Trichloroisocyanuric Acid as a Mild and Efficient Catalyst for Thioacetalization and Transthio-acetalization Reactions

H. Firouzabadi,* N. Iranpoor,* H. Hazarkhani

Department of Chemistry, College of Sciences, Shiraz University, Shiraz 71454, Iran
Fax +98(0711)2220027; E-mail: firouzabadi@chem.susc.ac.ir

Received 5 June 2001

Abstract: Trichloroisocyanuric acid (**1**), a cheap industrial chemical, catalyzes mild and efficient thioacetalization and transthioacetalization reactions. In addition, this catalyst is very selective for this purpose.

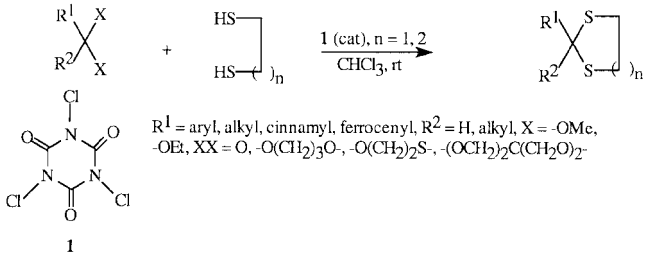
Key words: trichloroisocyanuric acid, thioacetals, protection, transdithioacetalization, carbonyl compounds

The protection of carbonyl compounds as 1,3-dithiolanes and 1,3-dithianes is a widely used method and has generally been prepared by protic or Lewis acids.[1] Transthioacetalization of acetals has also been used as an alternative method for the preparation of thioacetals.[2]

However, there are shortcomings for the use of acids in thioacetalization of carbonyl compounds namely harsh reaction conditions, stoichiometric use of expensive reagents and poor chemoselectivity. Many methods are reported such as lithium perchlorate in diethyl ether,[3] magnesium or zinc triflate,[4a] copper triflate,[4b] lanthanum chloride,[5] Nafion-H.[6] But the chemoselectivity between carbonyl functions has been reported with silica gel–thionyl chloride,[7a] Amberlyst-15 catalyst,[7b] indium chloride,[7c] tantalum(V) chloride–silica gel,[7d] bismuth(III) halides or sulfate,[7e] Fe^{3+}-montmorilonite.[7f] Very recently, we have introduced some efficient catalysts for chemoselective thioacetalization reactions.[8]

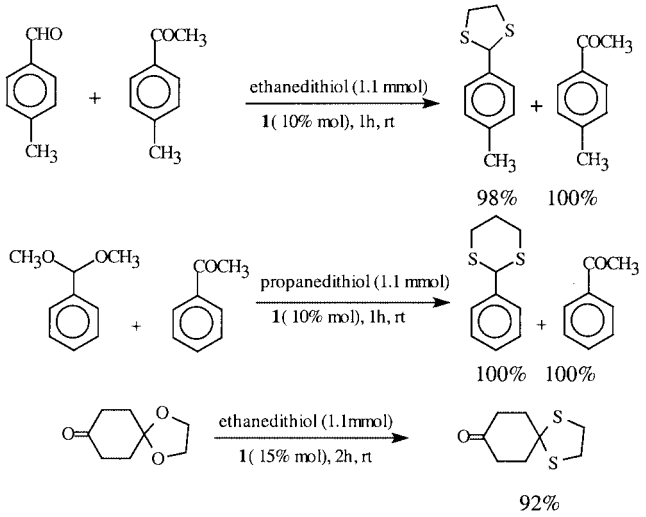
In continuation of our studies in this regard, we have found that trichloroisocyanuric acid (**1**) a cheap commercially available reagent used primarily as a disinfectant and deodorant, has found little application in organic chemistry. To the best of our knowledge it has been used for allylic halogenation,[9a] α-halogenation of saturated cyclic ethers,[9b] direct conversion of ethers to esters,[9c] chlorination of aromatic systems[9d] and deprotection of thioacetals.[9e] Very recently, a trichlorocyanuric acid/triphenylphosphine mixture was used for the conversion of alcohols into the corresponding alkyl halides.[10]

We now report that **1** catalyzes thioacetalization and transthioacetalization reactions at room temperature in $CHCl_3$ (Scheme 1).[11]



Scheme 1

As shown in the Table, aromatic and aliphatic aldehydes, *O*,*O*-acetals, *O*,*O*-ketals and *O*,*S*-acetals were cleanly converted into their 1,3-dithiolanes and 1,3-dithianes in excellent yields at room temperature. However, ketones were thioketalized after prolonged reaction times in poor to good yields. In order to show the high chemoselectivity of the method we have carried out the successful protection of an aldehyde in the presence of a ketone and the transthioacetalization of an acetal in the presence of a ketone (Scheme 2). The ratio of the products was determined by ^1H NMR analysis of the crude reaction mixture.



