The reaction mixture was then filtered from catalyst and fractionated through a 25-plate electrically heated column packed with "monel helipak." The desired vinylcarbinol was collected over a 1–2 degree range. All carbinols studied could actually be distilled at atmospheric pressure but for the higher boiling members of the series (3-methyl-1-nonen-3-ol and vinylcyclohexanol) vacuum distillation at 50–60 mm. is preferable.

Analytical Methods.[13] **A. Ethynylcarbinol Impurity.**[14]—Ethynylcarbinol or vinylcarbinol suspected of containing —C≡CH impurity was treated with a concentrated silver nitrate solution followed by standard base titration of the liberated nitric acid.

B. Vinylcarbinol.[15]—The vinylcarbinol was treated with excess bromine in methanol saturated with sodium bromide at room temperature. Bromination was complete in 3–5 min. Addition of potassium iodide followed by titration of the liberated iodine with standard sodium thiosulfate determines the bromine consumed. Ethynylcarbinols are completely unreactive under these conditions.

The bromination values represent minimum purities since gas chromatographic analyses of several samples of methyl butynol and methylpentynol from potassium hydroxide runs showed total impurities of less than 1%.

C. Ketone Impurity.[16]—The vinylcarbinol was treated with excess hydroxylamine hydrochloride solution in methanol solution for several hours at room temperature followed by titration of the liberated acid. Less active ketones such as acetophenone require refluxing for several hours.

(13) The services of L. Molinini and the Air Reduction Co. Analytical Department are gratefully acknowledged.

(14) L. Barnes, Jr., and L. J. Molinini, *Anal. Chem.*, **27**, 1025 (1955).

(15) N. D. Cheronis and J. B. Entrikin, "Semi Micro Qualitative Analysis," Thomas Y. Crowell Co., New York, N. Y., 1947, p. 471.

(16) Staff of Hopkins and Williams Research Laboratory, "Organic Reagents for Analysis," Chemical Publishing Co., Brooklyn, N. Y., 1946, p. 60.

The Action of Lithium Aluminum Hydride and of Grignard Reagents on Some Heterocyclic β-Ketoamides. Synthesis of 1-Aldehydes and 1-Ketones[1] of Phenothiazine, Phenoxazine, and Carbazole

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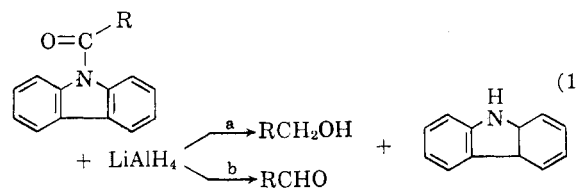
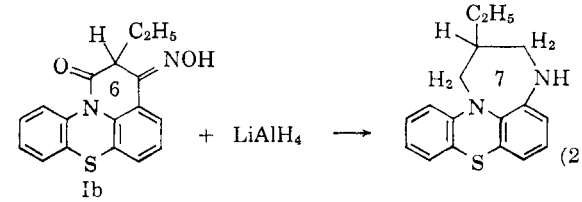
Condensation products of diethyl monoalkylmalonates with phenothiazine, carbazole, and phenoxazine, such as Ig and Il, can be converted by bromination and displacement of bromine by secondary amines, to the C,C-disubstituted "alkylmalonyl heterocycles"[6] *e.g.*, Ia and Ic–Ie. These and one example of a C,C-dialkyl analog (If) are reduced, by lithium aluminum hydride, to the hydroxycarbinolamines (of which IIb and IIc were isolated and characterized). These yield the retro-aldol products phenothiazine-1-aldehyde, phenoxazine-1-aldehyde, and carbazole-1-aldehyde, on decomposition of the hydride reduction mixture. Analogously, 1-acetylcarbazole was made by action of methylmagnesium iodide on Id to give IV, and a separate base-catalyzed retro-aldol reaction of IV. Some aspects of the significance of these results to the mechanisms of such reductions are briefly discussed.

Lithium aluminum hydride and related reducing agents are used so frequently in synthetic and structure determination problems in organic chemistry that any unusual reactions produced by these substances are of special interest. It is well known that treatment of amides derived from amines such as certain aromatic amines[2] and ethylene imine[3] with lithium aluminum hydride can lead to the aldehydes corresponding to replacement of the amine fragment by one hydrogen (equation 1, path b). In general, inverse addition of barely equivalent amounts of the hydride at temperatures below ambient is recommended to prevent further reduction either to the tertiary amine corresponding to loss of oxygen, or to the alcohol corresponding to loss of amine from the amine.[4] For example, N-benzoylcarbazole is reported[5] to give benzyl alcohol when treated with lithium aluminum hydride (equation 1, path a).



