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PREPARATION AND DIELS-ALDER REACTIVITY OF ETHYL-β-PHENYLSULFONYLPROPIOLATE

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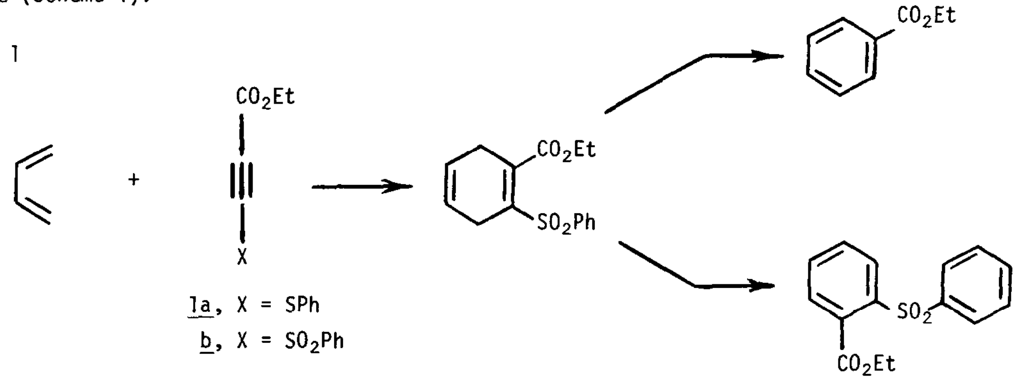
Ethyl-β-phenylsulfonylpropiolate (1b) is a reactive and highly regioselective dienophile in the Diels-Alder reaction.

We have been interested in the construction of aromatic ring systems by Diels-Alder based methodology.[1] For this purpose, ethyl-β-phenylsulfonylpropiolate (1b)[2] appeared to be a potentially versatile dienophile because elimination of benzenesulfinic acid from the diene adduct would produce a benzoic acid ester, while adduct dehydrogenation would give a diarylsulfone (Scheme 1).

Scheme 1

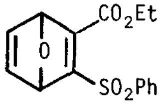
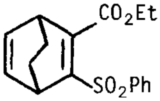


1a, X = SPh
b, X = SO_2Ph

Ethyl-β-phenylsulfonylpropiolate (1b) is conveniently prepared by sequential treatment o ethyl propiolate with lithium diisopropylamide (THF, -78°C) and phenyl phenylthiosulfonate[3] (THF, -78°C for 20 min → warm to room temperature) to give 1a (oil, 86% from silica gel chromatography or 50% from distillation at 60°C/0.5 mm Hg), followed by m-chloroperbenzoic acid oxidation (CH_2Cl_2, N_2 atm., 0°C → room temperature until reaction complete by tlc). Silica gel chromatography gives 1b as a lightly colored oil of seemingly high purity [^1H NMR analysis and chemical reactivity; IR (neat) 5.83, 7.46, 8.06, 8.55μ]. Sulfone 1b undergoes polymerization to a viscous dark substance on standing at room temperature; refrigeration and short-path silica gel filtration chromatography prior to use is recommended.

Ethyl-β-phenylsulfonylpropiolate (1b) undergoes essentially quantitative Diels-Alder addition to a variety of dienes at room temperature (Table 1). This observation is in marked contrast to that of 1a, in that 1a was found to be unreactive towards diene addition at 25°C and underwent polymerization at elevated temperature. The dienophilic reactivity of 1b must be greater than that of dimethyl acetylenedicarboxylate (DMAD). For example, reaction of pyrrole 2 (0.21 mmole) with 1b (0.20 mmole) in $CDCl_3$ (0.6 ml) was found to be complete in <20 min at room temperature (^1H NMR analysis). Silica gel chromatography of the reaction mixture gave adduct 3 in 75% isolated yield. Under comparably mild reaction conditions DMAD fails to undergo Diels-Alder addition to N-amino-2,5-dimethylpyrroles.[4]

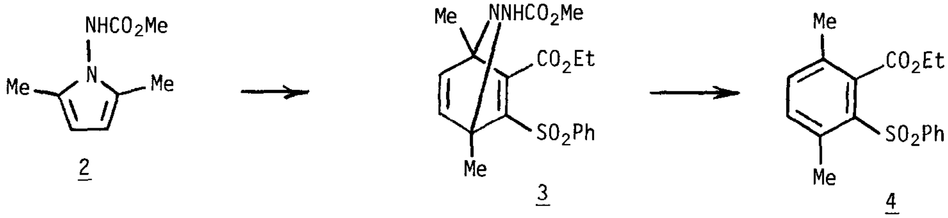
Table 1. Diels-Alder Reactions of Ethyl-β-phenylsulfonylpropiolate

Entry	Diene	Diels-Alder adduct[a]
1	cis/trans-1-methylbutadiene	5
2	furan	
3	cis/trans-1-acetoxybutadiene	8
4	1,3-cyclohexadiene	
5	pyrrole 2	3

[a] Product yields appear quantitative by ^1H NMR analysis; isolated yields are 73-75% after silica gel chromatography (and crystallization for 5).

