amine in chloroform an hour at room temperature should be sufficient. The original conditions were triethylamine in refluxing dimethylformamide which will cause dehydrohalogenation, but which are unnecessarily vigorous.

RIVERSIDE, CALIF.

[CONTRIBUTION FROM THE WELLCOME RESEARCH LABORATORIES]

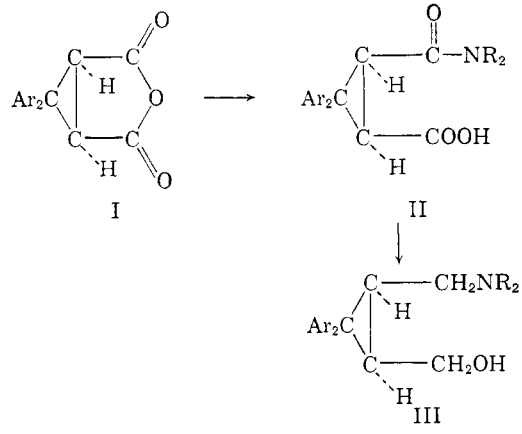
Cyclopropanes Derived from Diaryldiazomethanes. I. Amino Alcohols of the *cis* Series[1]

RICHARD BALTZLY, NARIMAN B. MEHTA, PETER B. RUSSELL,[2] RONALD E. BROOKS,[3] EUGENE M. GRIVSKY, AND ANNE M. STEINBERG[4]

Received February 8, 1961

Through the addition of diaryldiazomethanes to unsaturated carbonyl compounds good yields of 1,1-diphenylcyclopropanes were obtained. These were then converted to amides and thence to amines. The route studied most intensively utilized maleic and citraconic anhydrides which were converted to amido acids and to amino alcohols.

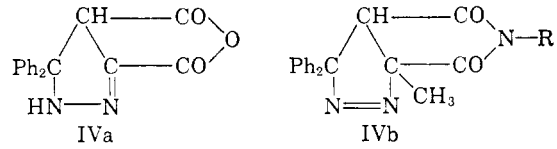
Staudinger[5] and later van Alphen[6] studied the addition of diphenyldiazomethane to unsaturated carbonyl derivatives. It has been established that the pyrazolines and cyclopropanes so obtained from maleic and fumaric esters have their ester functions in the *trans* position, *cis* derivatives being obtained only when the starting compound was cyclic in structure—as maleic anhydride or maleimide. Compounds of type A have been converted by the sequence I–III



I II III

into substances having resemblance to a variety of types possessing known pharmacological activity. Furthermore, the *trans* analogs[7] could also be prepared and structure-activity relationships could be studied through a wide range.

The reaction of diaryldiazomethanes with maleic anhydride and maleimides[8] gave Δ^2-pyrazolines (IVa), since they reduced permanganate in acetone solution at room temperature. In the citraconimide series,[8] the permanganate test was negative, indicating that Δ^1-pyrazolines (IVb) were obtained.



IVa IVb

The ease with which the pyrazolines were converted to cyclopropanes varied considerably. The pyrazolines derived from maleimides and citraconimides are considerably more labile than those obtained from acyclic compounds and those formed from maleic anhydride are still less stable. In most of our earlier work in which solutions of diaryldiazomethanes were employed without isolation of the pure reagents, the pyrazolines could not be isolated at all from reactions with maleic anhydride. Eventually it was discovered that the collapse of the pyrazoline was catalyzed by traces of mercuric ion. The reactions of diaryldiazomethanes with citraconic anhydride are much slower than those with maleic anhydride and the former have never in our hands given even traces of pyrazoline. It is possible that the attack of the reagent on the conjugated system may give an intermediate that does not cyclize instantaneously[9] and which may

(1) A portion of this material was presented by Dr. Mehta before the Organic Division of the American Chemical Society, Boston Meeting, April 1959.

(2) Present address: Wyeth Laboratories, West Chester, Pa.

(3) Present address: Chemistry Department, Brown University, Providence, R. I.

(4) Present address: Department of Chemistry, Fordham University, New York, N. Y.

(5) H. Staudinger, E. Anthes, and F. Pfenninger, *Ber.*, 49, 1928 (1916).

(6) J. van Alphen, *Rec. trav. chim.*, 62, 210 (1943).

(7) The preparation of the *trans* compounds requires intermediates (preferably maleamic esters) that were not readily available in the early stages of this work. Since also the *cis* compounds appeared more promising in early tests the *trans* series was studied much later. It will be reported in a separate publication.

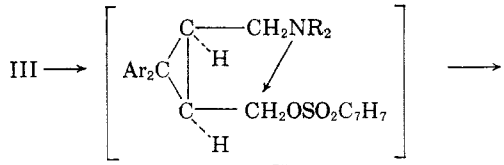
(8) R. Baltzly, N. B. Mehta, P. B. Russell, R. E. Brooks, E. M. Grivsky, and A. M. Steinberg, *J. Org. Chem., in press.*

(9) A kinetic study and discussion of the probable mechanisms of some of these reactions were presented before the Division of Organic Chemistry of the American Chemical Society, New York, 1960.

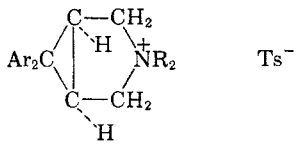
stabilize itself in more than one fashion. Not only the rate differences but also the final products indicate that variations in mechanism are possible. Whereas the slow reactions with citraconic anhydride afford high yields of product of type I, this type of product is formed from maleic anhydride in 50–60% yield only. Careful examination of the mother liquors revealed the presence of considerable amounts of both γ,γ-diphenylitaconic and γ,γ-diphenylcitraconic anhydrides.

Conversion of the anhydrides, I, to amido acids, II, by reaction with secondary amines proceeded smoothly as did reduction of the amido acids to amino alcohols, III. In early attempts to prepare esters of type III, also desired for physiological testing, unexpected difficulties were encountered due to a very facile cyclization.