(1)

We had previously reported[1] the reduction with rearrangement of the oxime Ib by lithium aluminum hydride, with conversion of the carbonyl attached to the phenothiazine nitrogen to a CH_2 group (equation 2). This occurred at least to a



(2)

(1) Paper II on tetracyclic phenothiazines and related compounds. Paper I is M. Harfenist and E. Magnien, *J. Am. Chem. Soc.*, **80**, 6080 (1958).

(2) *Cf.* N. G. Gaylord, "Reductions with Complex Metal Hydrides," Interscience Publishers, Inc., New York, N. Y., 1956, pp. 544 *et. seq.* and W. Ried and F. J. Königstein, *Angew. Chem.*, **70**, 165 (1958).

(3) H. C. Brown and A. Tsukamoto, *J. Am. Chem. Soc.*, **83**, 2016 (1961).

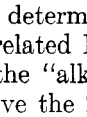
(4) N. G. Gaylord, ref. 2, pp. 580, 586.

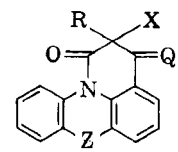
(5) A. Mustafa, *et al.*, *J. Am. Chem. Soc.*, **76**, 5447 (1954).

usable extent without cleavage of the carbon-to-phenothiazine bond even after prolonged heating of the ethereal solution. We therefore thought it not unlikely that compound Ia, on prolonged treatment with excess of lithium aluminum hydride in refluxing ether, would go by way of the hydroxy carbinolamine IIa (as a metallated derivative, of course) to the amino alcohol III, whose biological activity we wished to have determined.

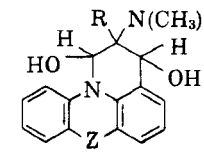
Compound Ia and the related Ic–Ie are readily made by bromination of the "alkylmalonyldiarylamines"[6] such as Ig, to give the 2-bromo- "alkylmalonyldiarylamines"[6] Ih–Ik, and subsequent facile replacement of the bromine by the appropriate amine to give Ia–Ie. It is of interest that bromination with excess of bromine in carbon tetrachloride gave no further bromination even of the normally highly electron-rich phenothiazine ring. The brominated products all contain "positive bromine" capable of converting acidified potassium iodide to free iodine. Indeed, on reaction even of base-extracted bromo compound, presumably free of the acidic "alkylmalonyldiarylamine" with the secondary amines, a substantial amount of "alkylmalonyldiarylamine" was generally produced.[7] The other reaction product, which was probably the tetraalkylhydrazine, was not sought.

Compound Il was so insoluble in most solvents that it had to be brominated in dimethylformamide, a reaction which sometimes gave nearly quantitative yields of Ii, but other times, unpredictably, gave low yields of difficultly purifiable product. In this case reaction of the crude bromination product with amines gave a poor but acceptable yield of the desired 2-amino compounds.

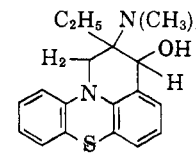
When compound Ia was boiled with a fourfold excess of lithium aluminum hydride in ether for two days, addition of a slight excess of water to the initially nearly colorless turbid ethereal solution led to rapid darkening of the solution, even with reasonably effective exclusion of air. Washing of the ether-insoluble solids (resulting from the addition of the water) with 95% ethanol led to formation of a much darker solution. The color change was obviously due to formation of an orange solute. This proved to be a *neutral* material which had a correct elemental analysis (C, H, N, and S) and a reasonable spectrum for the previously unknown phenothiazine-1-aldehyde. It formed an oxime and a thiosemicarbazone with correct elemental analyses. This reaction has been found to occur analogously in yields of 60–85% with related ketoamides of the carbazole (*e.g.*, Id) and phenoxazine (*e.g.*, Ie) series, giving carbazole-1-aldehyde and phenoxazine-1-aldehyde. R has been CH_3 or C_2H_5 and X was $N(CH_3)_2$ or  in the examples studied thus far.



