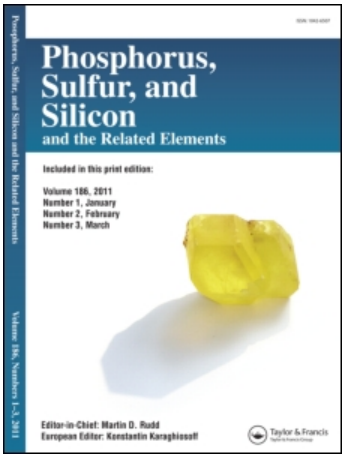


Phosphorus, Sulfur, and Silicon and the Related Elements

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

May Dithiophosphoric Acid Participate in the SET Process?

Leszek Doszczak[a]; Witold Przychodzen[a]; Dariusz Witt[a]; Janusz Rachon[a]
[a] Department of Organic Chemistry, Chemical Faculty, Technical University of Gdańsk, Gdańsk, Poland

Online publication date: 27 October 2010

To cite this Article Doszczak, Leszek , Przychodzen, Witold , Witt, Dariusz and Rachon, Janusz(2002) 'May Dithiophosphoric Acid Participate in the SET Process?', Phosphorus, Sulfur, and Silicon and the Related Elements, 177: 6, 1851 — 1854
To link to this Article: DOI: 10.1080/10426500212210
URL: http://dx.doi.org/10.1080/10426500212210

Phosphorus, Sulfur and Silicon, 2002, Vol. 177:1851–1854

1042-6507/02 $12.00 + .00
DOI: 10.1080/10426500290093225

MAY DITHIOPHOSPHORIC ACID PARTICIPATE IN THE SET PROCESS?

Leszek Doszczak, Witold Przychodzen, Dariusz Witt, and Janusz Rachon
Department of Organic Chemistry, Chemical Faculty, Technical University of Gdańsk, Gdańsk, Poland

(Received July 29, 2001; accepted December 25, 2001)

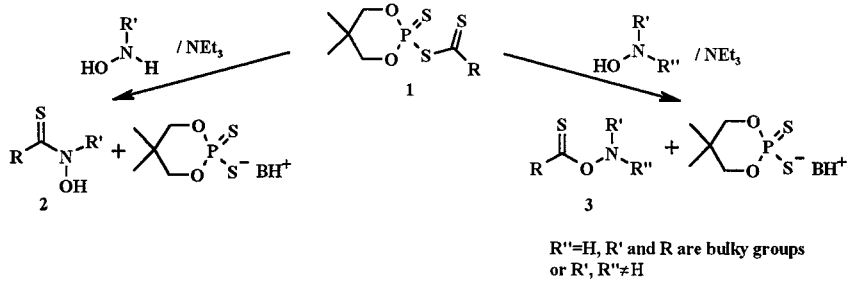
Recently we have developed a convenient method for the synthesis of S*-thioacyl dithiophosphates* ***1****, excellent thioacylating reagents. When hydroxylamines with one bulky group or two substituents on the nitrogen atom are treated with* S*-thioacyl dithiophosphates* ***1*** O*-thioacyl hydroxylamines* ***3*** *are produced exclusively. What is more important, compounds* ***3*** *undergo interesting reaction with dithiophosphoric acid* ***4*** *yielding amine and acyl thiophosphoryl disulfide* ***5****. The disulfide* ***5*** *can be formed as a product of thiophilic attack of the dithiophosphate anion on the thiocarbonyl group in protonated* O*-thioacyl hydroxylamine* ***3****. On the other hand, it is well known that dithiophosphate anions easily undergo one electron oxidation. Hence the dithiophosphate anion can act as single electron donor and disulfide* ***5*** *can be formed as a product of the SET reaction. The influence of light and radical traps strongly suggests that the second possibility operates in the reaction in focus.*

Keywords: Hydroxylamines; SET; thioacylation; thiohydroxamic acids

We have recently discovered that easily available *S*-thioacyl dithiophosphates **1** are excellent thioacylating agents. Mixed anhydrides of type **1** chemoselectively thioacylate nitrogen or sulfur nucleophiles in the presence of hydroxyl groups. This property allowed us to obtain hydroxythioamides, hydroxydithioesters, or thioxydroxamic acids as well, from substrates nonprotected on oxygen atom.[1] Particularly interesting is the synthesis of thiohydroxamic acids **2** in the reaction of hydroxylamines with mixed anhydrides **1**. Thiohydroxamic acids are a very important class of compounds from the technological, theoretical,

We gratefully acknowledge the Polish State Committee for Scientific Research for financial support (Grant No. 3 T09A 061 16).