When amino alcohols of type III are treated with *p*-toluenesulfonyl chloride (preferably in triethylamine) the isolated product is not a sulfonic ester, V, but rather the cyclic quaternary salt to be expected from V. This reaction, which is reported elsewhere[8] gives a line of synthesis of the quaternary salts, VI,



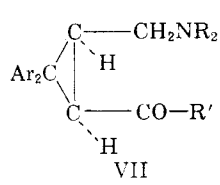
V



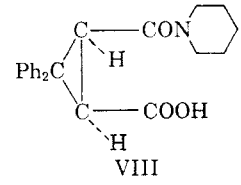
VI

having groupings (as when NR_2 is cyclic) not readily accessible by simple alkylation. When tertiary bases of type III are heated with acetic anhydride esterification presumably takes place but cyclic quaternary salts (VI—but not tosylate) are isolated.[10] A satisfactory technique for esterifying the amino alcohols was finally secured by dissolving the hydrochlorides in nitromethane and adding a slight excess of the appropriate acid chloride at room temperature or with gentle warming.

It also seemed desirable to prepare more direct analogs of Amidone such as VII. This was accomplished through conversion of the amido acid VIII to its acid chloride and subsequent reaction with diethylcadmium. The resultant



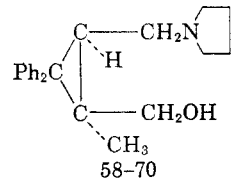
VII



VIII

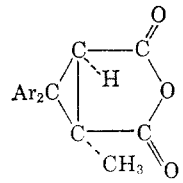
amido ketone was then reduced by lithium aluminum hydride to the amino alcohol (apparently only one pair of isomers) and this was re-oxidized to VII.

None of these variations[11] resulted in a sufficiently active analgesic to promise practical utility. However, a number of compounds showed the ability to counteract the effect of Tremorine on mice. The most active of these, 58–70 (compound 57, Table III) has been under trial in the treatment of Parkinsonism.

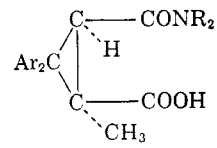


58–70

In the reactions of amines with the citraconic anhydride adduct IX, two isomeric amido acids are possible. With secondary amines only one amido acid[12] could be isolated in each case. It is



IX



X

assumed that reaction had taken place at the carbonyl adjacent to the less substituted carbon atom giving the isomer X. With primary amines addition appears to be less selective; the initial products were mixtures. Where these were separated cleanly, it was assumed that the major component corresponded to X and the minor to its isomer.

The preparation of most of the compounds shown in the Tables proceeded smoothly. Some difficulty was found with the chloro-substituted amino alcohols, analyses tending to run high in carbon. It is believed that there is some hydrogenolysis of chlorine in the lithium aluminum hydride reduc-

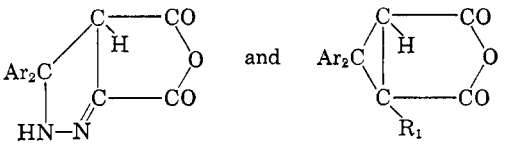
(10) Displacement reactions of tertiary amines with alkyl carboxylates are not usually rapid enough to cause interference with synthetic processes. For intermolecular reactions of this sort *cf.* R. Willstätter and W. Kahn, *Ber.*, **35**, 2757 (1902); L. P. Hammett and H. L. Pfluger, *J. Am. Chem. Soc.*, **55**, 4079 (1933).

(11) In all the physiological tests used so far, activity was diminished by substitution in the phenyl rings. However, only a limited variety of substitutions have been examined—only diazomethanes from bis(para-substituted)benzophenones have been used. Employment of a monosubstituted diphenyldiazomethane would be expected to lead to stereoisomers and that complication was considered undesirable at this stage.

(12) *Cf.* K. Auwers and H. Schnell, *Ber.*, **26**, 1517 (1893).

TABLE I

Δ²-PYRAZOLINES AND CYCLOPROPANE ANHYDRIDES[a]



Compound	Ar	R_1	M.P.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
1	*p*-$CH_3C_6H_4$		200	$C_{19}H_{16}N_2O_3$	70.7	71.0	5.3	5.0
2	*p*-$CH_3C_6H_4$	H	106	$C_{19}H_{16}O_3$	78.2	78.0	5.5	5.3
3	*p*-$CH_3C_6H_4$	CH_3	160	$C_{20}H_{18}O_3$	78.4	78.6	5.9	5.6
4	*p*-$CH_3OC_6H_4$		217	$C_{19}H_{16}N_2O_5$	71.3	71.5	5.0	5.3
5	*p*-$CH_3OC_6H_4$	H	115	$C_{19}H_{16}O_5$	70.4	70.6	4.9	5.0
6	*p*-$CH_3OC_6H_4$	CH_3	146	$C_{20}H_{18}O_5$	71.0	69.8	5.3	5.3
7	*p*-ClC_6H_4	H	176	$C_{17}H_{10}Cl_2O_3$	61.3	61.0	3.0	2.7
8	*p*-ClC_6H_4	CH_3	142	$C_{18}H_{12}Cl_2O_3$	62.3	62.1	3.5	3.3
9	$C_{12}H_8$[b]		154	$C_{17}H_{10}N_2O_3$	70.3	70.0	3.4	3.6
10	$C_{12}H_8$[b]	H	201	$C_{17}H_{10}O_3$	77.9	77.9	3.8	3.7
11	$C_{12}H_8$[b]	CH_3	156	$C_{18}H_{12}O_3$	78.4	78.5	4.3	4.0

[a] The 1,1-diphenyl analogs have been reported by van Alphen, *loc. cit.* [b] Ar_2 = *o*-biphenylene.

tions and that the deschloro compounds so obtained are not readily separated by crystallization.

