

It was purified by recrystallization from water, m. p. 156–157° (cor.) with decomposition.

Anal. Calcd. for $C_{13}H_{27}O_6N \cdot C_6H_5O_7N_3$: C, 49.48; H, 5.19; N, 9.62. Found: C, 49.73; H, 5.37; N, 9.76.

Summary

1. A new alkaloid grantianine has been isolated from *Crotalaria grantiana*.
2. It is saponified by methanolic potassium

hydroxide to retronecine and an acid not yet isolated in a pure state.

3. Reduction gives tetrahydrograntianine which is postulated as an amino acid.

4. Preliminary results thus indicate that grantianine may be retronecine esterified on both hydroxyls with one molecule of a dibasic acid.

URBANA, ILLINOIS

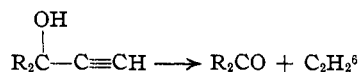
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[CONTRIBUTION NO. 257 FROM THE RESEARCH LABORATORY OF ORGANIC CHEMISTRY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY]

The Decomposition of Certain Acetylenic Carbinols

BY A. F. THOMPSON, JR., AND CHARLES MARGNETTI¹

Various catalysts are available for the vapor phase dehydration of tertiary acetylenic carbinols to yield vinylacetylene derivatives. Anhydrous magnesium sulfate,² basic aluminum sulfate,³ and aluminum phosphate,⁴ have all been used successfully for this dehydration reaction. Activated alumina has been shown by Vaughn⁵ to be a satisfactory dehydration catalyst for tertiary ethynyl carbinols only if the alkaline ingredients present, principally sodium oxide, are removed by suitable treatment, which he has devised. It has long been known that in the presence of alkali the decomposition of tertiary ethynyl carbinols proceeds to form ketones and acetylenic hydrocarbons according to the reaction



Recently, it was shown⁷ that hexynyl carbinols, in contrast to the ethynyl carbinols studied by Vaughn, were smoothly dehydrated over ordinary alumina, only relatively small amounts of hexyne being produced. A number of ethynyl and hexynyl carbinols were compared and these results confirmed in all cases. It seemed worthwhile to investigate more fully the effect of the

group R^1 , in the general formula $\begin{array}{c} \text{OH} \\ | \\ \text{R}_2\text{C}-\text{C}\equiv\text{CR}^1 \end{array}$, upon the relative extent of the two predominant decomposition reactions, cleavage and dehydration.

(1) From the thesis submitted by Charles Margnetti to the Massachusetts Institute of Technology in partial fulfillment of the requirements for the degree of Bachelor of Science.

(2) Zakharova, *Sci. Repts. Leningrad State Univ.*, **2**, 162 (1936).

(3) Carothers and Coffman, *This Journal*, **54**, 4074 (1932).

(4) Thompson and Powers, unpublished results.

(5) Vaughn, U. S. Patent 2,197,956.

(6) Moureu, *Bull. soc. chim.*, [3] **33**, 151 (1905).

(7) Thompson, Burr and Shaw, *This Journal*, **63**, 186 (1941).

A number of acetylenic tertiary carbinols were accordingly prepared, by condensation of the appropriate acetylenic Grignard reagent with the ketone in ethereal solution. Table I summarizes the properties of the carbinols obtained. The substances were analyzed for unsaturation by quantitative catalytic hydrogenation, which served to check the purity of the samples.

TABLE I

Acetylenic carbinol	Yield, %	B. p., °C.	mm.	n_D^{20}	Double bonds (cat. H ₂)
Methylethylpropynyl	70	132–135	760	1.4308	2.08
Methylethylisopropylethynyl	76	128–130	35	1.4169	2.05
Methylethyl- <i>t</i> -butylethynyl	58	137–140	35	1.4211	1.92
Methylethylphenylethynyl	65	138–140	15	1.5469	2.06
Methylethyl-(1,2-dimethyl)-vinylethynyl ⁸	79	117–120	15	1.4611	3.08
Methylamylpropynyl	71	105–108	15	1.4400	2.05
Methylamylphenylethynyl	78	114–117	2	1.5522	2.11
Methylamyl-(1,2-dimethyl)-vinylethynyl ⁸	79	115–118	5	1.4941	3.13
Diisopropylhexynyl	68	130–133	15	1.4565	2.14

