Synthetic Communications

ISSN: 0039-7911 (Print) 1532-2432 (Online) Journal homepage: http://www.tandfonline.com/loi/lsyc20

Reductive Cleavage of 2,2,2-Trichloroethyl Esters with Sodium Telluride

Gonzalo Blay , Luz Cardona , Begoña García , Cristina L. García & José R. Pedro

To cite this article: Gonzalo Blay , Luz Cardona , Begoña García , Cristina L. García & José R. Pedro (1998) Reductive Cleavage of 2,2,2-Trichloroethyl Esters with Sodium Telluride, Synthetic Communications, 28:8, 1405-1414, DOI: 10.1080/00397919808006839

To link to this article: http://dx.doi.org/10.1080/00397919808006839

SYNTHETIC COMMUNICATIONS, 28(8), 1405-1414 (1998)

REDUCTIVE CLEAVAGE OF 2,2,2-TRICHLOROETHYL ESTERS WITH SODIUM TELLURIDE

Gonzalo Blay, Luz Cardona, Begoña García, Cristina L.García and José R. Pedro*

Departament de Química Orgànica, Facultat de Química, Universitat de València, E-46100 Burjassot (València) Spain.

Abstract: Carboxylic acids are regenerated from their 2,2,2,-trichloroethyl esters by treatment with sodium telluride in dimethylformamide in smooth conditions and with good yields. The reaction conditions are compatible with other functional and protective groups such as methyl ester, acetate or *tert*-butyldimethylsilyl ethers.

Chemoselectivity in functional groups transformations remains a central problem in organic synthesis. In some cases, protection of functional groups allows to overcome this kind of problems. Carboxylic acids are usually protected as esters, being methyl esters one of the most common.[1] However the strongly acidic or basic conditions required for their removal may be disadvantageous. In such circumstances, *tert*-butyl esters, which can be removed by mild acid treatment, benzyl esters, which can be debenzylated by catalytic hydrogenolysis or 2-halo- and 2,2,2,-trihaloethyl esters may be more useful.

2-Chloro- and 2,2,2-trichloroethyl esters are usually deprotected in reductive conditions by treatment with Zn,[2] although other reductive methods such as

* To whom the correspondence should be addressed

electrolysis[3] and treatment with a catalytic amount of selenium in the presence of sodium borohydride[4] have been introduced later.

In the context of our work on the reactivity of sodium hydrogen telluride and sodium telluride towards functional substrates,[5] we report here the reductive cleavage of 2,2,2-trichloroethyl esters with sodium telluride (FIG.). The reagent is easily prepared by refluxing sodium borohydride and elemental tellurium in ethanol or in an aprotic solvent such as dimethylformamide (DMF).

Zhou et al.[6] have reported previously the reductive cleavage of 2-chloroethyl esters of aromatic acids and 2-bromoethyl esters of aliphatic acids with NaTeH in EtOH. A catalytic modification of this procedure has been devised by the same authors.[7]

However, when 2,2,2-trichloroethyl undecylenate (**1d**) was subjected to the conditions described by Zhou in no buffered EtOH, cleavage of the ester to give undecylenic acid (**2d**) was accompanied by transesterification to the ethyl ester,[8] giving a *ca.* 1:1 (GC-MS) mixture of both compounds. When the reaction was attempted in AcOH buffered EtOH,[9] we did not observe any reaction after two days at room temperature. Most surely, the ethyl ester arises from nucleophylic attack of an alcoholate anion formed during refluxing Na BH_4 in ethanol. Probably the greater electron-withdrawing ability of the trichloroethyl group is responsible for the different outcome of the reaction when compared with monochloroethyl

$$RCOOCH_2CCl_3 \xrightarrow[DMF]{Te^{2-}} RCOOH$$

FIG.

esters. For this reason, we decided to check the deprotection of 2,2,2-trichloroethyl esters in absence of alcoholic solvents.