Four amino alcohols of type III were subjected to catalytic hydrogenation with Adams' Catalyst in glacial acetic acid. Two of these (compounds 51 and 54 of Table III) absorbed three moles of hydrogen relatively slowly after which there was no further reduction. In both cases the hexahydro analogs were isolated in excellent yield. It seems reasonable to assume in both cases that the phenyl ring lying *trans* to the substituents in positions 2 and 3 was reduced. Compound 58–70, under similar conditions was unreduced as was the *ortho*-biphenylene derivative (compound 74 of Table III).[13] These findings are generally in agreement with Linstead's[14] ideas about the hydrogenation of aromatic system. It can be supposed that compounds of type III may assume a configuration wherein the phenyl ring *trans* to the substituents in positions 2 and 3 of the cyclopropane system can approximate itself to a planar portion of the catalyst surface. This could be prevented by the extra methyl group of 58–70 while in the *ortho*-biphenylene derivative (compound 74) both aromatic rings are held perpendicular to the cyclopropane ring and approximation to any planar surface is prevented.

EXPERIMENTAL

Data on new cyclopropane dicarboxylic anhydrides of Type I and related pyrazolines, on amido acids of Type II, amino alcohols (Type III) and their esters are presented in Tables I–IV. The preparations of a number of compounds not fitting into these categories are described in the text. Type procedures are also given in detail for the various operations. Melting points are uncorrected.

Hydrazones. These were prepared by reaction of the appropriate ketone with excess hydrazine hydrate in solution in a higher alcohol. In earlier preparations ethylene and propylene glycols were employed, ethanol not giving a high enough reflux temperature for a convenient reaction time. These procedures were essentially quantitative and gave quite pure products which needed, however, to be recrystallized from methanol or ethanol to free them from traces of glycol. When applied to the preparation of fluorenone hydrazone, the glycol procedures resulted in extensive loss due to formation of fluorene (interference by an unusually facile Wolff-Kishner reaction). This complication was avoided by use of 1-butanol as solvent and the modified method, essentially that of Schönberg, Fateen, and Sammour,[15] was subsequently employed in all hydrazone preparations.

Fluorenone hydrazone. To a solution of 14 g. (0.078 mole) of 9-fluorenone dissolved in 80 ml. of 1-butanol, 10 ml. of 85% aqueous hydrazine hydrate (0.266 mole) was added. After refluxing for 4 hr., the hot solution was poured into 200 ml. of methanol. On cooling there was deposited 13 g. of the product (67% yield). After recrystallization from methanol the m.p. was 152°.[16] Further material could be recovered from the mother liquors.

The following hydrazones were also prepared in nearly quantitative yields, using 1-butanol as the solvent: Benzophenone hydrazone,[17] m.p. 98°. 4,4′-Dimethylbenzophenone hydrazone,[18] m.p. 108°. 4,4′-Dimethoxybenzophenone hydrazone,[16] m.p. 85°. 4,4′-Dichlorobenzophenone hydrazone,[19] m.p. 96°.

Diaryldiazomethanes. As the reaction studied herein required diaryldiazomethanes, free of substances capable of reacting with carboxylic acid anhydrides, an exhaustive study was undertaken. We found that the oxidation was

(13) In these unsuccessful runs, reduction of cyclohexene showed that the catalyst had not been poisoned.

(14) R. P. Linstead, W. E. Doering, S. B. Davis, P. Levine, and R. R. Whetstone, *J. Am. Chem. Soc.*, **64**, 1985 (1942).

(15) A. Schönberg, A. E. K. Fateen, and A. E. M. A. Sammour, *J. Am. Chem. Soc.*, **79**, 6020 (1957).

(16) H. Staudinger and O. Kupfer, *Ber.*, **44**, 2197 (1911).

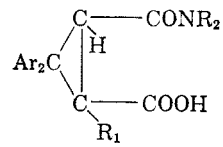
(17) L. I. Smith and K. L. Howard in E. C. Horning, *Org. Syntheses*, **Coll. Vol. III**, 351 (1955).

(18) H. Staudinger and J. Goldstein, *Ber.*, **49**, 1923 (1916).

(19) O. Grummitt and A. Jenkins, *J. Am. Chem. Soc.*, **68**, 914 (1946).