Address correspondence to Janusz Rachon, Department of Organic Chemistry, Chemical Faculty, Technical University of Gdańsk, ul. Narutowicza 11/12, 80-952 Gdańsk, Poland. E-mail: dzknt@chem.pg.gda.pl



SCHEME 1 Thioacylation of hydroxylamines with anhydrides **1**.

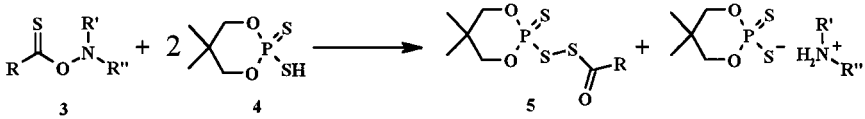
and biological point of view. Thus we decided to study scope and limitations of the new strategy of thioacylation. We treated the set of hydroxylamines with anhydrides **1**, efficiently isolating thiohydroxamic acids (see Table I, Entries **2a–l**). Surprisingly, from the reaction mixture composed of *S*-thiopivaloyl dithiophosphate **1d** (R = *t*-Bu) and *N*-isopropylhydroxylamine we were not able to isolate desired thiohydroxamic acid, but we obtained thiophosphoryl pivaloyl disulfide **5d** (R = *t*-Bu). In due course we have found that hydroxylamines with one but bulky group on the nitrogen atom, in the reaction with hindered *S*-thioacyl dithiophosphates **1**, furnish *O*-thioacyl hydroxylamines **3**,

TABLE I Thioacylation of Hydroxylamines with Anhydrides **1**

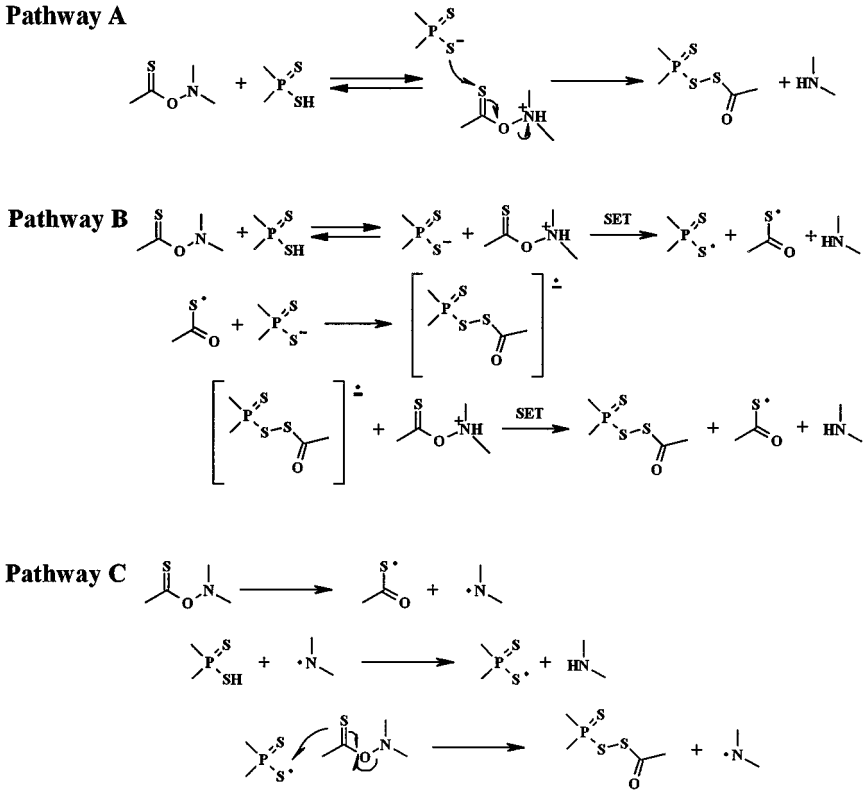
Entry	R	R′	R″	Yield (%)
2a	Ph	Me	H	68
2b	Ph	*i*-Pr	H	73
2c	Ph	CH(Me)Ph	H	72
2d	Pr	Me	H	83
2e	Pr	*i*-Pr	H	80
2f	Pr	CH(Me)Ph	H	77
2g	Pr	*t*-Bu	H	57
2h	$MeOCO(CH_2)_4$	Me	H	91
2i	$MeOCO(CH_2)_4$	*i*-Pr	H	91
2j	$MeOCO(CH_2)_4$	CH(Me)Ph	H	94
2k	$MeOCO(CH_2)_4$	*t*-Bu	H	82
2l	*t*-Bu	Me	H	71
3a	*t*-Bu	*i*-Pr	H	73[a]
3b	*t*-Bu	*t*-Bu	H	96
3c	*t*-Bu	CH(Me)Ph	H	95
3d	*t*-Bu	$CH_2CH_2OCH_2CH_2$		71
3e	*t*-Bu	*i*-Pr	PhCO	95[b]
3f	Ph	*t*-Bu	H	74

