After ten minutes 1.00 cc. (0.05 mole) of cold water was added dropwise to the stirred solution, whereupon a vigorous, exothermic reaction occurred with evolution of carbon dioxide. The reaction mixture was allowed to stand at room temperature for 36 hours with occasional stirring. Then the mixture was hydrolyzed with 200 cc. of 10% sodium bicarbonate solution, and an insoluble oily material was filtered off, then washed with cold ether, water and again cold ether. There remained 11.4 g. of pink, crystalline material, m.p. 156.5–158.5° dec. Fractional crystallization from acetone gave, as the first crops, a total of 2.7 g. (22%) of the compound which has tentatively been assigned the structure 2,6-diphenyl-4-keto-1,3,5-oxadiazine (V), diamond-shaped plates, m.p. 158.2–158.8°.

The acetone mother liquor upon concentration to progressively smaller volumes afforded a total of 7.3 g. (54%) of N,N′-dibenzoylurea (III), m.p. 214.0–215.0° dec., also in admixture with authentic III.

The dark, alkaline filtrate was combined with the wash solutions and steam distilled. The steam distillate was acidified with hydrochloric acid and extracted with ether. Upon distillation of the ether solution, dried over anhydrous magnesium sulfate, there remained 2 cc. of liquid having the odor of benzonitrile.

An additional 0.30 g. (2%) of III was obtained by filtration of the alkaline residue from the steam distillation. The alkaline filtrate was extracted with ether and chloroform, then made acid with hydrochloric acid. There was obtained 21.3 g. (87%) of benzoic acid on filtration and by ether extraction.

(b) **Addition of Water After 36 Hours.**—Another reaction mixture identical to the one above, but without the immediate addition of water, turned dark and gave off 150 cc. of carbon dioxide during the course of 36 hours at room temperature. One cc. of water was then added dropwise to the stirred reaction mixture, whereupon a vigorous reaction occurred with evolution of carbon dioxide. From the dark mixture, treated with sodium bicarbonate solution as above, was filtered 9.0 g. of violet-black solid. The substance could not be purified by attempted crystallization from acetone.

After steam distillation of the alkaline filtrate there was obtained 1.1 g. of brown gummy material from the distillation residue. Several recrystallizations from acetone finally gave a trace of N,N′-dibenzoylurea (III).

From the alkaline filtrate, after acidification, there was obtained 25.3 g. (103%, based on the original benzoyl chloride) of benzoic acid.

LAWRENCE, KANSAS

[CONTRIBUTION FROM THE CENTRAL RESEARCH LABORATORIES, MONSANTO CHEMICAL COMPANY]

Aralkyl and Carbanilinoalkyl Thiocyanates[1]

BY ARTHUR H. SCHLESINGER AND DAVID T. MOWRY

RECEIVED JUNE 24, 1953

The synthesis of various aralkyl and carbanilinoalkyl thiocyanates, R-CH_2SCN, is described. Structures wherein R = phenyl, monosubstituted phenyl, benzyl, phenylethyl, phenacyl, phenoxymethyl and 2,4-dichlorophenoxymethyl are of equal phytotoxicity in seed germination tests. When R = carbanilinomethyl and substituted carbanilinomethyl the phytotoxicity is comparable to that of the corresponding halide.

Reports in the literature concerning the insecticidal activity of various thiocyanates are numerous.[2] However, investigation of the phytotoxicity of various members of this class appears to have been neglected except for the work of Jones[3] concerning α-naphthylmethyl thiocyanate. Therefore, it was of interest to prepare and study various thiocyanates, in order to determine the relation of structure to phytotoxicity.

The thiocyanates I of Table I were prepared by the reaction of the appropriate bromide or chloride with an equivalent or slight excess of potassium thiocyanate in hot ethanol or acetone. Yields varied from 29–96% but were mostly of the order of 80%. The reaction was allowed to progress

$$R_1\text{—}CH_2\text{—}X + KSCN \longrightarrow \underset{\text{I}}{R_1\text{—}CH_2\text{—}SCN} + KX$$

