TABLE II

Radical	$(CH_3)_3NICH_2CHOH-R$				$(CH_3)_3NClCH_2CHOHR$				$(CH_3)_3NClCH_2CH(OOCCH_3)R$			
		Analyses, % N				Analyses, % N				Analyses, % N		
R =	M. p., °C.	Calcd.	Found		M. p., °C.	Calcd.	Found		M. p., °C.	Calcd.	Found	
C_2H_5	162–163	5.40	5.31	5.38	174–176[a]	8.36	8.36	8.35	144–146	6.68	6.79	7.04
n-C_3H_7	198–200[b]	5.13	5.07	4.98	115–117	7.71	7.58	7.73	168–169	6.26	6.16	6.25
n-C_4H_9	90–92	4.88	4.71	4.66	100.5–102	7.16	6.89	7.04	186–187	5.89	5.83	5.74
n-C_5H_{11}	98–100[c]	4.65	4.77	4.83	72–74	6.67	6.54	6.62	182–184	5.57	5.55	5.49
n-C_6H_{13}	109–110	4.44	4.16	4.22	69–71	6.28	6.45	6.22	169–171	5.26	5.06	4.98
n-C_7H_{15}	122.5–123.5	4.25	3.88	4.04	97–99	5.90	5.85	5.93	176–177	5.00	5.03	4.83

[a] β-Ethylcholine chloride and acetyl-β-ethylcholine sulfate were prepared first in this Laboratory by Dr. Albert B. Boese, Jr., at the request of one of us. [b] Walti [THIS JOURNAL, **56**, 2725 (1934)] reports that β-propylcholine iodide prepared from 1-dimethylaminopentanol-2 which had been obtained from pentene oxide-1,2 melted at 198°. [c] Braun and Schirmacher [*Ber.*, **56B**, 1845–1850 (1923)] report that β-amylcholine iodide melts at 106–108°. β-Amylcholine iodide was prepared in this Laboratory from 1-dimethylaminoheptanol-2 which had been prepared from *n*-amylethylene oxide, and that which had been prepared by the direct condensation of dimethylamine with 1-chloroheptanol-2. In both cases the β-amylcholine iodide after recrystallization from acetone–ether melted at 98–100°. No explanation for the discrepancy has been found.

The authors wish to express their appreciation to Messrs. Douglass F. Hayman and Sol Adler for the analyses recorded in this paper.

Summary

1. 1-Chlorononanol-2 has been prepared.

2. Several new dimethylaminoalkanols have been prepared, including 1-dimethylaminobutanol-2, 1-dimethylaminohexanol-2, 1-dimethylaminooctanol-2 and 1-dimethylaminononanol-2.

3. The homologous series of β-*n*-alkylcholine iodides from β-ethylcholine iodide to β-*n*-heptylcholine iodide inclusive has been prepared and characterized.

4. The homologous series of β-*n*-alkylcholine chlorides from β-ethylcholine chloride to β-*n*-heptylcholine chloride and their acetyl esters have been prepared and characterized.

5. A preliminary report upon the pharmacological action of the β-alkylcholines and their acetyl esters is presented.

RAHWAY, N. J. RECEIVED OCTOBER 25, 1935

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF STANFORD UNIVERSITY]

The Relative Rates of Ozonation of Unsaturated Compounds

BY C. R. NOLLER, J. F. CARSON, H. MARTIN AND K. S. HAWKINS

During the ozonation of dicyclohexenyl-1,1′ it was observed[1] that approximately one mole of ozone added rapidly but that the second mole of ozone added only slowly. A search of Harries' work revealed a statement[2] that compounds containing two conjugated double bonds add the first mole of ozone more rapidly than the second. While the work on dicyclohexenyl-1,1′ was in progress several articles by Brus and Peyresblanques[3] appeared in which they followed the course of ozonation by measuring the amount of unabsorbed ozone during the reaction. They gave curves for oleic acid, styrene, phenylcyclohexene, limonene, pinene, benzene and heptyne. With the concentrations of ozone used benzene added ozone extremely slowly, heptyne moderately so, while the other compounds added one mole of ozone very rapidly. During the past three years, the procedure of Brus and Peyresblanques has been used on a considerable number of compounds and the results of this exploratory work are of considerable interest.

A brief review of the procedure will be given in lieu of the experimental part. An ozone machine of the Henne type[4] is equipped with a flow meter and fitted by means of interchangeable ground joints to two 200-cc. gas washing bottles in series. The ozone machine is operated at constant voltage and temperature and a constant stream of air or oxygen passed through. Immediately before and after each run the ozonized air is passed for five minutes through 125 cc. of a 5% potassium iodide solution and the average

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[1] Noller and Kaneko, THIS JOURNAL, **57**, 2442 (1935).

