

Note

Deprotection of 1,3-oxathiolanes to carbonyl compounds with montmorillonite K10

S M S Chauhan*, Anil Kumar & B B Sahoo

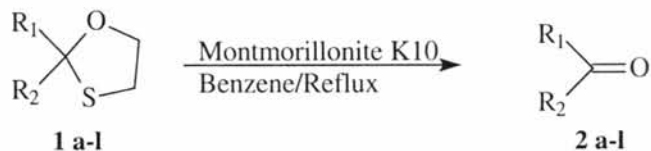
Department of Chemistry, University of Delhi, Delhi 110007, India
E-mail: smschauhan@chemistry.du.ac.in

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Montmorillonite K10 has been used in the deprotection of different aromatic and aliphatic 1,3-oxathiolanes to the corresponding carbonyl compounds in 73 to 97% yields under mild and environmentally compatible conditions.

The protection and deprotection of carbonyl compounds is of great importance in organic synthesis¹. The 1,3-oxathiolanes have been recognized as a useful protection of carbonyls due to its easy introduction and more stability towards acidic media as compared to 1,3-oxathiolanes and easy removal than the corresponding *S,S*-acetals. The 1,3-oxathiolanes are usually utilized as acyl equivalents for C-C bond formation. The 1,3-oxathiolanes have been deprotected to the parent carbonyl compounds by using Raney Ni², Mercury(II) chloride AgNO₃-I₂³, chloramine- T⁴, TMSOTf alone⁵ or in the presence of *p*-nitrobenzaldehyde⁶ or polymer supported *p*-nitrobenzaldehyde⁷ and NBS in acetone⁸. The deprotection of 1,3-oxathiolanes with some of these reagents requires harsh conditions and is contaminated with by-products. They also require expensive or toxic reagents, aqueous work-up and give relatively low yields of the carbonyl compounds. Thus, there is still need for better methods for the deprotection of 1,3-oxathiolanes that might proceed under milder reaction conditions involving simple work-up, use of inexpensive and non-corrosive catalyst, short reaction time and environmental compatibility.

Clays have been used as solid acids in place of mineral acids in organic reactions⁶. Montmorillonite K10 is industrially modified and acidified clay. It has been used as catalyst and solid support in the formation and cleavage of acetals,^{9,10} deoximation¹¹, removal of silyl and other protecting groups from hydroxyl functions¹², cyclocondensation for synthesis of heterocyclic compounds¹³ and many other reactions¹⁴⁻¹⁷. Herein, we report a facile deprotection of 1,3-oxathiolanes first time with montmorillonite



Scheme I

K10 in refluxing benzene in high yield under milder reaction conditions (Scheme I).

Result and Discussion

The 1,3-oxathiolanes **1c-l** have been synthesized by reaction of carbonyl compounds **2c-l** with 2-mercaptoethanol in the presence of BF₃-etherate in diethyl ether.¹⁸ The deprotection of 2-(4-methylamino-3-nitrophenyl)-1,3-oxathiolane **1a** with montmorillonite K10 was studied in different solvents. The graph plotted between % yield of **2a** versus time shows that benzene is the best solvent than other organic solvents for the deprotection of **1a** to **2a** (Figure 1). The reaction of 2-(4-methylamino-3-nitrophenyl)-1,3-oxathiolane **1a** with montmorillonite K10 in benzene gave 4-methylamino-3-nitrobenzaldehyde **2a** in 97% yield. The appearance of peak at 1705 cm⁻¹ in IR spectra and the aldehydic proton at 9.81 ppm in ¹H NMR spectra indicate the formation of aldehyde **2a**. Similarly, the reaction of other 1,3-oxathiolane **1b-1** in the presence of montmorillonite K10 in benzene gave the corresponding carbonyl compounds **2b-1** in good yields and their structures were characterized by comparison of their IR, ¹H NMR spectra, R_f values and melting point/or boiling point with authentic samples. It was noted that electron withdrawing chloro and nitro groups in aryl ring retard the deprotection reaction while electron donating groups enhance the yield of the carbonyl compounds (entry **2a-e**, in Table I). Further, the deprotection of 2-phenyl-1,3-dioxolane and 2-phenyl-1,3-dithiolane have also been observed under these conditions to give benzaldehyde in 56 and 37 % yields, respectively.

