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Note

A Novel Transformation to *S*-Methyl Phosphorodichloridothiolate and the Fungitoxicity of Diaryl *S*-Methyl Phosphorothiolates[†]

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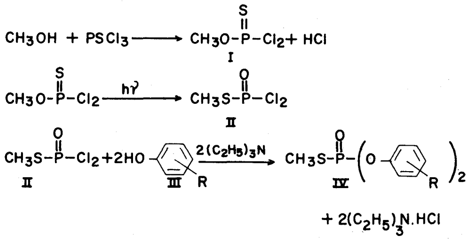
Several phosphorothiolates have been reported[1)] to possess antifungal activity and some of these have also been commercialized. With this in mind, the preparation (Scheme 1) and antifungal activity of diaryl *S*-methyl phosphothiolates were investigated. A literature method[2)] for the preparation of *S*-methyl phosphorodichloridothiolate is to heat the corresponding *O*-methyl derivative for 5 hours at 100°C. Although the method is time consuming, the product is an important intermediate for insectioides like methamidophos and acephate. Therefore, we were interested in studying the reaction in detail and found that the rearrangement can be achieved in quantitative yield in 25 to 30 minutes when *O*-methyl derivative is irradiated with a high pressure mercury lamp. The preparation methods, physico-chemical properties and fungicidal activity of diaryl esters derived form *S*-methyl phosphorodichloridothiolate are reported in this paper.



Scheme 1.

EXPERIMENTAL

Synthesis. All melting points and boiling points are uncorrected. Thin layer chromatography was carried out with silica gel chromatoplates (250 mμ thick), using a 9 : 1 (v/v) mixture of benzene and acetone as a developing solvent, and the spots were visualized in an iodine chamber. The infrared spectra of the phosphorothiolates recorded on a Perkin Elmer-457 spectrophotometer showed the following characteristic peaks; 1180 ~ 1200 cm^{-1} (P–O–C aromatic), 1240 ~ 1260 cm^{-1} (P=O) and 920 ~ 970 cm^{-1} (P–S–C). The most characteristic feature of this group of compounds in the NMR spectra, recorded on a Varian A-60 spectrometer, is the presence of a doublet at δ 2.30 ~ 2.35 (d, $J = 17$ Hz, P–S–CH_3)[3)] besides the usual signals due to aromatic protons and protons of substituents like CH_3, OCH_3, SCH_3 and the $C(CH_3)_3$ groups.

O-Methyl phosphorodichloridothionate (**I**). To a mixture of thiophosphorylchloride (20.2 g, 1.2 mol), freshly ignited calcium oxide (8.4 g, 1.5 mol) and a catalytic quantity of pyridine (100 mg) in methylene chloride (100 ml) kept at 5°C, methanol (6.4 g, 2 mol) was added dropwise with stirring. The reaction mixture was further stirred for three hours at room temperature to complete the reaction. The solution was washed with cold 2% HCl followed by saturated solution of NaCl and dried over anhydrous Na_2SO_4 to filter off the inorganic salts. After removing the solvent from the filtrate, the liquid product was distilled *in vacuo* and the fraction which boiled at 58°/50 mm was collected (yield 15 g) (reported[2] bp 60°/55 mm).

S-Methyl phosphorodichloridothiolate (**II**). Continuously stirred *O*-methyl phosphorodichloridothionate (**I**, 10 g) was irradiated for 25 ~ 30 minutes in a Pyrex flask with a high pressure mercury lamp (125 W Phillips) placed at a distance of 5 cm beneath the flask. The light brown coloured product obtained was distilled *in vacuo* and the fraction which boiled at 80°/20 mm was collected (yield 8 g) (reported[2)]) bp 75.5°/10 mm.

Diaryl S-methyl phosphorothiolates (**IV**). The general procedure is as follows. A solution of *S*-methyl phosphorodichloridothiolate (1 mol) in dry benzene was added dropwise with stirring to a cooled (0 ~ 5°C) solution of the substituted phenol (2 mol) in dry benzene containing dry triethyl amine (2 mol). After addition, the mixture was further stirred for 3 hours at room temperature. After filtering off the amine hydrochloride, the solvent was removed by distillation and the residue purified by recrystallization from a mixture of pet. ether and benzene. Column chromatography on silica gel was also used in the case of liquids when the distillation was unsuccessful. The physical and analytical data for the new phosphorothiolates (1 ~ 20) prepared in this way are listed in Table I.

Fungicidal activity. An assay for the fungicidal activity of the phosphorothiolates was carried out against *Pyricularia oryzae* cav., *Helminthosporium/oryzae* Auct. *Alternaria alternata* Breda de Haan, *Rhizoctonia Bataticola* (Tassi) Goid and *Pythium aphanidermatum* Eds. Fitzp. The poisoned food technique was applied, using standard potato/dextrose agar as described by Nene and Thapliyal.[4)] ED_{50} values were determined from the data for 5 concentrations on a log probit scale and

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[†] Contribution No. 199.