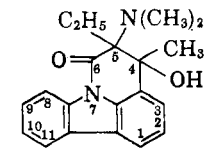
Ia–Il



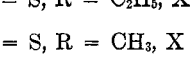
IIa–IIc



III



IV

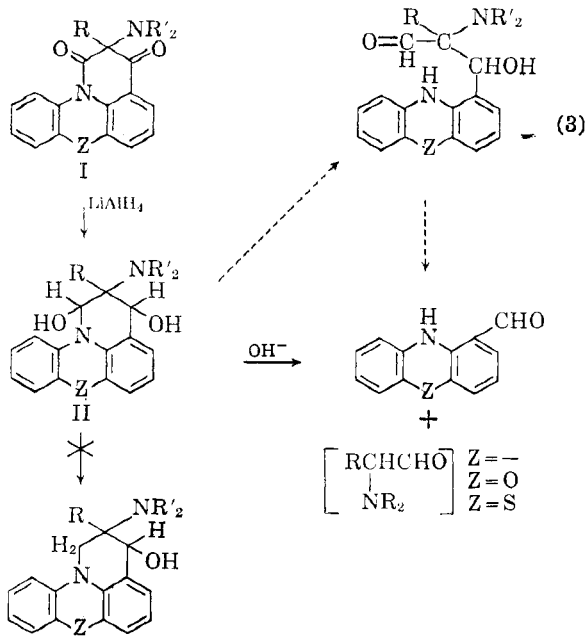
Ia. Z = S, R = C_2H_5, X = $N(CH_3)_2$, Q = O
Ib. Z = S, R = C_2H_5, X = H, Q = NOH
Ic. Z = S, R = CH_3, X =  , Q = O
Id. Z = —, R = C_2H_5, X = $N(CH_3)_2$, Q = O
Ie. Z = O, R = CH_3, X = $N(CH_3)_2$, Q = O
If. Z = S, R = CH_3, X = C_2H_5, Q = O
Ig. Z = S, R = C_2H_5, X = H, Q = O
Ih. Z = S, R = C_2H_5, X = Br, Q = O
Ii. Z = S, R = CH_3, X = Br, Q = O
Ij. Z = O, R = CH_3, X = Br, Q = O
Ik. Z = —, R = C_2H_5, X = Br, Q = O
Il. Z = S, R = CH_3, X = H, Q = O
IIa. Z = S, R = C_2H_5
IIb. Z = —, R = C_2H_5
IIc. Z = O, R = CH_3

It seemed obvious that we were dealing with a very facile retro-aldol reaction of the aldehyde–ammonia II or of the corresponding "opened" aldehyde, catalyzed by lithium hydroxide or aluminum hydroxide formed during the work-up of the reduction mixture (equation 3). It proved possible to isolate and characterize by satisfactory elemental analysis what appeared to be a hemihydrate and a monohydrate of the hydrochloride of the carbazole IIb as hygroscopic solids[8] which were colorless, but turned orange at their melting points. These hydrochlorides were readily converted to the colorless base IIb, which, however, was transformed to analytically pure yellow carbazole-1-aldehyde by two recrystallizations from ethanol–water. The analogous phenoxazine IIc hydrochloride monohydrate was also isolated, as outlined in the Experimental. The isolation of what are apparently the "aldehyde–ammonias"

(6) These substances, *e.g.*, I, are properly named as pyrido-amines. I, for example, is either 2-ethyl-1,3-diketo-2,3-dihydro-1H-pyrido-[3,2,1-kl]phenothiazine or, in its enolic form, 1-keto-2-ethyl-3-hydroxy-1H-pyrido[3,2,1-kl]phenothiazine. However, this systematic nomenclature causes the numbering to change with the amine moiety. For example, the carbazole directly analogous to I would be 5-ethyl-4,6-diketo-5,6-dihydro-4H-pyrido[3,2,1-jk]carbazole. We therefore will use trivial names based on the malonic acid and amine which might be regarded as combining with loss of water to form these compounds. Thus, I will be "ethylmalonylphenothiazine," while its carbazole analog will be "ethylmalonylcarbazole" in direct analogy. Ig and Il are shown in the diketo form only to save the space otherwise necessary to show the obvious enol form.

(7) J. W. Huffman, *J. Org. Chem.*, **26**, 1470 (1961), has reported that brominated "alkylmalonyl-*o*-anisidines" lose their bromine and revert to the "alkylmalonyl-*o*-anisidines" on treatment with collidine or methanolic potassium hydroxide.

(8) These have no absorption in the infrared attributable to a carbonyl group, and so the base is formulated as II.



indicate that at least in these cases (and probably in the case of a phenothiazine analog which, however, gave an unsatisfactory analysis as its poorly crystalline sulfate) the aldehyde is *not* present as such in the hydride reduction mixture contrary to statements in the literature.[4] This obviously is indicated by our ability to continue our reductions for prolonged periods with a large excess of lithium aluminum hydride, and still have a substance present at the end, presumably II, which can undergo the retro-aldol condensation to give such high yields of the aldehydes. If the "opened" aldehydes corresponding to II were present in the reduction mixture under our conditions, they would certainly be reduced further.[9] While base-catalyzed cleavage of 2,2-disubstituted 1,3-diols is known[10] it generally is not as facile a reaction as we have reported here.

To ensure that the amine group is not required for the facile retro-aldol reaction, If, the analog of Ia, in which X = CH_3, was prepared.[11] This could also be reduced and cleaved in analogous fashion to phenothiazine-1-aldehyde.