The decomposition reactions of the carbinols so obtained were then studied by heating them with alumina as previously described.⁷ The less volatile of the carbinols were distilled through the apparatus under diminished pressure and the decomposition products collected in a dry-ice trap. Separation was accomplished by careful fractionation of the liquid mixture. The ketones were identified by preparation of derivatives, and the hydrocarbons by catalytic hydrogenation. The acetylenic nature of the hydrocarbons formed was indicated by obtaining heavy precipitates of the

(8) The two vinylacetylenic carbinols were prepared from the dimethylvinylacetylene fraction obtained by dehydration of methylethylethynylcarbinol. This fraction should consist essentially of 3-methylpentene-1-ene-3, but there is no proof that a small amount of the alternative dehydration product, 2-ethylbutene-1-yne-3, is not also present.

TABLE II

Acetylenic carbinol	Dehydration reaction Vinylacetylene derivative					Cleavage reaction					
	Wt., g.	Wt., g.	B. p. °C.	mm.	n_D^{25}	Double bonds (cat. H ₂)	Wt., g.	Ketone B. p., °C. Found	°C. Reptd.	Acetylenic derivative B. p., °C. Found	°C. Reptd.
Methylethylpropynyl	34	12	72-75	760	1.4119	2.96	8	78-80 ^a	80.6	...	...
Methylethylisopropylethylyl	30	14.2	67- 70	30	1.3949	3.07	3	77- 80	80.6	...	...
Methylethyl- <i>t</i> -butylethylyl	12	4.1	75- 80	30	1.3881	2.88	1.1	75- 80 ^a	80.6	...	...
Methylethylphenylethylyl	14	..	...	...	..	..	3.1	78- 80 ^a	80.6	5.3	142-143
Methylethyl - (1,2 - dimethyl)- vinylethylyl	16	6.5	72- 75	10	1.4941	4.07	1.0	75- 80 ^a	80.6	1.5	65- 70
Methylamylpropynyl	40	18	80- 85	30	1.4158	2.98	12	148-151 ^b	151	...	...
Methylamylphenylethylyl	27	..	...	...	..	..	10.4	147-151 ^b	151	6.2	140-143
Methylamyl - (1,2- dimethyl)- vinylethylyl	25	6	75- 80	10	1.4549	4.12	2.4	147-151	151	3.3	65-70
Diisopropylhexynyl	24	10	115-117	15	1.4668	2.90	3.7	121-123 ^c	123.7	2.5	68- 72

^a Characterized as the semicarbazone m. p. 135-138°, literature 138°. ^b Characterized as the semicarbazone m. p. 120-122°, literature 122°. ^c Characterized as the 2,4-dinitrophenylhydrazone m. p. 84-85°, literature 86°.

silver salts. In the case of hexyne, it was shown that repeated passage through the furnace failed to reduce materially the quantity of the derivatives obtainable from a given sample. The results are summarized in Table II. Although it was naturally not possible to make an absolutely quantitative separation of the products, or recover them in a state of complete purity, Table II does give quite a comprehensive picture of the course of the decomposition of these carbinols.

Inspection of Table II, in connection with earlier results, shows that dehydration of acetylenic

carbinols $R_2\overset{\text{OH}}{\text{C}}-\text{C}\equiv\text{C}-R^1$ may be carried out successfully over alumina in every case so far investigated, except when R is H, phenyl, or CH₃. With these three groups the decomposition yields from 50-100% of the acetylenic hydrocarbon. Of the groups in the molecule, R¹ is by far the most important, but the other groups do have an effect, especially if they are peculiarly resistant to the dehydration reaction, as is isopropyl. Alkyl groups R¹, other than methyl, all have about the same effect, even when unsaturated, as in the case of dimethylvinyl. Other small effects may be noted from Table II.

Since it is hoped eventually to study substances

of the structure $R-\overset{\text{OH}}{\text{C}}-\text{C}\equiv\text{C}-R_1$ in order to

more accurately evaluate the relative effects of different groups R₁ and R₂ upon the course of the reaction, it was of interest to see how such dialkynyl carbinols would behave, under the decomposition conditions used. Accordingly propyldihexynylcarbinol was prepared by condensation of ethyl butyrate with hexynylmagnesium bromide. It was found to be quantitatively de-

hydrated during the treatment over alumina. Phenyldihexynylcarbinol was then prepared in the same way from ethyl benzoate. It was decomposed by heating to yield hexyne, but any acetylenic ketone formed decomposed with the formation of resinous products. The preparation of acetylenic ketones by this method is still under investigation.