TABLE II

1,1-DIARYLCYCLOPROPANE-2,3-DICARBOXYLIC ACID MONOAMIDES



Compound	Ar	R_1	NR_2	M.P.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
12	C_6H_5	H	C_2H_5NH	201	$C_{19}H_{19}NO_3$	73.7	73.5	6.2	5.9
13	C_6H_5	H	$(CH_3)_2N$	218	$C_{19}H_{19}NO_3$	73.7	73.7	6.2	6.3
14	C_6H_5	H	$(CH_3)_2CHNH$	195	$C_{20}H_{21}NO_3$	74.4	74.7	6.5	6.6
15	C_6H_5	H	$(CH_2)_4N$[a]	257	$C_{21}H_{21}NO_3$	75.2	75.5	6.3	6.4
16	C_6H_5	H	$O(CH_2)_4N$[b]	240	$C_{21}H_{21}NO_4$	71.8	71.6	6.0	5.9
17	C_6H_5	H	$(C_2H_5)_2N$	156	$C_{21}H_{23}NO_3$	74.7	75.0	6.8	6.6
18	C_6H_5	H	n-C_4H_9NH	194	$C_{21}H_{23}NO_3$	74.7	74.5	6.8	6.7
19	C_6H_5	H	$(CH_2)_5N$[c]	231	$C_{22}H_{23}NO_3$	75.7	75.5	6.6	6.3
20	C_6H_5	H	$CH_3N(CH_2)_4N$[d]	170	$C_{22}H_{24}N_2O_3$	72.5	72.6	6.6	6.7
21	C_6H_5	H	$(n$-$C_3H_7)_2N$	182	$C_{23}H_{27}NO_3$	75.6	75.4	7.4	7.3
22	C_6H_5	CH_3	$(CH_3)_2N$	199	$C_{20}H_{21}NO_3$	74.4	74.7	6.5	6.2
23	C_6H_5	CH_3	C_2H_5NH	200	$C_{20}H_{21}NO_3$	74.4	74.5	6.5	6.3
24	C_6H_5	CH_3	$(CH_2)_4N$[a]	218	$C_{22}H_{23}NO_3$	75.6	75.6	6.6	6.4
25	C_6H_5	CH_3	$(CH_2)_5N$[c]	132	$C_{23}H_{25}NO_3$	76.1	76.3	6.9	7.1
26	C_6H_5	CH_3	$CH_3N(CH_2)_4N$[d]	198	$C_{23}H_{26}N_2O_3$	73.0	72.9	6.9	7.2
27	C_6H_5	CH_3	$(n$-$C_4H_9)_2N$	113	$C_{26}H_{33}NO_3$	76.6	76.4	8.1	7.9
28	p-$CH_3C_6H_4$	H	$(CH_3)_2N$	207	$C_{21}H_{23}NO_3 \cdot 1/2\ H_2O$	72.8	72.7	6.9	6.9
29	p-$CH_3C_6H_4$	H	$(CH_2)_4N$[a]	174	$C_{23}H_{25}NO_3$	76.0	76.1	6.8	6.7
30	p-$CH_3C_6H_4$	H	$O(CH_2)_4N$[b]	190	$C_{23}H_{25}NO_4$	72.8	72.6	6.6	6.5
31	p-$CH_3C_6H_4$	H	$(CH_2)_5N$[c]	207	$C_{24}H_{27}NO_3$	76.4	76.5	7.2	6.9
32	p-$CH_3C_6H_4$	Me	$(CH_2)_5N$[c]	203	$C_{25}H_{29}NO_3$	76.6	76.4	7.4	7.1
33	p-$CH_3C_6H_4$	Me	$CH_3N(CH_2)_4N$[d]	202	$C_{25}H_{30}N_2O_3$	74.0	74.3	7.4	7.6
34	p-$CH_3OC_6H_4$	H	$(CH_3)_2N$	109	$C_{22}H_{25}NO_5$	68.9	69.0	6.5	6.5
35	p-ClC_6H_4	H	$(CH_3)_2N$	150	$C_{19}H_{17}NO_3Cl_2$	61.3	61.2	4.8	4.7
36	p-ClC_6H_4	H	$(CH_2)_4N$[a]	178	$C_{21}H_{19}NO_3Cl_2$	62.5	62.2	4.7	4.8
37	p-ClC_6H_4	H	$(CH_2)_5N$[c]	210	$C_{22}H_{21}NO_3Cl_2$	63.1	62.9	5.0	5.1
38	$C_{12}H_8$[f]	H	$(CH_3)_2N$	209	$C_{19}H_{17}NO_3$	74.3	74.1	5.5	5.0
39	$C_{12}H_8$[f]	H	$(CH_2)_4N$[a]	234	$C_{21}H_{19}NO_3$	75.7	75.7	5.7	6.0
40	$C_{12}H_8$[f]	H	$O(CH_2)_4N$[b]	238	$C_{21}H_{19}NO_4$	72.2	71.9	5.4	5.3
41	$C_{12}H_8$[f]	H	$(C_2H_5)_2N$	199	$C_{21}H_{21}NO_3$	75.2	75.0	6.2	6.2
42	$C_{12}H_8$[f]	H	$(CH_2)_5N$[c]	227	$C_{22}H_{21}NO_3$	76.1	76.4	6.1	6.3
43	$C_{12}H_8$[f]	H	$C_2H_5OOCN(CH_2)_4N$[e]	200	$C_{24}H_{24}N_2O_5$	68.6	68.7	5.7	6.0

[a] Pyrrolidine. [b] Morpholine. [c] Piperidine. [d] N'-Methylpiperazine. [e] N'-Carbethoxypiperazine. [f] Ar_2 = o-biphenylene.

catalyzed not only by alkali,[20] but initially also by traces of water. This is consistent with the findings of Staudinger[16,18] and his colleagues that the reaction is much more rapid in benzene or petroleum ether than in ether. Furthermore, the silver oxide reagent[21] of Schroeder was distinctly inferior to yellow oxide of mercury. The method exemplified below is similar to that described by Hancock, Gilby, and Westmoreland[22] although for our purposes certain deviations in detail were desirable.

9-Diazofluorene.[16] To a rapidly stirred[23] solution of 13 g. (0.066 mole) of fluorenone hydrazone in 1 l. of anhydrous ether were added 1 g. of potassium hydroxide and 0.5 cc. of water. Three 7-g. portions of yellow mercuric oxide were added, the solution being stirred for 45 min. and then decanted from the heavy sludge before each fresh addition. After the third decantation, the bluish purple ethereal solution was dried over magnesium sulfate for 1 hr. On concention and cooling, long needle-shaped crystals melting at 99° were obtained in 99% yield. The diazofluorene was recrystallized from pentane.

Oxidation of the appropriate hydrazones by the same procedure afforded diphenyldiazomethane, m.p. 30°,[5] bis-p-tolyldiazomethane, m.p. 107°,[18] bis(p-methoxyphenyl)-diazomethane, m.p. 112°,[16] and bis(p-chlorophenyl)diazomethane, m.p. 107°. This latter compound has been prepared previously in several laboratories and even employed in kinetic studies[22] but does not appear to have been isolated or characterized.

Anal. Calcd. for $C_{13}H_8Cl_2N_2$: N, 10.65. Found: N, (Dumas) 10.70.