A further consequence of this facile retro-aldol reaction is the possibility of preparing *ortho-acyl-arylamines* by treatment of C-disubstituted keto-amides such as the appropriate compounds I with Grignard reagents, and subsequent base-catalyzed cleavage. Indeed IV was prepared by treatment of Id with methylmagnesium iodide. It could be isolated and characterized apparently as a single diastereoisomeric hydrochloride. On treatment with aqueous-ethanolic sodium hydroxide, it gave the known[12] 1-acetylcarbazole in good yield.

The scope and limitations of this reaction sequence are being studied further.

Experimental

2-Bromo-"ethylmalonylphenothiazine"[6] (Compound Ih).—A solution of 29 g. (0.098 mole) of "ethylmalonylphenothiazine"[1,6] in 2 l. of boiling reagent grade carbon tetrachloride was cooled until the first crystals started to form. It was stirred vigorously while a solution of 16.8 g. (0.21 g.-atom) of bromine in 200 ml. of carbon tetrachloride was added as rapidly as the rapid evolution of gas would allow. (Under our conditions, 10 to 20 min.) The solution was kept an additional 15 min., and then the solvent was removed using a steam bath at water pump pressure. The residual oil was taken up in ether, extracted three times with aqueous sodium carbonate, briefly dried over magnesium sulfate, and again concentrated as before. The resulting oil soon solidified. It was 34.3 g. (93%), and melted at 126–127.5°. It was recrystallized twice more from ethanol–water for analysis, m.p. 130–132°.

Anal. Calcd. for $C_{17}H_{12}BrNO_2S$: C, 54.62; H, 3.25. Found: C, 54.76; H. 3.27.

One bromination of several performed in equal volumes of dimethylformamide and carbon tetrachloride gave an 81% yield of once recrystallized product of the correct melting point, but repetitions of this procedure gave far poorer yields.

2-Bromo-"methylmalonylphenothiazine"[6] (Compound Ii).—This substance had to be prepared in dimethylformamide solution, because of its low solubility in the more usual solvents available for bromination. Thus 13.8 g. (0.049 mole) of "methylmalonylphenothiazine" dissolved in 240 ml. of dried dimethylformamide was stirred while treated over 2 min. with 8.7 g. (0.054 g.-atom) of bromine dissolved in 100 ml. of carbon tetrachloride. The solution warmed spontaneously. It was allowed to remain for 2 hr., concentrated on the steam bath at the water pump to a small volume, and poured onto cracked ice. The oil so produced in theoretical yield solidified on being scratched, and melted at 108–128°. This was purified by extraction with three portions of boiling ethanol totaling 800 ml. The green insoluble residue was discarded, and the ethanol solution was treated with charcoal, filtered, and diluted at about 80° with water. Brown and yellow crystals came out slowly on scratching. A total of 10 g. was obtained, m.p. 101–109°. When twice recrystallized from heptane, it melted at 143–147.5° and was *impure*.

Anal. Calcd. for $C_{16}H_{10}BrNO_2S$: C, 53.23; H, 2.80. Found: C, 55.06; H, 3.06.

It served adequately for the preparations of the amines listed below, and so preparation of this substance was not investigated further.

2-Bromo-"methylmalonylphenoxazine"[6] (Compound Ij).

(9) This is not to say that aldehyde is never present (presumably as a metallated derivative) in reductions of compounds in the oxidation state of carboxylic acids. For example, an extremely interesting reduction of the carbomethoxy group of apoyohimbine by excess of lithium aluminum hydride, to give a mixture of the corresponding alcohol and *aldehyde* has been reported by J. Brüesch and P. Karrer, *Helv. Chim. Acta*, **38**, 905 (1955). This might be caused by competition in rate between direct reduction of the ester to the alcohol, and attack of the anion of the "carbazole-like" nitrogen at the ester carbonyl to form an amide-like intermediate, followed in this latter case by reduction analogous to that reported here to give the aldehyde–ammonia which would be resistant to further reduction. Alternatively, the aldehyde in the product might be the result of reduction of the ester to an aldehyde-like product which might be "trapped" by reaction with the anion of the "carbazole-like" nitrogen before further reduction could occur.

(10) *Cf.* S. Searles, Jr., R. G. Nickerson, and W. K. Witsiepe, *J. Org. Chem.*, **24**, 1839 (1959).

(11) If was prepared, together with the O-alkylation product, by methylation of the sodium salt of Ig. It was shown to be a C-alkylation product, as formulated, by its stability to acid under conditions which cleaved the O-alkylation product prepared by alkylation with diazomethane of the same starting material. Details of this preparation will appear in a report on the chemistry of Ig and its congeners: M. Harfenist and E. Magnien, *J. Org. Chem.*, in press.

(12) R. H. F. Manske and M. Kulka, *Can. J. Res.*, **28B**, 443 (1950).

—This was made by stirring 9 g. (0.034 mole) of "methylmalonylphenoxazine"[6,13] in 175 ml. of carbon tetrachloride with a 10% excess of bromine overnight, extracting with water and with dilute aqueous sodium carbonate, drying, and removing the solvent as above. The resulting 8 g. of orange solid was recrystallized from absolute ethanol, yielding 6.9 g. (59%) in two crops, of a product of m.p. 134–137°.