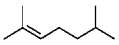
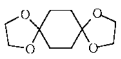
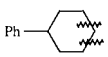
Scheme 2

In summary, in this study we have introduced a new and useful catalytic application of trichloroisocyanuric acid as an efficient catalyst for the thioacetalization of aldehydes, *O*,*O*-acetals and *S*,*O*-acetals under mild reaction conditions. The method is highly chemoselective.

Synlett 2001, No. 10, 28 09 2001. Article Identifier:
1437-210X,E;2001,0,10,1641,1643,ftx,en;G10601st.pdf.

ISSN 0936-5214

Table Thioacetalization of Carbonyl Functions, Transthioacetalization of *O,O*- and *S,O*-acetals Catalyzed by **1** in $CHCl_3$ at room temperature

Entry	R^1	R^2	X or XX	n	Time(h)	Yield[a,b](%)
1	Ph	H	O	1	1	95
2	Ph	H	O	2	1	95
3	4-$(CH_3)C_6H_4$	H	O	1	1	96
4	4-$(CH_3)C_6H_4$	H	O	2	1	94
5	4-$(CH_3)C_6H_4$	H	O	1	0.75	95
6	3-$(CH_3)C_6H_4$	H	O	2	0.75	95
7	2-$(CH_3)C_6H_4$	H	O	2	0.75	94
8	2-$(OH)C_6H_4$	H	O	2	1	94
9	4-$(Br)C_6H_4$	H	O	2	1.15	95
10	4-$(Cl)C_6H_4$	H	O	2	2	94
11	PhCH=CH	H	O	1	1	92
12	PhCH=CH	H	O	2	1	92
13		H	O	2	1.5	93
14	$Ph(CH_3)CH$	H	O	1	1.5	92
15	Ph	H	OCH_3	2	0.75	94
16	Ph	H	OCH_2CH_3	2	1	96
17	CH_3	CH_3	OCH_3	1	1.5	95
18	4-$(CH_3)C_6H_4$	H	$O(CH_2)_3O$	2	1	94
19	4-$(Cl)C_6H_4$	H	$O(CH_2)_3O$	2	2.5	96
20	4-$(CH_3O)C_6H_4$	H	$S(CH_2)_2O$	2	1.5	92
21	4-$(CH_3)C_6H_4$	H	$S(CH_2)_2O$	1	1.5	91
22	$PhCH_2CH_2$	CH_3	$O(CH_2)_3O$	2	1.5	89
23	Ph	CH_3	$O(CH_2)_3O$	2	2	88
24				1	2.5	90[c]
25	PhCH=CH	H	$C(CH_2O)_4$	2	1.5	94[c]
26	4-$(CH_3O)C_6H_4$	H	$C(CH_2O)_4$	2	1.5	96[c]
27	4-$(Cl)C_6H_4$	H	$C(CH_2O)_4$	1	2	92[c]
28	3,4-$(CH_3O)C_6H_3$	CH_3	O	2	12	30[d,e]
29	$PhCH_2$	Et	O	2	12	65[d,e]
30			O	1	12	40[d,e]
31	Acetyl ferrocene		O	1	12	60[d,e]
32	Propyl	H	O	1	3.5	87
33		H	O	1	3.5	85

[a] Isolated yields.
[b] Structures were confirmed by IR, ^1H NMR, ^{13}C NMR, mp/bp.
[c] 2.2 equiv of dithiol and 0.2 mol of **1** were used.
[d] 0.15 mol of **1** were used.
[e] NMR yields.

Acknowledgement

The authors are thankful to the Shiraz University Research Council for the support of this work.

