Tetrahedron Letters No. 3, pp 181 - 184, 1976. Pergamon Press. Printed in Great Britain.

DIRECT ATTACK ON THE SULFUR ATOM OF PHOSPHINODITHIOATE ESTERS BY ORGANOMETALLOIDS[1]

Koshiro GODA, Renji OKAZAKI, Kin-ya AKIBA, and Naoki INAMOTO
Department of Chemistry, Faculty of Science,
The University of Tokyo, Hongo, Tokyo 113, Japan

(Received in Japan 6 November 1975; received in UK for publication 8 December 1975)

Substitution on the phosphoryl group with Grignard reagents[2] and organolithiums[3] has been known and used as a synthetic method. However, it has recently been reported that phosphoric esters having one benzyl or allyl group undergo a facile Wittig type rearrangement via a carbanion.[4] On the other hand, it was disclosed that benzyl ester does not rearrange to phosphoryl group when it is linked with methylamino group.[5] Thus, rather simple reaction of phosphoryl group with organo-metalloids shows intriguing and unique feature depending on heteroatoms surrounding the phosphoryl group. We now wish to report evidences for direct attack of organometalloids on the sulfur atom of phosphinodithioate esters.

The reaction of methyl diphenylphosphinodithioate (1a) with n-butyllithium in tetrahydrofuran (THF) proceeded rapidly at -78°C to afford methyldiphenylphosphine sulfide (2) quantitatively by quenching the reaction mixture with excess methyl iodide. It was shown that the sulfide (2) was obtained almost quantitatively by a similar reaction with benzyl (1b) and phenyl (1c) esters. In each case, a considerable amount of the corresponding n-butyl sulfide (3) was obtained accompanied by methylated sulfonium iodide. When the reaction mixture was quenched with methanol or water, the corresponding n-butyl sulfides (3) were obtained in excellent yields. This method is applicable to the preparation of the sulfides.[6]

When n-butylmagnesium chloride was used as a nucleophile, the same products

were obtained in moderate yields by refluxing the THF solution for 3 hr.

These results show that diphenylphosphinothioylide anion (A) was generated in

$$Ph_2\overset{\overset{S}{\|}}{P}\text{-S-R} \xrightarrow[-78°C]{\text{n-BuM}} \text{n-Bu-S-R} + [Ph_2PS]M \xrightarrow{MeI} Ph_2\overset{\overset{S}{\|}}{P}\text{-Me} \qquad (1)$$

1a: R=Me
b: R=CH_2Ph
c: R=Ph

3 A (M=Li, MgCl) 2

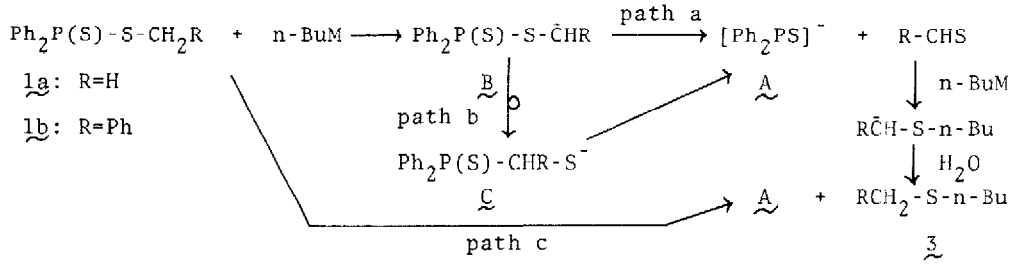
situ together with the corresponding sulfide (3) almost quantitatively. These results are in sharp contrast with the reaction of phosphinate esters with nucleophiles where substitution occurs on phosphorus atom exclusively.[2,3]

In order to prove the intermediacy of A in the reaction (1), ^{31}P-NMR chemical shifts[7] were measured for the reaction mixtures of 1 with n-butyllithium and n-butylmagnesium chloride. All reaction mixtures of 1 with n-butyllithium showed a single peak at -21.2 ppm and with n-butylmagnesium chloride at -14.3 ppm. These facts clearly show the generation of A as an intermediate, which was confirmed by the observation of the same chemical shifts in the treatment of diphenylphosphine sulfide with n-butyllithium and n-butylmagnesium chloride in THF.

There are three possible mechanisms for the generation of diphenylphosphinothioylide anion (A). When 1b is treated with a nucleophile, one of the methylene protons is abstracted to form the carbanion (B) (see Scheme 1), which decomposes to A spontaneously (path a), or rearranges to thiolate anion (C) to give A (path b), as was evidenced for phosphates.[4] The resulting thioaldehyde should react with organometalloids to give sulfides (3).[8] The third possibility is that the nucleophile attacks the ester sulfur atom directly to give A and the sulfide (3) (path c).