Anal. Calcd. for $C_{16}H_{10}BrNO_3$: C, 55.83; H, 2.93. Found: C, 56.23; H, 3.11.

2-Bromo-"ethylmalonylcarbazole"[6] (Compound Ik).—Bromination of "ethylmalonylcarbazole"[6,14] either in dimethylformamide or in the rather large amount of carbon tetrachloride required to dissolve this substance, followed by the work-up outlined above, gave an 86% yield of bromo compound of m.p. 144–146°. To obtain this yield in the dimethylformamide, however, 50% over the theoretical amount of bromine had to be used, as the usual 5–10% excess led to recovery of much starting material.

2-Bromo-"ethylmalonylcarbazole,"[6] after recrystallization from carbon tetrachloride, had m.p. 148–149.5°.

Anal. Calcd. for $C_{17}H_{12}BrNO_2$: C, 59.66; H, 3.54. Found: C, 59.33; H, 3.61.

Amines Ia, Ic, Id, and Ie.—These were made in most cases as given in Table I, by mixing the appropriate bromo compound dissolved in the rather large amount of ether necessary to dissolve it completely, with the required amine in tenfold excess. The solutions were generally stored in a Citrate of Magnesia (*i.e.*, pressure) bottle for the time given.

The portion of the reaction products which was alkali-insoluble and 0.2 *N* hydrochloric acid-soluble was converted to the base by 1 *N* sodium hydroxide, taken up in ether, dried, and heated on the steam bath at the water pump to remove solvent and excess of starting amine. It was then crystallized or converted to the hydrochloride and recrystallized to constant melting point for analysis.

Phenothiazine-1-aldehyde from Ia and from Ic.—A solution of 4.95 g. (14.6 mmoles) of 2-ethyl-2-dimethylamino-1,3-diketo-2,3-dihydro-1H-pyrido[3,2,1-kl]phenothiazine (Ia) in 100 ml. of commercial absolute ether was added during 10 min. with stirring to 1.30 g. (34 mmoles) of lithium aluminum hydride partly dissolved in 50 ml. of absolute ether. The nearly white suspension so produced was heated under reflux for 75 hr. and allowed to remain at room temperature for an additional day. Decomposition by the usual dropwise addition of 2.5 ml. of water caused slight yellowing of the initially creamy suspension. A white solid was filtered off. This, on being washed with 95% ethanol, gave an orange material, soluble in either ether or alcohol. Repeated washings with ethanol and ether gave an orange solution with an amine odor. This was extracted with water, then with 4 *N* aqueous hydrochloric acid, which removed a dark orange substance. Washings with *N* sodium hydroxide and water, drying over magnesium sulfate and evaporation of solvent, left 2.90 g. (88%) of lovely orange needles, m.p. *ca.* 65–72°. Two recrystallizations from ethanol–water gave analytically pure orange needles of m.p. 80–81°.

An analogous reduction of 1.78 g. (4.7 mmoles) of 2-methyl-2-(4-methylpiperazino)-1,3-diketo-2,3-dihydro-1H-pyrido[3,2,1-kl]phenothiazine by 417 mg. (11 mmoles) of lithium aluminum hydride gave after 72 hr. under reflux 83% of crude phenothiazine-1-aldehyde. This, after recrystallization had the same melting point and infrared absorption as that of the aldehyde from the 2-dimethylamino-"ethylmalonylphenothiazine"[6] above.

Anal. Calcd. for $C_{13}H_8NOS$: C, 68.69; H, 3.99; N, 6.16; S, 14.10. Found: C, 69.07; H, 4.57; N, 5.85; S, 13.70.

This formed an oxime, isolated in nearly quantitative yield as matted yellow needles, by addition of water after

TABLE I
PREPARATION OF THE AMINES Ia–Ie[a]

Amine	Bromo-compound	Reaction solvent	Time,[b] days	Yield, %	Product	M.p., °C.	Recryst. solvent[c]	Formula	Caled. C	Caled. H	Found C	Found H
$NH(CH_3)_2$	Ih	Ether	4	78	Ia	101[d]	A	$C_{19}H_{18}N_2O_2S$	67.44	5.36	67.22	5.06
NH, N—CH_3	Ii[e]	Ether	4	23	Ic	193–198[f]	AE	$C_{21}H_{21}N_3O_2S$·HCl	53.45	5.34	53.21	5.25
$NH(CH_3)_2$	Ij	$NH(CH_3)_2$	1	96	Ie	194–196[f]	AE	$C_8H_{16}N_2O_2$·HCl	62.80	4.97	63.00	5.04
$NH(CH_3)_2$	Ik	Ether	2	73	Id	88–92.5[g]	E	$C_{19}H_{18}N_2O_2$	74.49	5.92	74.33	5.82

[a] An outline of the general procedure used is given in the Experimental. [b] Reactions all run at 30–40°. All solvents were commercial anhydrous materials. [c] Recrystallization solvents were all commercial absolute: A = ethanol; AE = ethanol and ether. [d] Start of melting point. The base melted to an opaque bubbly material which became clear *ca.* 124°. The hydrochloride had m.p. 194–196°. [e] Impure bromo compound was used. [f] Amine hydrochloride. [g] The hydrochloride had m.p. 198–200°. It may be recrystallized from ethanol–ether.

