Tetrahedron Letters, Vol.32, No.26, pp 3119-3122, 1991
Printed in Great Britain

0040-4039/91 $3.00 + .00
Pergamon Press plc

Nucleophilic Addition–Elimination Reactions of *N*–(*p*–Tolylsulphonyl)vinylsulphoximines: Preparation of α–Methylene Nitriles and Phosphonates

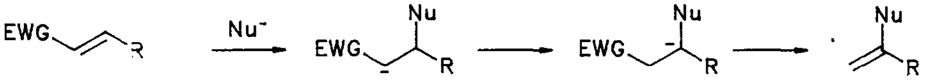
Peter L. Bailey and Richard F.W. Jackson*

Department of Chemistry, Bedson Building, The University, Newcastle upon Tyne, NE1 7RU, U.K.

Key Words: Michael Addition; Vinylsulphoximine; Methylene Nitrile; Methylene Phosphonate.

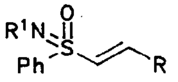
Abstract: Treatment of N–(p–*tolylsulphonyl)vinylsulphoximines* (1) *with lithium cyanide in DMF at room temperature leads to efficient formation of α,β–unsaturated nitriles* (3), via a *Michael addition–proton transfer–elimination process, in which the polarity of the double bond is reversed. Analogous reaction with lithium dimethylphosphonate leads to β–dimethylphosphonyl sulphoximines* (7), *which are converted to α,β–unsaturated phosphonates* (6) *by treatment with* NaOMe.

Electron–deficient alkenes are important intermediates in the planning of synthetic strategies. The ability to reverse the polarity of such electron–deficient alkenes under mild conditions enhances their utility even further. The simplest approach to effecting this transformation is by Michael addition of a nucleophile to an electron–deficient alkene, followed by proton transfer and β–elimination of the initial activating group. This strategy requires that the electron–withdrawing group can function as a leaving group, and that the nucleophile can stabilise an adjacent anionic centre (Scheme 1).



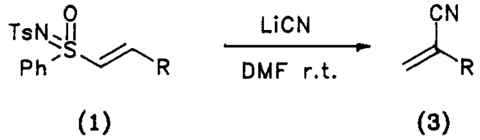
Scheme 1

To date, the activating groups which have been employed for this purpose are phenylsulphonyl[1] and nitro.[2] During our investigations into the nucleophilic epoxidation of *N*–(*p*–tolylsulphonyl)vinylsulphoximines (1),[3] we observed that addition of lithium t–butylhydroperoxide to these vinylsulphoximines occurred significantly faster than the corresponding addition to vinylsulphones,[4] and we therefore decided to explore the possibility that *N*–(*p*–tolylsulphonyl)vinylsulphoximines (1) would be effective substrates for the polarity reversal process. Nucleophilic addition to *N*–(*p*–tolylsulphonyl)–vinylsulphoximines (1)[5] and *N*–(phthalimido)vinylsulphoximines[6] has been briefly explored, together with their reactivity in Diels–Alder reactions.[7] The presence of the electron–withdrawing group on nitrogen renders the vinyl sulphoximines more reactive than the corresponding *N*–alkylvinylsulphoximines (2).[5,8]



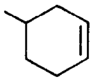
(1), R^1 = Ts
(2), R^1 = alkyl

Following the precedent of Taber, who established that vinyl sulphones could be converted to α-methylene nitriles (3) by treatment with KCN/dicyclohexyl-18-crown-6 in t-butanol at reflux, we have investigated the reaction between cyanide and *N*-(*p*-tolylsulphonyl)-vinylsulphoximines (1), prepared by our previously described method.[3] We chose to employ commercially available LiCN (0.5*M* in dimethylformamide) without additional solvent, and were pleased to discover that the reaction proceeded within 1h at r.t., to give satisfactory yields of the desired α-methylene nitriles (3) (Scheme 2).[9] Our results are described in Table 1.

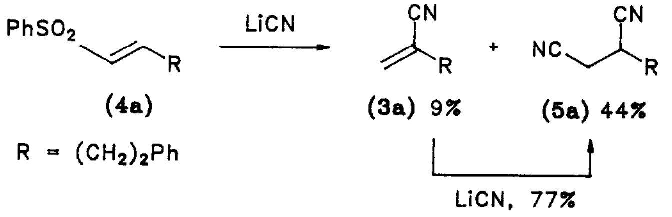


Scheme 2

Table 1. Preparation of α-Methylene Nitriles.