As first obtained the diazo compounds are contaminated by traces of ketazines from which they can be freed by repeated crystallization from pentane. For preparative purposes complete purity was not essential but for kinetic studies[7] ketazines in particular had to be removed since there is some overlapping in the visible absorption bands. All of these diazo compounds keep reasonably well (for several months, at least) in well closed containers at around −20° as solids. In solution, even at the same temperature, slow decomposition does take place, especially with the bis-p-methoxy derivative. Consequently it is best to carry out recrystallizations rapidly. Although less stable than its relatives, bis(p-methoxyphenyl)diazomethane does not require the special precautions reported by Staudinger and

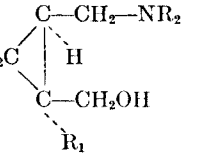
(20) A. Schönberg, W. I. Awad, and N. Latif, *J. Chem. Soc.*, 1368 (1951).

(21) W. Schroeder and L. Katz, *J. Org. Chem.*, 19, 718 (1954).

(22) C. K. Hancock, R. F. Gilby, Jr., and J. S. Westmoreland, *J. Am. Chem. Soc.*, 79, 1917 (1957).

(23) A magnetic stirrer is convenient.

TABLE III. 1,1-DIARYLCYCLOPROPANE AMINO ALKANOLS



Compound	Ar	R_1	NR_2	Amino Alkanols M.P.	Empirical Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Addition and Quaternary Salts M.P.	Empirical Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
44	C_6H_5	H	$(CH_3)_2N$	92	$C_{19}H_{23}NO$	81.2	80.9	8.2	8.2	196	$C_{19}H_{23}NO\cdot HCl$	71.9	71.9	7.6	7.7
45	C_6H_5	H	C_2H_5NH							160	$C_{19}H_{23}NO\cdot HCl\cdot H_2O$	67.9	67.7	7.7	7.4
46	C_6H_5	H	$(CH_3)_2CHNH$							192	$C_{20}H_{25}NO\cdot HCl$	72.5	72.7	7.5	7.8
47	C_6H_5	H	$(CH_2)_4N$[a]							214	$C_{21}H_{25}NO\cdot HCl$	73.4	73.7	7.6	7.8
48	C_6H_5	H	$(CH_2)_4N$[a]							236	$C_{21}H_{25}NO\cdot CH_3I$	58.8	59.2	6.3	6.5
49	C_6H_5	H	$(C_2H_5)_2N$							158	$C_{21}H_{27}NO\cdot HCl$	73.0	73.3	7.8	7.8
50	C_6H_5	H	n-C_4H_9NH	126	$C_{21}H_{27}NO$	81.4	81.2	8.7	8.6	165	$C_{21}H_{27}NO\cdot HCl$	73.0	73.2	7.8	8.1
51	C_6H_5	H	$(CH_2)_5N$[c]	142	$C_{22}H_{27}NO$	82.3	82.1	8.4	8.4	190	$C_{22}H_{27}NO\cdot HCl$	72.6	72.3	8.2	8.0
52	C_6H_5	H	$(CH_2)_5N$[c]							200	$C_{22}H_{27}NO\cdot C_7H_7SO_3CH_3$	71.0	70.7	7.3	7.1
53	C_6H_5	H	$CH_3N(CH_2)_4N$[d]	161	$C_{22}H_{28}N_2O$	78.6	78.6	8.3	8.4	204	$C_{22}H_{28}N_2O\cdot 2HCl\cdot 3/2\ H_2O$	60.6	60.6	7.6	7.4
54	C_6H_5	H	$O(CH_2)_4N$[b]	156	$C_{23}H_{25}NO_2$	78.1	78.4	7.7	7.6	178	$C_{23}H_{25}NO_2\cdot HCl\cdot H_2O$	66.7	66.7	7.4	7.5
55	C_6H_5	H	$(n$-$C_3H_7)_2N$							164	$C_{23}H_{31}NO\cdot HCl$	73.9	73.6	8.5	8.3
56	C_6H_5	CH_3	$(CH_3)_2N$	144	$C_{20}H_{25}NO$	81.4	81.7	8.5	8.5	216	$C_{20}H_{25}NO\cdot HCl$	72.5	72.3	7.5	7.5
57	C_6H_5	CH_3	$(CH_2)_4N$[a]	157	$C_{22}H_{26}NO$	82.3	82.4	8.4	8.2	201	$C_{22}H_{26}NO\cdot HCl$	73.8	73.5	7.8	7.8
58	C_6H_5	CH_3	$(CH_2)_5N$[c]	147	$C_{23}H_{29}NO$	82.4	82.3	8.7	8.6	158	$C_{23}H_{29}NO\cdot HCl\cdot 5/2\ H_2O$	66.2	65.9	8.4	8.3
59	C_6H_5	CH_3	$CH_3N(CH_2)_4N$[d]	198	$C_{23}H_{30}N_2O$	73.0	72.8	6.8	7.1	267	$C_{23}H_{30}N_2O\cdot 2HCl$	65.3	65.2	7.6	7.3
60	C_6H_5	CH_3	$(n$-$C_4H_9)_2N$							131	$C_{26}H_{37}NO\cdot HCl\cdot 1/2\ H_2O$	73.7	73.5	8.9	9.1
61	p-$CH_3C_6H_4$	H	$(CH_3)_2N$							222	$C_{21}H_{27}NO\cdot HCl$	72.8	72.5	8.3	8.0
62	p-$CH_3C_6H_4$	H	$(CH_2)_4N$[a]							214	$C_{23}H_{29}NO\cdot HCl$	74.3	74.4	8.1	8.2
63	p-$CH_3C_6H_4$	H	$O(CH_2)_4N$[b]	147	$C_{23}H_{29}NO_2$	78.6	78.6	8.2	7.9	268	$C_{23}H_{29}NO_2\cdot HCl$	71.2	71.5	7.7	8.0
64	p-$CH_3C_6H_4$	H	$(CH_2)_5N$[c]	114	$C_{24}H_{31}NO$	82.5	82.7	8.9	8.6	190	$C_{24}H_{31}NO\cdot HCl$	74.7	74.7	8.3	8.5
65	p-$CH_3C_6H_4$	H	$(CH_2)_5N$[c]							211	$C_{24}H_{31}NO\cdot CH_3I$	61.1	60.8	6.9	6.9
66	p-$CH_3C_6H_4$	CH_3	$(CH_3)_2N$							188	$C_{22}H_{29}NO\cdot HCl$	70.0	70.2	8.0	8.3
67	p-$CH_3C_6H_4$	CH_3	$(CH_2)_5N$[c]							211	$C_{25}H_{33}NO\cdot HCl\cdot 1/2\ H_2O$	73.6	73.9	8.6	8.3
68	p-CH_3O-C_6H_4	H	$(CH_3)_2N$							208	$C_{21}H_{27}NO_3\cdot HCl$	67.0	66.8	7.4	7.6
69	p-ClC_6H_4	H	$(CH_3)_2N$							232	$C_{19}H_{21}Cl_2NO\cdot HCl$	59.0	59.3	5.4	5.5
70	p-ClC_6H_4	H	$(CH_3)_2CHNH$							210	$C_{20}H_{23}Cl_2NO\cdot HCl$	59.8	60.1	5.8	5.8
71	p-ClC_6H_4	H	$(CH_2)_4N$[a]							220	$C_{21}H_{23}Cl_2NO\cdot HCl$	61.4	61.7	5.6	5.9
72	p-ClC_6H_4	H	$(CH_2)_5N$[c]	144	$C_{22}H_{25}Cl_2NO$	67.7	67.8	6.4	6.1	204	$C_{22}H_{25}Cl_2NO\cdot HCl$	61.9	62.1	6.1	5.9
73	p-ClC_6H_4	H	$(CH_2)_5N$[c]							267	$C_{22}H_{25}Cl_2NO\cdot CH_3I$	51.9	52.0	5.3	5.6
74	$C_{12}H_8$[f]	H	$(CH_3)_2N$	104	$C_{19}H_{21}NO$	81.7	81.4	7.5	7.3	288	$C_{19}H_{21}NO\cdot HCl$	72.3	72.1	7.0	6.9
75	$C_{12}H_8$[f]	H	$(CH_2)_4N$[a]	120	$C_{21}H_{23}NO$	82.6	82.8	7.5	7.4	259	$C_{21}H_{23}NO\cdot HCl$	73.8	74.1	7.0	7.0
76	$C_{12}H_8$[f]	H	$O(CH_2)_4N$[b]	75	$C_{21}H_{23}NO_2$	78.5	78.8	7.2	7.3	215	$C_{21}H_{23}NO_2\cdot HCl$	69.9	69.6	6.5	6.8
77	$C_{12}H_8$[f]	H	$(C_2H_5)_2N$	94	$C_{21}H_{25}NO$	82.1	82.4	8.1	8.1	208	$C_{21}H_{25}NO\cdot HCl$	73.4	73.1	7.6	7.4
78	$C_{12}H_8$[f]	H	$(CH_2)_5N$[c]	127	$C_{22}H_{25}NO$	82.5	82.6	7.8	7.6	233	$C_{22}H_{25}NO\cdot HCl$	74.3	74.3	7.3	7.6
79	$C_{12}H_8$[f]	H	$CH_3N(CH_2)_4N$[d,g]	144	$C_{22}H_{26}N_2O$	79.0	79.2	7.8	7.8	275	$C_{22}H_{26}N_2O\cdot 2HCl$	64.8	64.5	6.8	6.8
80	$C_{12}H_8$[f]	CH_3	$(CH_2)_4N$[a]	141	$C_{22}H_{25}NO$	82.7	82.9	7.8	7.8	236	$C_{22}H_{25}NO\cdot HCl$	74.3	74.2	7.3	7.5