(13) M. Harfenist, R. Blumfeld, T. Capiris, and E. Magnien, *J. Org. Chem.*, **27**, 3977 (1962).

(14) P. Baumgarten and M. Riedel, *Ber.*, **75**, 984 (1942).

18 hr. of boiling with hydroxylammonium acetate in ethanol–water. This was readily recrystallized from ethanol–water, m.p. 97–98.5°.

Anal. Calcd. for $C_{13}H_{10}N_2OS$: C, 64.41; H, 4.16. Found: C, 64.46; H, 4.31.

The oxime became discolored in light.

Phenothiazine-1-aldehyde thiosemicarbazone was prepared as orange needles of m.p. 232–237° dec. by heating 2.04 g. of the aldehyde with 1.07 g. of thiosemicarbazide in 230 ml. of absolute ethanol holding 3 ml. of glacial acetic acid for 5 hr. It was recrystallized from much ethanol–water.

Anal. Calcd. for $C_{14}H_{12}N_4S_2$: C, 55.97; H, 4.03. Found: C, 56.63; H, 4.06.

Phenothiazine-1-aldehyde from If.—A solution of 4.69 g. (15.1 mmoles) of 2-methyl-2-ethyl-1,3-diketo-2,3-dihydro-1H-pyrido[3,2,1-kl]phenothiazine (2-methyl-"ethylmalonylphenothiazine"[6]) suspended in 250 ml. of commercial anhydrous ether was added rapidly to 1.4 g. (37 mmoles) of lithium aluminum hydride, in 100 ml. of ether, and heated under reflux for 90 hr. The usual work-up gave a first crop which after two recrystallizations, weighed 980 mg., This was shown to be identical to a sample prepared from Ia by an undepressed mixture melting point and by identity of infrared absorption curves.

Phenoxazine-1-aldehyde and 2-Methyl-2-dimethylamino - 1,3 - dihydroxy - 2,3 - dihydro - 1H - pyrido[3,2,1-kl]phenoxazine (IIc) Hydrochloride from Ie.—A solution of 14.6 g. (0.05 mole) of 2-methyl-2-dimethylamino-1,3-diketo-2,3-dihydro-1H-pyrido[3,2,1-kl]phenoxazine was warmed with 350 ml. of ether previously dried over calcium hydride, until it dissolved. This solution was added slowly to a solution–suspension of 3.8 g. (0.1 mole) of lithium aluminum hydride, in 50 ml. of ether. When the spontaneous boiling had subsided, the reaction mixture was stirred and heated under reflux for 28 hr. and then decomposed by addition of 7.6 ml. of water added over about 7 min. This was followed by addition of 100 ml. each of 95% ethanol and 1 *N* aqueous sodium hydroxide. The mixture was now stirred for 8 min., transferred to a separatory funnel, and partitioned between ether and 1 *N* aqueous sodium hydroxide solution. The orange ethereal solution lost much of its color upon extraction with 1 *N* aqueous hydrochloric acid. It was then dried and concentrated. The resulting orange oil solidified and was washed with hexane, and recrystallized twice from isopropyl alcohol–water. It was then sublimed at 80° (air bath temperature) at 0.08-mm. gage pressure, for analysis. Its melting point remained essentially unchanged at 112–114°.

The above-mentioned hydrochloric acid extract, on standing, deposited colorless crystals of an amine hydrochloride which turned first to a white oil, then orange with aqueous-ethanolic sodium hydroxide. The hydrochloride was recrystallized by solution in water slightly acidified with hydrochloric acid and warming, followed by addition of concentrated aqueous hydrochloric acid to incipient turbidity. Tan crystals were obtained of approximately the same decomposition point as the initial crystals, 177–179° dec. These darkened only slightly on being dried for analysis at 100° (0.01 mm.) overnight, and gave a fair analysis for a monohydrate.

The filtrates of the hydrochloric acid solutions were combined, made basic, and extracted with ether. The residue of evaporation of the ether, on being boiled 17 hr. with 66% aqueous ethanol, gave 2 g. more of phenoxazine-1-aldehyde of m.p. 106–110°.

