r.t. under N_2. The mixture was then cooled to $-78°$, and the α,β-unsaturated ketone **10a-PG** (10 mmol) was dissolved in THF (50 ml) and added dropwise during 20 min. The mixture was stirred overnight and allowed to reach r.t. The reaction was quenched by adding sat. aq. NH_4Cl soln. followed by extraction with CH_2Cl_2 (3 ×). The combined extract was dried ($MgSO_4$) and concentrated: crude **11a-PG**.

[2-(3,3-Diethoxy-2-oxopropyl)-1,3-dithian-2-yl]methyl Benzoate (**11a-Bz**): From **10a-Bz** (3.67 g, 12.66 mmol) with *Method A*. The crude orange liquid (5.75 g) was purified by FC (hexanes/AcOEt 95 : 5): 1.28 g (25%) of **11a-Bz** and 2.74 g (74%) of **5a** both as a yellow liquid. **11a-Bz**: IR (film): 3064*w*, 2877*s*, 2900*s*, 1726*s*, 1601*w*, 1451*m*, 1422*m*, 1366*m*, 1315*m*, 1269*m*, 1103*m*, 1065*m*, 956*m*, 910*m*, 878*w*, 810*w*, 712*s*, 677*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 8.07–8.03 (*m*, 2 H); 7.60–7.40 (*m*, 3 H); 4.97 (*s*, 2 H); 4.57 (*s*, 1 H); 3.79–3.49 (*m*, 4 H); 3.29 (*s*, 2 H), 3.16–3.02 (*m*, 2 H); 2.76–2.65 (*m*, 2 H); 2.15–1.82 (*m*, 2 H); 1.23 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 200.8 (C); 165.6 (C); 132.9 (CH); 129.7 (C); 129.6 (2 CH); 128.2 (2 CH); 102.8 (CH); 63.9 (CH_2); 63.4 (2 CH_2); 48.8 (C); 42.8 (CH_2); 26.0 (2 CH_2); 24.3 (CH_2), 14.9 (2 Me). EI-MS: 398 (1, M^+), 370 (1), 353 (1), 263 (1), 253 (1), 231 (1), 203 (1), 203 (1),

189 (2), 161 (1), 146 (3), 132 (1), 122 (1), 103 (100), 75 (32), 47 (33). HR-MS: 398.121704 (M^+, $C_{19}H_{26}O_5S_2^+$; calc. 398.122168).

2-[2-[(Benzyloxy)methyl]-1,3-dithian-2-yl]-1,1-diethoxypropan-2-one (**11a-Bn**): From **10a-Bn** with *Methods A* and *B*. After purification by FC (hexanes/AcOEt 95:5), the yield of **11a-Bn** was 92% and 99%, resp. Yellow liquid. IR (film): 3030*w*, 2976*s*, 2901*s*, 1731*s*, 1450*m*, 1420*m*, 1391*m*, 1355*m*, 1318*m*, 1282*m*, 1244*m*, 1095*s*, 1067*s*, 910*w*, 975*w*, 815*w*, 741*m*, 700*m*, 654*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.37–7.25 (*m*, 5 H); 4.60 (*s*, 2 H); 4.58 (*s*, 1 H); 3.97 (*s*, 2 H); 3.74–3.64 (*m*, 4 H); 3.34 (*s*, 2 H); 2.86–2.80 (*m*, 4 H); 2.02–1.90 (*m*, 2 H); 1.22 (*t*, $J = 7.0$, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 201.4 (C); 137.8 (C); 128.1 (2 CH); 127.4 (3 CH); 102.6 (CH); 73.1 (CH_2); 72.9 (CH_2); 63.0 (2 CH_2); 49.9 (CH_2); 42.5 (C); 25.9 (2 CH_2); 24.7 (CH_2); 15.0 (2 Me). EI-MS: 384 (1, M^+), 356 (1), 338 (1), 293 (1), 146 (10), 103 (100), 91 (57), 75 (34), 65 (7), 47 (37). HR-MS: 384.143028 (M^+, $C_{19}H_{28}O_4S_2^+$; calc. 384.142903).

7. *Conversion of* **2b**–**2f** *to* **11b-Bn**–**11f-Bn** via **9b-Bn**–**9f-Bn** *and* **10b-Bn**–**10f-Bn**. 7.1. *Benzylation of* **2b**–**2f**: *General Procedure.* Alcohol **2** (100 mmol) was dissolved in CH_2Cl_2 (80 ml), benzyl chloride (16.4 g, 130 mmol), $(Bu_4N)HSO_4$ (1.0 g, 2.9 mmol), and 50% of aq. NaOH soln. (50 g) were added, and the mixture was refluxed. Extra benzyl chloride (5.0 g, 39.7 mmol) was added after 2.5 h. After a total of 5–10 h (TLC monitoring), the mixture was allowed to cool down, and H_2O was added followed by extraction with CH_2Cl_2. The combined org. extracts was dried ($MgSO_4$) and concentrated and the crude product purified by FC: **9-Bn**.

5-(Benzyloxy)-1,1,2,2-tetraethoxyhex-3-yne (**9b-Bn**): Yield 96%. Slightly yellow liquid. IR: 3031*m*, 2978*s*, 2931*s*, 2887*s*, 1450*m*, 1375*m*, 1329*m*, 1243*m*, 1080*s*, 1025*s*, 916*m*, 881*w*, 813*w*, 741*s*, 700*s*, 616*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.40–7.25 (*m*, 5 H); 4.84–4.50 (*m*, 2 H); 4.42 (*s*, 1 H); 4.30 (*q*, $J = 6.0$, 1 H); 3.89–3.67 (*m*, 8 H); 1.48 (*d*, $J = 6.0$, 3 H); 1.28–1.19 (*m*, 12 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 137.7 (C); 128.0 (2 CH); 127.8 (2 CH); 127.3 (CH); 103.8 (CH); 98.5 (C); 86.5 (C); 79.9 (C); 70.1 (CH_2); 64.3 (CH_2); 64.2 (CH_2); 64.0 (CH); 59.4 (CH_2); 59.3 (CH_2); 21.5 (Me); 15.1 (2 Me); 15.0 (2 Me). EI-MS: 319 (1, $[M - EtO]^+$), 289 (2), 273 (1), 261 (10), 214 (8), 185 (15), 119 (12), 103 (100), 91 (68), 75 (47), 65 (6), 47 (43). HR-MS: 319.1909 ($[M - EtO]^+$, $C_{19}H_{32}O_5^+$; calc. 319.1909).

5-(Benzyloxy)-1,1,2,2-tetraethoxyundec-3-yne (**9c-Bn**): Yield 88%. Clear liquid. IR (film): 3088*w*, 3031*m*, 1975*s*, 2956*s*, 2930*s*, 2862*s*, 2241*w*, 1496*m*, 1455*s*, 1390*m*, 1333*m*, 1241*m*, 1120*s*, 1082*s*, 1027*s*, 1020*s*, 913*m*, 878*m*, 845*w*, 816*w*, 806*w*, 737*m*, 699*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.40–7.23 (*m*, 5 H); 4.85–4.51 (*m*, 2 H); 4.41 (*s*, 1 H); 4.18 (*t*, $J = 6.5$, 1 H); 3.90–3.63 (*m*, 8 H); 1.84–1.72 (*m*, 2 H); 1.54–1.28 (*m*, 8 H); 1.24 (*t*, $J = 7.0$, 3 H); 1.23 (*t*, $J = 7.0$, 3 H); 1.22 (*t*, $J = 7.0$, 6 H); 0.87 (*t*, $J = 6.5$, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 138.0 (C); 128.2 (2 CH); 128.0 (2 CH); 127.5 (CH); 104.0 (CH); 98.7 (C); 86.2 (C); 80.7 (C); 70.4 (CH_2); 68.6 (CH); 64.4 (CH_2); 64.3 (CH_2); 59.8 (CH_2); 59.7 (CH_2); 35.5 (CH_2); 31.6 (CH_2); 28.9 (CH_2); 25.1 (CH_2); 22.5 (CH_2); 15.3 (2 Me); 15.2 (Me); 15.1 (Me); 14.0 (Me). EI-MS: 434 (2, M^+), 390 (7), 359 (9), 331 (80), 284 (20), 259 (30), 255 (35), 225 (20), 119 (65), 103 (50), 75 (100). HR-MS: 389.2692 ($[M - EtO]^+$, $C_{24}H_{37}O_4^+$; calc. 389.2692).

5-(Benzyloxy)-1,1,2,2-tetraethoxy-5-phenylpent-3-yne (**9d-Bn**). Instead of **9d-Bn**, complex mixture of products including *4,5,5-triethoxy-1-phenylpenta-2,3-dien-1-one* (**12**) and *1-(benzyloxy)-4,5,5-triethoxy-1-phenylpenta-1,2,3-triene* (**13**). IR: *Fig. 2*. ^{13}C-NMR: *Fig. 1*.

Data of **12**. EI-MS: 290 (10, M^+), 261 (30), 187 (20), 159 (40), 103 (100), 75 (90). HR-MS: 245.1180 ($[M - EtO]^+$, $C_{15}H_{17}O_3^+$; calc. 245.1178). *Data of* **13**: EI-MS: 380 (20, M^+), 352 (85), 335 (60), 323 (100), 249 (80), 221 (80), 185 (70), 143 (90), 104 (95).

