Pergamon

Tetrahedron Letters 43 (2002) 6185–6187

TETRAHEDRON LETTERS

In situ oxidative diol cleavage–Wittig processes

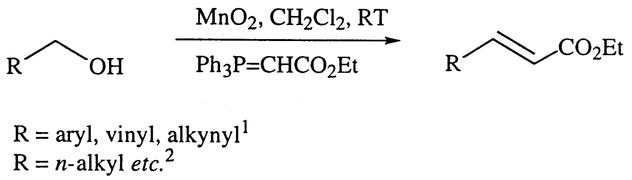
Helen S. Outram, Steven A. Raw and Richard J. K. Taylor*

Department of Chemistry, University of York, Heslington, York YO10 5DD, UK

Received 5 June 2002; accepted 28 June 2002

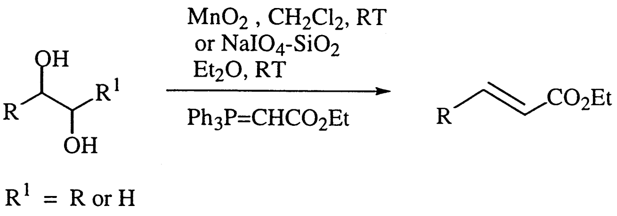
Abstract—1,2-Diol cleavage followed by in situ trapping of the resulting aldehyde with a stabilised phosphorane is described; both manganese dioxide and silica-supported sodium periodate can be used as the heterogeneous oxidant, but the latter reagent is generally the most efficient. © 2002 Elsevier Science Ltd. All rights reserved.

We have recently described an in situ manganese dioxide-mediated alcohol oxidation-stabilised Wittig sequence which can be applied to both activated[1] and non-activated[2] primary alcohols (Eq. (1)). We subsequently extended the oxidation–Wittig methodology to allow the use of phosphonates and non-stabilised phosphonium salts.[3] This one-pot methodology avoids the need to isolate the intermediate aldehydes, which is beneficial in terms of time and particularly useful if the aldehydes are toxic or unpleasant to handle.



(1)

We now report that similar conditions can be employed for an in situ diol oxidative cleavage–Wittig sequence (Eq. (2)).[4] This procedure can be effected using commercial activated manganese dioxide, but we have found that silica-supported sodium periodate[5] often gives even better yields. A recent report[6] from Dunlap et al. on the use of the periodate-mediated sequence prompts us to publish our own results in this area.



(2)

In the preliminary investigation, a range of 1,2-diols in dichloromethane were treated with $MnO_2/Ph_3P=CHCO_2Et$. The cleavage of 1,2-diols to give the corresponding carbonyl compounds using manganese dioxide is documented.[7] We were delighted to observe the successful conversion of most of the diols into the corresponding α,β-unsaturated esters, as summarised in Table 1.[8]

Initial studies were carried out using acyclic 1,2-diols (entries i–iv). 1,2-Dihydroxyhexane underwent cleavage–Wittig trapping to give adduct **1** in 33% yield (entry i). Ethyl 4-oxo-oct-2*E*-enoate (16%) was also isolated from this reaction, possibly as a result of keto-aldehyde formation.[7,11] In a similar manner, 1,2,6-trihydroxyhexane was transformed into enoate **2**, albeit in lower yield (entry ii). *meso*-Hydrobenzoin underwent this transformation much more efficiently giving **3** in high yield (97%, entry iii). A mannitol-derived diol was also studied (entry iv), but the expected product **4** was not observed using the manganese dioxide conditions.

Cyclic diols were also investigated (entries v–vii). Thus, *trans*-1,2-cyclohexanediol produced diester **5** in low yield (entry v). However, *cis*-1,2-cyclododecanediol[12] underwent the in situ cleavage–elaboration to give product **6** in 64% yield (entry vi), although the corresponding cyclododecadienediol[12] gave tetraene **7** rather less efficiently (entry vii).