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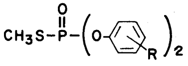
TABLE I. PHYSICAL ANALYTICAL DATA AND FUNGICIDAL ACTIVITY OF DIARYL *S*-METHYL PHOSPHOROTHIOLATES



IV

No.	R	mp (°C) bp (°C)	Yield (%)	S (%)		ED_{50} (mg ml^{-1})				
				Found	Calcd.	*P. oryzae*	*H. oryzae*	*A. alternata*	*R. bataticola*	*P. aphanidermatum*
1	H	99	75	11.1	11.4	0.45	0.60	0.80	1.0	1.0
2	4-Cl	168/0.05	72	9.3	9.1	0.14	0.45	0.25	0.30	0.35
3	2-Cl	162/0.1	70	9.4	9.1	0.15	0.50	0.26	0.25	0.40
4	4-CH_3	Liquid[b]	70	10.2	10.4	0.10	0.10	0.05	0.05	0.08
5	3-CH_3	164/0.25	71	10.3	10.4	0.18	0.15	0.12	0.10	0.10
6	2-CH_3	Liquid[b]	70	10.1	10.4	0.12	0.14	0.08	0.07	0.09
7	4-NO_2	109	74	8.4	8.6	0.06	0.10	0.24	0.20	0.40
8	3-NO_2	62	73	8.5	8.6	0.07	0.12	0.27	0.22	0.50
9	2-NO_2	68	78	8.4	8.6	0.08	0.09	0.22	0.19	0.60
10	4-OCH_3	39	76	9.5	9.7	0.90	0.80	0.90	NA[a]	NA[a]
11	2-OCH_3	Liquid[b]	73	9.6	9.7	1.0	0.90	1.0	NA[a]	NA[a]
12	4-t C_4H_9	146	76	7.9	8.1	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
13	4-SCH_3	64	75	25.7	25.8	0.80	0.75	1.0	NA[a]	NA[a]
14	2,4-Me_2	178/0.1	72	9.3	9.5	0.70	0.90	0.80	0.50	0.80
15	3-CH_3,4-Cl	Liquid[b]	70	8.6	8.5	0.50	0.50	0.75	0.70	0.80
16	2-Cl,4-NO_2	58	72	7.4	7.3	0.02	0.05	0.07	0.08	0.10
17	2,4-Cl_2	Liquid[b]	70	7.8	7.7	0.10	0.08	0.12	0.25	0.40
18	3-CH_3,4-SCH_3	106	71	8.1	8.0	1.0	1.0	1.0	NA[a]	NA[a]
19	2-NO_2,5-CH_3	78	73	8.2	8.0	0.40	0.50	NA[a]	0.50	NA[a]
20	2,4,5-Cl_3	87	74	6.8	6.6	0.005	0.03	0.05	0.03	0.06
O,O-Di(2,4,5-trichlorophenyl)dichloromethylphosphonate (for comparison)[c]						0.003	0.02	0.04	0.03	0.05

[a] NA, not active up to 1 mg ml^{-1}.

[b] Column purified.

[c] Unpublished data.

are presented in Table I.

RESULTS AND DISCUSSION

Table I shows that the fungitoxicity of the phosphorothiolates against *P. oryzae, H. oryzae, A. alternata, R. bataticola* and *P. aphanidermatum* is not dependent on the electronic nature of the substituents in the benzene ring. The simple phenyl analogue has poor activity against all the fungi tested. The degree of activity was greatly increased when the benzene ring was substituted by the nitro, methyl and chlorine groups (nitro > methyl > chlorine). Other substituents like thiomethyl, methoxy and the tertiary butyl group decreased the activity of the phosphorothiolates. With the introduction of a second substituent in the benzene ring, enhanced activity has been observed in some cases. The degree of activity is highest in the case of the 2-Cl, 4-NO_2 analogue followed by the 2,4-Cl_2 analogue. The most active compound in this series against all the fungi is *O,O*-bis(2,4,5-trichlorophenyl) *S*-methyl phosphorothiolate which is on a par with *O,O*-bis(2,4,5-trichlorophenyl) dichloromethylphosphonate (taken as the reference).*

REFERENCES

1) M. Eto, "Organophosphorus Pesticides, Organic and Biological Chemistry," CRC Press, USA, 1974, p. 313.
2) J. A. Labkowitz, A. P. Revilla and J. Barvel, *J. Agric. Food Chem.*, **22**, 151 (1974).
3) L. M. Jackman and S. Sternhell, "Application of NMR Spectroscopy in Organic Chemistry," Pergamon Press, USA, 1969, p. 351.
4) Y. L. Nene and P. N. Thapliyal, "Fungicides in Plant Disease Control," 2nd Ed., Oxford & UVG Publishing Co., New Delhi, 1979, p. 413.

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* Unpublished data.