5-(Benzyloxy)-1,1,2,2-tetraethoxy-5-methylhex-3-yne (**9e-Bn**): Yield 85%. Clear, yellowish liquid. IR(film): 3090*w*, 3065*w*, 3031*w*, 2977*s*, 2931*s*, 2889*s*, 2247*w*, 1498*w*, 1480*w*, 1454*m*, 1380*m*, 1360*m*, 1330*m*, 1258*m*, 1186*m*, 1159*s*, 1117*s*, 1081*s*, 1028*m*, 1020*m*, 961*w*, 952*w*, 902*m*, 877*m*, 839*w*, 801*w*, 736*m*, 697*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.40–7.20 (*m*, 5 H); 4.67 (*s*, 2 H); 4.41 (*s*, 1 H); 3.87–3.61 (*m*, 8 H); 1.57 (*s*, 6 H); 1.21 (*t*, $J = 7.1$, 12 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 139.0 (C); 128.2 (2 CH); 127.8 (2 CH); 127.3 (CH); 103.9 (CH); 98.6 (C); 89.1 (C); 79.4 (C); 70.7 (C); 66.7 (CH_2); 64.3 (2 CH_2); 59.7 (2 CH_2); 28.7 (2 Me); 15.3 (2 Me); 15.2 (2 Me). EI-MS: 378 (2), 285 (5), 199 (10), 133 (30), 117 (25), 103 (65), 89 (95), 73 (90), 59 (100). HR-MS: 333.2067 ($[M - EtO]^+$, $C_{20}H_{29}O_4^+$; calc. 333.2066).

1-[1-(Benzyloxy)cyclohexyl]-3,3,4,4-tetraethoxybut-1-yne (**9f-Bn**): Yield 75%. Yellow liquid. IR (film): 3029*m*, 2974*s*, 2934*s*, 2239*w*, 1710*w*, 1449*m*, 1382*m*, 1333*m*, 1294*m*, 1086*s*, 1026*s*, 940*m*, 905*m*, 850*w*, 801*w*, 727*m*, 700*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.14–7.23 (*m*, 5 H); 4.69 (*s*, 2 H); 4.41 (*s*, 1 H); 3.89–

3.60 (*m*, 8 H); 2.07–2.01 (*m*, 2 H); 1.75–1.48 (*m*, 8 H); 1.21 (*t*, *J* = 7.0, 6 H); 1.20 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 139.1 (C); 128.0 (2 CH); 127.7 (2 CH); 127.1 (CH); 104.0 (CH); 98.8 (C); 88.4 (C); 81.1 (C); 74.1 (C); 65.6 (CH_2); 64.1 (2 CH_2); 59.8 (2 CH_2); 37.1 (2 CH_2); 25.3 (CH_2); 22.7 (2 CH_2); 15.3 (2 Me); 15.1 (2 Me). EI-MS: 418 (1, M^+), 373 (1), 343 (2), 327 (7), 315 (12), 266 (6), 103 (100), 91 (42), 75 (36), 47 (37). HR-MS: 418.2708 (M^+, $C_{25}H_{38}O_5^+$; calc. 418.2719).

7.2. *Deketalization of* **9-Bn**, *Formation of* **10-Bn**. The reactions were carried out following the *General Procedure* used to prepare **10a-PG** (see above, *Exper. 6.4*).

5-(Benzyloxy)-1,1-diethoxyhex-3-yn-2-one (**10b-Bn**): Yield 82%. Slightly yellow liquid. IR: 3031*m*, 2981*s*, 2933*s*, 2878*s*, 2214*s*, 1691*s*, 1451*m*, 1387*m*, 1325*s*, 1242*m*, 1103*s*, 936*m*, 909*w*, 838*w*, 803*w*, 744*m*, 700*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.38–7.27 (*m*, 5 H); 4.84–4.50 (*m*, 2 H); 4.75 (*s*, 1 H); 4.38 (*q*, *J* = 6.7, 1 H); 3.81–3.56 (*m*, 4 H); 1.51 (*d*, *J* = 6.7, 3 H); 1.26 (*t*, *J* = 7.1, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.4 (C); 137.1 (C); 128.2 (2 CH); 127.9 (2 CH); 127.7 (CH); 101.3 (CH); 95.0 (C); 82.4 (C); 70.7 (CH_2); 64.0 (CH); 62.9 (CH_2); 62.8 (CH_2); 20.9 (Me); 14.9 (2 Me). EI-MS: 245 (1), 215 (1), 187 (1), 187 (1), 169 (1), 157 (1), 145 (1), 129 (2), 103 (100), 91 (32), 75 (31), 65 (7), 47 (37). HR-MS: 290.1540 (M^+, $C_{17}H_{22}O_4^+$; calc. 290.1518).

5-(Benzyloxy)-1,1-diethoxyundec-3-yn-2-one (**10c-Bn**): Yield 99%. Yellow liquid. IR (film): 3089*w*, 3065*w*, 3032*m*, 2977*s*, 2954*s*, 2929*s*, 2861*s*, 2209*m*, 1694*s*, 1497*m*, 1479*m*, 1455*s*, 1392*m*, 1371*m*, 1332*m*, 1242*m*, 1206*w*, 1159*m*, 1111*s*, 1072*s*, 1029*s*, 909*m*, 839*w*, 818*w*, 787*w*, 738*m*, 699*m*, 617*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.39–7.26 (*m*, 5 H); 4.86–4.50 (*m*, 2 H); 4.76 (*s*, 1 H); 4.26 (*t*, *J* = 6.6, 1 H); 3.82–3.57 (*m*, 4 H); 1.88–1.76 (*m*, 2 H); 1.59–1.40 (*m*, 8 H); 1.27 (*t*, *J* = 7.1, 6 H); 0.87 (*t*, *J* = 6.5, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.7 (C); 137.3 (C); 128.4 (2 CH); 128.1 (2 CH); 127.9 (CH); 101.5 (CH); 95.1 (C); 83.3 (C); 70.9 (CH_2); 68.4 (CH); 63.0 (CH_2); 62.9 (CH_2); 34.9 (CH_2); 31.6 (CH_2); 28.8 (CH_2); 25.1 (CH_2); 22.5 (CH_2); 15.1 (2 Me); 14.0 (Me). EI-MS: 360 (1, M^+), 330 (5), 314 (4), 287 (6), 255 (20), 227 (15), 209 (25), 169 (30), 143 (35), 129 (55), 115 (82), 92 (100), 65 (100). HR-MS: 359.2238 ($[M-H]^+$, $C_{22}H_{31}O_4^+$; calc. 359.2222).

5-(Benzyloxy)-1,1-diethoxy-5-methylhex-3-yn-2-one (**10e-Bn**): Yield 94%. Slightly yellow liquid. IR (film): 3031*m*, 2981*s*, 2932*s*, 2889*s*, 2213*s*, 1691*s*, 1452*m*, 1383*m*, 1319*s*, 1249*s*, 1161*s*, 1087*s*, 957*w*, 912*m*, 841*w*, 741*s*, 699*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.39–7.25 (*m*, 5 H); 4.73 (*s*, 1 H); 4.66 (*s*, 2 H); 3.79–3.53 (*m*, 4 H); 1.60 (*s*, 6 H); 1.23 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.7 (C); 138.1 (C); 128.1 (2 CH); 127.6 (2 CH); 127.4 (CH); 101.3 (CH); 97.4 (C); 81.7 (C); 70.4 (C); 66.9 (CH_2); 62.7 (2 CH_2); 27.9 (2 Me); 14.9 (2 Me). EI-MS: 259 (1), 229 (1), 201 (1), 183 (1), 171 (1), 152 (2), 103 (100), 91 (43), 75 (47), 65 (8), 47 (61). HR-MS: 304.1681 (M^+, $C_{18}H_{24}O_4^+$; calc. 304.1675).

4-[1-(Benzyloxy)cyclohexyl]-1,1-diethoxybut-3-yn-2-one (**10f-Bn**): Yield 86%. Slightly yellow liquid. IR (film): 3062*m*, 3031*m*, 2936*s*, 2207*s*, 1690*s*, 1450*s*, 1382*m*, 1318*m*, 1290*m*, 1093*s*, 941*m*, 910*m*, 848*w*, 739*m*, 700*m*. ^{1}H–NMR (200 MHz, $CDCl_3$): 7.40–7.23 (*m*, 5 H); 4.75 (*s*, 1 H); 4.67 (*s*, 2 H); 3.79–3.54 (*m*, 4 H); 2.10–2.00 (*m*, 2 H); 1.84–1.52 (*m*, 8 H); 1.24 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 182.8 (C); 138.4 (C); 128.1 (2 CH); 127.6 (2 CH); 127.3 (CH); 101.3 (CH); 97.3 (C); 83.7 (C); 74.0 (C); 65.9 (CH_2); 62.7 (2 CH_2); 36.5 (2 CH_2); 25.1 (CH_2); 22.4 (2 CH_2); 15.0 (2 Me). EI-MS: 241 (1), 229 (1), 211 (1), 200 (2), 185 (1), 229 (10), 117 (6), 111 (23), 103 (83), 97 (10), 91 (52), 83 (24), 75 (44), 58 (27). HR-MS: 344.2003 (M^+, $C_{21}H_{28}O_4^+$; calc. 344.1988).

