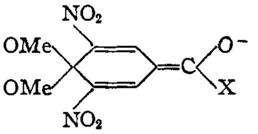
TABLE I

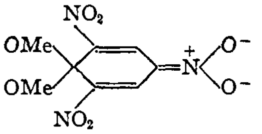
Compound	*Para* substituent	Rate constant (10^5k_2) l./moles $^{-1}$ sec. $^{-1}$ Experimental at temp. in parentheses			Calcd. at 0°	S.R.F. dinitro series (at 0°)	S.R.F. mononitro series (at 50°)	Activation energy, cal.	$\log_{10}$ frequency factor
1-Chloro-2,6-dinitrobenzene[a]	H	90.6 (26.35)	138 (30.2)	226 (35.0)	3.93	1	1	19400	11.1
Sodium 4-chloro-3,5-[a] dinitrobenzoate	CO_2^-	57.0 (0)	686 (26.1)	970 (30.2)	57.0	14.7	7.12	15500	9.2
4-Chloro-3,5-dinitrobenzamide	$CONH_2$	1190 (0)	2920 (9.0)	5390 (15.4)	1190	307	262	15300	10.3
Methyl 4-chloro-3,5-[a] dinitrobenzoate	CO_2Me	3610 (0)	6400 (5.2)	9170 (8.75)	3610	828	1560	16500	11.8
4-Chloro-3,5-dinitrobenzophenone	COPh	2990 4770 (−3.4) (0)	8620 (8.45)	8870 (8.7)	4070	1030	2655	14000	9.7

[a] Recorded in previous communications.[2,3]

parent compounds, of about 4–5000 cal., the effect being bigger for the more activating substituents: some uncertainty in the dinitro series makes the latter less clear-cut. In both series the frequency factor for the carboxylate appears to be definitely low, but no gross and simple effects are apparent for other substituents. All the dinitro compounds with carbonyl substituents (and others not yet reported) develop a red color almost immediately on mixing, though the development is retarded at lower temperatures. This suggests that the products of the reaction, *viz.*, the 4-methoxy-3,5-dinitro compound are involved. This was confirmed by mixing pure products with OMe^- in methanol, when a red color formed at once. The colored compounds almost certainly have the structure III, and are presumably present in equilibrium with the benzenoid compounds and OMe^-. The reversible interaction does not interfere with the over-all reaction which goes to completion, as shown by the agreement of calculated and experimental infinity readings, and also the isolation of pure 4-methoxy 3,5-dinitro compounds direct from the reaction mixtures.



III



IV

The structure III is analogous to that IV assumed for the red compound isolated by Meisenheimer[4] in a more reactive system. No doubt the phenomenon is more general than the visible development of color might suggest, and would be observable in the ultraviolet. It is intended to investigate this at a later date,

Experimental

The measurements were made as in the mononitro series[2]; the rates for the COPh compound at 8.45 and 8.7° being however regarded as a duplicate pair.

Preparation of materials: 1-chloro-2,6-dinitrobenzene as described in footnote 3; 4-chloro-3,5-dinitrobenzoic acid and methyl 4-chloro-3,5-dinitrobenzoate as described in footnote 2; 4-chloro-3,5-dinitrobenzamide m.p. 186° (lit. 186°) as described by Lindemann and Wessel[5]; 4-chloro-3,5-dinitrobenzophenone, m.p. 118° (lit. 118°), as described by Ullmann.[6]

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NEDLANDS, WESTERN AUSTRALIA
BERKELEY, CALIFORNIA

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The Reaction of Sulfenyl Chlorides with Trialkyl Phosphites[1]

BY D. C. MORRISON

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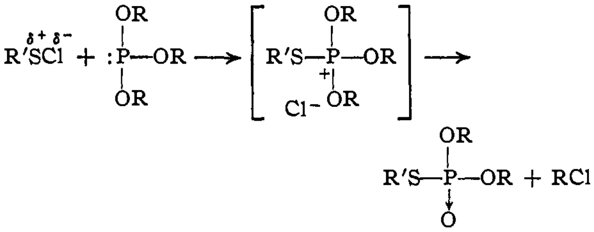
The reaction of various alkyl and acyl halides with tertiary phosphites, with loss of alkyl halide and formation of a phosphonate, has been observed with a large number of alkyl and acyl halides.[2–4] On the other hand, the reaction fails with sulfonyl chlorides and with ester chlorides of sulfuric acid.[2]

In the present work, the reaction of representative sulfenyl chlorides with trialkyl phosphites was studied. In most cases, a very rapid reaction took place, even at Dry Ice temperatures, resulting in esters of monothiophosphoric acid, probably as



This represents a nucleophilic displacement of chloride, accompanied by elimination of alkyl chloride.

The reaction occurred with aliphatic and aromatic sulfenyl chlorides, and with three trialkyl phosphites, Excellent yields of the thioesters were

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[1] The work reported in this paper was aided by a grant to Prof. D. M. Greenberg from the National Cancer Institute, United States Public Health Service (No. C2074).