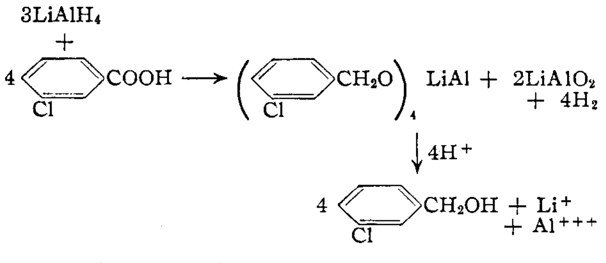
until the near-theoretical amount of potassium halide had been deposited. Intermediate carbanilates were prepared in 38–87.5% yields either by method A, which consisted of the reaction of a halohydrin with the appropriate aromatic isocyanate, or method B, the reaction of 2-chloroethyl chloroformate with the appropriate aromatic amine and pyridine in benzene.

$$\text{(A)}\quad X\text{—}R\text{—}OH + ArNCO \longrightarrow ArNHCO_2\text{—}R\text{—}X$$

$$\text{(B)}\quad ClCO_2CH_2CH_2Cl + ArNH_2 + C_5H_5N \longrightarrow ArNHCO_2CH_2CH_2Cl + C_5H_5N\cdot HCl$$

Table II lists the yields and physical properties of the haloalkyl carbanilates that were prepared as intermediates.

Incidental to the preparation of 3-chlorobenzyl thiocyanate, 3-chlorobenzyl alcohol was prepared in 91% yield by reduction of 3-chlorobenzoic acid with lithium aluminum hydride. The alcohol was converted in 60% yield by thionyl chloride to 3-chlorobenzyl chloride along with a small amount (17%) of 3-chlorobenzyl ether.



Examination of the thiocyanates and other related materials for phytotoxicity was done by a slight modification of the method of Thompson, Swanson and Norman.[4] Cucumber and wheat seeds (representing dicotyledenous and monocotyledenous species) were germinated in petri dishes

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[1] Presented before the 124th National Meeting of the American Chemical Society, Chicago, Ill., Sept. 7, 1953.

[2] R. Metcalf, Chem. Biol. Coördination Center, National Research Council, Washington, D. C., Review No. 1 (1948), reviews the insecticidal action of thiocyanates and presents the leading references. See also ref. 3.

[3] F. Jones, U. S. Patent 2,394,915 (1946).

[4] H. Thompson, C. Swanson and A. Norman, *Bot. Gazz.*, **107**, 476 (1946).

TABLE I: ARALKYL AND CARBANILINOALKYL THIOCYANATES R CH_2SCN

	R	B.p. or m.p., °C.	Mm.	$n^{25}D$	Reacn. time, hr.[a,b]	Yield, %	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
2-Chlorobenzyl[c]	$2\text{-}Cl\text{-}C_6H_4\text{-}$	138–141	5	1.5878	1[d]	82	C_8H_6ClNS	52.32	52.44	3.27	3.14		
3-Chlorobenzyl	$3\text{-}Cl\text{-}C_6H_4\text{-}$	142–145	2	1.5827	1	87	C_8H_6ClNS	52.32	52.80	3.27	3.45		
2,4-Dichlorobenzyl	$2,4\text{-}Cl_2C_6H_3\text{-}$	M. 56.5–57.0			2[d]	75.5	$C_8H_5Cl_2NS$	44.04	44.11	2.30	2.31		
4-*i*-Propylbenzyl	$4\text{-}(CH_3)_2CH\text{-}C_6H_4\text{-}$	170–172	18	1.5509	3	87	$C_{11}H_{13}NS$	69.11	69.38	6.81	6.57		
2-Phenylethyl	$C_6H_5CH_2\text{-}$	161–163	20	1.5598	4[e]	83.5	C_9H_9NS	66.26	66.13	5.51	5.39		
2-Phenoxyethyl	$C_6H_5OCH_2\text{-}$	157–159	5	1.5579	248	92	C_9H_9NOS	60.34	60.45	5.02	4.73		
2-(2,4-Dichlorophenoxy)-ethyl	$2,4\text{-}Cl_2C_6H_3OCH_2\text{-}$	Crude oil[f]			5[e]	83[f]	$C_9H_7Cl_2NOS$	[f]		[f]			
2-Carbanilinoethyl	$C_6H_5NHCO_2CH_2$	M. 58–59			4[d,e]	80	$C_{10}H_{10}N_2O_2S$					12.61	12.31
2-(4-Methoxycarbanilino)-ethyl	$4\text{-}CH_3O\text{-}C_6H_4\text{-}NHCO_2CH_2\text{-}$	M. 69–70			120	29	$C_{11}H_{12}N_2O_3S$	52.38	52.57	4.77	4.46		
2-(4-Nitrocarbanilino)-ethyl	$4\text{-}NO_2\text{-}C_6H_4\text{-}NHCO_2CH_2\text{-}$	M. 82–83			162	29	$C_{10}H_9N_3O_4S$	44.95	46.00[g]	3.37	3.56		
2-(3-Nitrocarbanilino)-ethyl	$3\text{-}NO_2\text{-}C_6H_4\text{-}NHCO_2CH_2\text{-}$	M. 79–81			97	48	$C_{15}H_9N_3O_4S$	44.95	45.04	3.78	3.56		
2-(4-Methylcarbanilino)-ethyl	$4\text{-}CH_3\text{-}C_6H_4\text{-}NHCO_2CH_2\text{-}$	M. 56–57			67	78	$C_{11}H_{12}N_2O_2S$	55.93	56.47	5.09	5.34		
2-(2-Methylcarbanilino)-ethyl	$2\text{-}CH_3\text{-}C_6H_4\text{-}NHCO_2CH_2\text{-}$	M. 40–42			138	63	$C_{11}H_{12}N_2O_2S$					11.88	11.52
2-(3-Chlorocarbanilino)-ethyl	$3\text{-}Cl\text{-}C_6H_4\text{-}NHCO_2CH_2\text{-}$	Crude oil[h]			139	72	$C_{10}H_9ClN_2O_2S$	46.78	46.70	3.52	3.83		
3-(3-Chlorocarbanilino)-propyl	$3\text{-}Cl\text{-}C_6H_4\text{-}NHCO_2(CH_2)_2\text{-}$	Crude oil[h]			2[e]	95	$C_{11}H_{11}ClN_2O_2S$	48.79	48.83	4.06	3.89	10.32	9.84

