Acetylenic Sulphoxides in Organic Synthesis: Diels–Alder Reactions†

Albert W. M. Lee,* and W. H. Chan,* and M. S. Wong

Department of Chemistry, Hong Kong Baptist College, 224 Waterloo Road, Kowloon, Hong Kong

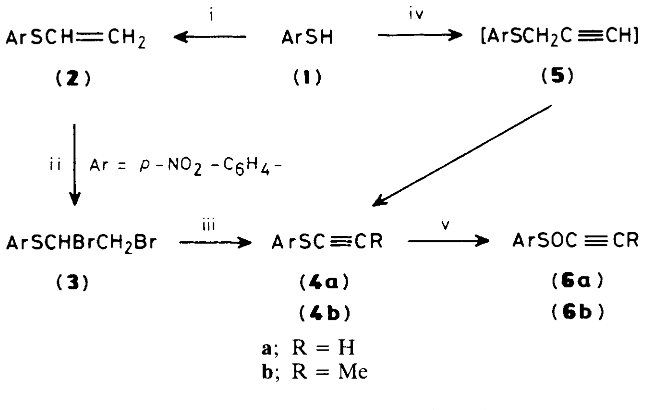
Preparation of *p*-nitrophenylsulphinylethyne (**6a**) and 1-(*p*-nitrophenylsulphinyl)propyne (**6b**) and their reactivities in Diels–Alder reactions are reported.

The Diels–Alder reaction is one of the most useful reactions in organic synthesis. In a single reaction, two new carbon–carbon bonds are formed with high stereoselectivity. In recent years, much effort has been put into the design of new diene components.[1] In contrast, the dienophiles have received much less attention. Except for some highly activated acetylenic compounds, like acetylenedicarboxylic acid, triple bond compounds are less frequently used as dienophiles in the Diels–Alder process than their ethenylic counterparts. We now report the preparation and the use of two acetylenic sulphoxides, *p*-nitrophenylsulphinylethyne (**6a**) and 1-(*p*-nitrophenylsulphinyl)propyne (**6b**) in Diels–Alder reactions.[2,3]

By using a similar procedure as in the preparation of phenyl vinyl sulphide,[4] *p*-nitrophenyl vinyl sulphide (**2**) was prepared from *p*-nitrobenzenethiol (**1**)[5] (Scheme 1). Bromination of (**2**) in chloroform afforded the dibromide (**3**) in almost quantitative yield. Instead of using the classic sodium amide/liquid ammonia procedure,[6] we found that it was quicker to bring about the elimination of the dibromide to acetylenic sulphide (**4a**)[7] by phase transfer.[8]

The preparation of the methyl series started from alkylation of *p*-nitrobenzenethiol with prop-2-ynyl bromide. Without isolation of the terminal acetylenic product (**5**), it was isomerized to the internal acetylenic sulphide (**4b**) in aqueous sodium hydroxide. Finally the two acetylenic sulphides (**4a**) and (**4b**) were oxidized to the corresponding sulphoxides (**6a**) and (**6b**) by *m*-chloroperoxybenzoic acid (MCPBA).

Results of Diels–Alder reactions of (**6a**) and (**6b**) towards a series of dienes are summarized in Table 1. For reactive dienes, the reaction took place readily at room temperature, or in refluxing benzene. For others, the reactions were carried out in refluxing xylene or in sealed tubes. In general, good to excellent yields of cycloadducts were obtained and (**6a**) is more reactive than (**6b**). It is also worth noting that in the Diels–Alder reaction acetylenic sulphoxide (**6a**) was found to be more reactive than the vinyl sulphoxide.[2]

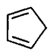
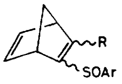
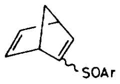
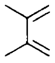
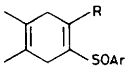
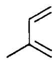
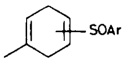
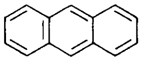
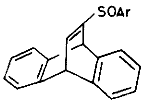
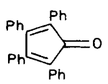
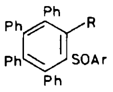
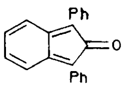
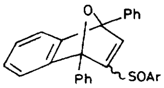


Scheme 1. *Reagents*: i, NaOMe, $BrCH_2CH_2Br$ (ref. 4); ii, $Br_2/CHCl_3$, 0 °C; iii, 40% aq. NaOH(w/v)/CH_2Cl_2, 2 equiv. $Bu^n{}_4NHSO_4$; iv, NaOMe, $BrCH_2C{\equiv}CH$; H_2O, stir overnight; v, MCPBA/CH_2Cl_2. (**6a**), m.p. 83—84 °C; (**6b**), m.p. 125—127 °C.

In the case of the reactions towards tetraphenylcyclopentadienone (entry 6), products involving loss of carbon monoxide were obtained.[9] Regioselectivity towards isoprene was slightly disappointing (entry 4). Direct n.m.r. and g.c.–mass spectral analysis of the cycloadducts indicated that 1:1 mixtures of regioisomers were formed.