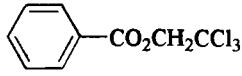
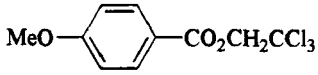
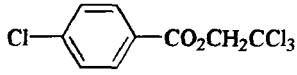
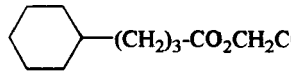
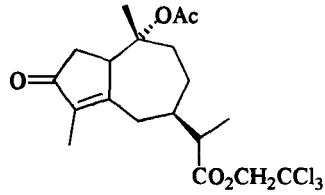
When trichloroethyl esters were treated with Na_2Te in DMF at room temperature the carboxylic acids were regenerated in good yields, although an excess of reagent was needed to ensure completion of the starting material. The results are summarized in the table.

The yields of deprotected aromatic acids (entries 1-3) were higher than 90%, either with electron donating or electron withdrawing substituents on the aromatic ring. Na_2Te also brought about the reductive cleavage of trichloroethyl esters of aliphatic acids in good yields. The reaction conditions are compatible with other functional and protective groups, such as methyl esters (entry 5), acetate (entry 7), or *tert*-butyldimethylsylil ethers (entry 8). The example in entry 10 with a guaiane acid bearing acetate and enone moieties illustrates the applicability of these conditions in the synthesis of natural products. With trichloroethyl ester of α,β–unsaturated acid **1k** reduction of the double bond, although some slower, occurred at a competitive rate, and therefore it was not possible to deprotect this kind of acids without affecting the double bond. However, it is possible to achieve reduction to the saturated acid by using a larger excess of reagent. Other electrophylic functional groups, such as epoxide (**1l**) or halides (**1m**) are not compatible with the reaction conditions as nucleophylic attack by telluride anion occurs on these groups.

EXPERIMENTAL

NMR spectra were run in a Bruker AC-200 instrument (200.1 MHz for ^1H NMR and 50.3 MHz for ^{13}C NMR) in $CDCl_3$. Mass spectra (CI) were recorded using

Table: Reductive Cleavage of 2,2,2-Trichloroethyl Esters

Entry		$RCO_2CH_2CCl_3$ (1)	RCO_2H (2) (Yield %)[a]
1	a		98
2	b		90
3	c		90
4	d	CH_2=CH-$(CH_2)_8$-$CO_2CH_2CCl_3$	87
5	e	MeO_2C-$(CH_2)_8$-$CO_2CH_2CCl_3$	82
6	f	HO-$(CH_2)_9$-$CO_2CH_2CCl_3$	92
7	g	AcO-$(CH_2)_9$-$CO_2CH_2CCl_3$	74[b]
8	h	TBDMSi-O-$(CH_2)_9$-$CO_2CH_2CCl_3$	85
9	i		94
10	j		81

[a] Yields refer to isolated and chromatographically pure compounds.
[b] Starting material (20 %) was also recovered.

$CH_3(CH_2)_4HC$=$CHCO_2CH_2CCl_3$ **1k**

$CH_3(CH_2)_7HC$$CH(CH_2)_7CO_2CH_2CCl_3$ **1l**

Br-$(CH_2)_9$-$CO_2CH_2CCl_3$ **1m**

methane as ionizating gas. All the trichloroethyl esters were obtained by esterification of the corresponding acids[10] or acyl halides by standard procedures. The structures of the recovered acids **2 a-d**, **2f**, and **2i** were ascertained by comparison of their spectroscopic constants with those of commercially available acids and structure of **2j** by comparison of its methyl ester (diazomethane) with literature data.[11]

General procedure

Te powder (160 mg, 1.5 mmol) and $NaBH_4$ (49 mg, 1.5 mmol) in DMF (2 mL) were heated under argon at 80°C for 30-45 min. The resulting deep purple mixture was allowed to reach room temperature and the substrate (0.5 mmol) in DMF (1 mL) was added. A dark precipitate and gas evolution was observed immediately. The mixture was stirred overnight and after this time opened to air and 2M HCl was added. The mixture was filtered, extracted with EtOAc and the extract washed with brine and chromatographed on silica gel (hexane-EtOAc) to afford the desired acid.

2',2',2'-Trichloroethyl benzoate (**1a**)

^{1}H NMR δ 4.94 (s, 2H), 7.45 (t, J = 8 Hz, 2H), 7.59 (t, J = 8 Hz, 1H), 8.10 (d, J = 8 Hz, 2H); ^{13}C NMR δ 74.3 (t), 94.9 (s), 128.5 (d), 129.9 (d), 133.8 (d), 164.9 (s); MS *m/e* 257, 255, 253 (M^++1, 5, 15, 15), 221, 219, 217 (M^+-Cl, 10, 48, 71), 123 (64), 105 (100).