References and Notes

(1) (a) Greene, T. W.; Wuts, P. G. M. *Protective Groups in Organic Synthesis*, 2nd ed.; Wiley: New York, **1991**, 178–207. (b) Hauptmann, H.; Moura, C. M. *J. Am. Chem. Soc.* **1950**, *72*, 1405. (c) Seebach, D.; Kolb, M. *Chem. Ind. (London)* **1974**, 687. (d) Ong, B. S. *Tetrahedron Lett.* **1980**, 4225. (e) Kumar, V.; Dev, S. *Tetrahedron Lett.* **1983**, *24*, 1289. (f) Ku, B.; Oh, D. Y. *Synth. Commun.* **1989**, *19*, 433. (g) Ong, B. S.; Chan, T. H. *Synth. Commun.* **1977**, *7*, 283. (h) Chowdhury, P. K. *J. Chem. Res., Synop.* **1993**, 124. (i) Das, N. B.; Nayak, A.; Sharma, R. P. *J. Chem. Res., Synop.* **1993**, 242. (j) Kumar, P.; Reddy, R. S.; Singh, A. P.; Pandey, B. *Tetrahedron Lett.* **1992**, *33*, 825. (k) Villemin, D.; Labiad, B.; Hammadi, M. *J. Chem. Soc., Chem. Commun.* **1992**, 1192. (l) Tateiwa, J.; Horiuchi, H.; Uemura, S. *J. Org. Chem.* **1995**, *60*, 4039. (m) Maiti, A. K.; Basu, K.; Bhattacharyya, P. *J. Chem. Res., Synop.* **1995**, 108. (n) Patney, H. K. *Tetrahedron Lett.* **1991**, *32*, 2259. (o) Patney, H. K.; Margan, S. *Tetrahedron Lett.* **1996**, *37*, 4621.

(2) (a) Park, J. H.; Kim, S. *Chem. Lett.* **1989**, 629. (b) Tani, H.; Masumoto, K.; Inamasu, T.; Suzuki, H. *Tetrahedron Lett.* **1991**, *32*, 2039. (c) Gajare, A. S.; Shingare, M. S.; Bandgar, B. P. *J. Chem. Res., Synop.* **1998**, 452. (d) Firouzabadi, H.; Iranpoor, N.; Karimi, B. *Synlett* **1998**, 739. (e) Jnaneshwara, G. K.; Barhate, N. B.; Sudalai, A.; Deshpande, V. H.; Wakharkar, R. D.; Gajare, A. S.; Shingare, M. S.; Sukumar, R. *J. Chem. Soc., Perkin Trans. 1* **1998**, 965.

(3) (a) Tietze, L. F.; Weigand, B.; Wulff, C. *Synthesis* **2000**, 69. (b) Saraswathy, V. G.; Sankararaman, S. *J. Org. Chem.* **1994**, *59*, 4665.

(4) (a) Corey, E. J.; Shimoji, K. *Tetrahedron Lett.* **1983**, *24*, 169. (b) Anand, R. V.; Saravanan, P.; Singh, V. K. *Synlett* **1999**, 415.

(5) Garlaschelli, L.; Vidari, G. *Tetrahedron Lett.* **1990**, *31*, 5815.

(6) Olah, G. A.; Narang, S. C.; Meider, D.; Salem, G. F. *Synthesis* **1981**, 282.

(7) (a) Kamitori, Y.; Hojo, M.; Masuda, R.; Kimura, T.; Yoshida, T. *J. Org. Chem.* **1986**, *51*, 1427. (b) Perni, R. B. *Synth. Commun.* **1989**, *19*, 2383. (c) Muthusamy, S.; Arulananda Babu, S.; Gunanathan, C. *Tetrahedron Lett.* **2001**, *42*, 359. (d) Chandrasekhar, S.; Takhi, M.; Ravindra, R. Y.; Mohapatra, S.; Rama, R. C.; Venkatram, R. K. *Tetrahedron* **1997**, *44*, 14997. (e) Komatsu, N.; Uda, M.; Suzuki, H. *Synlett* **1995**, 984. (f) Choudary, B. M.; Sudha, Y. *Synth. Commun.* **1996**, *26*, 2993.