The reaction rate is markedly dependent on the temperature. We found that at room temperature complete conversion of **1a** to **2a** required 16hr whereas in refluxing benzene reaction time reduced to 2hr. The isolation of 2-mercaptoethanol indicates that montmorillonite K10 acts as an acid as well as provides water from its interlayers¹⁹ for hydrolysis of

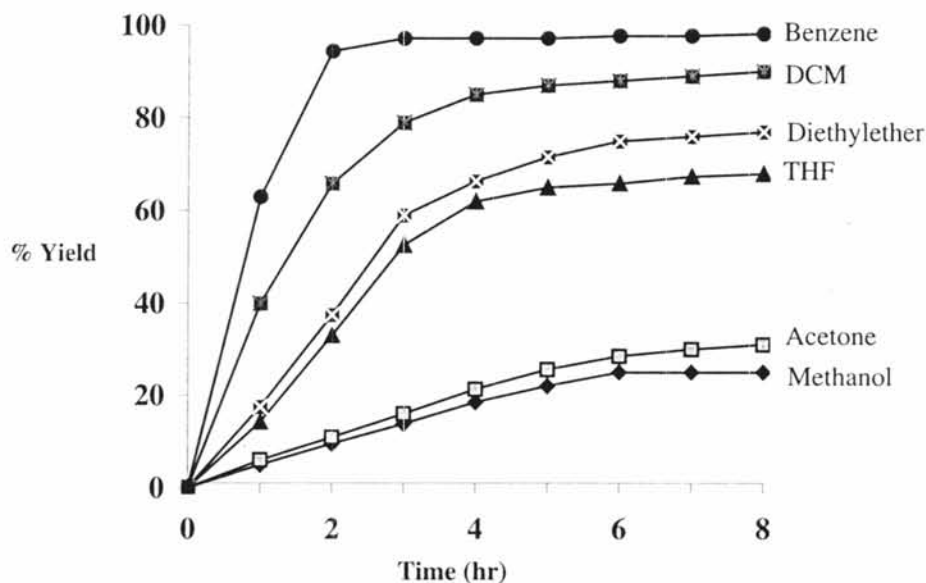


Figure 1—Plot of % yield vs time

Table I—Deprotection of 1,3-oxathiolanes **1a-l** with montmorillonite K10

Compd	Carbonyl compd 2	Time period (hr)	Yield ^a (%)	mp/bp (°C) (lit. mp) ²⁰
1a	4-methylamino-3-nitrobenzaldehyde 2a	2.0	97 ^b	167
1b	4-phenylamino-3-nitrobenzaldehyde 2b	2.0	94 ^c	183
1c	4-chloro-3-nitrobenzaldehyde 2c	5	76	64 (66)
1d	4-chlorobenzaldehyde 2d	3	87	45 (46)
1e	3-nitrobenzaldehyde 2e	3.5	85	59-60 (58)
1f	Benzaldehyde 2f	2	96 ^d	178 ^e
1g	Acetophenone 2g	2.5	83	84 ^e at 11 mm
1h	4-chloroacetophenone 2h	2.5	73	125 ^e at 24 mm
1i	Ethyl methyl ketone 2i	2.5	87	78-79 (79) ^e
1j	Methyl propyl ketone 2j	2.5	86	100-101 (100) ^e
1k	Butyraldehyde 2k	2.0	83	76 (75) ^e
1l	Cyclohexanone 2l	2.5	85	153-154 (155) ^e

^aIsolated yields; ^b**2a**: (¹H NMR): 9.81 (s, -CHO), 8.67 (d, *J* = 3 Hz, C-2H), 8.55 (bs, -NH), 8.00 (dd, *J* = 9 Hz, 3 Hz, C-6), 6.95 (d, *J* = 9 Hz, C-5H), 5.32 (d, *J* = 5.3 Hz, -NCH₃); ^c**2b**: (¹H NMR): 9.99 (bs, -NH), 9.82 (s, -CHO), 8.70 (d, *J* = 3 Hz, C-2H), 7.86 (dd, *J* = 9 Hz, 3 Hz, C-6), 7.46 (d, *J* = 9 Hz, C-5H), 7.24 (m, Ar-H); ^dDeprotection of 2-phenyl-1,3-dioxolane and 2-phenyl-1,3-dithiolane was observed in 56 and 37% yields, respectively; ^eBoiling point.

1,3-oxathiolanes. The recovered catalyst can be easily regenerated by washing with methanol followed by activating at 120°C for 3hr and recycled five times for the deprotection of 1,3-oxathiolane **1a** without any loss of catalytic activity.

In conclusion, the present procedure provides a facile and efficient catalytic method for the deprotection

of a variety of aliphatic and aromatic 1,3-oxathiolanes to carbonyl compounds involving simple work-up. This procedure has additional advantages such as use of inexpensive, non-corrosive and reusable catalyst, high yields, short reaction time and environmental compatibility. These advantages can make this procedure a useful and attractive alternative to the conventional methods in the synthetic organic chemistry.