2',2',2'-Trichloroethyl 4-chlorobenzoate (**1b**)

^{1}H NMR δ 4.95 (s, 2H), 7.45 (d, J = 8.5 Hz, 2H), 8.05 (d, J = 8.5 Hz, 2H); ^{13}C NMR δ 74.3 (t), 94.8 (s), 126.9 (s), 128.8 (d), 131.2 (d), 140.2 (s), 163.7 (s); MS

m/e 293, 291, 289, 287 (M^++1, 5, 23, 44, 30), 292, 290, 288, 286 (M+, 3, 10, 14, 8), 255, 253, 251 (M^+-Cl, 14, 41, 36), 139 (82), 49 (100).

2',2',2'-Trichloroethyl 4-methoxybenzoate (**1c**)

^{1}H NMR δ 3.88 (s, 3H), 4.92 (s, 2H), 6.94 (d, J = 9.0 Hz, 2H), 8.07 (d, J = 9.0 Hz, 2H); ^{13}C NMR δ 55.3 (q), 74.1 (t), 95.2 (s), 113.8 (d), 120.8 (s), 132.1 (d), 163.9 (s), 164.4 (s); MS *m/e* 287, 285, 283 (M^++1, 37, 45, 45), 286, 284, 282 (M^+, 35, 45, 41), 251, 249, 247 (M^+-Cl, 29, 46, 50), 153 (62), 135 (100).

2',2',2'-Trichloroethyl undecylenate (**1d**)

^{1}H NMR δ 1.1-1.4 (m, 10H), 1.63 (m, 2H), 1.98 (m, 2H), 2.39 (t, J = 7.3 Hz), 4.68 (s, 2H), 4.86 (dd, J = 1.5, 9.0 Hz, 1H), 4.92 (dd, J = 1.5, 15.5 Hz, 1H), 5.73 (m, 1H); ^{13}C NMR δ 24.7 (t), 28.8 (t), 28.9 (t), 29.1 (t), 29.2 (t), 32.7 (t), 33.8 (t), 73.7 (t), 94.8 (s), 114.2 (t), 138.9 (d), 171.8 (s); MS *m/e* 317, 315 (M^++1, 2, 2), 281, 279 (M^+-Cl, 7, 5), 167 (9), 41 (20), 29 (100).

2',2',2'-Trichloroethyl 9-methoxycarbonylnonanoate (**1e**)

^{1}H NMR δ 1.1-1.4 (m, 8H), 1.4-1.6 (m, 4H), 2.13 (t, J = 7.3 Hz, 2H), 2.29 (t, J = 7.4 Hz, 2H), 3.48 (s, 3H), 4.58 (s, 2H); ^{13}C NMR δ 24.5 (t), 24.6 (t), 28.8 (t), 33.6 (t), 33.7 (t), 51.2 (q), 73.6 (t), 95.0 (s), 171.7 (s), 173.9 (s); MS *m/e* 351, 349, 347 (M^++1, 2, 8, 8), 319, 317, 315 (M+-MeO, 23, 54, 57), 199 (100).

2',2',2'-Trichloroethyl 10-hydroxydecanote (**1f**)

^{1}H NMR δ 1.1-1.5 (m, 12H), 1.5-1.8 (m, 4H), 2.44 (t, J = 7.3 Hz, 2H), 3.62 (t, J = 6.5 Hz, 2H), 4.72 (s, 2H); ^{13}C NMR δ 24.5 (t), 25.7 (t), 28.8 (t), 28.9 (t), 29.2 (t), 32.4 (t), 33.7 (t), 62.4 (t), 73.6 (t), 94.9 (s), 172.0 (s); MS *m/e* 323, 321, 319

(M^++1, 11, 38, 40), 305, 303, 301 (M^+- H_2O, 7, 22, 23), 287, 285, 283 (M^+-Cl, 33, 78, 85), 171 (90), 153 (100).