(8) (a) Firouzabadi, H.; Iranpoor, N.; Hazarkhani, H. *Synlett* **2000**, 261. (b) Firouzabadi, H.; Iranpoor, N.; Hazarkhani, H. *Synlett* **1999**, 319. (c) Firouzabadi, H.; Iranpoor, N.; Karimi, B. *Synthesis* **1999**, 58. (d) Firouzabadi, H.; Karimi, B.; Eslami, S. *Tetrahedron Lett.* **1999**, 4055.

(9) (a) Ziegler, K. *Liebigs Ann. Chem.* **1942**, 80. (b) Juenge, E. C.; Spangler, P. L.; Duncan, W. P. *J. Org. Chem.* **1966**, *31*, 3836. (c) Juenge, E. C.; Beal, D. A. *Tetrahedron Lett.* **1968**, 5819. (d) Juenge, E. C.; Beal, D. A.; Duncan, W. P. *J. Org. Chem.* **1970**, *35*, 719. (e) Olah, G. A.; Narang, S. C.; Salem, G. F. *Synthesis* **1980**, 659.

(10) Hiegel, G. A.; Ramirez, J.; Barr, R. K. *Synth. Commun.* **1999**, *29*, 1415.

(11) *Typical Procedure for Thioacetalization of 4-Tolylaldehyde (entry 3)*: To a stirred solution of 4-tolylaldehyde (0.6 g, 5 mmol), 1,2-ethanedithiol (0.5 mL, 5.5 mmol) in $CHCl_3$ (25 mL), trichloroisocyanuric acid (0.12 g, 0.5 mmol) was added. After completion of the reaction (1 h, TLC) the reaction mixture was quenched with an aq solution of NaOH (10%, 25 mL). Then $CHCl_3$ (2 × 15 mL) was added to the resulting reaction mixture. The organic layer were separated, washed with H_2O (2 × 100 mL), dried ($MgSO_4$)and filtered. Evaporation of the solvent in vacuo gave the 2-(4-tolyl)-1,3-dithiolane (0.94 g, 96%), (white needles) which crystallized from petroleum ether, mp 56–58 °C(uncorrected). ^{1}H NMR ($CDCl_3$, 250 MHz) δ = 2.38 (s, 3 H) 3.28–3.45 (m, 4 H), 5.60 (s, 1 H), 7.11 (d, 2 H), 7.40 (d, 2 H); ^{13}C NMR ($CDCl_3$, 63 MHz)δ = 21.09, 40.16, 56.11, 127.79, 129.12, 137.10, 137.78; MS (20 eV) *m*/*z* (relative intensity) 196 (M^+, 68.9), 168 (M^+, CH_2=CH_2, 25.4), 153 (100), 135 (83.6), 91 (57.5), 45 (99.3), CHN analysis: %C (Calcd: 61.17; Found: 61.20), %H (Calcd.: 6.16; Found: 6.14).
Typical Procedure for Transthioacetalization of 1,4-cyclohexanedione diethylacetal (entry 24): To a solution of 1,4-cyclohexanedione diethylacetal (1.0 g, 5 mmol), 1,2-ethanedithiol (0.5 mL, 5.5 mmol) in $CHCl_3$ (25 mL), 1 (0.12 g, 0.5 mmol) was added and the resulting mixture was stirred at r.t. After completion of the reaction (2.5 h, TLC, CCl_4/EtOAc, 5:1) the reaction was quenched with aq solution of NaOH (10%, 25 mL). Then $CHCl_3$ (2 × 15mL) was added to the resulting reaction mixture. The organic layer was separated, washed with H_2O (2 × 100 mL), dried ($MgSO_4$) and filtered. Evaporation of the solvent in vacuo gave the desired pure product in a high yield (0.12 g, 90%) as yellow-white needles. Recrystallization from petroleum ether/EtOAc (3:2); mp 192-194 °C(uncorrected); ^{1}H NMR ($CDCl_3$, 250 MHz) δ = 2.29 (s, 8 H), 3.29 (s, 8 H), ^{13}C NMR ($CDCl_3$, 63 MHz) δ = 38.49, 42.19, 66.98; MS (20 eV) *m*/*z* (relative intensity) 264 (M^+, 73.7), 133 (100), 61 (28.3), 45 (54.1), CHN analysis: %C (Calcd.: 45.41; Found: 45.44), %H (Calcd: 6.09; Found: 6.08).