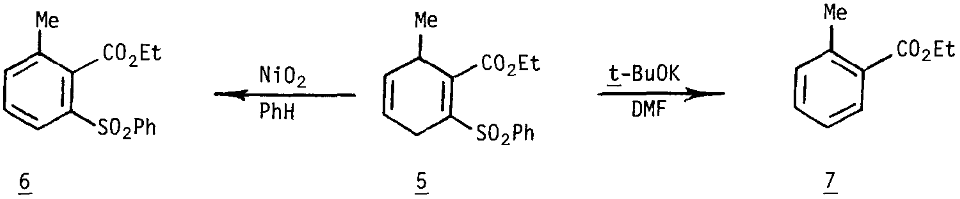
On heating 3 in benzene-cyclohexene solution (1:1), N-aminonitrene extrusion occurs and ethyl-2,5-dimethyl-6-phenylsulfonylbenzoate (4, mp 124-5°C from ethanol)[5] is produced in 42%

overall isolated yield from 1b. These results are of great practical interest in the context of N-aminonitrene generation in a "chemically-inert" environment.[6]



2 3 4

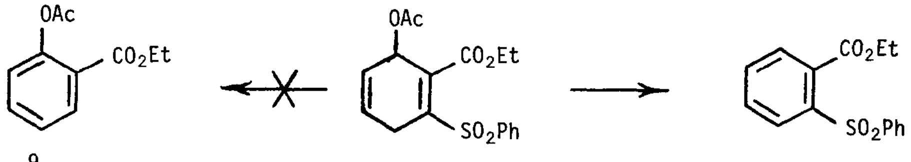
The regioselectivity of Diels-Alder addition of 1b to 1-substituted butadienes is extremely high. In fact, with 1-methyl and 1-acetoxybutadiene only one regioisomer is detected by ^1H NMR analysis of crude reaction mixtures; analytically pure adduct 5 is isolated in 74% yield after silica gel chromatography and crystallization from ethanol (mp 80.5-82.0°C).[5] This high regioselectivity of cycloaddition to trans-1-methylbutadiene is analogous to that reported for methyl propiolate.[7] Thus, the phenylsulfonyl substituent on a C-C triple bond is not competitive with the ethoxycarbonyl group for regiodirection;[8] on the other hand, based on the relative reactivities of 1b and DMAD, the phenylsulfonyl group is a better activator of the triple bond than an alkoxycarbonyl group.



6 5 7

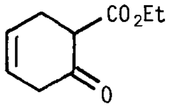
Adduct 5 serves as a precursor to aromatic ring systems by elimination of benzenesulfinic acid (t-BuOK in DMF, 80°C, 5h) to give ethyl-2-methylbenzoate (74% isolated yield) and dehydrogenation (excess NiO$_2$[9] in refluxing benzene, 2 days) to give diarylsulfone 6 (58%, mp 88.5-89.5°C from ethanol).[5]

For the 1-acetoxybutadiene adduct 8, elimination of benzenesulfinic acid to give 9 is not competitive with elimination of acetic acid; consequently, sulfone 10 is produced in quantitative yield on treatment of 8 with potassium carbonate in alcohol solution at room temperature.



9 8 10

The Diels-Alder adducts of 1b should undergo several other useful reactions; for example, transformations of the type vinyl sulfone hydrolysis → β-keto ester 11, vinyl ester hydrolysis and oxidative decarboxylation → β-keto sulfone 12 and vinyl ester addition-elimination → substituted vinyl ester 13 should be possible. The high regioselectivity of Diels-Alder addition implies that there should be good synthetic utility for such conversions. These and other applications of β-arylsulfonylpropiolate chemistry are under investigation.



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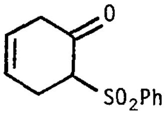

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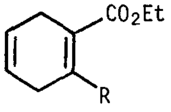

13

Acknowledgment

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1. For previous work in this area, see Schultz, A. G.; Shen, M. Tetrahedron Letts. 1981, 22, 1775 and references cited therein.
2. The related use of β-phenylsulfinyl-α,β-unsaturated carbonyl dienophiles in Diels-Alder reactions has been reported by Danishefsky, S.; Harayama, T. J.; Singh, R. K. J. Am. Chem. Soc. 1979, 101, 7008 and references cited therein.
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