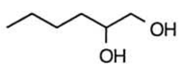
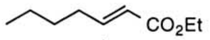
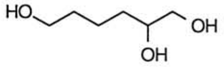
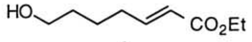
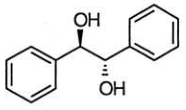
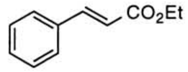
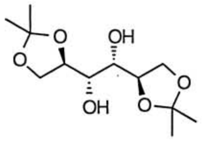
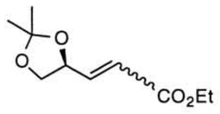
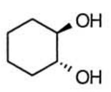
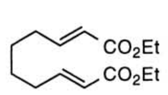
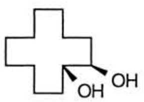
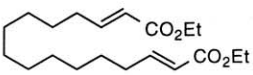
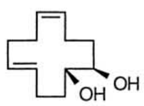
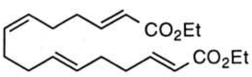
We also found that silica-supported sodium periodate is useful for the same one-pot transformation (Table 1, entries i–vii). It is noteworthy that the periodate procedure gave higher yields than manganese dioxide in most examples, with hydroxybenzoin the only exception (entry iii), and that the periodate procedure worked with the protected mannitol derivative whereas the

---

* Corresponding author. E-mail: rjkt1@york.ac.uk

0040-4039/02/$ - see front matter © 2002 Elsevier Science Ltd. All rights reserved.
PII: S0040-4039(02)01331-X

Table 1. In situ diol oxidative cleavage–Wittig processes[a]

Entry	Substrate	Product	Yields
i		 **1**	MnO_2: 33% (E:Z = 10:1)[b] $NaIO_4$: 85% (E:Z = 10:1)
ii		 **2**	MnO_2: 29% (E:Z = 4:1) $NaIO_4$: 51% (E:Z = 4.5:1)
iii		 **3**	MnO_2: 97% (E:Z = 15:1)[c] $NaIO_4$: 37% (E:Z = 14:1)
iv		 **4**	MnO_2: **4** not observed $NaIO_4$: 88% (E:Z = 1:1.5)
v		 **5**	MnO_2: 20% (E,E:E,Z = 6:1) $NaIO_4$: 70% (E,E:E,Z = 4:1)
vi		 **6**	MnO_2: 64% (E,E:E,Z = 4.5:1) $NaIO_4$: 73% (E,E:E,Z = 7:1)
vii		 **7**	MnO_2: 43% (E,E:E,Z = 7:1)[d] $NaIO_4$: 51% (E,E:E,Z = 6:1)[d,e]

[a] Using $MnO_2/Ph_3P{=}CHCO_2Et$ in CH_2Cl_2[9] or $NaIO_4\text{-}SiO_2/Ph_3P{=}CHCO_2Et$ in Et_2O.[10]

[b] Ethyl 4-oxo-oct-2E-enoate (16%) was also isolated.

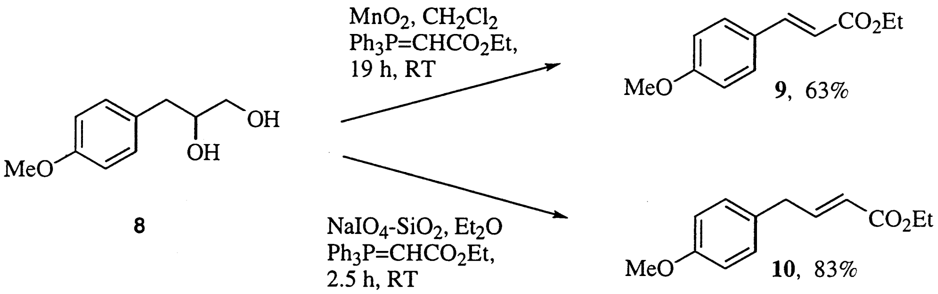
[c] Only 20 equiv. of MnO_2 was required for this conversion which was complete in 3 h.

[d] The E,Z-prefix refers to the newly-formed α,ω-dienes.

[e] Complete conversion was not observed even after 24 h. This may be due to the low solubility of the substrate in diethyl ether.

manganese dioxide procedure was unsuccessful (entry iv). The periodate reactions were carried out using diethyl ether as solvent, and in all but one of the cases the reactions were complete after 3 h. This compares to reaction times of 20 h when dichloromethane is employed as solvent.[6]

It should be noted that 3,3-dimethylbutane-1,2-diol did not undergo the cleavage–Wittig process with either oxidant, presumably for steric reasons. Another interesting observation was that 3-(4-methoxyphenyl)-propane-1,2-diol **8** gave the expected product **10** with silica-supported periodate but gave product **9**, resulting from further oxidative degradation[13]–Wittig trapping, under the manganese dioxide conditions (Scheme 1). In all cases, apart from the protected mannitol example with periodate (entry iv), the E-alkenes predominated, as expected. In the mannitol example, a predominance of the Z-alkene was seen; this is in contrast to the published[6] report (using dichloromethane as solvent) in which the E-isomer apparently predominates.