Experimental Section

The ^1H NMR spectra in CDCl_3 were recorded on a Bruker Heaven (300 Mhz) spectrophotometer (chemical shifts in δ , ppm); and IR spectra in KBr on a Perkin-Elmer Spectrum FT-2000 infrared. The melting points were taken on Thomas HOOVER capillary melting point apparatus and all the melting points and boiling points are uncorrected. The carbonyl compounds, 2-mercaptoethanol and BF_3 -etherate were purchased from SRL, India Ltd. Montmorillonite K10 was purchased from Fluka and treated directly for the reaction. The 4-chloro-3-nitrobenzaldehyde was prepared by the nitration of 4-chlorobenzaldehyde.

General method for preparation of 1,3-oxathiolanes. The carbonyl compounds (20 mmoles), 2-mercaptoethanol (25 mmoles) and BF_3 -etherate (1.0 mL) were refluxed in dry diethyl ether (25 mL) for 3hr. After completion of the reaction (monitored by TLC), the mixture was neutralized with sodium bicarbonate solution and the organic layer was dried over anhydrous sodium sulphate. The organic layer was concentrated and column chromatographed over neutral alumina to give 1,3-oxathiolane **1c-1** in quantitative yields. The 2-(4'-methylamino-3'-nitrophenyl)-1,3-oxathiolane **1a** and 2-(4'-phenylamino-3'-nitrophenyl)-1,3-oxathiolane **1b** were prepared by the reaction of methylamine and aniline with 2-(4'-chloro-3'-nitrophenyl)-1,3-oxathiolane **1c**, respectively. The 1,3-oxathiolanes were analysed by IR, ^1H NMR and mass spectroscopic data.

General method for deprotection of 1,3-oxathiolanes. A mixture of 1,3-oxathiolane (1.0 mmole) and montmorillonite K10 (100 mg) in benzene (10 mL) was refluxed with stirring for 1-5 hr (**Table I**). The progress of the reaction was monitored by TLC and after completion of the reaction, the reaction mixture was cooled to room temperature. The catalyst was filtered with celite, washed with methanol (20 ml) and the combined mixture was concentrated *in vacuo*, the products were purified by column chroma-

tography over neutral alumina and yield(s) of the products are given in **Table I**. The products were characterized by the IR and ^1H NMR spectroscopic data.

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References

- Green T W & Wuts P G M, Protective Groups in Organic Synthesis, 3rd edn (John Wiley & Sons Inc., New York), 1999.
- Djerassi C, Sharma M & Kan T Y, *J Am Chem Soc*, 80, 1958, 4723.
- Nishide K, Yokota K, Nakamura D, Sumiya T & Node M, *Tetrahedron Lett*, 1993, 3425.
- Emerson D W, Wynberg H & Hudeman W F J, *Tetrahedron Lett*, 1971, 3449.
- Ravindaranathan T, Chavan S P & Dantle S W, *Tetrahedron Lett*, 36, 1995, 2285.
- Ravindaranathan T, Chavan S P, Varghese J P, Dantle S W & Tejwani R B, *J Chem Soc, Chem Commun*, 1994, 1937.
- Ravindaranathan T, Chavan S P & Awachat M M, *Tetrahedron Lett*, 35, 1994, 8835.
- Karami B, Seradj H & Tabaei M H, *Synlett*, 2000, 1798.
- Lee J G & Hwong J P, *Chem Lett*, 1995, 507.
- Laszalo P & Polla E, *Synthesis*, 1985, 439.
- Mitra A K, De A & Karchaudhuri N, *J Chem Res Synop*, 1990, 560.
- Asakura J-I, Robins M J, Asaka Y & Kim T H, *J Org Chem*, 61, 1996, 9026.
- Chauhan S M S, Singh R & Gulati A, *Indian J Heterocycl Chem*, 9, 2000, 231.
- Delaude L & Laszalo P, *J Org Chem*, 61, 1996, 6360.
- Cornelis A & Laszalo P, *Synthesis*, 1985, 909.
- Kawai M, Onaka M & Izumi Y, *Bull Chem Soc Jpn*, 61, 1988, 2157.
- Tateiwa J, Horiuchi H & Uemera S, *J Org Chem*, 60, 1995, 4039.
- Romo J, Rosenkrantz G & Djerassi C, *J Am Chem Soc*, 73, 1951, 4961.
- Wade R C, *J Mol Catal*, 18, 1983, 273.
- Dictionary of Organic Compounds, 5th edn. (Chapman and Hall, New York), 1982.