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THE REACTIONS OF α-ALKOXYALLYLPHOSPHINE OXIDE YLIDES WITH SILICON, SULPHUR, AND PHOSPHORUS ELECTROPHILES

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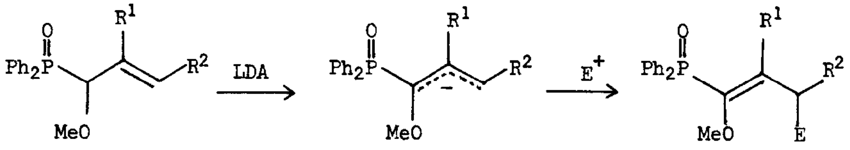
Abstract: Anions (2), derived from α-methoxyallylphosphine oxides (1), react with silicon, sulphur and phosphorus electrophiles in a highly regioselective fashion to give the products of γ-attack.

Investigations of the chemistry of allyl phosphorus anions has led to the development of several new synthetic reactions[1]. One of the most fascinating aspects of the behaviour of such species, the regiochemistry of their reactions, has received considerable attention, and a number of factors including the substitution pattern of the ylide[2], substituents on the phosphorus atom[3], and the nature of the incoming electrophile[4], have been identified as important influences in site selectivity. Generally speaking, the anions of allylic phosphorus systems react with electrophiles to yield mixtures of α- and γ-adducts. Cases of α-regioselectivity[5] and γ-regio selectivity[6] have been observed, but as yet there is no comprehensive basis for postulating the regiochemistry of the products, although steric effects[7] have been presented as an important factor. We now wish to report that α-alkoxyallylphosphine oxides (1), readily available from chlorodiphenylphosphine and acetals of α,β-unsaturated aldehydes[8], form anions (2) which react with silicon, sulphur, and phosphorus electrophiles to yield the products of γ-attack as the sole products, see Scheme I. Anions (2) were readily available from oxides (1) on treatment with lithium diisopropylamide (THF, -70°C). Silylation of these anions with trimethylsilyl chloride proved to be efficient (>80%) and regiospecific, the sole product being the α-methoxy-γ-trimethylsilyl vinylphosphine oxide (3a-c) as the E-isomer. In a similar manner, treatment of (2) with sulphur electrophiles ($MeSSO_2Me$, $PhSSO_2Ph$, PhSSPh) afforded a series of γ-sulphenylated products (3d-h).

It was anticipated that quenching agents based on phosphorus might also react with anions (2) at the γ-carbon atom. In the event, when phosphine oxides (1b) and (1c) were added to a solution of LDA at -78°C and the resulting anions quenched with diethylchlorophosphate, the only products isolated were (4b) and (4c), respectively. Such products presumably arise by the process shown in Scheme II.

Scheme I

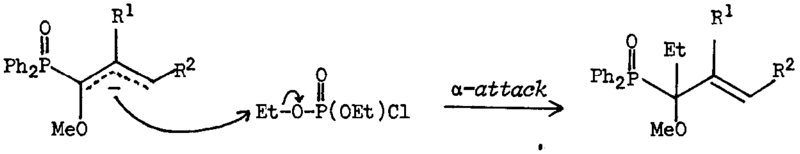


1 2 3

a	R^1	R^2	E	% Yield of 3^b
3a	H	H	$SiMe_3$	84
3b	Me	H	$SiMe_3$	82
3c	H	Me	$SiMe_3$	88
3d	H	H	SMe	79
3e	H	Me	SMe	84
3f	H	Me	SPh	82
3g	Me	H	SMe	72
3h	H	Ph	SMe	69
3i	Me	H	$P(O)(OEt)_2$	14
3j	H	Me	$P(O)Ph_2$	61

a The products were characterised by NMR, IR, mass spectra and chemical analysis.
b All yields are for isolated pure compounds.

Scheme II



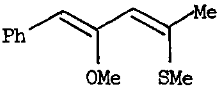
2 b,c 4 b,c

However, inverse addition of (2b) in the presence of 2 equivalents of HMPA resulted in the formation of (3i). Better yields of γ-adducts (e.g. 3j) were obtained when diphenylphosphinyl chloride was used as the quenching agent.

All products (3) were assigned as γ-adducts on the basis of their ^{1}H and ^{13}C NMR spectra. Typically, the starting allylphosphine oxides (1) displayed in their ^{1}H NMR a singlet at δ3.28 for the methoxyl protons, while in the products (3) these protons appeared at δ3.6-3.8, a downfield shift characteristic of a transition from an ether to an enol ether[9]. Further evidence for the assignments came from the observed phosphorus-hydrogen coupling constants. Thus the methyl group in (1c) was observed at δ1.69 as a double doublet with a coupling constant $^5J_{PH}$ = 6Hz. Alternatively, the product (3c) had the methyl group resonating at δ1.08 as a doublet with no observable long-range phosphorus coupling[2]. Coupling constants ($^3J_{PH}$ = 9-12Hz) in the products

(3a, c-f, h, j) were indicative of a hydrogen atom cis to the phosphorus moiety[10], hence the adducts were designated the E-isomers, which were thought to result from preferential co-ordination of lithium to the methoxy group. It is of interest to note that these γ-adducts were related to phosphonic acid derivatives recently developed as ester homoenolate equivalents[7,11].

A particularly attractive prospect arose from the possibility of sequential electrophilic quenching at the γ-carbon, as above, and then with a carbonyl electrophile at the α-carbon of the allylic moiety, followed by a Wittig-Horner reaction. In such circumstances, heterodienes containing a disguised ketone function would result. Thus γ-sulphenylated product (3e) on treatment with sodium hydride and quenching of the resulting anion with benzaldehyde, yielded the 1-dienylsulphide (5). These double quenching reactions are currently under study.



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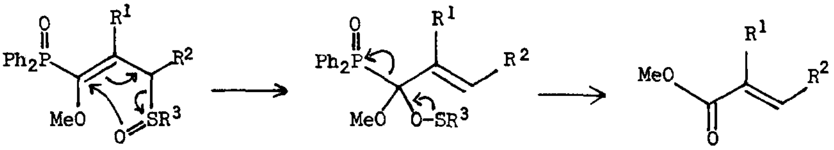
Products such as (3d-h) also allow, in principle, the preparation of acrylate derivatives (7) via oxidation of the allylic sulphoxide, [2,3]-sigmatropic rearrangement, and eventual removal of sulphur with a thiophile. Sulphides (3e, f, g) could all be efficiently oxidised to the corresponding sulphoxides (6) by mCPBA and the crude sulphoxides, on refluxing in toluene, were converted to the corresponding acrylates (7) and the S-methyl- or phenylthiodiphenylphosphine oxide. The prospect of using this γ-sulphenylation reaction as a means of generating the anion equivalent, $MeOOCCH=\bar{C}H$, is therefore very real, and is being investigated.



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