[2] Harries, *Ann.*, **374**, 304 (1910).

[3] Brus and Peyresblanques, *Compt. rend.*, **190**, 501, 685 (1930).

[4] Henne, THIS JOURNAL, **51**, 2676 (1929).

number of moles of ozone formed per minute is calculated. A solution of 0.05 mole or less of the compound to be tested in 125 cc. of glacial acetic acid is placed in the first gas washing bottle while in the second is placed a 5% solution of potassium iodide. As soon as a distinct coloration appears in the potassium iodide bottle, it is replaced by 125 cc. of fresh potassium iodide solution and the gas passed through for exactly five minutes. This is repeated for five minutes out of every half hour and the moles of ozone unabsorbed per minute is calculated.

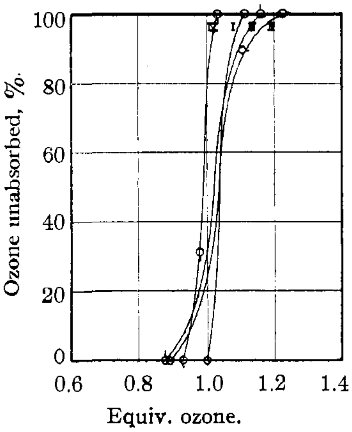

Fig. 1.—I, Oleic acid O; II, methyl oleate O-; III, elaidic acid Ó; IV, 1-phenylcyclohexene-1 O-.

The moles of unabsorbed ozone may be plotted directly against the time but because the concentration of ozone may vary from day to day, and because the solvent and solvent plus ozonide decompose ozone at different rates, it has been found more convenient to plot an "adjusted" per cent. of unabsorbed ozone against the equivalents of ozone entering the solution. All runs are made until the amount of ozone leaving the solution is approximately constant. This is considered as a measure of the rate at which the ozone is being decomposed by the solution although it is no longer being absorbed by the compound. By adjusting this value so that it becomes 100% and all of the other percentages in proportion one should get a first approximation of what the amount of unabsorbed ozone would be if there were no decomposition. A typical example given in Table I will illustrate this procedure.

Figure 1 gives the curves for methyl oleate, oleic acid, elaidic acid, and 1-phenylcyclohexene-1. It is obvious that for all of these substances ozone is completely absorbed until one equivalent has been passed into the solution, after which the unabsorbed ozone rapidly rises to the steady state. Apparently having the double bond in a ring and joined to one phenyl group as in phenylcyclohexene has no noticeable retarding effect on the addition of ozone.

TABLE I

OZONATION OF CROTONIC ALDEHYDE

Wt. of sample = 3.29 g. = 0.047 mole. Rate of production of ozone before start of reaction = 0.00157 mole per 5 min.; at end = 0.00153; average = 0.00155 mole per 5 min. Rate of flow of air = 1.25 l./5 min. Concn. of ozone = approx. 3% by volume or 5% by weight.

Time in min. after start of reaction	Amount of ozone passed into soln. Moles	Amount of ozone passed into soln. Equiv.	Moles of ozone unabsorbed per 5 min.	Per cent. of ozone unabsorbed	Adjusted per cent. of ozone unabsorbed
50	0.0155	0.330	None	None	None
80	.0248	.528	0.000104	6.9	10.9
110	.0341	.727	.000267	17.2	27.0
140	.0434	.927	.000480	30.9	48.5
170	.0527	1.125	.000935	60.3	94.6
200	.0620	1.322	.000985	63.6	100.0
230	.0713	1.520	.000920	59.3	...

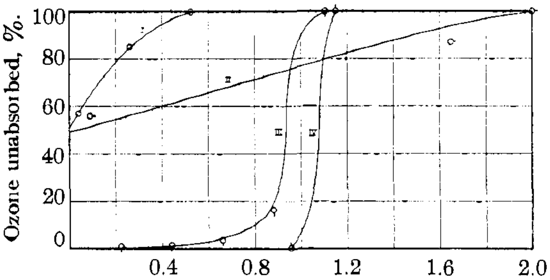

Fig. 2.—I, s-Dichloroethylene O; II, tetraphenylethylene O-; III, triphenylethylene O̩; IV, stilbene Ó.

In Fig. 2 are shown the curves for some phenylated ethylenes. It would appear from the curve for stilbene that two phenyl groups have no noticeable retarding effect on the addition of ozone; with three phenyl groups the effect is marked, while four phenyl groups practically inhibit the addition. The curve for *sym*-dichloroethylene shows that the effect of two chlorine atoms is about the same as that of four phenyl groups.