[a] Reaction times are given for the chloride unless specified otherwise. [b] Solvent is ethanol unless specified otherwise. [c] The insecticidal action of this material is described by A. Brown, D. Robinson, H. Hurtig and B. Wenner., *Can. J. Research*, **26D**, 177 (1948). However, no physical constants or details of preparation are given. [d] Acetone employed as solvent. [e] Bromide used as starting material. [f] The 83% yield is based upon % KBr obtained. The oil decomposed upon vacuum distillation and it could not be crystallized in the usual manner. [g] This material was very difficult to crystallize from 80% ethanol and despite repeated recrystallizations, carbon analyses consistently ran high (46.00, 46.04, 46.00). [h] The oil could not be crystallized or distilled at 3 mm. vacuum without decomposition. Therefore, it was carefully dried *in vacuo* at approximately 50° for several days prior to analysis.

TABLE II

HALOALKYL CARBANILATES, $ArNHCO_2CH(R_1)(R_2)$

Ar	R_1	R_2	Method of prep.	M.p. or b.p., (mm.)	Yield, %	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
$C_6H_5\text{-}$	H	$\text{-}CH_2CH_2Cl$	A[a,b]	154 (1)	83	$C_{10}H_{12}ClNO_2$	[c]		[c]	
$C_6H_5\text{-}$	H	$\text{-}CH_2Br$	A	76–77	87.5	$C_9H_{10}BrNO_2$	44.26	44.73	4.11	4.16
$3\text{-}Cl\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	A	50–51	59	$C_9H_9Cl_2NO_2$	46.16	46.43	3.84	3.69
$3\text{-}Cl\text{-}C_6H_4\text{-}$	CH_3	$\text{-}CH_2Br$	A[d]	186–190 (2)	38	$C_{10}H_{11}BrClNO_2$	41.02	41.50	3.76	3.86
$4\text{-}Cl\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	B	75.5–76.0[e]	41	$C_9H_9Cl_2NO_2$	46.16	46.39	3.84	3.72
$2\text{-}NO_2\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	B	64–65	73.5	$C_9H_9ClN_2O_4$	44.17	44.79	3.68	3.46
$3\text{-}NO_2\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	B	93.5–94.0	58.5	$C_9H_9ClN_2O_4$	44.17	44.45	3.68	3.53
$4\text{-}NO_2\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	B	117–118	59	$C_9H_9ClN_2O_4$	44.17	44.38	3.68	3.52
$2,4\text{-}Cl_2\text{-}C_6H_3\text{-}$	H	$\text{-}CH_2Cl$	B	77.5–78.5	66	$C_9H_8Cl_3NO_2$	40.22	40.52	2.98	2.89
$2,5\text{-}Cl_2\text{-}C_6H_3\text{-}$	H	$\text{-}CH_2Cl$	B	86–87	71.5	$C_9H_8Cl_3NO_2$	40.22	40.45	2.98	2.97
$2\text{-}C_6H_5\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	B	194–196 (3)[f]	70	$C_{15}H_{14}ClNO_2$	65.49	66.09	5.08	5.28
$4\text{-}CH_3O\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2Cl$	B	90–91	51.5	$C_{10}H_{12}ClNO_3$	52.29	52.54	5.23	5.07
$3\text{-}Cl\text{-}C_6H_4\text{-}$	H	$\text{-}CH_2CH_2Br$	A[d]	192–197 (3)	81	$C_{10}H_{11}BrClNO_2$	41.02	41.51	3.76	3.88

