CHEMISTRY LETTERS, pp. 831-834, 1983.

CARBON-CARBON BOND FORMATION VIA PHOSPHINE-INITIATED CLEAVAGE OF β-OXOSULFIDES

Yoshio UENO,* L. D. S. YADAV, and Makoto OKAWARA
Research Laboratory of Resources Utilization, Tokyo
Institute of Technology, Nagatsuta, Midoriku, Yokohama 227

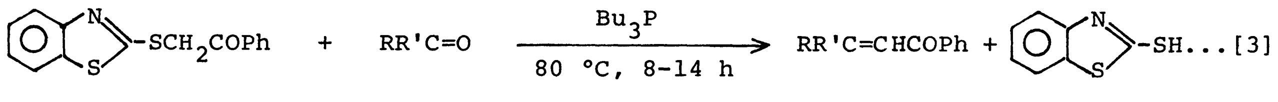
2-(Phenacylthio)benzothiazole (1) reacted with aldehyde or ketone in the presence of tri-n-butylphosphine at 80 °C to give α,β-enone and 2-mercaptobenzothiazole in good yield. The reaction scheme for this new type of enolate ion formation via C-S bond cleavage is also described.

An original reaction, i.e. oxidation-reduction condensation using disulfide-tertiary phosphine has been developed by Mukaiyama et al.(Eq. 1).[1)] In connection with our study towards a new type of desulfurization process,[2)] we focused our interest on the possibility of the C-S bond cleavage of sulfides with tertiary phosphine (Eq. 2).

$$\mathrm{RS{-}SR} \;+\; \geqslant\mathrm{P} \longrightarrow [\,\geqslant\overset{+}{\mathrm{P}}\mathrm{{-}SR}\quad \overset{-}{\mathrm{S}}\mathrm{R}\,] \xrightarrow{\text{substrate}} \text{product} \;....[1]$$

$$\mathrm{RS{-}CH_2R'} \;+\; \geqslant\mathrm{P} \dashrightarrow [\,\geqslant\overset{+}{\mathrm{P}}\mathrm{{-}SR}\quad {}^{-}\mathrm{CH_2R'}\,] \overset{\text{substrate}}{\dashrightarrow} \text{product} \;....[2]$$

To visualize our idea, the substituent (R') should be required to stabilize the adjacent carbanion. Accordingly we piked up a β-oxosulfide as a model compound. We wish to report here a facile α,β-enone formation via phosphine-initiated C-S bond cleavage of β-oxosulfide (1) (Eq. 3).



1 2 3 4

Thus, we found that sulfide (1) (1 equiv.) reacted with aldehyde (or ketone) (1 equiv.) in the presence of tri-n-butylphosphine (1 equiv.) at 80 °C for 8-14 h to give α,β-enone (3) and 2-mercaptobenzothiazole (4) in good yield. The results are summarized in the Table 1.

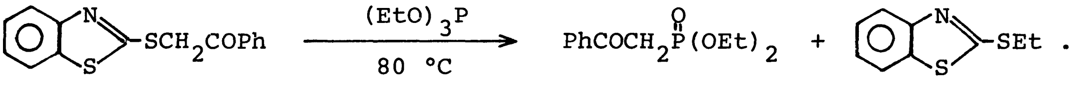
Table 1. Preparation of α,β-enone (3) starting from sulfide (1).

Carbonyl compound	α,β-Enone (3) 3)			Yield of (4)
(2)		Yield (%)	Bp or mp	(%)
$CH_3(CH_2)_3CHO$	$CH_3(CH_2)_3CH{=}CHCOPh$	85	117-121 °C/0.6 Torr	83
$CH_3(CH_2)_5CHO$	$CH_3(CH_2)_5CH{=}CHCOPh$	82	126-132 °C/0.6 Torr	80
PhCHO	PhCH=CHCOPh	70	53-55 °C	72
$p\text{-}MeOC_6H_4CHO$	$p\text{-}MeOC_6H_4CH{=}CHCOPh$	94	75-76 °C	90
$p\text{-}ClC_6H_4CHO$	$p\text{-}ClC_6H_4CH{=}CHCOPh$	78	112-114 °C	77
$Ph_2C{=}O$	$Ph_2C{=}CHCOPh$	63	84-86 °C	65

A typical procedure is as follows. A mixture of 1 (0.69 g, 2.4 mmol), p-anisaldehyde (0.29 ml, 2.4 mmol), and tri-n-butylphosphine (0.60 ml, 2.4 mmol) was heated at 80 °C for 8 h under nitrogen atmosphere. p-Methoxybenzalacetophenone (0.54 g, 94%) and 4 (0.36 g, 90%) were isolated from the reaction mixture upon treatment with column chromatography on silica gel eluted with dichloromethane-hexane (3:2) followed by chloroform. The structures of the products were fully confirmed by the comparison of the physical data with those of the authentic samples or the reported data.