Curves for a series of compounds all but one of which have the double bond conjugated with a carbonyl group are illustrated in Fig. 3. The retarding effect of the carbonyl group is very pronounced. Where the rate of addition is decreased by a carbonyl group, the effect of an additional phenyl group as in cinnamic acid appears to be noticeable. In vinylacetic acid the double bond is not conjugated with the carbonyl group but is separated by one CH_2 group and yet a slight but real retarding effect is noticeable. This may account for the position of the curve for itaconic acid, the effect of the conjugated carbonyl group being aided by that of the non-conjugated carbonyl group. Because of the crudeness of the method such conclusions, of course, cannot be certain.

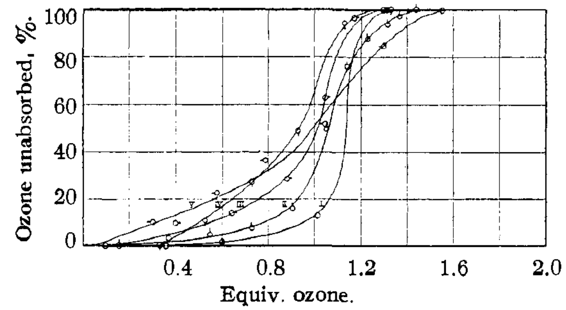

Fig. 3.—I, Vinylacetic acid ○; II, crotonic acid ȯ; III, cinnamic acid ○-; IV, crotonic aldehyde ọ; V, itaconic acid -○.

The curves shown in Fig. 4 are for compounds having two and three conjugated double bonds. It is apparent that only one mole of ozone is added rapidly. After the first mole is added, diphenylbutadiene with two double bonds behaves much the same as eleostearic acid with three, there being a gradual decrease in the rate of absorption. Addition of the second mole of ozone to sorbic acid is even slower than for diphenylbutadiene and eleostearic acid, indicating that the carbonyl group is helping to retard addition to the α,β double bond.

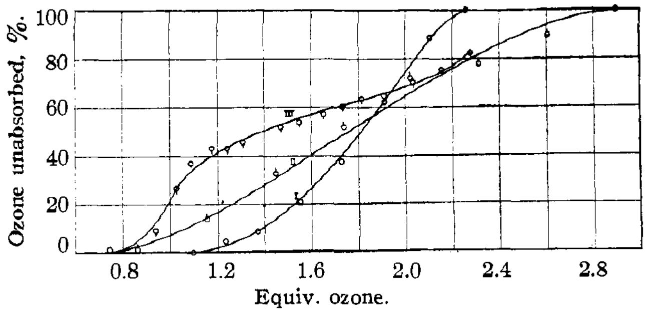

Fig. 4.—I, Diphenylbutadiene ○; II, eleostearic acid ȯ; III, sorbic acid ọ.

An interesting set of curves for certain *cis–trans* isomers is shown in Fig. 5. It will be noticed that in the case of the *cis-trans* isomers, oleic acid and elaidic acid given in Graph I, no appreciable difference can be detected. When, however, the rate of addition is slowed down by the presence of conjugated carbonyl groups, the *trans* compounds are found to add ozone more rapidly than the *cis*. The greater retarding effect of two conjugated carbonyl groups than one is also readily observed when the curves for mesaconic acid and methyl fumarate are compared with the curves given in Fig. 3.

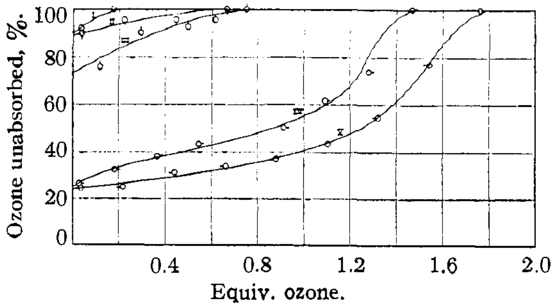

Fig. 5.—I, Citraconic acid ○; II, methyl maleate ọ; III, maleic acid ȯ; IV, mesaconic acid ○-; V, methyl fumarate -○.

There are several assumptions in this procedure which are obviously only roughly true. For one thing it assumes that ozone is not decomposed as long as no ozone is unabsorbed. The justification for this is that where ozone is absorbed rapidly as in the curves of Fig. 1, ozone escapes as soon as one mole has been passed into the solution. Where ozone is not absorbed rapidly, however, it is likely that decomposition as well as addition may be taking place before ozone escapes. A second assumption is that the amount of ozone decomposing is proportional to the amount unabsorbed and a third that the steady state is one of decomposition alone whereas in some cases it is probably a combination of decomposition and addition. Attempts are being made to refine the procedure but it is believed that even the simple and rather crude method outlined above reveals marked differences in the behavior of unsaturated compounds, and that when applied to unknown compounds will yield valuable information about their structure.

