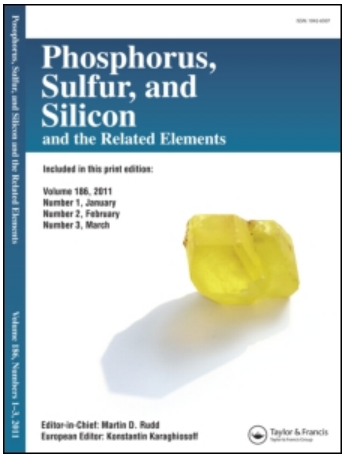


Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

STUDIES ON REACTIONS OF LAWESSON'S REAGENT WITH PHENYLTHIOUREA AND OXAMIDE

Liang-Nian He[a]; Tian-Bao Huang[a]; Fei Cai[a]; Ru-W Chen[b]
[a] Institute of Organic Synthesis, Central China Normal University, Wuhan, PR. China [b] Institute of Elemento-Organic Chemistry, Nankai University, Tianjin, P.R. China

To cite this Article He, Liang-Nian , Huang, Tian-Bao , Cai, Fei and Chen, Ru-W(1998) 'STUDIES ON REACTIONS OF LAWESSON'S REAGENT WITH PHENYLTHIOUREA AND OXAMIDE', Phosphorus, Sulfur, and Silicon and the Related Elements, 132: 1, 147 — 153
To link to this Article: DOI: 10.1080/10426509808036982
URL: http://dx.doi.org/10.1080/10426509808036982

Phosphorus, Sulfur and Silicon, Vol. 132, pp. 147-153
Reprints available directly from the publisher
Photocopying permitted by license only

STUDIES ON REACTIONS OF LAWESSON'S REAGENT WITH PHENYLTHIOUREA AND OXAMIDE

LIANG-NIAN HE[a*], TIAN-BAO HUANG[a], FEI CAI[a] and RU-YU CHEN[b]

[a]*Institute of Organic Synthesis, Central China Normal University, Wuhan, 430079,P.R. China and* [b]*Institute of Elemento-Organic Chemistry, Nankai University, Tianjin, 300071, P.R. China*

(Received 14 May, 1997; In final form 2 July, 1997)

Lawesson's reagent reacted with phenylthiourea in toluene at 110 °C to give a product of ring-opening (**2**) instead of a 4-membered ring **2a**. Its structure was determined by X-ray diffraction analysis. A mechanism is proposed to explain the formation of compound **2**. The O-S exchange reaction of Lawesson's reagent with oxamide in acetonitrile was also investigated.

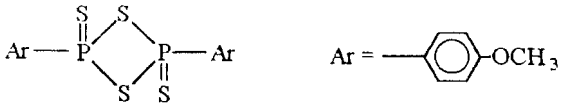
Keywords: Lawesson's reagent; phenylthiourea; oxamide; molecular structure

INTRODUCTION

2,4-Bis(4-methoxyphenyl)-1, 3,2,4-dithiadiphosphetane-2,4-disulfide **1**, generally called Lawesson's reagent (**LR**), has been developed as a superior reagent for the conversion of carbonyl to thiocarbonyl[1]. **LR** also undergoes ring -closure reactions with substrates containing two functional groups to yield phosphorus heterocycles[2–4]. In our previous paper[5–7] it was reported that **LR** reacted with certain bifunctional substrates, for example glycinamides, 3-mercapto-4-amino-5-substituted-1,2,4-triazoles,alkyl propanediamides, to form 5-membered and 6-membered phosphorus heterocycles These cyclization reactions of **LR** with bifunctional compounds represent novel routes to biologicaly active phosphorus heterocycles. The present study was done with the hope to synthesize novel 4- and 5-membered phosphorus heterocycles with two carbonyl groups. However it was found that **LR** reacted with oxamide by an O-S exchange to

* To whom correspondence should be addressed

yield dithiooxamide and with phenylthiourea **LR** reacted by ring-opening to yield the novel compound **2**. Details of our results are reported in this paper.

