TRANSFORMATIONS OF HYDROXYALKYL ESTERS OF DIMETHYLAMIDO-O-PHENYLTHIOPHOSPHORIC ACID

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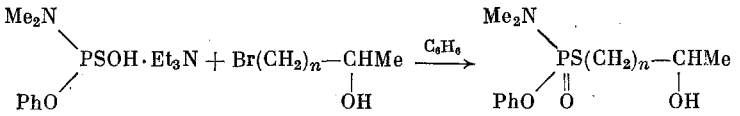
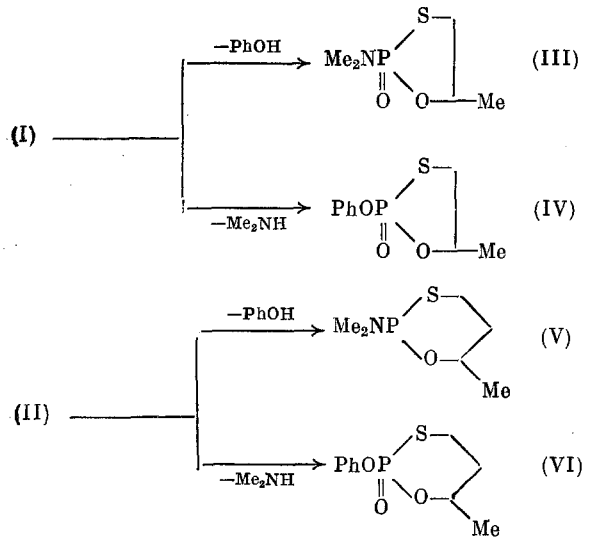
The transformations of 2- and 3-hydroxyalkyl esters of phosphorus thioesters give products which differ either in the length of the **mercaptoalkyl** substituent at the phosphorus atom [1, 2] or the ring size [3-6]. Thus, the cyclization of 2- and 3-hydroxyalkyl esters of isopropylphenylthiophosphoric acid proceeds with the loss of phenol [3, 4].

In the present work, we studied the transformations of 2- and 3-hydroxyalkyl esters of dimethylamido-O-phenylthiophosphoric acid and found a significant difference in the structures of the products formed. Due to the instability of dimethylamido-O-phenylthiophosphoric acid, the synthesis of the hydroxyalkyl esters through the oxiranes and oxetanes is difficult. Thus, the salt of the acid and the corresponding bromoalkanols were used to prepare the starting bromoalkanols



$n = 1$ (I); 2 (II).

Since esters (I) and (II) phenoxydialkylamido substituents are good leaving groups, the transformations presumably proceed with the formation of cyclic compounds (III)-(VI):



In our previous work [3-6], physical indices and ^{31}P NMR data are given for (III), (IV), (VI) and analog (V), which were used to determine the structure of the products obtained from esters (I) and (II).

The reaction mixture for the preparation of ester (II) after 60-90 min heating was shown by ^{31}P NMR spectroscopy to contain mostly ester (II) with δP 34 ppm, while more vigorous heating leads to the appearance of (VI). The formation of dimethylamine and (VI) occurs during the distillation of (II). Heating (II) in m-xylene at reflux for about 3 h leads to a ~1:1 mixture of (II) and (VI) as indicated by ^{31}P NMR spectroscopy.

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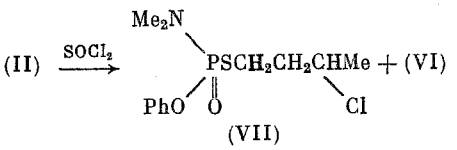
The reaction of (II) with $SOCl_2$ in the absence of base yields a mixture of (VII) and (VI)



(VII)

Assuming that the HCl released in this reaction facilitates the cyclization of (II), the latter was heated with hydrogen chloride in dioxane at reflux. The ^{31}P NMR spectrum of the reaction mixture contains only signals corresponding to (VI).