Summary

Curves are given showing the relative rates of ozonation of a number of unsaturated compounds. It is found that whereas a double bond, unaffected by the presence of other groups, adds ozone extremely rapidly, the rate is markedly decreased when the double bond is conjugated with carbonyl groups. Three or more phenyl groups or two

chlorine atoms attached to the doubly bound carbon atoms also decrease the rate of addition. Where two or three double bonds are conjugated with each other, one bond adds ozone rapidly while the others add only slowly. In the case of *cis–trans* isomers where the rate of addition is decreased by other groups, the *trans* is found to add more rapidly than the *cis* form. The procedure should prove valuable in the investigation of unsaturated compounds of unknown structure.

STANFORD UNIVERSITY, CALIF.

RECEIVED SEPTEMBER 23, 1935

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE STATE UNIVERSITY OF IOWA]

A Study of Possible Rearrangement Reactions of Monochloroamine and Certain Grignard Reagents

BY GEORGE H. COLEMAN AND ROBERT A. FORRESTER

It has been observed that in the reaction of formaldehyde with benzylmagnesium chloride *o*-tolylcarbinol[1] is formed instead of benzylcarbinol as expected. Other compounds[2] such as benzaldehyde, ethyl formate, and ethyl chlorocarbonate have also been found to react abnormally with this reagent. Rearrangement occurs in varying amounts, usually forming the *o*-tolyl products. Numerous other reactants, however, such as carbon dioxide, acetone, many acetals and esters, produce the normal product with benzylmagnesium chloride. Thus the nature of the reactant has an important influence on the possibility of rearrangement.

Certain other Grignard reagents such as α-naphthylmethylmagnesium chloride and cinnamylmagnesium chloride[3] react abnormally with some compounds. The former may produce a compound having methyl in the alpha-position and the other group in the beta-position, similar to the *o*-tolyl product from benzylmagnesium chloride. Cinnamyl chloride may undergo rearrangement in the formation of the Grignard reagent itself, subsequently reacting normally with the reactant used.[4]

Monochloroamine has been used[5,6] with various Grignard reagents to produce the corresponding primary amines. The normal product obtained from benzylmagnesium chloride would be benzylamine. If rearrangement had occurred as outlined, the product would be *o*-toluidine. Likewise α-naphthylmethylamine would be the normal product from α-naphthylmethylmagnesium chloride but a rearrangement would form α-methyl-β-naphthylamine. Cinnamylmagnesium chloride if it has the α-phenylallyl structure would normally form α-phenylallylamine. If cinnamyl chloride forms a normal Grignard reagent, cinnamylamine would be obtained as a normal product in the reaction with monochloroamine.

In the present work a study has been made of the reaction of monochloroamine with the three Grignard reagents mentioned for the purpose of determining whether rearrangement occurs, and if so to what extent.

With benzylmagnesium chloride and α-naphthylmethylmagnesium chloride, benzylamine and α-naphthylmethylamine are formed, respectively. No indication of the formation of the rearrangement products, *o*-toluidine and α-methyl-β-naphthylamine was obtained and it was shown that if present at all they were present to the extent of less than 1% in the reaction products. From cinnamylmagnesium chloride and monochloroamine the only amine obtained was cinnamylamine. The structure was confirmed by reduction to γ-phenyl-*n*-propylamine.

Experimental

Preparation of Monochloroamine.—The method used by Coleman and Hauser[5] was modified slightly to increase

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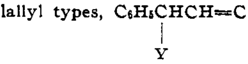
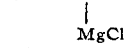
[1] Tiffeneau and Delange, *Compt. rend.*, **137**, 573 (1903).

[2] Austin and Johnson, THIS JOURNAL, **54**, 647 (1932).

[3] (a) Gilman and Kirby, *ibid.*, **51**, 3475 (1929); (b) Gilman and Harris, *ibid.*, **53**, 3541 (1931).

[4] To quote from Gilman and Harris "In general, it appears that α-phenylallyl types,  $C_6H_5\underset{\overset{|}{Y}}{C}HCH{=}CH_2$, are formed from the cinnamyl chloride Grignard reagent and all reactants, or in any event, from a greater variety of reactants than give rise to the nuclear substitutions observed with benzylmagnesium chloride types. This is hardly incontrovertible evidence in all cases for an α-phenylallylmagnesium chloride structure,  $C_6H_5\underset{\overset{|}{MgCl}}{C}HCH{=}CH_2$. We might have initially a cinnamylmagnesium chloride, $C_6H_5CH{=}CHCH_2MgCl$, some of whose reaction products might, under the experimental conditions, rearrange to α-phenylallyl derivatives."

[5] Coleman and Hauser, THIS JOURNAL, **50**, 1193 (1928).

[6] Coleman and Yager, *ibid.*, **51**, 567 (1929).