7.3. *Addition of Propane-1,3-dithiol to* **10-Bn**, *Formation of* **11-Bn**. *Methods A* and *B* used to perform double conjugate addition of propane-1,3-dithiol to protected **10a-Bn** were applied (see above, *Exper. 6.5*).

3-{2-[1-(Benzyloxy)ethyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one (**11b-Bn**): From **10b-Bn**. *Method A:* After FC, 92% yield. *Method B:* After FC, 99% yield. Yellow liquid. IR (film): 3030*m*, 2975*s*, 2926*s*, 1729*s*, 1449*m*, 1375*m*, 1320*m*, 1283*m*, 1242*m*, 1069*s*, 972*m*, 908*m*, 812*w*, 740*s*, 700*m*, 656*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.36–7.23 (*m*, 5 H); 4.67 (*s*, 1 H); 4.64–4.74 (*m*, 2 H); 4.28 (*q*, *J* = 6.3, 1 H); 3.70–3.39 (*m*, 4 H); 3.43 (*m*, 2 H); 2.96–2.81 (*m*, 4 H); 2.04–1.84 (*m*, 2 H); 1.42 (*d*, *J* = 6.3, 3 H); 1.20 (*t*, *J* = 7.0, 3 H); 1.19 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 201.7 (C); 138.2 (C); 127.9 (2 CH); 127.5 (2 CH); 127.2 (CH); 102.5 (CH); 79.7 (CH); 71.8 (CH_2); 62.9 (2 CH_2); 55.5 (C); 42.7 (CH_2); 26.6 (CH_2); 26.0 (CH_2); 24.6 (CH_2); 15.0 (Me); 14.9 (Me); 14.8 (Me). EI-MS: 398 (1, M^+), 353 (1), 308 (1), 263 (25), 103 (100), 91 (50), 75 (35), 47 (36). HR-MS: 398.1593 (M^+, $C_{20}H_{30}O_4S_2^+$; calc. 398.1586).

3-{2-[1-(Benzyloxy)heptyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one (**11c-Bn**): From **10c-Bn** with *Method B*. After FC, 71% yield. Yellow liquid. IR (film): 3088*w*, 3063*w*, 3030*m*, 2954*s*, 2926*s*, 2857*s*, 2870*s*, 1728*s*, 1605*w*, 1585*w*, 1549*w*, 1454*m*, 1424*m*, 1394*m*, 1371*m*, 1342*m*, 1314*m*, 1278*m*, 1240*w*, 1206*w*, 1164*m*, 1097*s*, 1065*s*, 1028*s*, 926*w*, 910*m*, 874*w*, 816*w*, 787*w*, 735*m*, 698*m*, 678*w*, 650*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.39–7.21 (*m*, 5 H); 4.86–4.62 (*m*, 2 H); 4.66 (*s*, 1 H); 4.10 (*dd*, *J* = 2.7, 9.0, 1 H); 3.69–3.41 (*m*, 4 H); 3.39 (*s*, 2 H); 3.03–2.76 (*m*, 4 H); 2.71–2.57 (*m*, 1 H); 2.33–2.19 (*m*, 1 H); 2.11–1.27 (*m*, 10 H); 1.21 (*t*, *J* = 7.0, 3 H); 1.18 (*t*, *J* = 7.0, 3 H); 0.88 (*t*, *J* = 6.3, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 202.1 (C); 138.5 (C); 128.1 (2 CH); 127.6 (2 CH); 127.3 (CH); 102.6 (CH); 84.3 (CH); 75.2 (CH_2); 63.1 (CH_2); 63.1 (CH_2); 56.4 (C); 42.7 (CH_2); 31.8 (CH_2); 31.7 (CH_2); 29.4 (CH_2); 27.3 (CH_2); 26.4 (CH_2); 26.3 (CH_2); 24.7 (CH_2); 22.5 (CH_2); 15.1 (Me); 15.0 (Me); 14.0 (Me). DART-MS: 468 (52, M^+), 460 (22), 459 (38), 455 (33), 449 (10), 442 (52), 430 (31), 423 (100), 404 (8). HR-MS: 423.2029 ($[M-\text{EtO}]^+$, $C_{23}H_{35}O_3S_2^+$; calc. 423.2028).

3-{2-[1-(Benzyloxy)-1-methylethyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one (**11e-Bn**): From **10e-Bn** with *Method A*. After FC, 84% yield. Yellow liquid. IR (film): 3029*m*, 2975*s*, 2928*s*, 1721*s*, 1447*m*, 1418*m*, 1288*m*, 1317*m*, 1286*m*, 1244*m*, 1160*m*, 1088*m*, 1065*s*, 963*m*, 910*w*, 848*w*, 811*w*, 737*m*, 698*m*, 609*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.40–7.19 (*m*, 5 H); 5.20 (*s*, 1 H); 4.36 (*s*, 2 H); 3.36 (*s*, 2 H); 3.39–3.14 (*m*, 4 H); 3.12–2.98 (*m*, 2 H); 2.87–2.75 (*m*, 2 H); 2.14–2.03 (*m*, 1 H); 1.95–1.83 (*m*, 1 H); 1.58 (*s*, 6 H); 1.06 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 201.6 (C); 138.8 (C); 127.9 (2 CH); 126.8 (3 CH); 100.9 (CH); 82.4 (C); 63.4 (CH_2); 62.2 (C); 61.6 (2 CH_2); 44.7 (CH_2); 26.4 (2 CH_2); 24.5 (CH_2); 20.8 (2 Me); 15.0 (2 Me). EI-MS: 412 (3, M^+), 367 (1), 321 (1), 281 (1), 263 (28), 103 (100), 91 (80), 75 (39), 65 (5), 47 (48). HR-MS: 412.1760 (M^+, $C_{21}H_{32}O_4S_2^+$; calc. 412.1742).

3-{2-[1-(Benzyloxy)cyclohexyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-one (**11f-Bn**). From **10f-Bn**. *Method A:* After FC, 85% yield. White solid. M.p. 89–90°. *Method B:* After FC, 93% yield. White solid. M.p. 87–88°. IR (KBr): 3083*w*, 2919*s*, 2863*s*, 1710*s*, 1442*m*, 1390*w*, 1367*m*, 1327*m*, 1291*m*, 1259*m*, 1196*m*, 1134*s*, 1057*s*, 934*m*, 910*m*, 858*m*, 737*m*, 694*m*, 662*w*, 638*w*, 582*w*, 563*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.38–7.19 (*m*, 5 H); 4.66 (*s*, 2 H); 4.56 (*s*, 1 H); 3.51–3.25 (*m*, 6 H); 3.10–2.96 (*m*, 2 H); 2.88–2.75 (*m*, 2 H); 2.43–2.36 (*m*, 2 H); 2.08–1.78 (*m*, 4 H); 1.65–1.48 (*m*, 6 H); 1.10 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 202.1 (C); 139.4 (C); 128.0 (2 CH); 127.3 (2 CH); 126.9 (CH); 101.7 (CH); 83.1 (C); 65.7 (C); 65.6 (CH_2); 62.5 (2 CH_2); 40.2 (CH_2); 29.6 (2 CH_2); 27.0 (2 CH_2); 25.2 (CH_2); 24.0 (CH_2); 22.0 (2 CH_2); 15.0 (2 Me). EI-MS: 407 (1, $[M-\text{EtO}]^+$), 361 (1), 349 (1), 315 (1), 299 (1), 263 (1), 189 (15), 103 (88), 91 (100), 75 (32), 47 (35). HR-MS: 407.172951 ($[M-\text{EtO}]^+$, $C_{22}H_{31}O_3S_2^+$; calc. 407.171464).

8. *Conversion of Ketones* **11-Bn** *to Alcohols* **15-Bn**. *Typical Procedure.* The ketone **11-Bn** (7.2 mmol) in THF (10 ml) was added to a soln. of $NaBH_4$ (0.32 g, 8.5 mmol) in THF (20 ml) and H_2O (1 ml) at r.t. The mixture was stirred overnight before H_2O was added, and the hydrolyzate was extracted with CH_2Cl_2 (3 × 50 ml). The combined extract was dried ($MgSO_4$) and concentrated to give a residue from which **15-Bn** was isolated by FC.

3-{2-[(Benzyloxy)methyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-ol (**15a-Bn**): From **11a-Bn** (5.09 g, 13.2 mmol). Yield 99% (5.12 g) after FC. Slightly yellow liquid. IR (film): 3471*s*, 3086*w*, 3061*w*, 3030*m*, 2974*s*, 2902*s*, 1496*m*, 1452*s*, 1421*s*, 1372*s*, 1277*s*, 1244*m*, 1206*m*, 1095*s*, 1028*s*, 944*m*, 909*m*, 817*m*, 738*s*, 699*s*, 679*w*, 660*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.39–7.29 (*m*, 5 H); 4.65 (*s*, 2 H); 4.34 (*d*, *J* = 5.2, 1 H); 4.07–3.97 (*m*, 1 H); 3.86–3.50 (*m*, 6 H); 3.14 (*d*, *J* = 3.5, 1 H); 2.85–2.73 (*m*, 4 H); 2.44 (*dd*, *J* = 1.4, 15.2, 1 H); 2.10–1.90 (*m*, 3 H); 1.23 (*t*, *J* = 7.0, 3 H); 1.22 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 137.5 (C); 128.3 (2 CH); 127.6 (3 CH); 104.4 (CH); 74.4 (CH_2); 73.4 (CH_2); 68.8 (CH); 63.3 (CH_2); 63.2 (CH_2); 51.8 (C); 39.8 (CH_2); 26.2 (CH_2); 25.7 (CH_2); 25.0 (CH_2); 15.3 (2 Me). EI-MS: 385 (2), 322 (22), 277 (8), 263 (14), 247 (15), 230 (15), 216 (10), 203 (12), 186 (32), 175 (21), 157 (20), 133 (67), 106 (100), 91 (91), 72 (73), 59 (98). HR-MS: 386.1601 (M^+, $C_{19}H_{30}O_4S_2^+$; calc. 386.1586).