Scheme 1.

The above procedure allows aliphatic aldehydes to be generated and trapped under extremely mild conditions and so complements the in situ oxidation–Wittig route using manganese dioxide with non-activated alcohols, which requires extensive periods in refluxing toluene.[2] In addition, these reactions are extremely easy to perform, the work-up consisting simply of filtration followed by solvent evaporation and chromatography. We are currently optimising these procedures and applying them in natural product synthesis.

Acknowledgements

We thank the BBSRC for a quota studentship (S.A.R.).

References

1. (a) Wei, X.; Taylor, R. J. K. *Tetrahedron Lett.* **1998**, *39*, 3815–3818; (b) Wei, X.; Taylor, R. J. K. *J. Org. Chem.* **2000**, *65*, 616–620.
2. Blackburn, L.; Wei, X.; Taylor, R. J. K. *Chem. Commun.* **1999**, 1337–1338.
3. Blackburn, L.; Pei, C.; Taylor, R. J. K. *Synlett* **2002**, 215–218.
4. For recent examples of the sequential process, see: (a) Ray, P. C.; Roberts, S. M. *J. Chem. Soc., Perkin Trans. 1* **2001**, 149–153; (b) Terrell, L. R.; Ward, J. S.; Maleczka, R. E. *Tetrahedron Lett.* **1999**, *40*, 3097–3100.
5. (a) Daumas, M.; Vo-Quang, Y.; Vo-Quang, L.; Le Goffic, F. *Synthesis* **1989**, 64–65; (b) Zhong, Y.-L.; Shing, T. K. M. *J. Org. Chem.* **1997**, *62*, 2622–2624.
6. Dunlap, N. K.; Wosenu, M.; Jones, J. M.; Carrick, J. D. *Tetrahedron Lett.* **2002**, *43*, 3923–3925.
7. Ohloff, G.; Giersch, W. *Angew. Chem., Int. Ed. Engl.* **1973**, *12*, 402–402.
8. Novel products were fully characterised; known products gave consistent spectroscopic data.
9. General procedure for manganese dioxide process: To a solution of the diol in CH_2Cl_2 (10 ml/mmol) was added (carboethoxymethylene)triphenylphosphorane (2.2 equivalents) followed by activated MnO_2 (Aldrich, 21764-6; 20 equiv.) and the reaction was stirred at rt. A further two portions of MnO_2 (20 equiv. each) were added at 4 h intervals. After a total of 24 h, the mixture was filtered through Celite® and the volatiles removed in vacuo. The products were then purified by column chromatography.
10. General procedure for sodium periodate process: A 0.65 M solution of $NaIO_4$ in warm H_2O (1.3 equiv.) was added dropwise to a suspension of silica (1.5 g/mL of $NaIO_4$ solution) in diethyl ether (10 mL/mmol of diol) with vigorous stirring. To this mixture was added the diol and (carboethoxymethylene)triphenylphosphorane (2.2 equiv.) and the resulting mixture was stirred at rt for 1–3 h. After the reaction was complete, the mixture was filtered through a sinter and the volatiles were removed in vacuo. The products were then purified by column chromatography.
11. Runcie, K. A.; Taylor, R. J. K. *Chem. Commun.* **2002**, 974–975.
12. (a) Ohno, M.; Okamoto, M.; Torimitsu, S. *Bull. Chem. Soc. Jpn.* **1966**, *2*, 316–319; (b) Becker, H.; Soler, M. A.; Sharpless, K. B. *Tetrahedron* **1995**, *51*, 1345–1376.
13. (a) Crotti, P.; Macchia, F. *J. Org. Chem.* **1983**, *48*, 1350–1352; (b) Santaniello, E.; Ponti, F.; Manzocchi, A. *Tetrahedron Lett.* **1980**, *21*, 2655–2656.