The present reaction offers an alternative procedure for the Wittig reaction, in which three steps are necessary, i.e. (1) formation of phosphonium salt, (2) generation of phosphorane using a suitable base, and (3) condensation of the resulting phosphorane with carbonyl compounds furnishing alkenes.

Contrary to the Wittig reaction, the present reaction provides a one-pot procedure starting from tertiary phosphine. In order to clarify the reaction scheme, we also examined the reaction of 1 with triethyl phosphite. Thus, the sulfide (1) reacted with triethyl phosphite (1 equiv.) at 80 °C for 28 h to afford diethyl phenacylphosphonate (5) and 2-(ethylthio)benzothiazole (6) (Eq. 4).



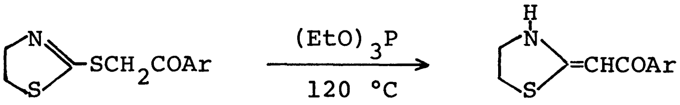
....[4]

1 5 6

73% (97%) 74% (98%)

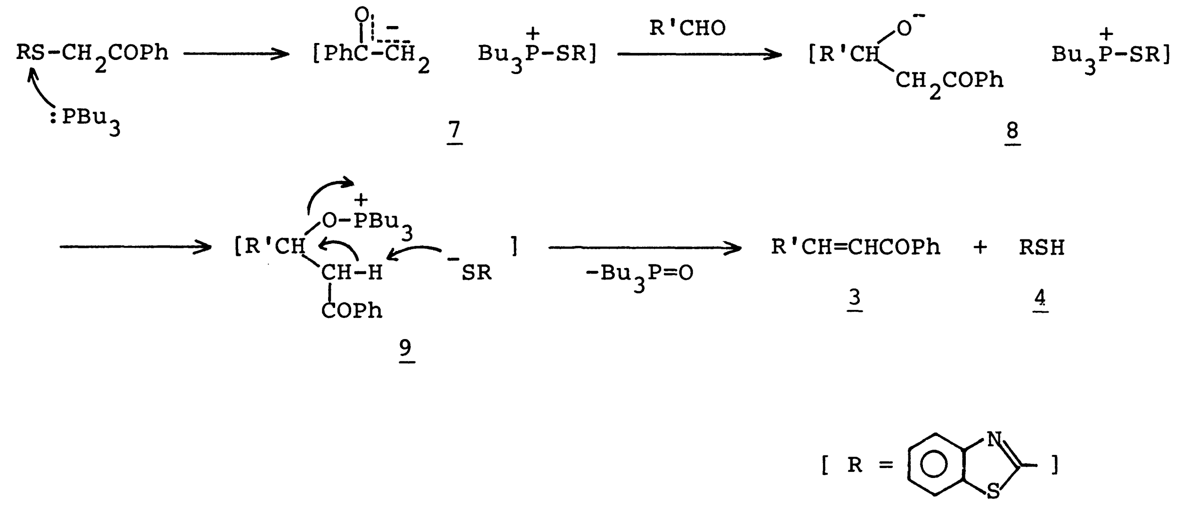
The figures in parenthesis are the yields based on the consumption of 1. The formation of oxophosphonate (5) instead of vinyl phosphate [$(EtO)_2P(O)C(Ph)=CH_2$] excludes a Perkow type reaction,[4)] i.e. a mechanism involving the attack of phosphite on the carbonyl carbon in the compound 1 followed by the rearrangement.