3-{2-[1-(Benzyloxy)ethyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-ol (**15b-Bn**): From **11b-Bn** (2.71 g, 6.8 mmol). The crude product (2.71 g, 99%) consisted of two diastereoisomers. A pure sample of each diastereoisomer was obtained by FC (hexanes/AcOEt 95:5).

Diastereoisomer **15b-Bn-I**: IR (film): 3463*m*, 3087*w*, 3062*m*, 3030*m*, 2973*s*, 2929*s*, 2902*s*, 1497*m*, 1454m, 1443*m*, 1423*m*, 1417*m*, 1394*m*, 1374*m*, 1342*m*, 1328*m*, 1277*m*, 1242*m*, 1210*m*, 1093*s*, 1027*s*, 946*w*, 908*m*, 886*w*, 845*w*, 806*w*, 739*m*, 698*m*, 681*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.39–7.27 (*m*, 5 H); 4.72–4.59 (*m*, 2 H); 4.2 (*d*, *J* = 4.8, 1 H); 4.14–4.05 (*m*, 1 H); 4.02 (*d*, *J* = 2.9, 1 H); 3.95 (*q*, *J* = 6.5, 2 H); 3.85–3.52

(*m*, 4 H); 3.03–2.53 (*m*, 4 H); 2.19–1.76 (*m*, 3 H); 1.41 (*d*, *J* = 6.5, 3 H); 1.23 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 137.3 (C); 128.4 (2 CH); 127.9 (2 CH); 127.8 (CH); 104.6 (CH); 81.2 (CH); 72.9 (CH_2); 69.6 (CH); 63.8 (CH_2); 62.8 (CH_2); 57.4 (C); 35.7 (CH_2); 26.3 (CH_2); 25.1 (CH_2); 25.0 (CH_2); 15.4 (Me); 15.3 (Me); 14.6 (Me). EI-MS: 399 (1), 383 (5), 276 (4), 248 (6), 216 (8), 201 (11), 175 (24), 145 (21), 133 (67), 117 (53), 105 (80), 91 (90), 77 (83), 59 (100). HR-MS: 400.1732 (M^+, $C_{20}H_{32}O_4S_2^+$; calc. 400.1742).

Diastereoisomer **15b-Bn-II**: IR (film): 3462*m*, 3087*w*, 3062*w*, 3029*w*, 2973*s*, 2927*s*, 2897*s*, 1496*m*, 1453*m*, 1423*m*, 1341*m*, 1277*m*, 1244*m*, 1208*m*, 1094*s*, 1070*s*, 1028*s*, 952*w*, 909*m*, 886*w*, 878*w*, 801*w*, 737*s*, 698*s*, 676*w*, 665*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.41–7.24 (*m*, 5 H); 4.70–4.54 (*m*, 2 H); 4.32 (*d*, *J* = 5.1, 1 H); 4.28–4.19 (*m*, 1 H); 3.97 (*q*, *J* = 6.3, 1 H); 3.82–3.48 (*m*, 4 H); 3.25 (*d*, *J* = 2.7, 1 H); 2.89–2.81 (*m*, 4 H); 2.42 (*dd*, *J* = 1.4, 15.4, 1 H); 2.25–2.04 (*m*, 2 H); 2.01–1.58 (*m*, 1 H); 1.39 (*d*, *J* = 6.3, 3 H); 1.21 (*t*, *J* = 7.0, 3 H); 1.20 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 138.2 (C); 128.1 (2 CH); 127.4 (2 CH); 127.3 (CH); 104.4 (CH); 81.3 (CH); 72.2 (CH_2); 69.2 (CH); 63.2 (CH_2); 62.9 (CH_2); 56.8 (C); 37.2 (CH_2); 26.2 (CH_2); 26.0 (CH_2); 24.6 (CH_2); 15.2 (Me); 15.1 (Me); 14.8 (Me). EI-MS: 397 (1), 383 (2), 353 (2), 310 (3), 293 (4), 260 (6), 219 (18), 160 (10), 145 (13), 133 (34), 108 (40), 89 (91), 73 (87), 59 (100). HR-MS: 400.1740 (M^+, $C_{20}H_{32}O_4S_2^+$; calc. 400.1742).

3-{2-[1-(Benzyloxy)heptyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-ol (**15c-Bn**): From **11c-Bn** (1.69 g, 3.6 mmol). The crude product (1.69 g, 99%) consisted of two diastereoisomers. A pure sample of each diastereoisomer was obtained by FC.

Diastereoisomer **15c-Bn-I**: IR (film): 3462*s*, 3088*w*, 3063*m*, 3030*m*, 2973*s*, 2919*s*, 2871*s*, 1497*m*, 1454*s*, 1418*s*, 1395*m*, 1375*m*, 1343*m*, 1276*m*, 1242*m*, 1213*m*, 1063*s*, 1027*s*, 952*m*, 909*m*, 870*m*, 816*w*, 802*w* 727*s*, 698*s*, 679*w*, 665*w*, 605*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.40–7.26 (*m*, 5 H); 5.01–4.63 (*m*, 2 H); 4.42 (*d*, *J* = 4.6, 1 H); 4.17 (*d*, *J* = 2.7, 1 H); 4.15–4.07 (*m*, 1 H); 3.84–3.50 (*m*, 5 H); 3.06–2.54 (*m*, 5 H); 2.12–2.00 (*m*, 2 H); 1.96–1.76 (*m*, 3 H); 1.28 (br. *m*, 8 H); 1.23 (*t*, *J* = 7.0, 3 H); 1.22 (*t*, *J* = 7.0, 3 H); 0.91–0.84 (*m*, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 137.5 (C); 128.4 (2 CH); 127.9 (CH); 127.8 (2 CH); 104.6 (CH); 86.2 (CH); 77.5 (CH_2); 69.7 (CH); 63.9 (CH_2); 62.7 (CH_2); 58.1 (C); 36.1 (CH_2); 31.7 (CH_2); 31.2 (CH_2); 29.2 (CH_2); 27.1 (CH_2); 26.3 (CH_2); 25.1 (CH_2); 25.0 (CH_2); 22.6 (CH_2); 15.4 (Me); 15.3 (Me); 14.0 (Me). EI-MS: 448 (2), 408 (7), 374 (2), 347 (17), 316 (15), 257 (68), 209 (25), 169 (24), 145 (49), 133 (58), 106 (84), 91 (93), 73 (68), 59 (100). HR-MS: 470.2520 (M^+, $C_{25}H_{42}O_4S_2^+$; calc. 470.2525).

Diastereoisomer **15c-Bn-II**: IR (film): 3472*m*, 3087*w*, 3063*w*, 3029*m*, 2973*s*, 2930*s*, 1497*m*, 1454*s*, 1423*s*, 1394*s*, 1374*s*, 1342*m*, 1306*m*, 1277*m*, 1240*m*, 1211*m*, 1099*s*, 1028*s*, 946*w*, 910*m*, 886*w*, 843*m*, 815*w*, 802*w*, 735*m*, 697m, 676*w*, 666*w*, 600*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.42–7.25 (*m*, 5 H); 4.98–4.62 (*m*, 2 H); 4.34–4.25 (*m*, 2 H); 3.87–3.47 (*m*, 5 H); 3.21 (*d*, *J* = 2.2, 1 H); 2.94–2.82 (*m*, 4 H); 2.42 (*dd*, *J* = 1.4, 15.7, 1 H); 2.19–1.55 (*m*, 5 H), 1.27 (br. *m*, 8 H); 1.21 (*t*, *J* = 7.1, 3 H); 1.20 (*t*, *J* = 7.1, 3 H); 0.88 (*t*, *J* = 6.4, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 138.6 (C); 128.2 (2 CH); 127.4 (2 CH); 127.4 (CH); 104.5 (CH); 85.5 (CH); 75.8 (CH_2); 69.4 (CH); 63.4 (CH_2); 63.0 (CH_2); 57.7 (C); 37.3 (CH_2); 31.7 (CH_2); 31.7 (CH_2); 29.4 (CH_2); 27.3 (CH_2); 26.4 (CH_2); 26.2 (CH_2); 24.7 (CH_2); 22.6 (CH_2); 15.3 (Me); 15.2 (Me); 14.1 (Me). EI-MS: 431 (2), 385 (1), 364 (3), 319 (9), 301 (5), 270 (8), 257 (38), 243 (13), 231 (28), 217 (37), 169 (58), 145 (52), 132 (34), 103 (100), 91 (95), 75 (92), 59 (100). HR-MS: 470.2513 (M^+, $C_{25}H_{42}O_4S_2^+$; calc. 470.2525).