2',2',2'-Trichloroethyl 10-acetoxydecanoate (**1g**)

^{1}H NMR δ 1.2-1.4 (m, 12H), 1.5-1.8 (m, 4H), 2.01 (s, 3H), 2.43 (t, J = 7.5 Hz, 2H), 4.02 (t, J = 6.7 Hz, 2H), 4.71 (s, 2H); ^{13}C NMR δ 20.8 (q), 24.5 (t), 25.7 (t), 28.4 (t), 28.8 (t), 28.9 (t), 29.0 (t), 33.7 (t), 64.3 (t), 73.6 (t), 94.9 (s), 170.8 (s), 171.8 (s); MS *m/e* 365, 363, 361 (11, 32, 33), 329, 327, 325 (M^+-Cl, 10, 44, 53), 213 (100).

2',2',2'-Trichloroethyl 10-*tert*-butyldimethylsilyloxydecanoate (**1h**)

^{1}H NMR δ 0.03 (s, 6H), 0.87 (s, 9H), 1.1-1.5 (m, 10H), 1.5-1.7 (m, 4H), 2.44 (t, J = 7.3 Hz, 2H), 3.57 (t, J = 6.5 Hz, 2H), 4.72 (s, 2H); ^{13}C NMR δ -5.2 (q), 18.4 (s), 24.7 (t), 25.8 (t), 25.9 (q), 29.0 (t), 29.1 (t), 29.3 (t), 32.8 (t), 33.9 (t), 63.2 (t), 73.8 (t), 94.8 (s), 172.1 (s); MS *m/e* 437, 435, 433 (M^++1, 12, 35, 43), 421, 419, 417 (M^+-Me, 17, 49, 48), 401, 399, 397 (M^+-Cl, 20, 78, 91), 379, 377, 375 (M^+-C_4H_9, 47, 100, 100).

2',2',2'-Trichloroethyl 4-cyclohexylbutanoate (**1i**)

^{1}H NMR δ 0.86 (m, 2H), 1.1-1.3 (m, 6H), 1.5-1.7 (m, 7H), 2.42 (t, J = 7.5 Hz, 2H), 4.72 (s, 2H); ^{13}C NMR δ 22.1 (t), 26.3 (t), 26.6 (t), 33.2 (t), 34.2 (t), 36.7 (t), 37.3 (t), 73.8 (t), 95.0 (s), 172.1 (s); MS *m/e* 305, 303, 301 (M^++1, 4, 13, 16), 269, 267, 265 (M^+-Cl, 4, 14, 17), 135 (17), 41 (100).

2',2',2'-Trichloroethyl ester of guaiane acid (**1j**)

^{1}H NMR (main peaks) δ 1.00 (s 3H), 1.22 (d, J = 6.9 Hz, 3H), 1.62 (d, J = 1.1

Hz, 3H), 1.94 (s, 3H), 4.02 (brs, 1H), 4.65 (d, J = 12.0 Hz, 1H), 4.83 (d, J = 12.0 Hz); ^{13}C NMR δ 8.2 (q), 12.6 (q), 19.2 (q), 22.4 (q), 28.6 (t), 35.7 (t), 37.1 (t), 38.2 (d), 38.7 (t), 45.3 (d), 48.5 (d), 73.9 (t), 86.0 (s), 94.9 (s), 138.7 (s), 170.2 (s), 170.3 (s), 173 (s), 207.2 (s); MS *m/e* 411, 409, 407 (M^+ -MeO, 12, 30, 34), 399, 397, 395 (M^+-MeCO, 5, 13, 20), 383, 381, 379 (M^+-MeCOO, 68, 100, 100).

9- Methoxycarbonylnonanoic acid (**2e**)

^{1}H NMR δ 1.1-1.4 (m, 8H), 1.5-1.7 (m, 4H), 2.29 (t, J = 7.5 Hz, 2H), 2.56 (t, J = 7.6 Hz, 2H), 3.62 (s, 3H); ^{13}C NMR δ 24.5 (t), 24.8 (t), 28.9 (t), 33.9 (t), 51.4 (q), 174.3 (s), 180.1 (s); MS *m/e* 217 (M^++1, 45), 200 (68), 199 (100).