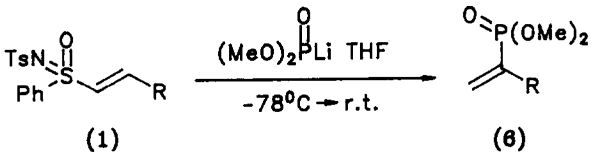
R	Product	Yield, %
CH_2CH_2Ph	(3a)	81
$(CH_2)_6Me$	(3b)	63
	(3c)	64

In order to establish that the greater electron-withdrawing ability of *N*-(*p*-tolylsulphonyl)sulphoximine group was responsible for the faster reaction, we treated the vinyl sulphone (4a), prepared by the method of Oh,[10] under identical conditions. We were able to isolate some of the α-methylene nitrile (3a), although the major product was the *bis*-nitrile (5a), which we presumed was formed by subsequent Michael addition of cyanide to (3a). Support for this suggestion was provided by the observation that treatment of (3a) with lithium cyanide under the same conditions gave the *bis*-nitrile (5a) in good yield (Scheme 3). It appears that more rapid (and perhaps more complete) addition of cyanide to the *N*-(*p*-tolylsulphonyl)vinylsulphoximine, compared with the vinyl sulphone, is responsible for the difference.



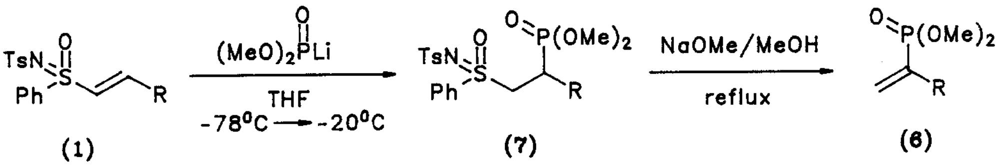
Scheme 3

In an effort to extend the scope of the process, we have explored the reaction between *N*-(*p*-tolylsulphonyl)vinylsulphoximines (1) and lithium dimethylphosphonate. Vinyl phosphonates have been prepared by the addition of dimethyl hydrogen phosphite to nitroalkenes at 90 °C, followed by elimination of nitrous acid.[2] Addition of a solution of the *N*-(*p*-tolylsulphonyl)vinylsulphoximine (1) to lithium dimethylphosphonate in THF at -78 °C, followed by warming to r.t. allowed the isolation in moderate yields of the desired α-methylene phosphonates[11] (6) (Scheme 4).



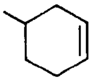
Scheme 4

Subsequently, we established that it was more efficient to isolate the initial Michael adduct (7) (which was stable in the reaction mixture up to -20 °C), and then effect the β-elimination process in a separate step using sodium methoxide in refluxing methanol (Scheme 5, Table 2).[12] It is also possible to effect the elimination at room temperature using DBU in dichloromethane, although extended reaction times are necessary (typically 7 days).



Scheme 5

Table 2. **Preparation of α-Methylene Phosphonates.**

R	Product	Overall Yield, %
CH_2CH_2Ph	**(6a)**	64
$(CH_2)_6Me$	**(6b)**	59
	**(6c)**	58
Ph	**(6d)**	60
${}^iPr$	**(6e)**	54

We believe that these observations significantly extend the use of *N*-(*p*-tolylsulphonyl)vinylsulphoximines in synthesis,[13] and we are currently exploring new applications of these systems.

Acknowledgements: We thank the SERC for a postgraduate studentship (P.L.B.), Prof. O. Meth-Cohn for helpful discussion, and Sterling Organics for support (CASE award to P.L.B).