3-{2-[1-(Benzyloxy)-1-methylethyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-ol (**15e-Bn**): From **11e-Bn** (2.97 g, 7.2 mmol). Yield 96% (2.69 g) after FC. Clear liquid. IR (film): 3452*m*, 3088*w*, 3062*w*, 2974*s*, 2928*s*, 1497*w*, 1454*m*, 1444*m*, 1418*m*, 1389m, 1369*m*, 1343*m*, 1320*m*, 1278*m*, 1243*m*, 1203*m*, 1158*s*, 1139*s*, 1086*s*, 1062*s*, 1027*s*, 944*w*, 908*w*, 864*w*, 847*w*, 801*w*, 735*s*, 698*s*, 681*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.38–7.24 (*m*, 5 H); 4.64–4.50 (*m*, 2 H); 4.38 (*d*, *J* = 4.9, 1 H); 4.27–4.20 (*m*, 1 H); 3.96 (br. *s*, 1 H); 3.82–3.48 (*m*, 4 H); 3.06–2.57 (*m*, 5 H); 2.26–2.14 (*m*, 1 H), 2.06–1.78 (*m*, 2 H) ,1.65 (*s*, 3 H); 1.56 (*s*, 3 H); 1.21 (*t*, *J* = 7.1, 3 H); 1.19 (*t*, *J* = 7.1, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 138.4 (C); 128.3 (2 CH); 127.4 (CH); 127.4 (2 CH); 104.6 (CH); 83.8 (C); 70.0 (CH); 64.7 (CH_2); 63.8 (CH_2); 62.4 (C); 62.2 (CH_2); 37.3 (CH_2); 26.9 (CH_2); 26.9 (CH_2); 24.8 (CH_2); 21.7 (2 Me); 15.3 (2 Me). EI-MS: 368 (4), 323 (10), 261 (15), 236 (28), 203 (69), 175 (30), 165 (70), 145 (100), 107 (76), 87 (63), 73 (68). HR-MS: 369.1555 ($[M - EtO]^+$, $C_{19}H_{29}O_3S_2^+$; calc. 369.1558).

3-{2-[1-(Benzyloxy)cyclohexyl]-1,3-dithian-2-yl}-1,1-diethoxypropan-2-ol (**15f-Bn**): From **11f-Bn** (1.65 g, 3.7 mmol). Yield 95% (1.58 g) after FC. Clear liquid. IR (film): 3454*m*, 3088*w*, 3063*w*, 3031*w*,

2971*s*, 2930*s*, 2863*s*, 1496*m*, 1449*m*, 1421*m*, 1392*m*, 1374*m*, 1348*m*, 1325*m*, 1306*m*, 1276*m*, 1258*m*, 1242*w*, 1211*w*, 1142*s*, 1063*s*, 1026*s*, 944*m*, 909*m*, 886*m*, 854*m*, 817*w*, 785*w*, 734*m*, 697*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.41 – 7.21 (*m*, 5 H); 5.03 – 4.80 (*m*, 2 H); 4.56 (*s*, 1 H); 4.41 (*d*, *J* = 4.7, 1 H); 4.10 – 4.03 (*m*, 1 H); 3.85 – 3.50 (*m*, 4 H); 3.29 – 3.07 (*m*, 2 H); 2.89 (*d*, *J* = 16.2, 1 H); 2.80 – 2.53 (*m*, 3 H); 2.32 – 1.41 (*m*, 12 H); 1.22 (*t*, *J* = 7.0, 3 H); 1.21 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 138.4 (C); 128.4 (2 CH); 127.5 (CH); 127.4 (2 CH); 104.8 (CH); 83.6 (C); 69.8 (CH); 67.2 (CH_2); 64.1 (CH_2); 63.9 (C); 62.3 (CH_2); 36.9 (CH_2); 31.1 (CH_2); 28.6 (CH_2); 27.3 (CH_2); 25.1 (2 CH_2); 24.6 (CH_2); 22.2 (CH_2); 22.0 (CH_2); 15.4 (2 Me). EI-MS: 408 (1), 383 (1), 361 (2), 337 (1), 302 (3), 284 (1), 243 (3), 214 (4), 177 (4), 133 (11), 108 (100), 91 (84), 79 (97), 59 (31). HR-MS: 409.1883 ($[M - EtO]^+$, $C_{22}H_{33}O_3S_2^+$; calc. 409.1871).

9. *Synthesis of* **16-Bn** *by Dethioketalization of* **15-Bn**. 9.1. *Method 2: Typical Procedure.* To a soln. of **15a-Bn** (2.13 g, 5.50 mmol) and $CaCO_3$ (5.52 g, 55.2 mmol) in MeCN (48 ml), H_2O (12 ml), and THF (12 ml) at r.t., MeI (51.5 ml, 0.83 mol) was added. The mixture was heated to 50° and stirred for 42 h before quenching with sat. aq. NH_4Cl soln., followed by extracting with CH_2Cl_2 (3 ×). The combined extract was dried ($MgSO_4$) and concentrated and the crude green liquid (0.92 g) purified by FC: 0.46 g (28%) of **16a-Bn**. Yellow liquid.

9.2. *Method 3: Typical Procedure.* To a soln. of **15a-Bn** (0.39 g, 1.00 mmol) and $CaCO_3$ (0.25 g, 2.5 mmol) in MeCN (40 ml) and H_2O (10 ml) at r.t., MeI (2.5 ml) was added. The mixture was stirred at r.t. for 47 h before quenching with sat. aq. NH_4Cl soln., followed by extracting with CH_2Cl_2 (3 ×). The combined extract was dried ($MgSO_4$) and concentrated and the crude clear liquid (0.30 g) purified by FC: 0.25 g (84%) of **16a-Bn**. Clear liquid.

9.3. *Method 4: Typical Procedure.* A soln. of **15-Bn** (6.5 mmol) in MeCN (50 ml) and sat. aq. $NaHCO_3$ soln. (50 ml) was cooled to 0°, and I_2 (6.6 g, 26 mmol) was added portionwise during 10 min before stirring and attaining r.t. overnight. The mixture was quenched by adding sat. aq. $NaHCO_3$/sat. aq. $Na_2S_2O_4$ soln. 1:1 (50 ml) followed by extraction with CH_2Cl_2 (3 ×). The combined extract was dried ($MgSO_4$) and concentrated an the crude product subjected to FC (SiO_2, hexane/AcOEt): **16-Bn**.

9.4. *Products* **16-Bn**. *1-(Benzyloxy)-5,5-diethoxy-4-hydroxypentan-2-one* (**16a-Bn**): All the three methods were used at various scales. *Method 4* applied to 4.93 g (12.8 mmol) of **15a-Bn** gave, beside unreacted starting material, 2.02 g (54%) of **16a-Bn**. Yellowish liquid. IR (film): 3479*m*, 3088*w*, 3063*w*, 3031*w*, 2975*s*, 2928*s*, 2883*s*, 1725*s*, 1497*m*, 1454*m*, 1389*m*, 1374*m*, 1341*m*, 1310*m*, 1277*m*, 1208*m*, 1095*s*, 1063*s*, 1028*s*, 909*w*, 888*w*, 841*w*, 817*w*, 740*m*, 699*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.37 – 7.27 (*m*, 5 H); 4.60 (*s*, 2 H); 4.39 (*d*, *J* = 5.1, 1 H); 4.17 – 4.06 (*m*, 3 H); 3.82 – 3.48 (*m*, 4 H); 3.73 – 2.68 (*m*, 3 H); 1.21 (*t*, *J* = 7.0, 3 H); 1.20 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 207.9 (C); 137.1 (C); 128.4 (2 CH); 127.9 (CH); 127.9 (2 CH); 103.9 (CH); 75.3 (CH_2); 73.2 (CH_2); 68.5 (CH); 63.8 (CH_2); 63.5 (CH_2); 40.6 (CH_2); 15.3 (Me); 15.2 (Me). EI-MS: 295 (2), 278 (2), 265 (2), 251 (2), 233 (1), 219 (2), 205 (3), 187 (2), 175 (4), 157 (2), 144 (18), 129 (13), 107 (23), 103 (74), 91 (100), 75 (43), 65 (15), 59 (16).

2-(Benzyloxy)-6,6-diethoxy-5-hydroxyhexan-3-one (**16b-Bn**)*: Diastereoisomer* **16b-Bn-I**. *Method 4* applied to 0.79 g (2.0 mmol) of **15b-Bn-I** gave 0.24 g (39%) of **16b-Bn-I**. Slightly yellow liquid. IR (film): 3475*m*, 3088*w*, 3063*w*, 3031*w*, 2976*s*, 2930*s*, 2898*s*, 2874*s*, 1720*s*, 1497*m*, 1454*m*, 1372*m*, 1326*m*, 1308*m*, 1208*m*, 1095*s*, 1067*s*, 1028*s*, 912*w*, 818*w*, 788*w*, 737*m*, 698*m*, 665*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.37 – 7.28 (*m*, 5 H); 5.64 – 4.46 (*m*, 2 H); 4.42 (*d*, *J* = 5.2, 1 H); 4.20 – 4.10 (*m*, 1 H), 3.97 (*q*, *J* = 6.8, 1 H); 3.83 – 3.50 (*m*, 4 H); 2.85 (*d*, *J* = 6.4, 2 H); 2.32 – 2.13 (*m*, 1 H); 1.35 (*d*, *J* = 6.8, 3 H); 1.22 (*t*, *J* = 7.0, 3 H); 1.21 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.4 (C); 137.5 (C); 128.4 (2 CH); 127.8 (CH); 127.7 (2 CH); 103.8 (CH); 80.6 (CH); 71.8 (CH_2); 68.3 (CH); 63.7 (CH_2); 63.4 (CH_2); 39.1 (CH_2); 17.1 (Me); 15.3 (Me); 15.2 (Me). EI-MS: 365 (1), 219 (3), 201 (4), 175 (13), 158 (36), 135 (18), 129 (54), 103 (98), 91 (100), 75 (67), 59 (38). HR-MS: 265.1440 ($[M - EtO]^+$, $C_{15}H_{21}O_4^+$; calc. 265.1440).