[a]Product not isolated, the yield estimated on isolated disulphide **5**.
[b]The thioacylation of hydroxamic acid required application of DBU as a base.

which are stable under basic conditions and can be isolated with high yields (Table I, Entries **3a–f**). Naturally hydroxylamines possessing two substituents on the nitrogen atom give the same results. But what is more important, if dithiophosphoric acid **4** is present in the reaction mixture, *O*-thioacylhydroxylamines **3** undergo an interesting process, yielding amine and acyl *O*,*O*-dialkylthiophosphoryl disulfides **5** (Scheme 2). From the theoretical point of view the first step



SCHEME 2 Reaction of *O*-thioacyl hydroxylamines **3** with dithiophosphoric acid **4**.



SCHEME 3 Proposed mechanisms of reaction of *O*-thioacyl hydroxylamines with dithiophosphoric acids.

(Scheme 3, Pathway A) should be the protonation of the nitrogen atom. In the second step the nucleophilic (thiophilic) attack of dithiophosphate anion on the sulfur atom of the thiocarbonyl group occurs. However, dithiophosphoric acid anion easily undergoes one electron oxidation process, hence disulfide **5** can be formed as a product of the SET reaction (Scheme 3, Pathway B). In pathway B the principal process is the single-electron transfer from dithiophosphate anion into the protonated form of *O*-thioacylhydroxylamines, producing amine and acyl thioradical. The key step in the mechanism outlined in Scheme 4, Pathway B is the formation of the disulfide anion radical as a consequence of the reaction between the monothiocarboxyl radical and dithiophosphate anion. Subsequent electron transfer from the disulfide anion radical to *O*-thioacyl hydroxylamine provides chain process. How we can distinguish between these two mechanisms? Well, in pathway B radicals are transient species, thus radical traps should decrease the yield of the products. Contrary light promotes SET process and thus should influence the yield as well. Reaction proceeding with pathway A should be insensitive to both factors. And indeed *O*-thioacyl hydroxylamine does not react with dithiophosphoric acid in the darkness, and only irradiation (or daylight exposure) leads to disulfide **5** formation. Consequently, ionic mechanism (Scheme 3, Pathway A) is excluded. Also, the addition of radical scavengers like 2,6-dimethylthiophenol prevents the formation of disulfide **5**, confirming proposed SET mechanism (Scheme 3, Pathway B). On the other hand, at this point one can also argue that during light irradiation of *O*-thioacyl hydroxylamines, homolytic cleavage of the N—O bond can lead to aminyl and monothiocarboxy radicals. These radicals can initiate the radical chain process (Scheme 3, Pathway C). However thioacylhydroxylamines are resistant to irradiation under the same conditions (or even more drastic one) and no products of homolysis are formed. This fact makes Pathway C doubtful.

REFERENCE

[1] L. Doszczak and J. Rachon, *Chem. Comm.*, **21,** 2093 (2000).