Since these results bore a relation to those of Faworsky,⁶ who studied the decomposition reactions of acetylenic carbinols in potassium hydroxide solution, it was considered of interest to compare the behavior of some ethynyl and hexynyl carbinols on heating with strong potassium hydroxide solutions. Since Faworsky's experimental directions were lacking, it was necessary to estab-

TABLE III

Acetylenic carbinol	KOH cleavage reagent	Ketone, g.		Acetylenic derivative, g.	
		Calcd.	Isolated	Calcd.	Isolated
Methylethylethylyl	50%	7.3	6.5 ^a		
	66%	7.3	6.3		
	Alc. (satd.)	7.3	3.5 ^a		
Methylethylhexynyl	30%	4.8	0	5.2	0
	50%	4.8	4.2 ^a	5.2	4.6 ^a
	66%	4.8	4.0 ^a	5.2	4.0 ^a
Methylpropylhexynyl	50%	2.6	2.2 ^b	2.4	1.7 ^c
Methylamylethylyl	30%	7.6	0		
	50%	7.6	6.4 ^c		
	Alc. (satd.)	7.6	3.5 ^c		
Methylamylhexynyl	66%	5.8	5.2	4.2	3.5 ^e
	50%	5.8	5.0	4.2	3.2 ^e
	Solid	5.8	3.9 ^c	4.2	1.0
Diisopropylethylyl	10%	24.4	0		
	50%	24.4	20.6 ^d		
	Solid	8.2	6.3 ^d		
Propyldihexynyl	50%	22.6	0	12.4	7 ^e
Phenyldihexynyl	50%	17.5	0	7.5	5.5 ^e

^a Characterized as semicarbazone m. p. 135-138°.

^b Characterized as 2,4-dinitrophenylhydrazone m. p. 139-140°, literature 141°. ^c Characterized as semicarbazone m. p. 121-122°. ^d Characterized as 2,4-dinitrophenylhydrazone m. p. 84-85°. ^e Characterized as (C₄H₉C≡C)₂Hg m. p. 93-96°, literature 96°, and as hexanone-2 semicarbazone m. p. 117-119°, literature 121°.

lish optimum conditions for the reaction. Results of these experiments are summarized in Table III. The ketones were characterized by derivatives, the hexyne by its mercury derivative and by hexanone-2-semicarbazone. Presence of acetylene could be shown by testing the evolving gases with silver solution.

As can be seen from Table III, aqueous potassium hydroxide of 50–66% strength is the best cleavage agent. Alkali of lower concentration was not effective in causing cleavage. Solid potassium hydroxide and alcoholic solutions were effective, but any ketone formed reacted further. The results of treatment with alkaline solutions are of interest when compared with the behavior of the carbinols over alkaline alumina.

Thus, the effect of the butyl group, of reducing the rate of the cleavage reaction, so that dehydration becomes the principal reaction in the vapor phase of hexynyl carbinols, is not observed in the reaction carried out in solution; in all cases the carbinols were found to give the ketone and hydrocarbon in high yield, so that the cleavage reaction is the only significant one in these solutions.

The conclusions are to be amplified, particularly in the vapor phase, by studies of the decomposition of acetylene derivatives containing dissimilar alkynyl residues, either carbinols or glycols.

Experimental

Preparation of Acetylenic Carbinols.—The ethynyl carbinols used in this work were prepared according to the directions of Thompson, Burr and Shaw.⁷ The alkynyl carbinols were prepared from the corresponding ketones and alkynyl Grignard reagents according to directions in the same paper.⁷ Methylacetylene required for preparation of propynyl carbinols was obtained from propylene bromide according to Heisig.⁹ Isopropylacetylene was prepared from 3-methyl-butene-1, by addition of bromine and removal of hydrobromic acid according to Norris.¹⁰ *t*-Butylacetylene was prepared from pinacolone by treatment with phosphorus pentachloride, followed by potassium hydroxide according to Ivitzky.¹¹ A crude mixture of hydrocarbons was obtained by this procedure. The fraction boiling at 35–50°, which gave a strong silver test, was used for the preparation of *t*-butylacetylenemagnesium bromide, since only an acetylene derivative would react, and no other acetylene had ever been reported as formed during this reaction. From the gas evolved during the reaction of the hydrocarbon with ethylmagnesium bromide, it was estimated that the fraction contained 60% *t*-butylacetylene.