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TABLE I

$(RO)_2PO(SR')$

R	R	d^{25}_4	Yield, %	Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found	B.p. °C.	B.p. Mm.
Ethyl	Phenyl	1.0941	71.1[a]	48.78	48.34	6.10	6.16	182–186	30
Ethyl	β-Chloroethyl	1.2036	67.9[a]	30.97	30.87	6.02	5.88	147	5
Ethyl	Methyl	1.1168	92.4	32.61	32.79	7.07	7.13	145–150	50
n-Propyl	Ethyl	1.0588	95.2	42.48	42.82	8.41	8.23	141–142	25
n-Butyl	Ethyl	1.0264	88.6	47.24	47.45	9.06	9.08	132	4

[a] Yield from crude disulfide.

obtained. The sulfenyl chlorides react at least as readily as acyl halides, which are known to react rapidly and exothermally with tertiary phosphites at room temperature.[4]

Methanesulfenyl chloride,[5,6] benzenesulfenyl chloride[7,8] and β-chloroethanesulfenyl chloride[9] were treated with triethyl phosphite and ethanesulfenyl chloride[10] was added to tri-*n*-propyl and tri-*n*-butyl phosphites.

A somewhat related group of substances was studied by Foss,[11] who found that aromatic sulfenyl chlorides react with sodium dialkyl thiophosphates, $(RO)_2PO{\cdot}SNa$, forming aryl sulfenyl thiophosphates, $Ar{\cdot}S{\cdot}S{\cdot}PO(OR)_2$.

The reaction of sulfur monochloride with triethyl phosphite, in benzene solution at 5°, was also examined for comparison, and evidently proceeded as

$$S_2Cl_2 + 3(EtO)_3P \longrightarrow 2(EtO)_3PS + (EtO)_3PCl_2 \text{ and}$$
$$(EtO)_3PCl_2 \longrightarrow EtCl + (EtO)_2POCl$$

Three moles of the phosphite ester was required to decolorize one mole of the sulfur chloride.

The compounds were used for biological testing in cancer chemotherapy studies. Attention was directed mainly to the β-chloro thioester, $ClCH_2{\cdot}CH_2{\cdot}S{\cdot}PO(OEt)_2$ as a possible mustard analog.

Experimental

The sulfenyl chlorides were prepared in toluene or chloroform solutions, by chlorinating the mercaptan or disulfide with sulfuryl chloride at ice or Dry Ice temperatures.[5,6] The solution was then treated with the phosphite in the same solvent, though the reverse order of addition could be used.

Reactions carried out at 0° gave poorer yields than those done at Dry Ice–acetone temperatures and the addition occurred satisfactorily in the range −10 to −60°. The course of the reaction could be followed as in a titration by observing the fading of the orange color of the sulfenyl chloride. The preparation of S-ethyl-O-O-dibutyl thiophosphate is given as a representative example, other syntheses being similar.

A solution of 12.2 ml. (0.1 mole) of diethyl disulfide in 50 ml. of toluene was treated dropwise at −30° with a solution of 8.1 ml. (0.1 mole) of sulfuryl chloride in 15 ml. of toluene. The red-orange solution was left 20 minutes in the bath, and then treated dropwise with 54.1 ml. (0.2 mole) of tri-*n*-butyl phosphite in toluene solution. The red-orange color of the sulfenyl chloride was discharged toward the end of the addition.

The liquid was warmed to room temperature and extracted with an excess of dilute sodium carbonate solution, and then with water. The toluene solution was dried (Na_2SO_4), the solvent removed, and the residue distilled. The product had b.p. 132° at 4 mm., and weighed 45 g. or 88.6%.

The other esters are listed in Table I, together with yields, constants and analyses.

DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY
UNIVERSITY OF CALIFORNIA MEDICAL SCHOOL
BERKELEY, CALIFORNIA

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Some Derivatives of 8-Chloro-6-methylquinoline

BY THOMAS A. NEELY AND JULIUS D. CAPPS

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Since it has been demonstrated that 2,6,8-trichloroquinoline,[1] 2,6-dichloro-8-methylquinoline[2] and 6-bromo-2-chloro-8-methylquinoline[2] are readily nitrated to give the corresponding 5-nitroquinolines and that no 8-bromo-2-chloro-6-methyl-5-nitroquinoline[3] was isolated when an attempt was made to nitrate 8-bromo-2-chloro-6-methylquinoline, an investigation was undertaken to determine whether 2,8-dichloro-6-methyl-5-nitroquinoline (VII) could be obtained readily by the nitration of 2,8-dichloro-6-methylquinoline (XVII). Although good yields of VII did result from the nitration of XVII, no 8-chloro-2-hydroxy-6-methyl-5-nitroquinoline (XII) was obtained when 8-chloro-2-hydroxy-6-methylquinoline (XVIII) was nitrated. Inasmuch as the failure to produce 5-nitroquinolines from the nitration of 8-bromo-2-hydroxy-6-methylquinoline[3] and 6-bromo-2-hydroxy-8-methylquinoline[2] has been reported previously, the failure to produce XII by the nitration of XVIII is not particularly surprising.

Satisfactory methods for preparing several amino, acetamido and benzamido substituted 8-chloro-6-methylquinolines, and some arsonic acids derived from 8-chloro-6-methylquinoline were accomplished and are described.

Experimental

8-Chloro-6-methyl-5-nitroquinoline (I) A.—8-Chloro-6-methylquinoline (50 g.) (obtained in 62 to 66% yields from 4-amino-3-chlorotoluene under conditions as reported by Richter and Smith[4] for effecting Skraup ring closures) was dissolved in sulfuric acid (62.5 ml., sp. gr. 1.84) and the solution resulting added dropwise with stirring at 0° or less to a solution of nitric acid (45 ml., sp. gr. 1.42) in sulfuric acid (62.5 ml., sp. gr. 1.84). After removing the reaction system from the cooling-bath and allowing it to remain suspended in the atmosphere of the laboratory for ten hours,

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