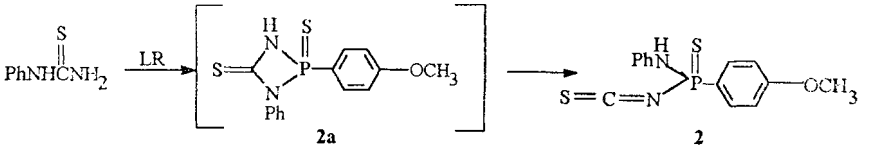


1 (Lawesson's reagent ,LR)

RESULTS AND DISCUSSION

A. Reaction of LR with Phenylthiourea and the Molecular Structure of its Product

An amount of 0. 01 mole of **LR** was reacted with 2 equivalence of phenylthiourea at 110 °C in dry toluene under argon for 4h, but the expected ring-closure compound **2a** did not form. Instead of a product of ring-opening(**2**) was obtained (Scheme 1). Its structure was determined by elemental analysis, IR,NMR,MS spctra, and X-ray diffraction analysis.



SCHEME 1

Elemental analysis for **2** corresponded to $C_{14}H_{13}N_2OPS_2$. Its IR spectrum showed strong absorptions at 1979cm^{-1} due to N=C=S vibration, at 3296 cm^{-1} due to N-H vibration, and at 634 cm^{-1} due to P=S vibration. Its ^{1}H MR spectrum showed signals at δ ($CDCl_3$): 7.20–7.80 (dd,2H,$^3J_{PH}$=15.96Hz, $^3J_{HH}$=8.4Hz, ortho protons to phosphorus of the anisole ring). The remaining aromatic protons gave rise to a multiplet at δ 6.65 – 7.22 (m,7H,Ar-H), 5.46 (s, 1H, NH), 3.87(S, 3H, OCH_3). In its^{31}P NMR spectrum it exhibited only a singlet at δ ($CDCl_3$) :46.56.

Compound **2** under electron impact showed the molecular ion peak m/z (%):320 (46.78) and the base peak at 263 (M-NCS,21.41). The other conspicuous peaks were of 228 (M-PhNH,21.41), 154(Ph-N=C=S,54.25),122 (Ph-N=P,35.86).

A single crystal of **2** was obtained by recrystallization from a mixture petroleum ether and anhydrous ethyl ether. The crystal is monoclinic with the space group $P2_1/n$, a=1.1310(2) nm, b=0.83630(3)nm, c=1.68470(4)nm, β =105.01(2), Z=4, F(000) =728, μ (M_oKa) = 0.43mm^{-1}, Dx=1.38Mg/m^3. The final R factor has the value 0.051 and for Rw a value of 0.052 was established. The coordinates of non-hydrogen atoms is given in Table I. Selected bond lengths and bond angles are listed in Table II and Table III, respectively. Figure 1 shows the molecular structure of compound **2** as well as the atom numbering scheme . The atoms N(2),N(1),S(2), and C(11) form a distorted tetrahedron with SP^3 hydridized phosphorus atom in the center. The bond length of P-S (2) with a value of 0.1928 nm is close that of the normal double bond length of P=S namely 18.90 nm[4]. The angle N(1)-C(1)-S(1) was measured to 178.0(8)° , indicating that the atoms N(1),C(1), and S(1) are in a line. The dihedral angle between the plane (2) of benzene and the plane (1) of 4-methoxybenzene (anisole ring) is 67.25 °.