[a] We are indebted to Mr. Richard Morner of these laboratories for the initial preparation of this material. [b] Chloroform was employed as solvent; in all other preparations using method A no solvent was used unless specified otherwise. [c] *Anal.* Calcd. for $C_{10}H_{12}ClNO_2$: N, 6.56. Found: N, 6.55. [d] Hexane employed as solvent. [e] R. Adams and J. Segur, THIS JOURNAL, **45**, 785 (1923), report a m.p. 62–63°. [f] $n^{25}D$ 1.5955.

in the presence of aqueous solutions or suspensions of the test chemical. The results, see Table III, are expressed as percentage of the normal growth of the primary root in a water control. 2,4-Dichlorophenoxyacetic acid and isopropyl carbanilate, commercially important herbicides, are included for comparison. In general, the phytotoxicity exhibited by benzyl thiocyanate (I, $R_1 = C_6H_5$) at 100 parts per million is unaffected by the introduction of monosubstituents in any of the ring positions while disubstitution markedly decreases activity. Variations of I in which R_1 is $C_6H_5CH_2\text{-}$, $C_6H_5CH_2CH_2\text{-}$, $C_6H_5CO\text{-}$, $C_6H_5OCH_2\text{-}$, and $2,4\text{-}Cl_2C_6H_3OCH_2\text{-}$ exhibit no loss of phytotoxicity. Comparison of the activities of the 2-chloroethyl substituted carbanilates with their corresponding

TABLE III

PHYTOTOXICITY OF THIOCYANATES AND RELATED COMPOUNDS TO GERMINATING CUCUMBER AND WHEAT SEEDS

	Cucumber		Wheat	
	Percentage root growth at			
	100 p.p.m.	10 p.p.m.	100 p.p.m.	10 p.p.m.
Thiocyanate				
Benzyl[a]	3	83	13	70
4-Nitrobenzyl[b]	7	66		
2-Chlorobenzyl	5	105		
3-Chlorobenzyl	12	93	33	97
4-Chlorobenzyl[c]	14	91		
2,4-Dichlorobenzyl	55	115		
4-*i*-Propylbenzyl	5	75		
1-Phenylethyl[d]	33	88		
2-Phenylethyl	8	71		
3-Phenylpropyl[e]	9	67		
1-Phenyl-2-propyl[f]	30	90	33	85
Phenacyl[g]	20	115		
2-Phenoxyethyl	10	87		
2-(2,4-Dichlorophenoxy)-ethyl	10	20	22	50
α-Naphthylmethyl[i]	46	101		
2-Carbanilinoethyl	5	6	6	21
2-(3-Chlorocarbanilino)-ethyl	7	7	11	25
2-(3-Nitrocarbanilino)-ethyl	14	41		
2-(4-Nitrocarbanilino)-ethyl	25	72		
2-(2-Methylcarbanilino)-ethyl	4	8		
2-(4-Methylcarbanilino)-ethyl	9	54	55	105
2-(4-Methoxycarbanilino)-ethyl	6	30		
3-(3-Chlorocarbanilino)-propyl	24	43	17	70
n-Butyl[j]	94	100		
Phenyl thiocyanoacetate[d]	40	87		
Potassium thiocyanoacetate[h]	30	89		
Carbanilates				
2-Chloroethyl	11	24	7	12
2-Chloroethyl 3-chloro-	5	14	4	12
2-Chloroethyl 4-chloro-	17	68	20	84
2-Chloroethyl 2-nitro-	20	82		
2-Chloroethyl 3-nitro-	11	53		
2-Chloroethyl 4-nitro-	26	73		
2-Chloroethyl 2-methyl-	17	75		
2-Chloroethyl 4-methyl-	8	41	22	77
2-Chloroethyl 2,4-dichloro-	38	79		
2-Chloroethyl 2,5-dichloro-	15	36		
2-Chloroethyl 2-phenyl-	50	95		
2-Chloroethyl 4-methoxy-	37	77		
Isopropyl	7	11	2	8
Benzyl chloride	77	97		
2,4-Dichlorophenoxyacetic acid	6	9	5	21

