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Reactions of 5-Arylimino-4-chloro-5*H*-1,2,3-dithiazoles with Stable Phosphoranes: Novel Preparation of Dithiomethylenephosphoranes

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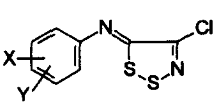
Abstract: *The reactions of 5-arylimino-4-chloro-5H-1,2,3-dithiazoles with 2 equivalents of stable phosphoranes such as carboethoxymethylene-, acetylmethylene-, 4-chlorobenzoylmethylene-, and cyanomethylenetriphenylphosphoranes in the presence of pyridine in* CH_2Cl_2 *at room temperature gave a new type of the corresponding phosphoranes with aryliminocyanomethyldithiomethylene moiety as a major product.*

Much attention has been focused on 5-arylimino-4-chloro-5*H*-1,2,3-dithiazoles (**1**) owing to their potential synthetic utility[1] and biological importance[2] since their first appearance in 1977.[2a] In addition, compounds **1** are mechanistically an interesting class of heteroaromatic compounds bearing several electron deficient centers such as S-1, S-2, C-4, and C-5 atoms as a result of delocalization of 6 π electrons possessed by a five membered ring. The formation of dithiazolobenzoxazine (**2**) from the reaction of 4-chloro-5-(2-hydroxyphenylimino)-5*H*-1,2,3-dithiazole (**1**) (X = 2-OH, Y = H) with NaH in THF is an unique example of the intramolecular nucleophilic displacement of chlorine atom at C-4 by phenoxide ion. However, no intermolecular analogous reaction has been reported. There have been proposals in which S-1 atom is conceived to be attacked by nucleophiles.[1c] Recently we have shown the involvement of S-2 as a nucleophilic center by isolation of a variety of (arylimino)cyanomethyl (alkyl)amino disulfides **3** from the reactions of **1** with either primary or secondary alkylamines.[3] It has been also found that the reactions of **1** with some sterically bulky secondary alkylamines in CH_2Cl_2 at room temperature give 5-arylimino-4-dialkylamino-5*H*-1,2,3-dithiazoles (**4**) by way of disulfides **3**.[4]



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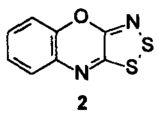

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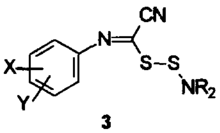

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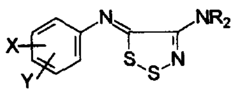

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As part of our studies on the chemistry of **1**, we were interested in finding other nucleophiles giving similar results obtained from the reactions with alkylamines. Since compounds **1** are readily attacked by hydroxide base in aqueous acetone at room temperature to give *N*-arylcyanothioformamide along with unidentifiable complex mixtures,[5] and by organometallic bases even at -78 °C to give unknown mixtures,[5] we turned our attention to nucleophiles classified as a soft base which can be utilized in a nonaqueous solution.

Stable phosphoranes such as carboethoxylmethylene-,[6] acetylmethylene-,[7] 4-chlorobenzoylmethylene-,[7] and cyanomethylenetriphenylphosphoranes[8] were prepared according to the literature and reactions of **1** with phosphorans prepared were carried out. Typical procedure: To a solution of **1** (X = 4-CH_3, Y = H) (75 mg, 0.309 mmol) in CH_2Cl_2 (40 mL) was added 1 drop of pyridine (ca. 25mg, 0.32mmol), followed by addition of acetylmethylenetriphenylphosphorane (192 mg, 0.603 mmol). The mixture was stirred for 3 h at room temperature. After removal of the solvent, the residue was chromatographed on silica gel (70 - 230 mesh, 1.5 x 17 cm). Elution with a mixture of *n*-hexane and CH_2Cl_2 (4:1) gave unreacted **1** (X = 4-CH_3, Y = H) (6 mg, 8%). Subsequent elution with CH_2Cl_2 gave *N*-(4-methylphenyl)cyanothioformamide (**5i**) (4 mg, 7%); mp 130-131°C (*n*-hexane-$CHCl_3$) (lit.[9] 130-131°C). Continued elution with $CHCl_3$ gave (4-methylphenylimino)-cyanomethyldithioacetylmethylenetriphenylphosphorane (**6i**) (125 mg, 77%); mp 68-71°C (*n*-hexane-$CHCl_3$); ^1H NMR ($CDCl_3$, 80 MHz) δ 2.40 (s, 3H), 2.52 (s, 3H), 6.73 - 7.76 (m, 19 H); IR (KBr) 1562, 1498, 1482,