A total of 6.71 g. (58%) of phenoxazine-1-aldehyde of analytical purity was obtained.

Phenoxazine-1-aldehyde. *Anal.* Calcd. for $C_{13}H_9NO_2$: C, 73.92; H, 4.29. Found: C, 73.90; H, 4.39.

IIc hydrochloride hydrate. *Anal.* Calcd. for $C_{18}H_{20}N_2O_3 \cdot HCl \cdot H_2O$: C, 58.93; H, 6.32. Found: C, 59.43; H, 6.23.

Carbazole-1-aldehyde and 5-Ethyl-5-dimethylamino-4,6-dihydroxy - 5,6 - dihydro - 4H - pyrido[3,2, - jk]carbazole (Compound IIb).—A solution of 16.5 g. (0.054 mole) of 5 - ethyl - 5 - dimethylamino - 4,6 - diketo - 5,6 - dihydro-4H-pyrido[3,2,1-jk]carbazole (*i.e.*, 5-dimethylamino-"ethylmalonylcarbazole"[6]) in 750 ml. of anhydrous ether, analogously heated under reflux with 8.3 g. (0.22 mole) of lithium aluminum hydride for 68 hr., was carefully decomposed by addition of 60 ml. of acetic acid. An attempt to filter off the solids and extract them separately with ether and ethanol was unsatisfactory, but use of a large excess of sodium fluoride solution, and potassium carbonate in excess led to a turbid solution–suspension which could be extracted with ether. Each ether layer was extracted with water once, and then extracted three times with a total of 350 ml. of 0.6 *N* aqueous hydrochloric acid. A precipitate which formed at this point was filtered off. It was 9 g. of a white solid, m.p. 178–180°, found subsequently to be quite pure IIb hydrochloride hydrate. This was recrystallized twice by solution in hot 0.5 *N* aqueous hydrochloric acid, and addition of 6 *N* hydrochloric acid to incipient turbidity. Two interchangeable salts were obtained, one melting at 165.5–168°, and the other, of m.p. 184–186°, produced by prolonged drying (*e.g.*, 100° at 0.01 mm. in a thin layer overnight). The latter gave satisfactory elemental analyses in duplicate for a hemihydrate, although once, presumably due to uptake of moisture by this very hygroscopic substance, an analysis for the monohydrate was obtained. The less hygroscopic salt melting about 166° gave satisfactory analyses for the monohydrate.

The combined hydrochloric acid filtrates from which the 9 g. had been obtained gave, on evaporation of solvent at the water pump on the steam bath, an additional 3 g. of less pure IIb hydrochloride. The total yield was thus 61%.

The ether which had been acid-extracted gave on evaporation 2.8 g. of a yellow solid which, on recrystallization from ethanol–water, gave 2.18 g. (21%) of carbazole-1-aldehyde of m.p. 146–146.5°.

When a sample of the hydrochloride of IIb was converted to the base by aqueous sodium hydroxide and taken up in ether, it could be recrystallized from ethanol–water and melted at 119–121° to a turbid melt. A second recrystallization from ethanol–water gave analytically pure yellow carbazole-1-aldehyde. This formed a thiosemicarbazone melting at 246° to a turbid melt clear at 253°.

Carbazole-1-aldehyde. *Anal.* Calcd. for $C_{13}H_9NO$: C, 79.98; H, 4.64; N, 7.18. Found: C, 79.43, 79.48; H, 4.47, 4.24; N (Dumas), 7.33.

Compound IIb. *Anal.* Calcd. for $C_{19}H_{22}N_2O_2 \cdot HCl \cdot H_2O$: C, 62.54; H, 6.90. Found: C, 62.38, 62.56; H, 7.08, 6.78. Calcd. for $C_{19}H_{22}N_2O_2 \cdot HCl \cdot {}^1/_2H_2O$: C, 64.01; H, 6.80. Found: C 64.32, 63.81; H, 6.71, 6.93.

Carbazole-1-aldehyde thiosemicarbazone. *Anal.* Calcd. for $C_{14}H_{12}N_4S$: C, 62.66; H, 4.51. Found: C, 62.62; H, 4.44.

6-Keto-5-ethyl-5-dimethylamino-4-methyl-4-hydroxy-5,6-dihydro-4H-pyrido[3,2,1-jk]carbazole (Compound IV).—A solution of 5 g. (0.0163 mole) of 5-ethyl-5-dimethylamino-4,6 - diketo - 5,6 - dihydro - 4H - pyrido[3,2,1 - jk]carbazole (compound Id) in 50 ml. of anhydrous ether was added to a Grignard reagent from 550 mg. (0.025 g.-atom) of magnesium and 3.0 g. (0.021 mole) of methyl iodide in 60 ml. of anhydrous ether. The reaction was heated under reflux for 5 hr. and then decomposed by addition of saturated aqueous ammonium chloride. The ethereal solution was extracted once with water, then three times with aqueous 1 *N* hydrochloric acid. The combined acidic layers were evaporated on the steam bath at the water pump leaving 5.05 g. (90%) of off-white solid. This was recrystallized from ethanol–ether twice, yielding 2.8 g. of hydrochloride, m.p. 183–184° dec. The base prepared by cautious treatment of the hydrochloride with aqueous alkali had m.p. 54–57°. Any of the other possible stereoisomers of IV hydrochloride which might have been present could not be induced to crystallize from the mother liquors.