[a] Obtained from Eastman Kodak Co. [b] C. Jackson and F. Whitmore, THIS JOURNAL, **37**, 1915 (1915). [c] C. Jackson and A. Field, *Am. Chem. J.*, **2**, 85 (1880). [d] H. Wheeler and T. Johnson, *ibid.*, **26**, 185 (1901). [e] E. Bergmann, *J. Chem. Soc.*, 1361 (1935). [f] J. Kenyon, H. Phillips and V. Pittman, *ibid.*, 1072 (1935). [g] L. Arapides, *Ann.*, 7 (1888). [h] P. Claesson, *Ber.*, **10**, 1346 (1877). [i] Reference 3. [j] R. Kaufmann and R. Adams, THIS JOURNAL, **45**, 1744 (1923).

2-(substituted carbanilino)-ethyl thiocyanates indicates that replacement of chlorine by thiocyanate has a negligible effect on the already toxic molecule. The 4-methoxy derivative is an exception to this generalization, the thiocyanate being appreciably more phytotoxic. Thus the thiocyanate moiety appears to be the phytotoxic essential in the aralkyl type thiocyanates while in the carbanilino type the carbanilate residue is the active portion.

Experimental[5]

Aralkyl and Carbanilinoalkyl Thiocyanates (I).—The preparation of 2-phenylethyl thiocyanate and 2-(4-methylcarbanilino)-ethyl thiocyanate are illustrative of the preparation of the two types.

A 2-liter flask was charged with 60 g. (0.324 mole) of 2-phenylethyl bromide, 32 g. (0.330 mole) of potassium thiocyanate and 1 liter of acetone. After 4 hr. of refluxing, 37 g. of potassium bromide (theoretical KBr = 38.6 g.) was removed by filtration and the filtrate diluted with sufficient water to throw out an oil. The oil was separated and a chloroform extract of the aqueous phase added to it. The chloroform solution after drying over sodium sulfate was concentrated *in vacuo* and distilled. There was obtained 2-phenylethyl thiocyanate, a white liquid with cinnamon-like odor, b.p. 161–163° at 20 mm., n^{25}_{D} 1.5598. The yield was 44 g. or 83.5%.

Anal. Calcd. for C_9H_9NS: C, 66.26; H, 5.51. Found: C, 66.13; H, 5.39.

To 500 ml. of boiling absolute ethanol there was added 30 g. (0.14 mole) of 2-chloroethyl 4-methylcarbanilate and 14.5 g. (0.15 mole) of potassium thiocyanate. The solution was refluxed for 67 hr. and filtered while hot to remove 9.9 g. of potassium chloride (theoretical KCl = 10.5 g.). The filtrate was concentrated *in vacuo*, water was added and an oil separated. The aqueous layer was washed with chloroform and the organic extract combined with the oil. Attempts to crystallize the oil out of the chloroform or from chloroform–hexane resulted in failure. Chilling produced only an oil which was dried *in vacuo*. After standing at room temperature several days it solidified to pale lemon needles, m.p. 56–57°, yield 25.8 g. or 78%.

Anal. Calcd. for $C_{11}H_{12}N_2O_2S$: C, 55.93; H, 5.09. Found: C, 56.47; H, 5.34.

Table I summarizes the reaction conditions, physical properties of the products, yields and analytical data of the other thiocyanates.

Haloalkyl Carbanilates.—These were prepared by either A, the reaction of a halohydrin and the appropriate isocyanate, or B, the reaction of 2-chloroethyl chloroformate and the appropriate aromatic amine. The preparation of 3-bromopropyl 3-chlorocarbanilate and 2-chloroethyl 2,4-dichlorocarbanilate are presented as examples of methods A and B, respectively.