It is also noteworthy that our reaction is remarkably contrast to the following reaction reported by Hirai et al.[5)] Our reaction can be termed as a thio-Arbusov type reaction.[6)]



....[5]

The experimental facts obtained so far suggest the following reaction scheme. Thus, the reaction is initiated by the attack of phosphine on the sulfur atom to produce enolate thiophosphonium ion pair (7). The attack of enolate ion to the carbonyl compound and subsequent ligand exchange afford the species (9), which yields the final products via a deprotonation as outlined below.

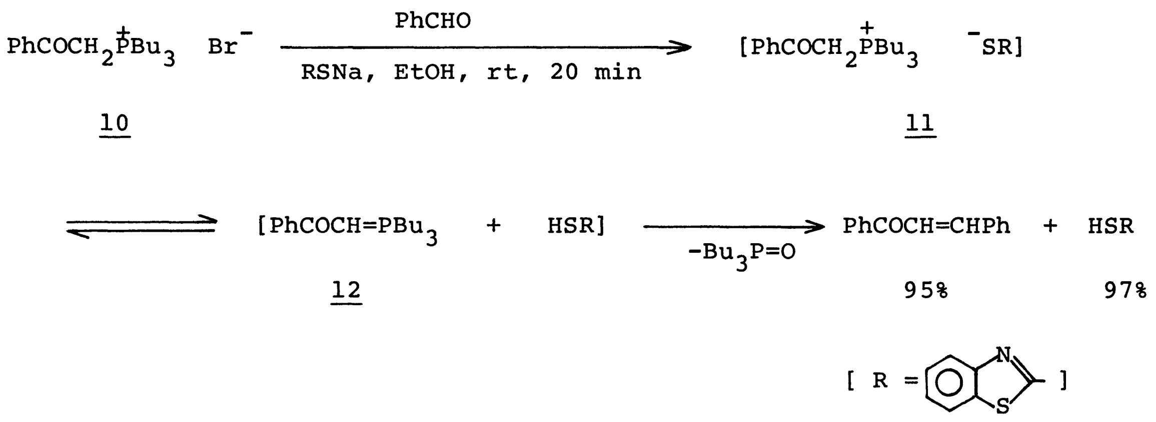


In summary, although the detailed mechanism is not clear at present time,[7)] a C-S bond cleavage of β-oxosulfide (1) with tri-n-butylphosphine is quite apparent, and a synthetic application of such a phosphine-initiated cleavage could be visualized by a simple procedure. 2-Mercaptobenzothiazole recovered can be recycled for the preparation of the starting sulfide (1).

Moreover, β-oxosulfides are generally useful synthetic intermediates and their facile modification such as an alkylation at the relatively acidic methylene carbon is promising.[8)] The present reaction may be applicable to sulfides containing other electron-withdrawing substituents.

References

1) T. Mukaiyama, Angew. Chem., Int. Ed. Engl., 15, 94 (1976).
2) Y. Ueno, S. Aoki, and M. Okawara, J. Am. Chem. Soc., 101, 5414 (1979).
3) The predominant formation of E-stereoisomers of α,β-enones was observed in each case.
4) E. M. Gaydou and J. -P. Bianchini, Can. J. Chem., 54, 3626 (1976).
5) K. Hirai and Y. Kishida, Heterocycles, 2, 185 (1974).
6) For a kinetic study of Arbusov reaction, see, L. Toke, I. Petnehazy, and G. Szakal, J. Chem. Res., 1978, (S) 155; (M) 1975.
7) An alternative scheme is a mechanism involving phenacyl tributylphosphorane (12), which may arise from the species 7 via the compound 11. In fact, we observed the following reaction starting from phosphonium bromide (10).



$$\mathrm{PhCOCH_2\overset{+}{P}Bu_3\ \ Br^-} \xrightarrow[\text{RSNa, EtOH, rt, 20 min}]{\text{PhCHO}} [\mathrm{PhCOCH_2\overset{+}{P}Bu_3\ \ {}^-SR}]$$

10 11

$$\rightleftharpoons [\mathrm{PhCOCH{=}PBu_3} + \mathrm{HSR}] \xrightarrow[-\mathrm{Bu_3P{=}O}]{} \mathrm{PhCOCH{=}CHPh} + \mathrm{HSR}$$

12 95% 97%

8) N. Ono, H. Miyake, Y. Tanabe, K. Tanaka, and A. Kaji, Chem. Lett., 1980, 1365.

(Received March 17, 1983)