Footnote symbols *a–d* and *f* are defined in Table II. [g] Prepared by lithium aluminum hydride reduction of the carbethoxy intermediate No. 43.

TABLE IV. ESTERS OF 1,1-DIARYLCYCLOPROPANE AMINO ALKANOLS

Compound	Ar	R_1	NR_2	R_3	M.P.	Formula	Carbon %, Calcd.	Carbon %, Found	Hydrogen, %, Calcd.	Hydrogen, %, Found
81	C_6H_5	H	$(CH_3)_2N$	CH_3	202	$C_{21}H_{25}NO_2 \cdot HCl$	70.1	69.9	7.3	7.6
82	C_6H_5	H	$(CH_2)_4N^a$	CH_3	153	$C_{23}H_{27}NO_2 \cdot HCl \cdot 1/2\ H_2O$	70.0	70.1	7.4	7.4
83	C_6H_5	H	$(CH_2)_5N^c$	CH_3	110	$C_{24}H_{29}NO_2 \cdot HCl \cdot H_2O$	69.0	68.9	7.7	7.7
84	C_6H_5	H	$(CH_2)_5N^c$	$CH{=}CH{-}C_6H_5$	196	$C_{31}H_{33}NO_2 \cdot HCl \cdot 1/2\ H_2O$	74.9	74.8	7.1	7.4
85	C_6H_5	CH_3	$(CH_2)_4N^a$	CH_3	142	$C_{24}H_{29}NO_2 \cdot HCl \cdot H_2O$	69.0	69.3	7.7	7.9
86	C_6H_5	CH_3	$CH_3N(CH_2)_4N^d$	CH_3	224	$C_{25}H_{32}N_2O_2 \cdot 2HCl \cdot 1/2\ H_2O$	63.3	63.3	7.4	8.0
87	C_6H_5	CH_3	$(CH_2)_4N^a$	$CH{=}CH{-}C_6H_5$	145	$C_{31}H_{33}NO_2 \cdot HCl \cdot 3/2\ H_2O$	72.3	72.4	7.2	7.5
88	p-$CH_3C_6H_4$	H	$(CH_2)_5N^c$	CH_3	135	$C_{26}H_{33}NO_2 \cdot HCl \cdot H_2O$	70.0	69.9	8.0	7.9
89	p-$CH_3C_6H_4$	CH_3	$(CH_3)_2N$	CH_3	140	$C_{24}H_{31}NO_2 \cdot HCl \cdot 1/2\ H_2O$	70.2	70.5	7.8	7.7
90	p-$CH_3C_6H_4$	CH_3	$(CH_2)_6N^c$	CH_3	195	$C_{27}H_{35}NO_2 \cdot HCl \cdot 1/2\ H_2O$	72.1	72.3	8.2	8.2
91	$C_{12}H_8{}^f$	H	$(CH_3)_2N$	CH_3	236	$C_{21}H_{23}NO_2 \cdot HCl$	70.4	70.2	6.7	6.4
92	$C_{12}H_8{}^f$	CH_3	$(CH_2)_4N^a$	CH_3	207	$C_{24}H_{27}NO_2 \cdot HCl \cdot 3/2\ H_2O$	68.0	68.3	7.3	7.6
93	$C_{12}H_8{}^f$	CH_3	$(CH_2)_4N^a$	$CH{=}CH{-}C_6H_5$	210	$C_{31}H_{31}NO_2 \cdot HCl \cdot 1/2\ H_2O$	75.2	74.9	6.7	6.8