(9) Heisig and Davis, *THIS JOURNAL*, **57**, 339 (1935).

(10) (a) Norris and Joubert, *ibid.*, **49**, 2873 (1927); (b) Norris and Reuter, *ibid.*, **49**, 2624 (1927).

(11) Ivitzky, *Bull. soc. chim.*, [4] **35**, 357 (1924).

Phenylacetylene was obtained from β -bromostyrene with potassium hydroxide according to "Organic Syntheses."¹² 1,2-Dimethylvinylacetylene was prepared by dehydration of methylethylethynylcarbinol according to Thompson, Milas and Rovno.¹³

Preparation of Di-acetylenic Carbinols.—Propyldihexynylcarbinol was prepared from ethyl butyrate by refluxing for two hours with hexynylmagnesium bromide. Twenty-four grams of carbinol was obtained from eighteen grams of ester, b. p. 130–132° (2 mm.), n_D^{20} 1.4689, yield 67%; double bonds, by catalytic hydrogenation, 4.13. Phenyl-dihexynylcarbinol was prepared in the same way from ethyl benzoate in 55% yield, b. p. 168–170° (2 mm.), n_D^{20} 1.5173; double bonds, by catalytic hydrogenation, 4.03.

Decomposition of Acetylenic Carbinols.—The decomposition reactions of the carbinols were studied by passing the vapors of the carbinols, in a stream of nitrogen, over alumina and examining the decomposition products. The alumina used was the "Grade A" product, 8–14 mesh, furnished by the Aluminum Ore Company. Three separate batches have been used during two years of work; identical results were obtained with the different batches. The apparatus and conditions used have previously been described.⁷ The liquid products were collected in dry-ice cooled receivers, the water separated, and the organic liquids fractionally distilled. As may be seen from Table II, few difficultly separable mixtures were obtained; most of the liquids resulting in a given reaction had widely separated boiling points. In two instances the liquids obtained were difficult to separate: the products from methyl-ethylpropynylcarbinol, and from methylamylphenylethynylcarbinol. In these two cases the hydrocarbons were separated from the ketones by forming the bisulfite addition products, from which the ketones were recovered. A derivative was prepared from the ketones in most cases to establish the nature of the ketone fractions. Absence of acetylenic hydrocarbons from the ketone fractions was demonstrated by negative silver tests. The acetylene fractions were tested with silver solution and in all cases heavy precipitates were obtained. All the unsaturated hydrocarbon fractions were analyzed by quantitative catalytic hydrogenation; under the conditions used platinum oxide scarcely catalyzes hydrogenation of ketones at all. In two cases, that of hexyne, and of 3,6-octadien-2,6-yne-4, 25-g. samples of the hydrocarbon were passed repeatedly through the furnace under the decomposition conditions. No change of physical properties or other evidence of isomerization was obtained in the case of the material recovered. This indicates that the analysis by catalytic hydrogenation is a reliable method of checking the purity of the hydrocarbon fractions having the correct boiling points. The divinylacetylene derivative used for the above experiment was prepared from the corresponding vinyl ethynylcarbinol by dehydration with acetic anhydride.

Decomposition of Acetylenic Carbinols by Potassium Hydroxide Solution.—The reactions of the carbinols in potassium hydroxide solution were studied by heating the carbinol under reflux with the alkaline solution of the de-

(12) "Organic Syntheses," Collected Volume I, p. 428.

(13) Thompson, Milas and Rovno, *THIS JOURNAL*, **63**, 754 (1941).

sired strength. With potassium hydroxide solutions of less than 40% strength, up to ten hours of heating with strong mechanical stirring had no effect, the carbinols being recovered to the extent of 95%.