To 100 ml. of hexane there was added 28 g. (0.20 mole) of trimethylene bromohydrin and 30.7 g. (0.20 mole) of 3-chlorophenyl isocyanate. The solution spontaneously became warm after which it was refluxed overnight. The two-phase system was concentrated on a vacuum column to remove hexane and 3-bromopropyl 3-chlorocarbanilate was obtained as a thick oil, b.p. 192–197° at 3 mm., 47 g. (81%) yield.

Anal. Calcd. for $C_{10}H_{11}BrClNO_2$: C, 41.02; H, 3.76. Found: C, 41.51; H, 3.88.

A solution of 60 g. (0.37 mole) of 2,4-dichloroaniline and 29.2 g. (0.37 mole) of pyridine in 300 ml. of benzene was cautiously treated with 53 g. (0.37 mole) of 2-chloroethyl chloroformate. After the initial exothermic reaction had subsided the solution was refluxed for 2 hours and then cooled. The benzene phase was separated from the pyridine hydrochloride and washed successively with water, dilute hydrochloric acid, dilute sodium carbonate and water. The benzene was removed *in vacuo* and the residue twice crystallized from hexane–chloroform to give 64.5 g. (66%) of white needles, m.p. 77.5–78.5°.

Anal. Calcd. for $C_9H_8Cl_3NO_2$: C, 40.22; H, 2.98. Found: C, 40.52; H, 2.89.

The summary of reaction conditions, physical properties and analytical data of other carbanilates is found in Table II.

β-(2,4-Dichlorophenoxy)-ethyl Bromide.—In a 3-liter 3-neck flask, a suspension of 326 g. (2.0 moles) of 2,4-dichlorophenol, 470 g. (2.5 moles) of ethylene dibromide and 1 liter of water was brought to reflux. A solution of 84 g. (2.1 moles) of sodium hydroxide in 250 ml. of water was dripped into the boiling solution over a 1-hr. period. The solution was refluxed and stirred for 10 hr. After cooling, the layer was separated and distilled. There was obtained 79 g. of ethylene dibromide, b.p. 38–41° at 24 mm.; 35 g. of 2,4-

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[5] All melting points listed are corrected.

dichlorophenol, b.p. 105–108° at 24 mm., and 368 g. of β-(2,4-dichlorophenoxy)-ethyl bromide, b.p. 157–159° at 10 mm., $n^{25}\mathrm{D}$ 1.5785. The yield based upon the phenol is 69%.

Anal. Calcd. for $C_8H_7BrCl_2O$: C, 35.58; H, 2.59. Found: C, 36.03; H, 2.67.

3-Chlorobenzyl Alcohol.—This material had previously only been reported as being prepared by electrolytic reduction of 3-chlorobenzoic acid.[6] A more convenient laboratory procedure is as follows. In a 3-liter 3-neck flask equipped with stirrer, reflux condenser and dropping funnel there was prepared a solution of 52 g. (1.38 moles, 50% excess) of lithium aluminum hydride in 500 ml. of anhydrous ether. To this stirred solution there was added over a 2-hr. period, a slurry of 192 g. (1.23 moles) of 3-chlorobenzoic acid in 800 ml. of ether. The excess hydride was then carefully decomposed by dropwise addition of about 150 ml. (excess) ethyl acetate. The flask was cooled in an ice-bath and a stream of iced concentrated hydrochloric acid was slowly added. After vigorous stirring the solids partially dissolved into the aqueous layer. The ether was removed by decantation and 600 ml. of 10% sulfuric acid was added to the aqueous phase. This dissolved the remaining aluminum salts. The solution was washed with ether and both ether solutions combined. The ether was washed successively with water, potassium carbonate and dilute ferrous sulfate. The ether was removed by distillation and 3-chlorobenzyl alcohol was obtained as a white liquid, b.p. 131–132° at 19 mm. (lit.[6] value, 234° at atm. pressure), $n^{25}\mathrm{D}$ 1.5521, yield 159 g. or 91%.

3-Chlorobenzyl Chloride and 3-Chlorobenzyl Ether.—The chloride had been prepared previously by the chlorination of toluene.[7] In our hands the following was a more convenient synthesis. To 100 g. (excess) of thionyl chloride in 100 ml. of benzene there was added 52 g. (0.36 mole) of 3-chlorobenzyl alcohol over a 10-min. period. The solvent and excess thionyl chloride were removed by distillation. There was obtained 34 g. (60%) of 3-chlorobenzyl chloride, b.p. 101–103° at 17 mm. (lit.[7] value, 104° at 17 mm.), $n^{25}\mathrm{D}$ 1.5526.