References

1. D.F. Taber and S.A. Saleh, *J. Org. Chem.*, 1981, **46**, 4817.
2. M. Yamashita, M. Sugiura, T. Oshikawa, and S. Inokawa, *Synthesis*, 1987, 62; M. Yamashita, Y. Tamada, A. Iida, and T. Oshikawa, *Synthesis*, 1990, 420.
3. P.L. Bailey, W. Clegg, R.F.W. Jackson, and O. Meth-Cohn, *J. Chem. Soc., Perkin Trans. 1*, 1990, 200.
4. O. Meth-Cohn, C. Moore, and H.C. Taljaard, *J. Chem. Soc., Perkin Trans. 1*, 1988, 2663; M. Ashwell and R.F.W. Jackson, *J. Chem. Soc., Perkin Trans. 1*, 1989, 835.
5. C.R. Johnson, J.P. Lockard, and E.R. Kennedy, *J. Org. Chem.*, 1980, **45**, 264.
6. R. Annunziata and M. Cinquini, *J. Chem. Soc., Perkin Trans. 1*, 1979, 1684; R. Annunziata, M. Cinquini, and S. Colonna, *J. Chem. Soc., Perkin Trans. 1*, 1980, 2422.
7. R.S. Glass, K. Reinecke, and M. Shanklin, *J. Org. Chem.*, 1984, **49**, 1527.
8. S.G. Pyne, *J. Org. Chem.*, 1986, **51**, 81; S.G. Pyne, *Tetrahedron Lett.*, 1986, **27**, 1691.
9. General procedure: lithium cyanide (0.5*M* in N,N-dimethylformamide, *ex* Aldrich, 1.3 cm³) was added to the *N*-(*p*-tolylsulphonyl)vinylsulphoximine **(1)**, (0.5 mmol) under N_2. The mixture was stirred at r.t. for between 30 and 60 min. Phosphate buffer (pH 7, 1 cm³) was added, and the mixture extracted with CH_2Cl_2 (3 x 10 cm³). The combined organic extracts were dried ($MgSO_4$), concentrated and the residue was purified by flash chromatography (eluent 10% ethyl acetate in petrol) to yield the α-methylene nitriles **(3)** as colourless oils.
10. J.W. Lee and D.Y. Oh, *Synth. Commun.*, 1989, **19**, 2209.
11. For previous routes to α-methylenephosphonates, see: P. Tavs and H. Weitkamp, *Tetrahedron*, 1970, **26**, 5529; J.-N. Collard and C. Benezra, *Tetrahedron Lett.*, 1982, **23**, 3725. See also reference 2.
12. General procedure: a solution of dimethyl hydrogen phosphite (1.1 mmol) in dry THF was cooled to -78 °C. n-Butyllithium (1.1 mmol, solution in hexanes) was added and, after 5 min, a solution of the *N*-(*p*-tolylsulphonyl)vinylsulphoximine **(1)** (1 mmol) in dry THF (5 cm³) was added. The mixture was stirred for a further 10 min at -78 °C, and then warmed to -20 °C over 2h. Phosphate buffer (pH 7, 10 cm³) was added, and the mixture then extracted with ethyl acetate (3 x 20 cm³). The combined organic extracts were dried ($MgSO_4$) and concentrated to yield the Michael adducts **(7)**, which could be purified by flash chromatography (eluent ethyl acetate), although recovery from the column was rather inefficient. A solution of the crude Michael adduct **(7)** was treated with sodium methoxide (2 mmol) in dry MeOH (10 cm³) under reflux for 4 h and, after being cooled, the mixture was concentrated under reduced pressure. The residue was purified by flash chromatography (eluent 70% ethyl acetate in petrol) to yield the vinyl phosphonates **(6)** as colourless oils.
13. For other methods to prepare *N*-(*p*-tolylsulphonyl)vinylsulphoximines, see: I. Erdelmeier and H.-J. Gais, *Tetrahedron Lett.*, 1985, **26**, 4359; H.-J. Veith, H.-J. Gais, and I. Erdelmeier, *Helv. Chim. Acta*, 1987, **70**, 1041. Recently, methods for the preparation on unprotected vinylsulphoximines, which could likely be applied to the synthesis of *N*-(*p*-tolylsulphonyl)vinylsulphoximines, have been described: K.-J. Hwang and E.W. Logusch, *Tetrahedron Lett.*, 1987, **28**, 4149; R.S. Paley and S.R. Snow, *Tetrahedron Lett.*, 1990, 31, 5853.

(Received in UK 27 March 1991)