TABLE I The Coordinates of non-hydrogen atoms

Atom	*X*	*Y*	*Z*
S(1)	0.05162(3)	0. 06234(4)	0.05997(2)
S(2)	0.06772(2)	0.00583(4)	0.05949(2)
P	0.05578(2)	0.01204(3)	0.06526(2)
O	0.06520(6)	-0.00503(9)	0.10018(4)
N(1)	0.05398(7)	0.0319(1)	0.06517(4)
N(2)	0.04271(6)	0.00402(9)	0.06101(4)
C(1)	0.05301(7)	0.0454(1)	0.06274(5)
C(11)	0.05927(6)	0.0078(1)	0.07598(5)
C(12)	0.05773(8)	-0.0077(1)	0.07839(5)
C(13)	0.05981(8)	-0.0115(1)	0.08650(5)
C(14)	0.06370(7)	-0.0000(1)	0.09227(5)
C(15)	0.06589(8)	0.0152(1)	0.09014(5)
C(16)	0.06354(8)	0.0192(1)	0.08183(5)
C(17)	0.06861(9)	0.0065(2)	0.10637(6)
C(21)	0.03145(7)	0.00401(1)	0.06359(5)
C(22)	0.02258(8)	-0.0065(1)	0.05964(5)
C(23)	0.01142(8)	-0.0070(1)	0.06184(6)
C(24)	0.01008(8)	0.0026(1)	0.06814(5)
C(25)	0.01887(8)	0.0128(1)	0.07208(5)
C(26)	0.02983(7)	0.0134(1)	0.06983(5)

TABLE II Selected Bond Lengths(nm)

Bond	*Dist.*	*Bond*	*Dist.*
S(1)-C(1)	0.1486(9)	P-N(2)	0.1613(6)
S(2)-P	0.1928(3)	P-C(11)	0.1781(7)
P-N(1)	0.1674(8)	N(1)-C(1)	0.1197(9)
N(2)-C(21)	0.1449(8)		

TABLE III Selected Bond Angles (°)

Angle	*(°)*	*Angle*	*(°)*
S(2)-P-N(1)	111.4(3)	C(1)-P-C(11)	101.6(3)
S(2)-P-N(2)	110.2(2)	N(2)-P-C(11)	107.7(3)
S(2)-P-C(11)	117.2(2)	P-N(1)-C(1)	160.0(7)
N(1-P-N(2)	108.3(3)	P-N(2)-C(21)	130.1(5)
P-C(11)-C(16)	119.3(7)	S(1)-C(1)-N(1)	178.0(8)
P-C(11)-C(12)	118.2(5)		

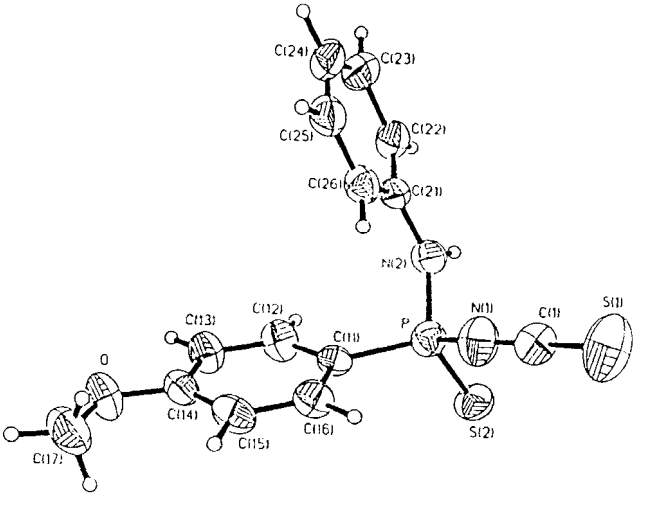
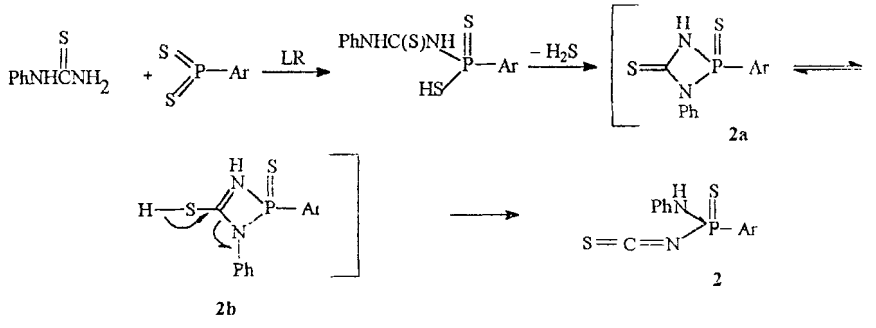