Diastereoisomer **16b-Bn-II**. *Method 4* applied to 0.28 g (0.70 mmol) of **15b-Bn-II** gave 0.18 g (59%) of **16b-Bn-II**. Slightly yellow liquid. IR (film): 3467*m*, 3088*w*, 3063*w*, 3030*w*, 2976*s*, 2930*s*, 2899*s*, 1728*m*, 1497*m*, 1453*m*, 1420*w*, 1389*w*, 1373*w*, 1341*w*, 1315*w*, 1278*w*, 1257*w*, 1242*w*, 1207*w*, 1095*s*, 1064*s*, 1028*m*, 960*w*, 909*w*, 737*m*, 698*m*, 667*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.36 – 7.26 (*m*, 5 H); 5.61 – 4.45 (*m*, 2 H); 4.40 (*d*, *J* = 5.2, 1 H); 4.18 – 4.07 (*m*, 1 H); 3.97 (*q*, *J* = 6.9, 1 H), 3.82 – 3.49 (*m*, 4 H); 2.81 (*d*, *J* = 6.2, 2 H); 2.27 – 2.19 (*m*, 1 H); 1.34 (*d*, *J* = 6.9, 3 H); 1.21 (*t*, *J* = 7.0, 3 H); 1.20 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.2 (C); 137.4 (C); 128.3 (2 CH); 127.7 (CH); 127.7 (2 CH); 103.8 (CH); 80.6 (CH); 71.7 (CH_2); 68.3 (CH); 63.6 (CH_2); 63.3 (CH_2); 39.1 (CH_2); 16.9 (Me); 15.2 (Me); 15.1 (Me). EI-MS: 309 (1),

292 (2), 281 (1), 265 (3), 247 (2), 219 (5), 201 (7), 175 (40), 158 (75), 135 (58), 129 (90), 103 (93), 92 (77), 75 (100), 65 (72), 59 (90). HR-MS: 265.1452 ($[M-EtO]^+$, $C_{15}H_{21}O_4^+$; calc. 265.1440).

5-(Benzyloxy)-1,1-diethoxy-2-hydroxyundecan-4-one (**16c-Bn**)*: Diastereoisomer* **16c-Bn-I**. *Method 4* applied to 0.73 g (1.50 mmol) of **15c-Bn-I** gave 0.49 g (83%) of **16c-Bn-I**. Slightly yellow liquid. IR (film): 3483*m*, 3089*w*, 3064*w*, 3031*m*, 2973*s*, 2955*s*, 2928*s*, 2871*s*, 2860*s*, 1716*s*, 1497*m*, 1455*s*, 1394*m*, 1375*s*, 1334*m*, 1307*m*, 1286*m*, 1207*m*, 1066*s*, 1028*s*, 942*w*, 911*w*, 889*w*, 846*w*, 817*w*, 787*w*, 737*m*, 698*s*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.36–7.30 (*m*, 5 H); 4.67–4.37 (*m*, 2 H); 4.42 (*d*, *J* = 5.1, 1 H); 4.20–4.09 (*m*, 1 H); 3.84–3.50 (*m*, 5 H); 2.86–2.79 (*m*, 2 H); 2.29–2.19 (*m*, 1 H); 1.70–1.62 (*m*, 2 H); 1.43–1.26 (*m*, 8 H); 1.22 (*t*, *J* = 7.0, 3 H); 1.21 (*t*, *J* = 7.0, 3 H); 0.90–0.83 (*m*, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.8 (C); 137.5 (C); 128.3 (2 CH); 127.8 (2 CH); 127.7 (CH); 103.8 (CH); 84.8 (CH); 72.2 (CH_2); 68.2 (CH); 63.6 (CH_2); 63.2 (CH_2); 39.2 (CH_2); 31.8 (CH_2); 31.5 (CH_2); 28.9 (CH_2); 25.1 (CH_2); 22.4 (CH_2); 15.2 (Me); 15.1 (Me); 13.9 (Me). EI-MS: 379 (1), 362 (2), 335 (4), 317 (6), 289 (10), 271 (62), 259 (32), 243 (3), 228 (96), 206 (57), 199 (73), 175 (75), 157 (56), 149 (38), 129 (74), 110 (96), 102 (100), 88 (73), 71 (85), 59 (93). HR-MS: 352.2230 ($[M-EtO]^+$, $C_{20}H_{31}O_4^+$; calc. 335.2222).

Diastereoisomer **16c-Bn-II**. *Method 4* applied to 0.59 g (1.30 mmol) of **15c-Bn-II** gave 0.36 g (75%) of **16c-Bn-II**. Slightly yellow liquid. IR (film): 3488*m*, 3089*w*, 3064*w*, 3031*w*, 2972*s*, 2955*s*, 2870*s*, 2859*s*, 1717*s*, 1497*m*, 1455*m*, 1394*m*, 1375*m*, 1333*m*, 1307*m*, 1287*m*, 1207*w*, 1070*s*, 1028*m*, 943*w*, 910*w*, 887*w*, 847*w*, 817*w*, 786*w*, 736*m*, 698*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.36–7.30 (*m*, 5 H); 4.62–4.37 (*m*, 2 H); 4.41 (*d*, *J* = 5.2, 1 H); 4.18–4.07 (*m*, 1 H); 3.85–3.49 (*m*, 5 H); 2.80–2.77 (*m*, 2 H); 2.32–2.12 (*m*, 1 H); 1.73–1.62 (*m*, 2 H); 1.43–1.25 (*m*, 8 H); 1.22 (*t*, *J* = 7.0, 3 H); 1.20 (*t*, *J* = 7.0, 3 H); 0.90–0.83 (*m*, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.7 (C); 137.5 (C); 128.3 (2 CH); 127.8 (2 CH); 127.7 (CH); 103.8 (CH); 85.0 (CH); 72.3 (CH_2); 68.3 (CH); 63.5 (CH_2); 63.3 (CH_2); 39.3 (CH_2); 31.6 (CH_2); 31.5 (CH_2); 28.9 (CH_2); 25.0 (CH_2); 22.4 (CH_2); 15.2 (Me); 15.2 (Me); 13.9 (Me). EI-MS: 380 (1), 337 (1), 323 (1), 309 (1), 295 (2), 281 (1), 270 (1), 248 (1), 208 (9), 175 (6), 131 (14), 103 (13), 91 (100), 73 (30), 59 (41). HR-MS: 352.2214 ($[M-EtO]^+$, $C_{20}H_{31}O_4^+$; calc. 335.2222).

2-(Benzyloxy)-6,6-diethoxy-5-hydroxy-2-methylhexan-3-one (**16e-Bn**): *Method 4* applied to 2.68 g (6.50 mmol) of **15e-Bn** gave 1.90 g (91%) of **16e-Bn**. Slightly yellow liquid. IR (film): 3479*m*, 3089*w*, 3064*w*, 3031*w*, 2977*s*, 2930*m*, 2898*m*, 2877*m*, 1716*s*, 1497*w*, 1466*m*, 1454*m*, 1383*m*, 1344*w*, 1285*w*, 1232*w*, 1168*m*, 1139*m*, 1063*s*, 1029*s*, 933*w*, 911*w*, 888*w*, 781*w*, 736*m*, 698*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.39–7.24 (*m*, 5 H); 4.49–4.35 (*m*, 2 H); 4.42 (*d*, *J* = 5.3, 1 H); 4.21–4.10 (*m*, 1 H); 3.82–3.47 (*m*, 4 H); 3.08–2.80 (*m*, 3 H); 1.41 (*s*, 6 H); 1.21 (*t*, *J* = 7.0, 3 H); 1.18 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 213.9 (C); 138.3 (C); 128.2 (2 CH); 127.4 (CH); 127.3 (2 CH); 103.8 (CH); 82.0 (C); 68.4 (CH); 66.1 (CH_2); 63.5 (CH_2); 63.2 (CH_2); 37.9 (CH_2); 22.9 (Me); 22.8 (Me); 15.2 (Me); 15.1 (Me). EI-MS: 323 (2), 305 (2), 279 (4), 261 (3), 233 (3), 215 (18), 175 (78), 150 (83), 129 (68), 104 (77), 92 (100), 83 (91), 73 (89), 65 (97), 60 (88). HR-MS: 279.1590 ($[M-EtO]^+$; $C_{16}H_{23}O_4^+$; calc. 279.1596).