10-Acetoxydecanoic acid (**2g**)

^{1}H NMR δ 1.2-1.4 (m, 12H), 1.4-1.6 (m, 4H), 1.99 (s, 3H), 2.29(t, J = 7.5 Hz, 2H), 3.99 (t, J = 7.0 Hz, 2H), ^{13}C NMR δ 20.8 (q), 24.4 (t), 25.6 (t), 28.3 (t), 28.8 (t), 28.9 (t), 29.0 (t), 33.8 (t), 64.5 (t), 171.2 (s), 179.8 (s); MS *m/e* 231 (M^++1, 74), 214 (M+-OH, 68), 213 (M^+-H_2O, 100), 153 (84).

10-*tert*-Butyldimethylsilyloxydecanoic acid (**2h**)

^{1}H NMR δ 0.02 (s, 6H), 0.86 (s, 9H), 1.1-1.4 (m, 10H), 1.4-1.7 (m, 4H), 2.31 (t, J = 7.4 Hz, 2H), 3.57 (t, J = 6.5 Hz, 2H); ^{13}C NMR δ -5.3 (q), 18.3 (s), 24.7 (t), 25.7 (t), 25.9 (q), 29.0 (t), 29.2 (t), 29.3 (t), 32.8 (t), 34.1 (t), 63.3 (t), 180.1 (s); MS *m/e* 303 (M^++1, 42), 285 (62), 269 (55), 245 (52, 227 (100).

Acknowledgement

Financial support from DGICYT (project PB94-0985) is gratefully acknowledged.

References and footnotes

1. a) Kocienski, P.J. *Protecting Groups*; Georg Thieme Verlag: Stuttgart, 1994. b) Greene, T.W.; Wuts, P.G.M. Protective groups in Organic Synthesis; John Wiley & sons inc.: New York, 1991.
2. Woodward, R.B.; Hensler, K.; Gosteli, J.; Naegeli, R.; Oppolzer, W.; Ramage, R.; Ranganathan, S.; Korbrüggen, H. *J.Am.Chem.Soc.* **1966**, *88*, 852.
3. Semmelhack, M.F.; Heinshon, G.E. *J.Am.Chem.Soc.* **1972**, *94*, 5139.
4. Huang, Z-Z.; Zhou, X-J. *Synthesis* **1989**, 693.
5. a) Blay, G.; Cardona, L.; García, B.; Pedro, J.R. *Synlett* **1995**, 1189. b) Blay, G.; Cardona, L.; García, B.; Lahoz, L.; Pedro, J.R. *Tetrahedron* **1996**, 52, 8611. c) Bargues, V.; Blay, G.; Fernández, I.; Pedro, J.R. *Synlett* **1996**, 655.
6. Chen, J.; Zhou, X-J. *Synthetic Comm.* **1987**, *17*, 161.
7. Huang, Z-Z.; Zhou, X-J. *Synthesis* **1990**, 633.
8. Sodium hydrogen telluride catalyzed transesterifications of alkyl and aryl esters of aromatic carboxylic acids to ethyl esters in EtOH have been reported previously. In order to test the role of sodium telluride in the transesterifcation of **1d** the following blank probe was carried out: Sodium borohydride (1.5 eq) was refluxed in ethanol for 45 minutes, and to the resulting solution was added **1d** at room temperature. After completion of the starting material, a *ca.* 9:1 (GC-MS) mixture of ethyl undecylenate and 11-undecenol resulting from the reduction of the ester group was obtained. It seems from this reult that NaTeH is not essential in this case. See: Suresh, J.R.; Mohan, P.S.; Shanmugam, P. *Indian J. Chem. Sect. B* **1994**, *33B*, 290
9. Barton, D.H.R.; McCombie, S.W. *J.Chem.Soc. Perkin Trans. I* **1975**, 1574.
10. Hamada, Y.; Kondo Y.; Shibata M.; Shioiri, T.J. *J.Am.Chem.Soc.* **1989**, *111*, 669.

11. a) Bargues, V.; Blay, G.; Cardona, L.; García, B.; Pedro, J.R. *Tetrahedron Lett.* **1995**, *36*, 8469. b) Francisco, C.G.; Freire, R.; Rodríguez, M.S.; Suárez, E. *Tetrahedron Lett.* **1991**, *32*, 3413.

(Received in the UK 16 September 1997)