If the reaction with $SOCl_2$ is carried out in the presence of Et_3N, the signal for (VI) disappears and the major reaction product is (VII). In the transformations of (II), the ^{31}P NMR spectrum never was found to contain signals corresponding to (V).

The reaction of the triethylammonium salt of dimethylamido-O-phenylthiophosphoric acid with 1-bromo-2-propanol features considerable tar formation. The ^{31}P NMR spectrum of the reaction mixture indicated that upon the formation of dimethylamido-O-phenyl-S-(hydroxypropyl) thiophosphate (I), it is completely transformed with the loss of phenol to give cyclic ester (III).

Thus, we have discovered a significant difference in the transformations of 2- and 3-hydroxyalkyl esters of dimethylamido-O-phenylthiophosphoric acid. When a thiaoxaphosphorane ring is formed, the phenoxy group is lost, while the analogous 3-hydroxyalkyl ester undergoes cyclization with the loss of dimethylamine.

EXPERIMENTAL

Reaction of the Trimethylammonium Salt of Dimethylamido-O-phenylthiophosphoric Acid with 1-Bromo-3-butanol. A mixture of 3.5 g water and 19.8 g Et_3N in 20 ml THF was added with stirring and ice water cooling to 45.3 dimethylamido-O-phenylphosphoric acid diacid chloride in 250 ml benzene and warmed to about 20°C. The precipitate was filtered off. THF and about one-third of the benzene were distilled off at 10 mm. A sample of 19.7 g Et_3N in 20 ml benzene was added to the acid phosphite obtained in benzene and then 6.2 g sulfur was added. The mixture was heated until the sulfur was fully dissolved. Then, 30 g 1-bromo-3-butanol was added to the starting salt and the mixture was heated at moderate reflux in benzene for 1 h with stirring. The precipitate was filtered off after three days. Benzene was distilled off at 10 mm to give 63 g ester (II) as a thick brown residue. Since the loss of $Et_3N \cdot HBr$ was noted on the following day, product (II) was passed through a silica gel column using benzene as eluant to give 53.3 g (II) which was used for all the subsequent transformations.

Heating 14 g (II) for about 3 h in 50 m-xylene at reflux leads to a ~1:1 mixture of (II) and (VI). Distillation of the mixture gave a fraction with bp 105-112°C (0.08 mm) (3.2 g) which was crystallized on the following day, mp 97-99°C (from CCl_4). Found: C 49.16; H 5.23; P 12.86%. $C_{10}H_{13}O_3PS$ (VI). Calculated: C 49.18; H 5.32; P 12.70%.

Reaction of (II) with $SOCl_2$. A sample of 15.7 g (II) in 20 ml CH_2Cl_2 was heated at reflux for 20 min with 7 g $SOCl_2$. The volatile compounds and CH_2Cl_2 were distilled off at 10 mm. The residue was divided approximately in half. The first half (7.4 g) after vacuum distillation gave 2.67 g of a fraction with bp 90-100°C (0.1 mm) which is a mixture of dimethylamido-O-phenyl-S-(3-chlorobutyl) thiophosphate (VII) with cyclic thiophosphate (VI). Chromatography on silica gel with CH_2Cl_2 as eluant gave (VII), d_4^{20} 1.2047, n_D^{20} 1.5368. Found: C 46.40; H 6.34; P 10.00%. $C_{12}H_{19}ClNO_2PS$. Calculated: C 46.82; H 6.17; P 10.08%. Product (VII) was not isolated upon chromatography of the second half of the residue without prior distillation.

Reaction of (II) with $SOCl_2$ in the Presence of Et_3N. A sample of 3.43 g Et_3N was added with stirring and ice water cooling to 9.81 g (II) in 50 ml CH_2Cl_2 and then 4.04 g $SOCl_2$ was added slowly. The mixture was heated for 15 min at reflux and CH_2Cl_2 was distilled off at 10 mm. A sample of 100 ml ether was added to the tarry residue. $Et_3N \cdot HCl$ was filtered off and ether was distilled off at 10 mm. The thick dark brown residue was distilled. The fraction with bp 98-140°C (0.1 mm) (1.7 g) had a strong ^{31}P NMR signal at δP 34 ppm and a small impurity signal at 80 ppm. The signal for (VI) was absent. The purification of (VII) was

also carried out by chromatography, d_4^{20} 1.2042, n_D^{20} 1.5358. Found: N 4.26; P 10.32%. $C_{12}H_{19}ClNO_2PS$. Calculated: N 4.55; P 10.08%.