According to paths a and b, two moles of n-butyllithium should be consumed per one mole of 1a or 1b, but the reaction proceeded almost quantitatively with an equimolar mixture of the two reagents. Furthermore, benzyl ester (1b) was treated with n-butyllithium and rapidly quenched by deuterium oxide at -78°C. The careful integration of the ^{1}H NMR signals of the resulting benzyl n-butyl

sulfide (3b) revealed that no deuterium was incorporated in the sulfide. This result was also supported by analysis of the mass spectrum of the sulfide. These results can exclude the possibility of paths a and b. Above conclusion

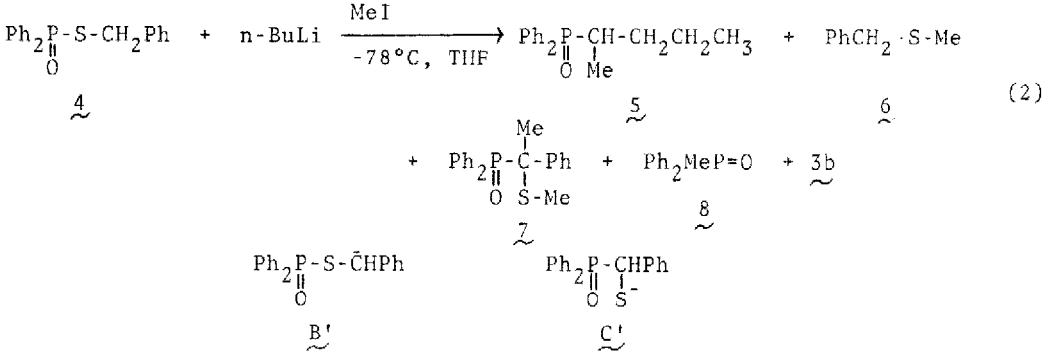


Scheme 1

was also supported by the fact that phenyl ester (1c) afforded A and 3c quantitatively.

Thus it is now concluded that the formation of A and the sulfide (3) proceeds through path c, that is the direct attack on the sulfur atom by organometalloids.

In the reaction of S-benzyl diphenylphosphinothioate (4) with n-butyllithium (1.8 eqv.), several products were obtained after quenching with methyl iodide as shown in equation (2); 5 (57%), 6 (54%), 7(11%), 8(14%), and 3b (12%).[9]



(2)

Though formation of major products 5 and 6 indicates that the main reaction was nucleophilic substitution on phosphorus, the formation of 7 shows that carbanion (B') formed by the abstraction of the methylene proton rearranged to thiolate anion (C'), which was quenched by methyl iodide. The second methyl group of 5 and 7 was introduced by excess n-butyllithium and methyl iodide.

Above result shows that rearrangement of the carbanion (B') (path b) and direct attack on the sulfur atom (path c) compete with the nucleophilic substitution reaction on phosphorus.

Further study has been continued on the nature of phosphoryl and thiophosphoryl groups towards organometalloids.

References and Notes

1) Metal phosphinylides and phosphinothioylides. V. For Part IV see: K. Goda, M. Yoshifuji, R. Okazaki, and N. Inamoto, Bull. Chem. Soc. Japan, 48, 2484 (1975).

2) K. D. Berlin and G. B. Butler, J. Amer. Chem. Soc., 82, 2712 (1960); K. D. Berlin and R. U. Pagilagan, J. Org. Chem., 32, 129 (1967); O. Korpium, R. A. Lewis, J. Chickos, and K. Mislow, J. Amer. Chem. Soc., 90, 4842 (1968).

3) J. L. Williams, Chem. and Ind., 1957, 235

4) G. Sturtz and B. Corbel, Compt. Rend., 276 (C), 1807 (1973); ibid., 277 (C), 395 (1973).

5) P. Savignac, M. Dreux, and Y. Leroux, Tetrahedron Lett., 1974, 2651

6) K. Goda and N. Inamoto, Chem. Lett., 1975, 1009.

7) ppm from 85% phosphoric acid as an external standard. We are grateful to Drs. M. Yoshifuji and T. Kawashima of our laboratory for measurement of ^{31}P-NMR.

8) P. Beak and J. W. Worley, J. Amer. Chem. Soc., 94, 597 (1972); D. Seebach, Chem. Ber., 105, 487 (1972).

9) NMR (CCl_4); 5 : δ 0.83 (m, 3H), 1.08 (dd, J_{HH} 9, J_{PCCH} 16 Hz, 3H), 1.40 (m, 4H), 2.0-2.7 (m, 1H), and 7.2-8.0 (m, 10H); 7 : δ 1.85 (d, J_{PCCH} 14 Hz, 3H), 2.03 (s, 3H), 7.13 (s, 5H), and 7.2-8.1 (m, 10H).