In 50% solution two hours of heating was sufficient for complete reaction; actually this was much longer than necessary in most cases. An arrangement for partial condensation permitted hexyne and volatile ketones to distill off as formed. The distillate and organic material in the reaction flask were then combined, washed, dried, and carefully fractionated. Inspection of Table III shows the results obtained. Ketones were characterized by derivatives; hexyne by its mercury derivative, and by isolation of hexanone-2 semicarbazone. No effort was made to determine gaseous acetylene; its presence could always be shown by precipitation of silver acetylide from the gases evolved during decomposition of ethynyl carbinols. With dihexynyl carbinols it was possible to obtain hexyne in good yields but the residue in the reaction flask invariably was resinified.

Summary

A number of acetylenic tertiary carbinols have been prepared, with different alkynyl radicals. The effect of the alkynyl residue upon the decomposition of the carbinols over commercial alumina has been studied. Two types of decomposition have been observed, cleavage to ketone and acetylene derivative being favored by ethynyl and phenylethynyl substituents, and simple dehydration by alkylethynyl substituents. These results contrast with the decomposition with aqueous potassium hydroxide solution which invariably causes cleavage of the acetylenic group. Further studies are in progress to evaluate relative effects of groups.

CAMBRIDGE, MASS.

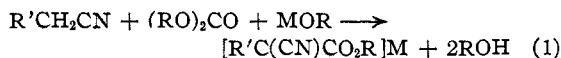
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[CONTRIBUTION FROM THE RESEARCH LABORATORIES OF THE MALLINCKRODT CHEMICAL WORKS]

Alkyl Carbonates in Synthetic Chemistry. III. Condensation with Nitriles. Synthesis of α -Cyano Esters¹

BY V. H. WALLINGFORD, DAVID M. JONES AND AUGUST H. HOMEYER

Previous papers in this series described the condensation of alkyl carbonates with organic esters to give malonic esters² and with ketones to give β -keto esters.³ Similarly, alkyl carbonates may be condensed with nitriles to give α -cyano esters as illustrated by eq. (1).



Earlier work on this reaction was devoted to the condensation of diethyl carbonate with phenylacetonitrile. Hessler⁴ first prepared ethyl α -cyanophenylacetate in 55% yield by adding phenylacetonitrile to a mixture of diethyl carbonate, ether and sodium. The same result was obtained by Nelson and Cretcher,⁵ who repeated Hessler's method and also tried other condensing agents. Sodamide gave a 30% yield in benzene and 70% in ether. Sodium ethylate in alcohol gave 55%. Ruggli, Caspar and Hegedus⁶ carried out the carbethoxylation in toluene by

means of sodium ethylate, and added *o*-nitrobenzoyl chloride directly to the reaction mixture. The yield of ethyl α -cyano- α -(*o*-nitrobenzoyl)-phenylacetate was 57%. Adickes and Hinderer⁷ attempted to force the condensation further to completion by the use of alcohol-free sodium ethylate, a reaction medium of xylene, and distillation of alcohol from the reaction medium. The yield of ethyl α -cyanophenylacetate was 63%. *p*-Methoxyphenylacetonitrile, the only other nitrile tried successfully in this reaction that has come to our attention, was carbethoxylated in ether by means of sodium giving a 55% yield.⁸

While previous workers obtained fair results with the reaction in the case of phenylacetonitriles, none has indicated that the method was generally applicable for the synthesis of α -cyano esters. By employing the technique described in earlier papers^{2,3} a carbalkoxyl group has been introduced into a variety of nitriles as shown in Table I. The method consists in heating the nitrile with a metal alcoholate and a large excess of alkyl carbonate. Thus the use of sodium metal, sodamide and mixed solvents is avoided. Alcohol introduced with the metal alcoholate and that

(1) Presented before the Division of Organic Chemistry at the Atlantic City Meeting of the American Chemical Society, September 9, 1941.

(2) Wallingford, Homeyer and Jones, *THIS JOURNAL*, **63**, 2056 (1941).

(3) Wallingford, Homeyer and Jones, *ibid.*, **63**, 2252 (1941).

(4) Hessler, *Am. Chem. J.*, **32**, 119 (1904).

(5) Nelson and Cretcher, *THIS JOURNAL*, **50**, 2758 (1928).

(6) Ruggli, Caspar and Hegedus, *Helv. Chim. Acta*, **20**, 250 (1937).

(7) Adickes and Hinderer, *J. prakt. Chem.*, [2] **150**, 89 (1938).

(8) Niederl, Roth and Plentl, *THIS JOURNAL*, **59**, 1901 (1937).