Fractionation of the high-boiling pot residue yielded 8 g. (17%) of 3-chlorobenzyl ether, b.p. 195–199° at 4 mm., $n^{25}\mathrm{D}$ 1.5787.

Anal. Calcd. for $C_{14}H_{12}Cl_2O$: C, 62.92; H, 4.50. Found: C, 62.95; H, 5.00.

Procedure for Herbicidal Assay.—The method is substantially that described by Thompson, *et al.*,[4] with the modifications noted by Schlesinger and Mowry.[8] Where compounds were tested with wheat, the procedure was the same except for substitution of wheat seeds for cucumber seeds in the petri dishes. The data obtained are listed in Table III.

Acknowledgment.—The authors wish to express their gratitude to Mrs. Emma Mori, Mr. Richard Martin and Dr. R. M. Hedrick for the herbicidal evaluation data and to Miss Mary Neal, Mrs. Betty Kosicki, Mrs. Winifred Harden, and Messrs. Paul Adams and Donald Stoltz for the microanalyses.

DAYTON, OHIO

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[6] C. Mettler, *Ber.*, **38**, 1745 (1905).

[7] G. Bennett and B. Jones, *J. Chem. Soc.*, 1815 (1935).

[8] A. Schlesinger and D. Mowry, THIS JOURNAL, **73**, 2614 (1951).

[CONTRIBUTION FROM STERLING-WINTHROP RESEARCH INSTITUTE]

Alkylaminoalkylamino Derivatives of Xanthones, Acridones and Anthraquinones

BY S. ARCHER, LOIS B. ROCHESTER AND MARY JACKMAN

RECEIVED SEPTEMBER 8, 1953

The three series mentioned in the title were prepared from appropriately halogenated nuclei and substituted alkylenediamines. The acridones and anthraquinones were ineffective schistosomicidal agents but moderately high activity against *S. mansoni* infections in mice was found among the xanthones.

At the time that we were preparing a series of basic thiaxanthones[1] for evaluation as schistosomicidal drugs we synthesized three groups of isosteric compounds in which the sulfur atom of the thiaxanthone nucleus was replaced by oxygen, imino and carbonyl groups to furnish the corresponding xanthones, acridones and anthraquinones. The description of the preparation of these substances and some of the preliminary chemotherapeutic results form the basis of this report.

Heller[2] prepared 1-chloro-4-methylanthraquinone and demonstrated the lability of the halogen by effecting a replacement reaction with aniline at high temperature.[3] We found that a 1-chloroanthraquinone and an alkylenediamine such as diethylaminopropylamine reacted smoothly in pyridine solution within a few hours to give the desired 1-aminoanthraquinone which was isolated and purified as the hydrochloride. The compounds listed in Table I were all prepared according to this general technique.

The 1-chloroacridones needed in this work were prepared by the customary Ullmann method. Since Nisbet[4] reported that a 1-piperidinoacridone could be prepared from piperidine and a 1-chloroacridone it seemed likely that the method used successfully for the synthesis of the basic anthraquinones could be used here. When a pyridine solution of 3-diethylamino-2-hydroxypropylamine and 1-chloro-4-methylacridone was refluxed for 16 hours only starting material was isolated from the reaction mixture. By omitting the pyridine it was possible to raise the reaction temperature sufficiently to permit the condensation to take place in a reasonable time. The method adopted for preparing the compounds listed in Table II is described in the Experimental part.

Mauss[5] prepared many 1-(2-dialkylaminoalkylamino)-xanthones, at least two of which showed high schistosomicidal activity. These were 1-(2-diethylaminoethylamino-4-methylxanthone (III, R = H) and the corresponding 7-chloro (III, R = Cl) derivative. The required nuclei (II) were prepared from 2-methyl-5-chlorophenol[6] and an appropriate 2-halobenzoic acid followed by ring closure of the intermediate phenoxybenzoic acid

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[1] S. Archer and C. M. Suter, THIS JOURNAL, **74**, 4296 (1952).

[2] G. Heller and K. Schülke, *Ber.*, **41**, 3627 (1908).

[3] G. Heller, *ibid.*, **45**, 792 (1912).

[4] H. B. Nisbet, *J. Chem. Soc.*, 2772 (1932).

[5] H. Mauss, *Chem. Ber.*, **81**, 19 (1948).

[6] Th. Zincke and O. Preiss, *Ann.*, **417**, 207 (1918).