Anal. Calcd. for $C_{26}H_{22}N_2O_2 \cdot HCl$: C, 66.93; H, 6.46. Found: C, 66.77; H, 6.08.

1-Acetylcarbazole.—A solution of 1.02 g. (0.0285 mole) of IV hydrochloride (see above) dissolved in 100 ml. of water was treated with 4 ml. of 1 *N* aqueous sodium hydroxide and the base was filtered off and washed with water. It was then dissolved in 50 ml. of ethanol and treated with 10 ml. of 6.5 *N* aqueous sodium hydroxide. The solution, which turned yellow immediately, was heated under reflux for 4 hr., water was added to incipient turbidity, and the solution was filtered and cooled. The resulting long yellow needles weighed 510 mg. (86%) and had m.p. 128°. Two recrystallizations from ethanol–water gave material of m.p. 134–136° (lit.,[12] m.p. 133–134°).

Anal. Calcd. for $C_{14}H_{11}NO$: C, 80.36; H, 5.30. Found: C, 80.30; H, 5.60.

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Preparation and Polymerization of S-, O-, and N-Vinyl Derivatives of Carbonic Acid.[1] Unsaturated Carbonic Acid Derivatives. II

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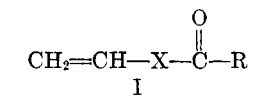
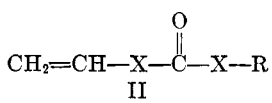
This paper describes the preparation, physical properties, and homopolymerization of several vinyl carbamates, vinyl thiolcarbamates, and vinyl thiolcarbonates. These monomers were prepared by the dehydrochlorination of the corresponding β-chloroethyl compounds which were prepared by the reaction of (A) β-chloroethyl chloroformate or β-chloroethyl chlorothiolformate with amines, alcohols, or mercaptans; (B) ethylene sulfide with chloroformates or chlorothiolformates; or (C) chlorothiolformates with β-chloroethylamines or N-substituted ethyleneimines.

S-, O-, and N-vinyl derivatives of carboxylic acids (I) are well known and are of scientific as well as commercial interest.[3,4]



I

X = S, O, NR



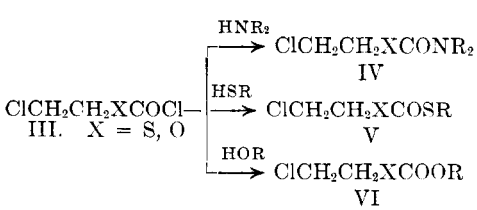
II

Surprisingly, the analogous derivatives of carbonic acid (II) have not yet been carefully investigated. The literature describes a series of N-unsaturated carbonic acid derivatives, prepared by the reaction of vinyl- and isopropenylisocyanate with alcohols, mercaptans, and amines.[5–8] Little work has been done in the field of vinyl thiolcarbonates and vinyl thiolcarbamates. Sauer published the synthesis of vinyl N,N-dialkyldithiocarbamates[9] and the cyclicpolymerization of divinyl dithiolcarbonate was studied in this institute.[10]

In connection with our investigation concerning the preparation of nitrogen- and sulfur-containing polymers as potential radiation prophylactics,[11] we have been interested in S-, O-, and N-vinyl compounds. This paper describes the preparation and homopolymerization of new vinyl carbamates, thiolcarbamates, and thiolcarbonates.

Several unsuccessful attempts were made to prepare these monomers either by dehydration of β-hydroxyethyl carbamates, thiolcarbamates, and thiolcarbonates or by cracking the corresponding β-acetoxyethyl compounds. A convenient synthesis was found to be the dehydrochlorination of the corresponding β-chloroethyl compounds.

For the preparation of these new S-, O-, and N-β-chloroethyl carbonic acid derivatives, three principal procedures were used: (A) reaction of β-chloroethyl chloroformate (III) and β-chloroethyl chlorothiolformate (III) with amines, alcohols, and mercaptans.[10,12]



III. X = S, O

IV

V

VI

(1) This is the 24th in a series of papers concerned with the preparation and properties of new monomers and polymers; for the previous paper in this series see C. G. Overberger and J. J. Ferraro, *J. Org. Chem.*, **27**, 3539 (1962); for the first paper in the subseries see ref. 10.

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