Footnote symbols as in Table II.

Kupfer.[16] In particular, we have not found it sensitive to oxygen.[24]

The products of decomposition are of higher molecular weight. Ketazines and tetraaryl ethylenes have been reported by Staudinger. We have also isolated triaryl carbinols as major break-down products. The formation of these must involve relatively complex processes and suggests further investigation.

Reaction of diphenyldiazomethane with maleic anhydride (unpurified diazo compound). Ten grams of benzophenone hydrazone (0.05 mole) was oxidized with 12 g. of mercuric oxide in 200 cc. of ether in the presence of 18 g. of calcium sulfate and 1 g. of sodium methoxide. The reaction was conducted in a stoppered bottle on a shaking machine and required 36 hr. The filtered solution was added to 6 g. (0.06 mole) of maleic anhydride in 1 l. of hexane. The color of the solution faded rather rapidly, evolution of nitrogen lagging slightly behind the fading. Before the reaction was finished precipitation of 1,1-diphenylcyclopropane-2,3-*cis*-dicarboxylic acid anhydride[6] had begun. This was collected and a second crop obtained on concentration of the mother liquors. Together these weighed 6.7 g. (0.03 mole) and were substantially pure. On further evaporation there were obtained successively 1.4 g. of γ,γ-diphenylitaconic anhydride,[25] m.p. 152° and 1.5 g. of γ,γ-diphenylcitraconic anhydride, m.p. 96–97°.[26] Isolation of this last had to be preceded by shaking the organic material in ethereal solution with sodium bicarbonate solution to remove unchanged maleic anhydride. (An alternative procedure is to remove maleic anhydride in high vacuum at about 60°.) The diphenylitaconic anhydride is not much less soluble than the cyclopropane isomer but crystallizes much less rapidly. More of the diphenylcitraconic anhydride was probably present than could be isolated.

5,5-o-Biphenylene-Δ^2-pyrazoline-3,4-cis-dicarboxylic acid anhydride (compound 9). To 29 g. (0.15 mole) of crystalline 9-diazofluorene dissolved in 1.5 l. of anhydrous ether was added 20 g. (0.185 mole) of maleic anhydride in 200 ml. of anhydrous ether. The solution was shaken vigorously for a few minutes and allowed to stand for 10 hr. at room temperature. Within 90 min., the bluish purple color was discharged. The deposited yellowish white crystals of pyrazoline were collected, 33 g. (84%). After recrystallization from boiling benzene the m.p. was 154° dec. A small sample of the pyrazoline in acetone decolorized permanganate. Other pyrazolines reported in Table I were prepared by a similar procedure.

1,1-o-Biphenylenecyclopropane-2,3-cis-dicarboxylic acid anhydride (compound 10). Thirty-three grams of 5,5-*o*-biphenylene-Δ^2-pyrazoline-2,3-*cis*-dicarboxylic acid anhydride was heated to reflux in 150 ml. of xylene for 30 min. Vigorous effervescence (because of the release of nitrogen) was observed. The solution was then cooled and concentrated. There was obtained 31 g. of the cyclopropane product. Crystallization from acetone-hexane mixture gave colorless crystals, m.p. 201°.

Other pyrazolines were decomposed similarly using as solvents benzene, toluene, or xylene.

1,1-o-Biphenylene-3-methylcyclopropane-2,3-cis-dicarboxylic acid anhydride (compound 11). To 13 g. (0.0676 mole) of crystalline 9-diazofluorene dissolved in 800 ml. of anhydrous ether, was added 8 g.[27] (0.0674 mole) of freshly distilled citraconic anhydride. The solution was shaken vigorously and left on the edge of the steam bath for 6 hr. It was then diluted with 500 ml. of pentane and crystallization was induced by scratching. After 24 hr. 14 g. of thick needles had separated

(24) Staudinger and Kupfer employed an atmosphere of carbon dioxide. The instability they reported could have been due to reaction with carbonic acid.

(25) H. Stobbé and P. Kohlmann, *Ann.*, **308**, 89 (1899).

(26) R. Fittig and A. Rieche, *Ann.*, **300**, 352 (1904).

(27) If citraconic anhydride is employed in excess an oily product is obtained.

from the straw yellow supernatant. Recrystallization from benzene gave long needles, m.p. 156°, in 72% yield.

Others in the series prepared by the same procedure are shown in Table I. With citraconic anhydride, no pyrazolines were isolated.

1,1-o-Biphenylenecyclopropane-2,3-cis-dicarboxylic acid monopiperidide (compound 42). A mixture of 5.2 g. (0.02 mole) of the anhydride (compound 10, Table I) and 20 ml. of freshly distilled piperidine was refluxed with stirring for 5 hr. On removal of the excess amine *in vacuo*, the reaction mixture was extracted with 5% sodium hydroxide solution, filtered, and precipitated by hydrochloric acid. Crystallization from benzene and methanol gave 4.7 g. (66%) of colorless needles, m.p. 227°.

