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ORGANOPHOSPHORUS ENAMINES I.

A NEW SYNTHETIC ROUTE TO β-KETO DIPHENYLPHOSPHINE OXIDES

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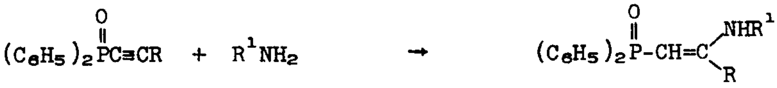
The nucleophilic addition of primary and secondary amines to 1-alkynyldiphenylphosphine oxides has been described.[4] We have further investigated nucleophilic additions of amines to 1-alkynylphosphine oxides, phosphine sulfides, phosphonates and thiophosphonates in order to obtain enamine phosphorus compounds for the synthesis of α,β-unsaturated ketimines and/or ketones. From this study, we have found that the addition of primary amines to 1-alkynylphosphine oxides 1, to provide enamine phosphine oxides 2, is particularly facile (eq. 1). The white crystalline enamine-diphenylphosphine oxides 2a-j were prepared in high yield as shown in Table I.



$$(C_6H_5)_2\overset{O}{\overset{\|}{P}}C\equiv CR \;+\; R^1NH_2 \;\rightarrow\; (C_6H_5)_2\overset{O}{\overset{\|}{P}}\text{-}CH{=}C\begin{matrix}NHR^1\\ R\end{matrix} \qquad (1)$$

1 2

R may be alkyl, cycloalkyl or aryl

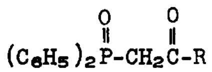
R^1 may be alkyl

Our initial attempts to prepare these enamines involved heating the diphenyl-1-alkynylphosphine oxides with a 3.5 molar excess of amine in benzene. Although addition did occur, as evidenced by the loss of the C≡C absorption (about 4.55 μ) and growth of the C=C absorption (about 6.2 μ), it was evident that the reaction was quite sluggish under these conditions. Addition of a more polar solvent, such as acetonitrile, increased the rate of addition. In fact, the additions were rapid, if the phosphine oxides were stirred at room temperature or refluxed in the neat amines. In the case of low boiling amines, if heating was necessary, the reaction was run in a sealed tube at 80-100° C.[5]

The enamine phosphine oxides were obtained pure by recrystallization from benzene-ligroin.

The enamines 2 were characterized by their infrared and nmr spectra as well as microanalysis.[6] In most cases, both geometric isomers were obtained as determined from the nmr spectrum of the crude enamine.[7] This was indicated by a pair of doublets of different coupling in the 3.8-6 ppm region of the spectrum. Typically, the lower field doublet displayed a J_{PH} = 13-18 Hz and the higher field doublet was split by 20-23 Hz. We are presently involved in a detailed 100 MHz nmr study of these enamines which we shall report shortly.

The enamine phosphine oxides reported herein are useful precursors to a host of new β-keto phosphine oxides 3 which are of interest as metal extractants[8] and of synthetic interest due to their similarity to the Emmons Reagent. We therefore desired to prepare a number of the β-keto phosphine oxides for further synthetic work. In this regard, an ethereal solution of 1c, d, e, f, or i, when stirred overnight with 10% aqueous oxalic acid provided the corresponding β-keto phosphine oxides 3 as crystalline solids in 83-94% yield. Purification of these compounds was accomplished by sublimation (140-160° C/0.05 mm Hg) followed by recrystallization from benzene-ligroin (Table II). Previous methods of preparing the β-keto phosphine oxides were not very satisfactory due to the low yields obtained.[8,9] Our method, however, combines straightforward reactions with extremely mild conditions and very high yields.[10] The nature of the R group does not seem to affect the course or the yields of the reaction.



$$(C_6H_5)_2\overset{O}{\overset{\|}{P}}\text{-}CH_2\overset{O}{\overset{\|}{C}}\text{-}R$$

3

TABLE I

ENAMINE-PHOSPHINE OXIDES PREPARED BY ADDITION OF R^1NH_2 TO $(C_6H_5)_2\overset{O}{\overset{\|}{P}}C\equiv CR$

	Phosphine Oxide 1[a] R	Amine R^1	Mp °C	% Yield
a	H[4]	$n\text{-}C_4H_9$	141-147	35
b	C_2H_5	$n\text{-}C_4H_9$	115-116	--
c	$n\text{-}C_3H_7$	$n\text{-}C_4H_9$	118-120	93
d	$t\text{-}C_4H_9$[b]	$n\text{-}C_4H_9$	142-144	--
e		$n\text{-}C_4H_9$	164-165	--
f		$n\text{-}C_4H_9$	157-158	95
g	$CH_2CH_2C_6H_5$	$C_6H_5CH_2$	137-139	78
h	C_6H_5[4]	$C_6H_5CH_2$	124-126	90
i	C_6H_5[4]	$n\text{-}C_4H_9$	107-109	96
j	C_6H_5[4]	H	122-124	61

a. The solid oxides were prepared by treating an acetone solution of the diphenyl-1-alkynylphosphine with 3% aqueous H_2O_2.

b. This phosphine oxide was otherwise unknown. It had mp 135-137° C and was prepared by the H_2O_2 oxidation of diphenyl(t-butylethynyl)phosphine (bp 151-152/.2 mm Hg).

TABLE II

THE β-KETO DIPHENYLPHOSPHINE OXIDES

	R	Mp °C	% Yield[a]	nmr[b] $>\overset{O}{\overset{\|}{P}}\text{-C}\underline{H}_2\text{C-}$
a	C_6H_5	139-141[8]	83	4.15, d, J_{PH} = 15 Hz
b	$n\text{-}C_3H_7$	110-111	94	3.60, d, J_{PH} = 15 Hz
c	$t\text{-}C_4H_9$	143-148	85	3.70, d, J_{PH} = 15 Hz
d		118-119	91	3.65, d, J_{PH} = 15 Hz
e		86-87	86	3.65, d, J_{PH} = 15 Hz

a. These % yields are based on the diphenyl-1-alkynylphosphine oxide.

b. Obtained in $CDCl_3$ and expressed in δ (ppm) downfield from TMS. d = doublet

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3. To whom correspondence should be addressed.
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5. The addition of n-butyl amine to diphenyl-1-ethynylphosphine oxide occurred exothermically, even in dilute benzene solution.
6. Microanalyses were performed by Geller Laboratories, P. O. Box 423, Saddle River, New Jersey 07458.
7. Specific experimental details will be sent to anyone on request.
8. J. J. Richard and C. V. Banks, J. Org. Chem., 28, 123 (1963), mp 139-140° C.
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10. It is of interest that diphenylphenylethynylphosphine, when treated with concentrated sulfuric acid, provided a 70% yield of 3a. However, with diphenyl-1-alkylethynylphosphines, only the corresponding phosphine oxides were obtained under the same conditions.