1-[1-(Benzyloxy)cyclohexyl]-4,4-diethoxy-3-hydroxybutan-1-one (**16f-Bn**): *Method 4* applied to 1.43 g (3.20 mmol) of **15f-Bn** gave 1.04 g (91%) of **16f-Bn**. Clear, colorless liquid. IR (film): 3498*m*, 3089*w*, 3064*w*, 3031*w*, 2974*s*, 2933*s*, 2860*s*, 1710*s*, 1497*m*, 1451*m*, 1377*m*, 1343*m*, 1280*m*, 1257*m*, 1212*w*, 1140*s*, 1084*s*, 1063*s*, 1028*s*, 956*m*, 914*w*, 890*w*, 852*w*, 736*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 7.43–7.26 (*m*, 5 H); 4.39 (*d*, *J* = 5.3, 1 H); 4.40–4.25 (*m*, 2 H); 4.20–4.09 (*m*, 1 H); 3.81–3.46 (*m*, 4 H); 3.03–2.78 (*m*, 2 H); 2.73 (*d*, *J* = 4.2, 1 H); 1.98–1.56 (*m*, 10 H); 1.21 (*t*, *J* = 7.0, 3 H); 1.17 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 214.7 (C); 138.3 (C); 128.3 (2 CH); 127.5 (2 CH); 127,4 (CH); 103.9 (CH); 82.9 (C); 68.5 (CH); 65.7 (CH_2); 63.6 (CH_2); 63.2 (CH_2); 37.7 (CH_2); 30.9 (CH_2); 30.7 (CH_2); 25.3 (CH_2); 21.4 (CH_2); 21.3 (CH_2); 15.3 (Me); 15.2 (Me).

10. *Dihydroxylated Ketones* **17** *by Hydrogenolytic Removal of the Bn Protection from* **16-Bn**: *Typical Procedure.* To a soln. of **16-Bn** (2.40 mmol) in 96% EtOH (50 ml), 5% Pd/C (0.4 g) was added. The mixture was stirred under H_2 for 1–3 d (TLC monitoring). Then the mixture was filtered through a *Celite* plug and the filtrate concentrated: **17** which appeared to be essentially pure.

5,5-Diethoxy-1,4-dihydroxypentan-2-one (**17a**): With 0.70 g (2.4 mmol) of **16a-Bn**: 0.48 g (99%) of **17a**. Clear, colorless liquid. IR (film): 3437*s*, 2976*s*, 2929*s*, 2900*s*, 1721*s*, 1481*m*, 1444*m*, 1398*m*, 1375*m*, 1345*m*, 1285*m*, 1121*s*, 1066*s*, 884*w*, 841*w*, 807*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.39 (*d*, *J* = 5.1, 1 H); 4.30 (*m*, 2 H); 4.11 (*m*, 1 H); 3.83–3.50 (*m*, 4 H); 3.29 (br. *s*, 1 H); 2.87 (br. *s*, 1 H); 2.75–2.56 (*m*, 2 H); 1.22 (*t*, *J* = 7.0, 3 H); 1.21 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 209.1 (C); 103.9 (CH); 68.9 (CH_2); 68.7

(CH); 64.0 (CH_2); 63.7 (CH_2); 40.1 (CH_2); 15.2 (Me); 15.1 (Me). EI-MS: 205 (1), 175 (63), 161 (38), 143 (88), 129 (90), 115 (63), 104 (79), 88 (80), 73 (90), 60 (100). HR-MS: 161.0811 ($[M-EtO]^+$, $C_7H_{13}O_4^+$; calc. 161.0814).

6,6-Diethoxy-2,5-dihydroxyhexan-3-one (**17b**)*: Diastereoisomer* **17b-I**. With 0.22 g (0.70 mmol) of **16b-Bn-I**: 0.14 g (91%) of **17b-I**. Clear, slightly yellow liquid. IR (film): 3420*s*, 2976*s*, 2931*s*, 2904*s*, 1717*s*, 1447*m*, 1374*s*, 1276*m*, 1023*s*, 913*m*, 733*s*, 666*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.41 (*d*, *J* = 5.1, 1 H); 4.29 (*q*, *J* = 7.1, 1 H); 4.13 (*dt*, *J* = 7.1, 5.1, 1 H); 3.83–3.49 (*m*, 6 H); 2.87–2.66 (*m*, 2 H); 1.38 (*d*, *J* = 7.1, 3 H); 1.22 (*t*, *J* = 7.0, 3 H); 1.21 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.2 (C); 103.7 (CH); 73.0 (CH); 68.7 (CH); 64.0 (CH_2); 63.6 (CH_2); 39.1 (CH_2); 19.3 (Me); 15.2 (Me); 15.1 (Me). EI-MS: 219 (1), 207 (2), 203 (3), 175 (52), 157 (18), 129 (72), 117 (18), 101 (100), 89 (63), 73 (71), 59 (88). HR-MS: 175.0966 ($[M-EtO]^+$, $C_8H_{15}O_4^+$; calc. 175.0970).

Diastereoisomer **17b-II**. With 0.12 g (0.40 mmol) of **16b-Bn-II**: 0.070 g (89%) of **17b-II**. Clear, colorless liquid. IR (film): 3454*s*, 2979*s*, 2931*s*, 2900*s*, 1766*w*, 1716*s*, 1481*m*, 1447*s*, 1374*s*, 1277*s*, 1052*s*, 912*m*, 818*w*, 805*w*, 733*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.42 (*d*, *J* = 5.0, 1 H); 4.29 (*q*, *J* = 7.1, 1 H); 4.13 (*dt*, *J* = 5.0, 7.0, 1 H); 3.84–3.50 (*m*, 6 H); 2.84–2.64 (*m*, 2 H); 1.38 (*d*, *J* = 7.1, 3 H); 1.22 (*t*, *J* = 7.1, 3 H); 1.21 (*t*, *J* = 7.1, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.2 (C); 103.8 (CH); 73.4 (CH); 68.7 (CH); 64.0 (CH_2); 63.7 (CH_2); 39.0 (CH_2); 19.2 (Me); 15.2 (Me); 15.1 (Me). EI-MS: 203 (1), 185 (2), 175 (3), 157 (6), 129 (33), 103 (100), 88 (27), 75 (70), 59 (26). HR-MS: 175.0964 ($[M-EtO]^+$, $C_8H_{15}O_4^+$; calc. 175.0970).

1,1-Diethoxy-2,5-dihydroxyundecan-4-one (**17c**)*: Diastereoisomer* **17c-I**. With 0.46 g (1.2 mmol) of **16c-Bn-I**: 0.36 g (99%) of **17c-I**. Clear, colorless liquid. IR (film): 3461*s*, 2973*s*, 2956*s*, 2927*s*, 2859*s*, 2872*s*, 1713*s*, 1456*m*, 1445*m*, 1394*m*, 1376*m*, 1344*m*, 1284*m*, 1221*m*, 1116*s*, 1066*s*, 1029*s*, 946*w*, 909*w*, 888*w*, 842*w*, 803*w*, 725*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.42 (*d*, *J* = 5.1, 1 H); 4.24–4.08 (*m*, 2 H); 3.83–3.49 (*m*, 5 H); 2.84–2.64 (*m*, 3 H); 1.91–1.73 (*m*, 2 H); 1.63–1.28 (*m*, 8 H); 1.22 (*t*, *J* = 7.0, 6 H); 0.91–0.85 (*m*, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.0 (C); 103.7 (CH); 76.8 (CH); 68.8 (CH); 64.0 (CH_2); 63.7 (CH_2); 39.4 (CH_2); 33.3 (CH_2); 31.6 (CH_2); 29.0 (CH_2); 24.7 (CH_2); 22.5 (CH_2); 15.2 (Me); 15.1 (Me); 14.0 (Me). EI-MS: 289 (1), 277 (1), 272 (1), 260 (1), 245 (2), 227 (3), 199 (16), 175 (3), 158 (4), 131 (40), 113 (14), 103 (100), 88 (73), 75 (61), 55 (54). HR-MS: 245.1759 ($[M-EtO]^+$, $C_{13}H_{25}O_4^+$; calc. 245.1753).

Diastereoisomer **17c-II**. With 0.34 g (0.90 mmol) of **16c-Bn-II**: 0.25 g (95%) of **17c-II**. Slightly yellow liquid. IR (film): 3465*s*, 2974*s*, 2956*s*, 2929*s*, 2872*s*, 2859*s*, 1764*w*, 1713*s*, 1456*m*, 1446*m*, 1393*w*, 1376*s*, 1344*m*, 1280*m*, 1066*s*, 910*w*, 886*w*, 844*w*, 803*w*, 733*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.42 (*d*, *J* = 4.9, 1 H); 4.24–4.09 (*m*, 2 H); 3.84–3.50 (*m*, 5 H); 3.11 (br. *s*, 1 H); 2.74–2.71 (*m*, 2 H); 1.91–1.72 (*m*, 2 H); 1.63–1.28 (*m*, 8 H); 1.23 (*t*, *J* = 7.1, 3 H); 1.22 (*t*, *J* = 7.1, 3 H); 0.91–0.85 (*m*, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 212.1 (C); 103.8 (CH); 77.3 (CH); 68.9 (CH); 64.0 (CH_2); 63.7 (CH_2); 39.2 (CH_2); 33.2 (CH_2); 31.6 (CH_2); 29.0 (CH_2); 24.8 (CH_2); 22.5 (CH_2); 15.3 (Me); 15.2 (Me); 14.0 (Me). EI-MS: 277 (1), 262 (2), 251 (1), 243 (1), 226 (1), 199 (8), 170 (2), 141 (9), 131 (100), 113 (12), 103 (7), 85 (36), 75 (4), 59 (86). HR-MS: 245.1757 ($[M-EtO]^+$, $C_{13}H_{25}O_4^+$; calc. 245.1753).