The stereochemistry of reactions towards cyclopentadiene, cyclohexa-1,3-diene, and 2,5-diphenylbenzofuran (1, 2, and 7) needs further comment. Besides the chirality of the sulphoxide centre, a new chiral element is created in each of these bicyclic cycloadducts. Although we are unable to assign the

Table 1. Diels–Alder reactions of (**6a**) and (**6b**).

Entry	Diene	Dienophile	Conditions[a] t/h (% yield)	Adduct
1		(**6a**) (**6b**)	A, 6 (97)[b] B, 6 (82)[c]	
2		(**6a**)	B, 2 (76)[d]	
3		(**6a**) (**6b**)	C, 7 (82) C, 20 (73)	
4		(**6a**) (**6b**)	C, 8 (74)[e] C, 20 (64)[e]	
5		(**6a**)	D, 25 (53)	
6		(**6a**) (**6b**)	D, 1 (97) C[f], 12 (57)	
7		(**6a**)	D, 2 (80)[g]	

[a] A, room temp.; B, C_6H_6, reflux; C, sealed tube, 140 °C; D, xylene, reflux. [b] 1.6:1 mixture of diastereoisomers, m.p.s 135—136 and 100—102 °C. [c] 6:5 mixture of diastereoisomers, m.p.s 154—155 and 146—147 °C. [d] 2:1 mixture of diastereoisomers, m.p.s 157—159 and 101—102 °C. [e] 1:1 mixture of regioisomers. [f] At 135 °C. [g] Mixture of diastereoisomers.

---

† Presented in part at the 30th National Organic Chemistry Symposium of the American Chemical Society, Vancouver, Canada, June 1987.

structures, t.l.c. and/or n.m.r. clearly indicate that two sets of diastereoisomers were formed with ratios as indicated in Table 1.‡ In the first two cases, the diastereoisomers were separated by column chromatography. They all have distinct melting points. To support further their diastereoisomeric relationship, the chirality at the sulphur atom was destroyed by oxidizing the sulphoxides to sulphones. In all cases, a single racemic sulphone resulted.

In summary, acetylenic sulphoxides (**6a**) and (**6b**) were prepared and their reactivities in Diels–Alder reactions studied. Further elaboration of the cycloadducts such as Michael addition to the resulting α,β-unsaturated sulphoxides and their application in natural product synthesis are in progress.

Financial support from a Sir Run Run Shaw research grant (RRS-007) is gratefully acknowledged. We also thank the Chinese University of Hong Kong and the Hong Kong Polytechnic for providing some spectroscopic services.

Received, 19th July 1988; Com. 8/02943A

---

‡ The structures of all new compounds were supported by satisfactory i.r., n.m.r., high resolution m.s. and/or elemental analysis data.

References

1 *E.g.*, a series of trimethylsilyloxydienes have been investigated: S. Danishefsky, *Acc. Chem. Res.*, 1981, **14**, 400; M. E. Jung, C. A. McCombs, Y. Takeda, and Y. G. Pan, *J. Am. Chem. Soc.*, 1981, **103**, 6677, and references therein.

2 Sulphone and sulphoxide have been used as the activating group of ethenylic and allenic dienophiles: L. A. Paquette, R. E. Moerck, B. Harirchian, and P. D. Magnus, *J. Am. Chem. Soc.*, 1978, **100**, 1597; R. V. C. Carr and L. A. Paquette, *ibid.*, 1980, **102**, 853; O. De Lucchi and G. Modena, *J. Chem. Soc., Chem. Commun.*, 1982, 914; O. De Lucchi, V. Lucchini, L. Pasquato, and G. Modena, *J. Org. Chem.*, 1984, **49**, 596; N. Ono, A. Kamimura, and A. Kaji, *Tetrahedron Lett.*, 1986, 1595; K. Hayakawa, H. Nishiyama, and K. Kamematsu, *J. Org. Chem.*, 1985, **50**, 512.

3 Uses of acetylenic sulphones in cycloaddition have been reported. A. P. Davis and G. H. Whitham, *J. Chem. Soc., Chem. Commun.*, 1980, 639; O. De Lucchi, G. Licini, L. Pasquato, and M. Senta, *Tetrahedron Lett.*, 1988, 831.

4 L. A. Paquette and R. V. C. Carr in 'Organic Synthesis,' ed. A. S. Kende, Wiley, New York, 1985, vol. 64, p. 157.

5 C. C. Price and G. W. Stacy, *J. Am. Chem. Soc.*, 1946, **68**, 498.

6 N. A. Khan, F. E. Deatherage, and J. B. Brown, in *Org. Syn., Coll. Vol., 4*, ed. N. Rabjohn, Wiley, New York, 1963, p. 404.

7 E. Angeletti, F. Montanari, and A. Negrini, *Gass. Chim. Ital.*, 1957, **87**, 1115. *CA.* 1958, **52,** 9985d and 9985g.

8 A. Gorgues and A. LeCoq, *Tetrahedron Lett.*, 1976, 4723.

9 S. Yankelevich and B. Fuchs, *Tetrahedron Lett.*, 1967, 4945, and references therein.