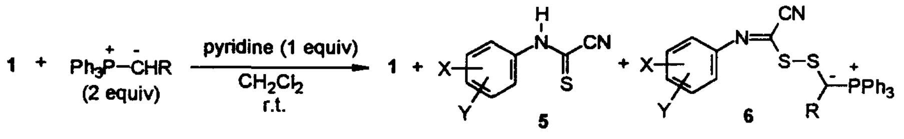
Table 1. Reactions of **1** with some stable phosphoranes.

Entry	X	Y	R	Yield,† %		
				1	**5**	**6**
a	4-MeO	H	CO_2Et	7	11	69
b	4-Me	H	CO_2Et	8 (11)	7 (32)	81 (38)
c	2-Cl	H	CO_2Et	9	28	41
d	4-Cl	H	CO_2Et	6	14	75
e	4-Br	H	CO_2Et	7	7	78
f	4-NO_2	H	CO_2Et	15 (17)	8 (38)	70 (32)
g	2-Me	4-NO_2	CO_2Et	9	12	74
h	4-MeO	H	COMe	7 (6)	9 (38)	79 (39)
i	4-Me	H	COMe	8	7	77
j	4-Cl	H	COMe	5	14	70
k	4-Br	H	COMe	5	7	80
l	2-CN	H	COMe	8	8	68
m	3-NO_2	H	COMe	7	9	76
n	4-NO_2	H	COMe	9	9	76
o	2-Me	4-NO_2	COMe	10	8	64
p	2-Me	H	4-ClC_6H_4CO	16	11	48
q	2-Me	4-NO_2	4-ClC_6H_4CO	8	14	63
r	4-MeO	H	CN	15	16	53
s	2-Me	H	CN	14	20	58
t	2-Me	4-NO_2	CN	21	20	45

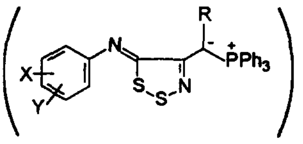
†Isolated yield. Number in the parenthesis represents the yield in the absence of pyridine.

1435, and 1353 cm^{-1}. *Anal.* Calcd for $C_{30}H_{25}N_2OPS_2$: C, 68.68; H, 4.80; N, 5.34; S, 12.22 %. Found: C, 68.54; H, 4.76; N, 5.37; S, 12.32 %.

The results obtained from other reactions are summarized in Table 1.



The structures of *N*-arylcyanothioformamides **5** were determined on the basis of the spectroscopic and mass spectral data along with the comparison with those of authentic samples.[9] However, the structures of compounds **6** were determined unambiguously on the basis of the *X*-ray crystallographic analysis of **6l**. Since infrared spectrum of each compound **6** did not exhibit a characteristic -C≡N stretching absorption near 2200 cm^{-1}, it was difficult to distinguish between two structural isomers, compounds **6** and 7. The *X*-ray crystallographic data shows clearly the binding position between the S-2 atom and phosphorane.[10]