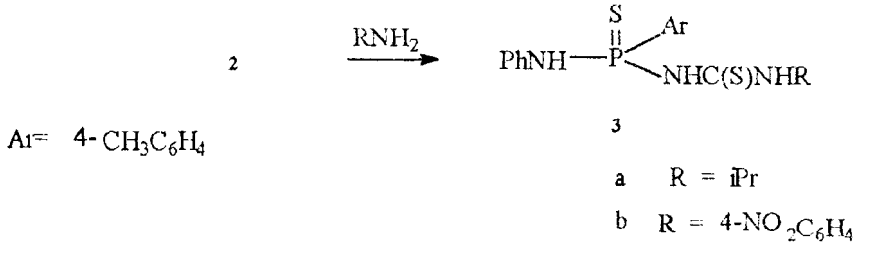
FIGURE 1 The molecular structure of **2**

As to the formation of **2**, one can assume that the electrophilic center of phosphorus of the monomeric part of **LR** could attack the more nucleophilic center namely the amino group of phenylthiourea, to give a dithiophosphonamide which looses hydrogen sulfide to form an unstable 4-membered cyclic intermediate (**2a**), which subsequently rearranges to yield **2** (Scheme 2).



SCHEME 2

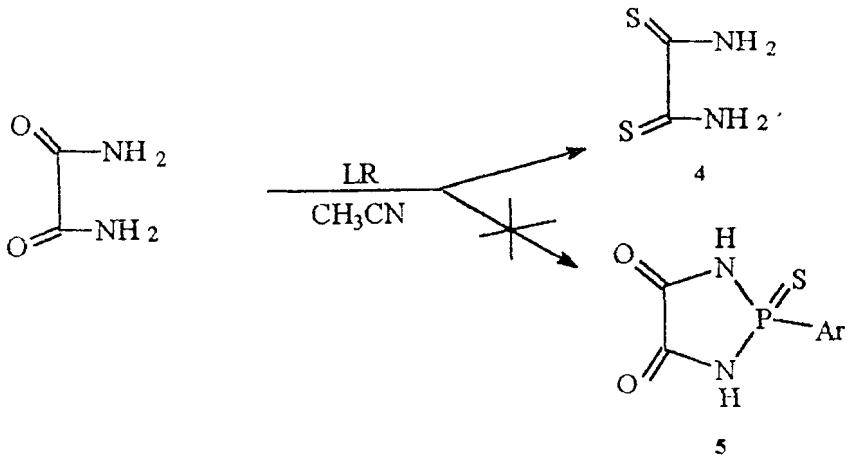
The structure of **2** has been established spectroscopically as well as by chemical evidence. The open chain product (**2**) will react with amines to form the adducts **3** (Scheme 3).



SCHEME 3

B. Reaction of Lawesson's Reagent with Oxamide

LR reacted with oxamide at refluxing temperature in dry acetoniltrile to give dithiooxamide, an O-S exchange product (**4**) of carbonyl groups, instead of the expected product (**5**) formed as a result of heterocyclization (Scheme 4).



SCHEME 4

Melting point of **4** is identical to that of dithiooxamide as reported in catalog handbook of Aldrich chemical reagents. Its structure was also confirmed by IR, ^{1}H NMR,and MS spectra. In the ^{1}H NMR spectrum (DMSO-d_6), there appeared only a broad peak. The chemical shift of mobile proton (N-H,broad peak) was found at 9.40.It disappeared when deuteration. The IR spectrum showed normal stretching mode and absorption bands, indicating the existence of the groups N-H (3393;3267), 1580 (N-C=S). The EI-MS spectrum confirmed the assigned structure by the molecular ion peak and base peak (120,M^+). Another identifiable fragmentation ion was found at 60 [$C(S)NH_2$, 53.54].