Reaction of (II) with HCl. Heating 8.1 g (II) with 1 g HCl in 20 ml dioxane at reflux yields only (VI) as indicated by ^{31}P NMR spectroscopy. Prior to distillation the product considered of a 3:2 mixture of stereoisomers with δP 12 and 14 ppm. Heavy tar formation occurred upon the distillation of (VI). The introduction of a seed led to crystallization of the distillate to give the isomer of (VI) with δP 12 ppm. Recrystallization from CCl_4 gave 1.3 g (20%) (VI), mp 96-98°C. Found: C 49.07; H 5.31; P 12.52%. $C_{10}H_{13}O_3PS$. Calculated. C 49.18; H 5.32; P 12.70% [4].

Reaction of the Triethylammonium Salt of Dimethylamido-O-phenylthiophosphoric Acid with 1-Bromo-2-propanol. A mixture of 3.43 g water and 19.26 g Et_3N in 20 ml THF was added with stirring and ice water cooling to 44.15 g dimethylamidophenylphosphorous acid chloride in 250 ml benzene and warmed to about 20°C. The $Et_3N \cdot HCl$ residue was filtered off and THF and about one-third of the benzene were distilled off the residue. Then, 19.26 g Et_3N and in 20 ml benzene was added to the acid phosphite in benzene and 6.1 g sulfur was introduced. The mixture was heated until all the sulfur dissolved. 1-Bromo-2-propanol (28.5 g) was added to the salt obtained and stirred at reflux for 1.5 h. The mixture was cooled to 20°C and $Et_3N \cdot HBr$ was filtered off. Benzene was distilled off at 10 mm. After distillation of the solvent, ^{31}P NMR spectroscopy showed virtually only one signal with δP 49 ppm with a small impurity signal at 80 ppm. Distillation of this residue gave a fraction with bp 100-115°C (0.1 m) (10.1 g) which was shown by ^{31}P NMR spectroscopy to contain 75-80% (III) and an impurity giving rise to a signal at 70-80 ppm. Chromatography on silica gel with CH_2Cl_2 as eluant gave (III), d_4^{20} 1.2186, n_D^{20} 1.5070; a phenol impurity is present. Found: N 7.88%. $C_5H_{12}NO_2PS$. Calculated: N 7.3%. δP 47 ppm [5]. d_4^{20} 1.2228, n_D^{20} 1.5055. The PMR spectra for (III) and that published previously for this compound [5] were identical.

CONCLUSION

Phenol is given off in the cyclization of 2-hydroxyalkyl esters of dimethylamido-O-phenylthiophosphoric acid, while dimethylamine is released upon the cyclization of the corresponding 3-hydroxyalkyl esters.

LITERATURE CITED

1. O. N. Nuretdinova and F. F. Guseva, Izv. Akad. Nauk SSSR, Ser. Khim., 2594 (1980).
2. O. N. Nuretdinova and B. A. Arbuzov, Izv. Akad. Nauk SSSR, Ser. Khim., 1128 (1981).
3. O. N. Nuretdinova and B. A. Arbuzov, Izv. Akad. Nauk SSSR, Ser. Khim., 1130 (1981).
4. B. A. Arbuzov and O. N. Nuretdinova, Izv. Akad. Nauk SSSR, Ser. Khim., 675 (1983).
5. O. N. Nuretdinova and F. F. Guseva, Izv. Akad. Nauk SSSR, Ser. Khim., 1659 (1982).
6. O. N. Nuretdinova and F. F. Guseva, Izv. Akad. Nauk SSSR, Ser. Khim., 2136 (1984).