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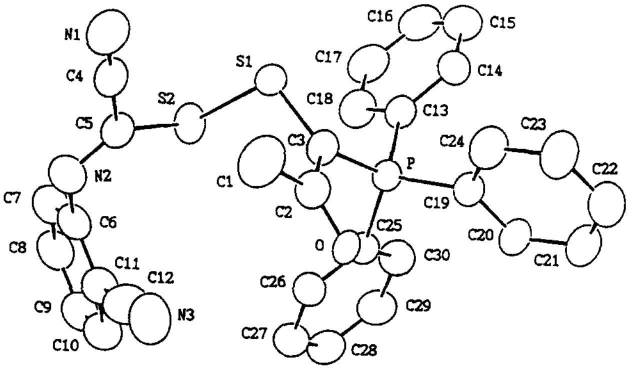
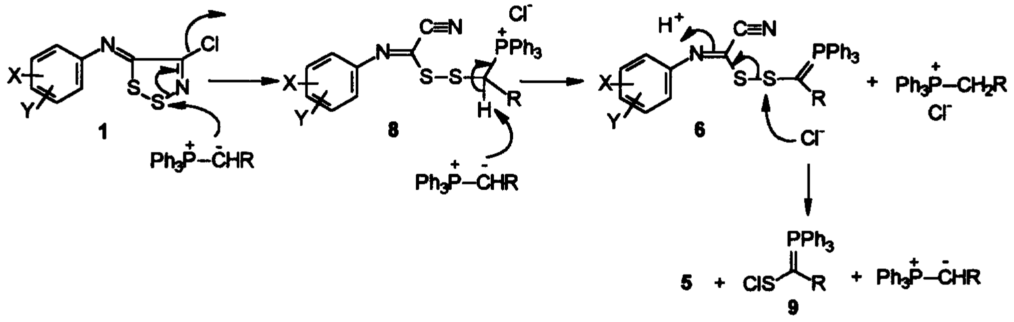


Fig 1. ORTEP drawing of compound **6l**.

As demonstrated by entries **b**, **f**, and **h**, the reactions carried out in the absence of pyridine gave increased yields of **5b**, **5f**, and **5h** at the expense of the yields of **6b**, **6f**, and **6h**, respectively as well as essentially no change in the amount of the recovered starting materials **1**. The result indicates that compounds **5** are formed by the reactions of compounds **6** with hydrogen chloride gas. Since compounds **6** are formed even in the absence of pyridine, the major role of pyridine is conceived to trap hydrogen chloride gas formed. However, the yield of **6b** decreased to 35 % along with the formation of unidentifiable complex mixtures when a excess of pyridine (10 equivalents) was used.

The mechanism of the formations of **5** and **6** can be rationalized by a nucleophilic attack of phosphorane to S-2 to form a phosphonium chloride **8**, which loses a hydrogen chloride in the presence of another molecule of phosphorane to form a dithiomethylenephosphorane **6**. Compounds **6** react with hydrogen chloride to form cyanothioformamides **5**, which was confirmed by isolation of **5h** in 65 % yield from the reaction of **6h** with hydrogen chloride gas independently prepared in CH_2Cl_2 at room temperature. In the meantime, the fate of new phosphoranes **9**, which are conceived to be generated with the compounds **5** during the reactions is uncertain at this moment. Further study on the chemistry of **1** is in progress.



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10. *X*-ray crystal data of **6l**: $C_{30}H_{22}N_3OPS_2$, M = 535.63, monoclinic, space group = $P2_1/n$, a = 13.789 (1), b = 10.495 (2), c = 19.625 (1) Å, β = 106.99 (1) °, V = 2717.0 (1) $Å^3$, d (calc) = 1.31 gcm^{-3}, F(000) = 1112, Z = 4. X-ray intensity data were measured on an Enraf-Nonius CAD4 diffractometer with MoKα radiations with the dimension 0.97 x 0.45 x 0.37 mm. Of 4621 unique reflections measured, 4057 had I > 2.0σ(I) and were used for all calculations. The structure was solved by direct methods and refined by least-square methods. The final agreement factors were R = 0.049 and Rw = 0.048. All calculations and drawings were performed using a Micro VAX II computer with the MolEN software. Selected bond lengths (Å) and angles (deg); S1-S2 2.134, S1-C3 1.699, P-C3 1.759, C2-C3 1.444, O-C2 1.240, C1-C2 1.516; S1-S2-C5 104.3, S2-S1-C3 106.9, S1-C3-P 119.6, S1-C3-C2 124.7, P-C3-C2 115.4, C3-P-C13 108.8, O-C2-C1 120.6, O-C2-C3 119.7, C1-C2-C3 119.7.

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