EXPERIMENTAL

Elemental analysis was performed with a CHN CORDERD MT-3 elementary analyzer. Mass spectra were recorded with a VG-7070E spectrometer. ^{1}H NMR spectra were recorded with Varian XL-200 spectrometer . TMS was used as an internal standard for the ^{1}H NMR spectra and 85% H_3PO_4 was used as an external standard for the ^{31}P NMR spectra. The IR spectra were measured by using a SHIMADZU-435 instrument. Melting points were determined with a model YANACO MP-500 apparatus and are uncorrected. Column chromatography was performed on silica gel II (10 – 40 μ ,Hai Yang Chemical Factory of Qingdao). Lawesson's reagent was prepared as described in Ref. 8.

A single crystal of **2** was cultured from the mixturre of petroleum ether and dry ethyl ether. The reflection in the range of $4° \leq 2\theta \leq 46°$ were collected on an ENRAF-NONIUS CAD_4 X-ray diffractiometer with $M_oK\ \alpha$ radiation (λ =0.071073nm). All calculations were performed on a PDP11/44 computer using the SDP-PLUS program system.

Procedure of the reaction of Lawesson's reagent with phenylthiourea

A solution of 0.01 mole of phenylthiourea and 0.005 mole of Lawesson's reagent in 10 ml dry toluene was stirred with a magnetic mixer at 110°C until no more of the starting material could be detected (TLC). The solvent was evaporated under reduced pressure and the residue purified on a silica gel column using a petroleum ether/dry ethyl ether mixture as eluent. Compound **2**, m.p. 83 – 85 °C was obtained in a yield of 41.25%.Anal calcd for $C_{14}H_{13}N_2OPS_2$:

C,52. 50;H,4.06;N,8.75. Found : C,52.16;H,4.343; N,8.59.

Procedure of the reaction of Lawesson's reagent with oxamide

An amount of 0.01 mole of Lawesson's reagent and 0.01 mole of oxamide were refluxed in 15 ml of anhydrous acetonitrile with stirring until no more of the starting material could be detected by TLC. Evaporation of the solvent under reduced pressure followed by purifying of the residue on a silica gel column using dry ethyl ether / petroleum ether mixture as eluent gave compound **4** (dithiooxamide);m.p. 244 – 245 °C(lit. m.p. 245 °C),yield 67.36%. Anal Calcd for $C_2H_4N_2S_2$:C,20.00;H,3.33;N,23.33. Found: C,20.23;H,3.15;N,23.08.

Acknowledgements

We gratefully acknowledge support for this work by the National Science Foundation of China and the China Postdoctoral Science Foundation. The authors also would like to express thanks to Hong-Gen Wang and Xin-Kan Yan and the Central Laboratory of Nankai University for providing the X-ray diffraction analysis.

References

[1] M. P. Cava, M. I. Levinson, *Tetrahedron*, **41**, 5061(1985)
[2] R. Shabana, F. H. Osmann, S. S. Atress, *Tetrahedron*, **50**, 6975 (1994)
[3] R. Shabana, S. S. Atress, *Phosphorus, Sulfur and Silicon*, **105**, 57 (1995)
[4] T. Nishio. *Tetrahedron lett.* ,**36(34)**,6113 (1995)
[5] L.-N. He, R.-Y. Chen, R.-X. Zhuo, *Chem. J. Chinese Univ.*, 1997, in press
[6] L.-N. He, R.-Y. Chen, *Phosphorus, Sulfur and Silicon*, 1997, to be pulished
[7] L.-N. He, R.-Y. Chen, *J. Heterocycl. Commun.*, 1997, to be published.
[8] I. Thomsen, K. Clausen, S. Scheibye, and S. O. Lawesson, *Org. Synth.* , **62**, 158 (1984)