6,6-Diethoxy-2,5-dihydroxy-2-methylhexan-3-one (**17e**): With 0.16 g (0.50 mmol) of **16e-Bn**: 0.11 g (99%) of **17e**. Clear, colorless liquid. IR (film): 3461*s*, 2976*s*, 2931*s*, 1713*s*, 1463*m*, 1446*m*, 1374*s*, 1288*m*, 1440*s*, 1059*s*, 1029*s*, 969*m*, 910*m*, 889*w*, 796*w*, 783*w*, 665*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.43 (*d*, *J* = 5.0, 1 H); 4.20–4.10 (*m*, 1 H); 3.95 (br. *s*, 1 H); 3.83–3.47 (*m*, 4 H); 3.08 (br. *s*, 1 H); 2.96–2.73 (*m*, 2 H); 1.37 (*s*, 6 H); 1.22 (*t*, *J* = 7.0, 6 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 214.2 (C); 103.7 (CH); 76.4 (C); 68.6 (CH); 63.7 (CH_2); 63.5 (CH_2); 37.3 (CH_2); 26.1 (Me); 26.0 (Me); 15.1 (2 Me). EI-MS: 233 (1), 215 (1), 207 (1), 189 (2), 171 (18), 158 (8), 146 (18), 130 (15), 125 (14), 112 (86), 103 (100), 88 (94), 75 (70), 59 (88). HR-MS: 189.1111 ($[M-EtO]^+$, $C_9H_{17}O_4^+$; calc. 189.1127).

4,4-Diethoxy-3-hydroxy-1-(1-hydroxycyclohexyl)butan-1-one (**17f**). With 1.00 g (2.8 mmol) of **16f-Bn**: 0.74 g (99%) of **17f**. Clear, colorless liquid. IR (film): 3463*s*, 2975*s*, 2931*s*, 2862*s*, 1705*s*, 1481*m*, 1448*s*, 1375*s*, 1345*m*, 1262*s*, 1124*s*, 1061*s*, 1038*s*, 986*m*, 914*w*, 888*w*, 850*w*, 834*w*, 814*w*, 770*w*. ^{1}H-NMR (200 MHz, $CDCl_3$): 4.43 (*d*, *J* = 5.0, 1 H); 4.17–4.07 (*m*, 1 H); 3.84–3.50 (*m*, 5 H); 2.97–2.74 (*m*, 3 H); 1.75–1.48 (*m*, 10 H); 1.23 (*t*, *J* = 7.0, 3 H); 1.22 (*t*, *J* = 7.0, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 214.7 (C); 103.8 (CH); 78.2 (C); 67.0 (CH); 63.9 (CH_2); 63.6 (CH_2); 37.5 (CH_2); 33.6 (CH_2); 33.5 (CH_2); 25.2 (CH_2); 21.0 (CH_2); 20.9 (CH_2); 15.3 (2 Me). EI-MS: 229 (2), 211 (14), 186 (51), 158 (25), 130 (46), 99 (100), 88 (43), 75 (94), 55 (96). HR-MS: 229.1429 ($[M-EtO]^+$, $C_{12}H_{21}O_4^+$; calc. 229.1440).

11. *6-Hydroxy-2*H*-pyran-3(6*H*)-one* (**18**). A mixture of **17a** (40 mg, 0.19 mmol), MeCN (10 ml), and 50% HBF_4 soln. (0.5 ml) was stirred at r.t. After 18 h, H_2O was added, and the hydrolyzate was extracted with CH_2Cl_2. The combined org. extract was dried ($MgSO_4$) and concentrated: 20 mg (90%) of essentially pure **18**. Brown liquid. Spectroscopic data: in agreement with those reported in [15].

12. *Dihydro-2,2-dimethyl-5*H*-1,3-dioxolo[4,5-*b*]pyran-6(3a*H*)-one* (**19**). To a soln. of **17a** (0.060 g, 0.29 mmol) in acetone (20 ml), H_2O (3 drops) and conc. H_2SO_4 soln. (0.4 ml) were added. The mixture was stirred at 0° for 1 h, and H_2O was added before extraction with CH_2Cl_2. The combined org. extract was dried ($MgSO_4$) and concentrated and the crude product (0.35 g) purified by FC: 30 mg (60 %) of **19**. Clear liquid. IR (film): 2983*s*, 2935*s*, 1740*s*, 1675*m*, 1615*w*, 1454*m*, 1418*m*, 1380*s*, 1311*m*, 1256*s*, 1216*s*, 1179*s*, 1117*s*, 1070*s*, 1027*s*, 993*s*, 928*s*, 868*s*, 806*m*, 746*w*, 671*m*. ^{1}H-NMR (200 MHz, $CDCl_3$): 5.67 (*d*, *J* = 5.1, 1 H); 4.70 (*dt*, *J* = 3.1, 5.1, 1 H); 4.09 (*m*, 2 H); 2.75 (*m*, 2 H); 1.53 (*s*, 3 H); 1.37 (*s*, 3 H). ^{13}C-NMR (50 MHz, $CDCl_3$): 207.1 (C); 109.2 (C); 96.9 (CH); 72.7 (CH); 66.5 (CH_2); 39.0 (CH_2); 25.6 (Me); 25.0 (Me). EI-MS: 172 (M^+, 1), 157 (20), 126 (10), 115 (12), 97 (8), 85 (20), 59 (31), 55 (11), 43 (100). HR-MS: 172.073124 (M^+, $C_8H_{12}O_4^+$; calc. 172.073559).

REFERENCES

[1] L. K. Sydnes, *Eur. J. Org. Chem*. **2000**, 3511; O. H. Kvernenes, L. K. Sydnes, *Org. Synth.* **2005**, *83*, 184; L. K. Sydnes, B. Holmelid, O. H. Kvernenes, M. Sandberg, M. Hodne, E. Bakstad, *Tetrahedron* **2007**, *63*, 4144; B. Holmwelid, O. H. Kvernenes, M. Hodne, L. K. Sydnes, *Arkivoc* **2008**, *vi*, 26

[2] L. K. Sydnes, S. Valdersnes, *Pure Appl. Chem.* **2007**, *79*, 2137.

[3] L. K. Sydnes, B. Holmelid, O. H. Kvernenes, S. Valdersnes, M. Hodne, K. Boman, *Arkivoc* **2008**, *xiv*, 242.

[4] L. K. Sydnes, B. Holmelid, M. Sengee, M. Hanstein, *J. Org. Chem*. **2009**, *74*, 3430.

[5] S. Valdersnes, L. K. Sydnes, *Eur. J. Org. Chem.* **2009**, 5816.

[6] M. Sengee, L. K. Sydnes, *Pure Appl. Chem*. **2011**, *83*, 587.

[7] M. Sengee, L. K. Sydnes, *Synthesis* **2011**, 3899.

[8] M. J. Gaunt, H. F. Sneddon, P. R. Hewitt, P. Orsini, D. F. Hook, S. V. Ley, *Org. Biomol. Chem.* **2003**, 15; H. F. Sneddon, M. J. Gaunt, S. V. Ley, *Org. Lett*. **2003**, *5*, 1147.

[9] A. Malabarba, T. I. Nicas, R. C. Thompson, *Med. Res. Rev.* **1997**, *17*, 69.

[10] D. A. Thayer, C.-H. Wong, *Chem. – Asian J.* **2006**, *1*, 445.

[11] N. B. Lorette, W. L. Howard, J. H. Brown, *J. Org. Chem*. **1959**, *24*, 1731.

[12] G. S. Zweifel, M. H. Nantz, 'Modern Organic Synthesis: An Introduction', W. H. Freeman & Co., New York, 2007.

[13] E. Wenkert, T. E.Goodwin, *Synth. Commun.* **1977**, *7*, 409.

[14] T. W. Greene, P. G. M. Wuts, 'Protective Groups in Organic Synthesis', 2nd edn., John Wiley & Sons, New York, 1991.

[15] T. Ishikawa, T. Mizuta, K. Hagiwara, T. Aikawa, T. Kudo, S. Saito, *J. Org. Chem.* **2003**, *68*, 3702.

[16] H. D. Verkruijsse, L. Brandsma, *Synth. Commun*. **1990**, *20*, 3355; H. D. Verkruijsse, L. Brandsma, *Synth. Commun*. **1991**, *21*, 657.

[17] A. M. Felix, E. P. Heimer, T. J. Lambros, C. Tzougraki, J. Meinenhofer, *J. Org. Chem.* **1978**, *43*, 4194; M. Eckert-Maksic, D. Margetic, *Energy Fuels* **1991**, *5*, 327; F. Pinna, F. Menegazzo, M. Signoretto, P. Canton, G. Fagherazzi, N. Pernicone, *Appl. Catal., A* **2001**, *219*, 195.

[18] A. T. Khan, E. Mondal, P. R. Sahu, *Synlett* **2003**, 377.

[19] A. B. Smith III, S. M. Condon, J. A. McCauley, J. L. Leazer Jr., J. W. Leahy, R. E. Maleczka, *J. Am. Chem. Soc.* **1997**, *119*, 947.

[20] A. F. Petri, S. M. Kuhnert, F. Scheufler, M. E. Maier, *Synthesis* **2003**, 940.

Received August 7, 2012