Others in the series shown in Table II were prepared by the same procedure, except when dimethylamine was required. In such cases, the following modification was employed.

1,1-Diphenylcyclopropane-2,3-cis-dicarboxylic acid monodimethyl amide (compound 13). To 2.64 g. of 1,1-diphenylcyclopropane-2,3-*cis*-dicarboxylic acid anhydride dissolved in 10 ml. of benzene in a pressure bottle, 5 g. of 30% dimethylamine in ether was added. The solution was allowed to stand on the edge of the steam bath for 16 hr., when crystalline product separated. The solvents and the excess amine were removed under reduced pressure and the product, 2.8 g., was crystallized from benzene, m.p. 218°.

1,1-o-Biphenylene-2-hydroxymethyl-3-cis-piperidinomethylcyclopropane (compound 78). The solid amido acid (compound 42 in Table II) (4.6 g., 0.013 mole) was dropped portionwise through a powder addition funnel,[28] into a rapidly stirred solution of 3 g. (0.08 mole) of lithium aluminum hydride in 200 ml. of anhydrous ether. After refluxing for 24 hr., it was decomposed by addition of water and then of 3 ml. of 10% sodium hydroxide solution. The clear ethereal layer was separated, dried over anhydrous potassium carbonate and concentrated. A viscous yellow product was obtained. Crystallization from ether-hexane gave 3.3 g. (80% yield) of the base, m.p. 127°.

Others in the series, shown in Table III, were prepared by the same procedure. The hydrochlorides of the bases, were obtained by the addition of ethanolic hydrogen chloride solution to dry ethereal solutions of the bases.

1,1-Bis(p-tolyl)-2-hydroxymethyl-3-cis-piperidinomethylcyclopropane methiodide (compound 65). To 2.8 g. of the amino alcohol, 1,1-bis(*p*-tolyl)-2-hydroxymethyl-3-*cis*-piperidinomethylcyclopropane (compound 64), dissolved in 15 ml. of dry acetone, 10 ml. of methyl iodide was added. The solution was refluxed for 4.5 hr. On cooling and addition of anhydrous ether, colorless needles separated. Recrystallization from ethanol-ether gave needles, m.p. 211°.

1,1-Diphenyl-2-hydroxymethyl-3-cis-piperidinomethylcyclopropane methyl tosylate (compound 52). To 1 g. of the base, 1,1-diphenyl-2-hydroxymethyl-3-*cis*-piperidinomethylcyclopropane (compound 50), dissolved in 10 ml. of dry acetone, 1.2 g. of methyl *p*-toluenesulfonate was added and the solution was refluxed for 1 hr. The solvent was removed *in vacuo* and the residue triturated several times with ether. Recrystallization from isopropyl alcohol gave 1 g. of crystals, m.p. 200°.

1,1-Bis(p-tolyl)-2-piperidinomethyl-3-methyl-3-cis-acetoxymethylcyclopropane hydrochloride hemihydrate (compound 90). To 1.5 g. of the amino alcohol hydrochloride (compound 67) dissolved in 25 ml. of nitromethane was added 3 ml. of acetyl chloride. The reaction mixture was placed in a pressure bottle and left on the edge of the steam bath for 10 hr. After removing the solvent *in vacuo*, the residue was recrystallized from acetone-ether as a hemihydrate in quantitative yield, m.p. 195°.

1,1-Diphenylcyclopropane-2,3-cis-dicarboxylic acid monopiperidide mono acid chloride. To 33 g. (0.097 mole) of 1,1-diphenylcyclopropane-2,3-*cis*-dicarboxylic acid monopiperidide (compound 19) dissolved in 1.5 l. of benzene, 87 g. of thionyl chloride was added. The solution was stirred at 70–80° for 65 hr. After removal of excess thionyl chloride and much of the solvent, a brownish white crystalline product was obtained in 87% yield. It was recrystallized from benzene and washed with *n*-pentane, m.p. 187°. On exposure to moist air it was readily converted to the starting compound.

Anal. Calcd. for $C_{22}H_{22}ClNO_2$: C, 71.8; H, 6.0. Found: C, 71.9; H, 6.2.

1,1-Diphenyl-2-piperidinocarbonyl-3-cis-propionylcyclopropane. A solution of ethylmagnesium bromide was prepared from 3.6 g. of magnesium and 15 g. of ethyl bromide in 100 ml. of anhydrous ether. The solution was cooled in an ice bath and anhydrous cadmium chloride, 14 g., was added in portions with rapid agitation. The mixture was refluxed for 45 min. and most of the ether was then removed *in vacuo*. The dark residue was diluted with 150 ml. of dry benzene, and the mixture was refluxed for 1 hr. A solution of the above piperidino acid chloride, 31 g., in 100 ml. of dry benzene was then added very gradually—the reactionwas exothermic. The reaction mixture was then stirred and refluxed for 20 hr., cooled in an ice bath and hydrolyzed with ice and dilute sulfuric acid. The benzene layer was separated and washed successively with water, sodium carbonate solution, and again with water. It was dried over sodium sulfate, filtered, and evaporated *in vacuo*. When the residue was dissolved in ether and pentane was added, 13.4 g. of the product separated, m.p. 104–105°.

Anal. Calcd. for $C_{24}H_{27}NO_2 \cdot H_2O$: C, 76.0; H, 7.4. Found: C, 76.3; H, 7.2.

1,1-Diphenyl-2-piperidinomethyl-3-cis(1'-hydroxypropyl)-cyclopropane. Seven grams of the above anhydrous amido ketone was added to a rapidly stirred slurry of 6 g. of lithium aluminum hydride in 500 ml. of anhydrous ether. After refluxing for 18 hr., the reaction mixture was decomposed by water and 6 ml. of 10% sodium hydroxide solution. The ether extract was dried over anhydrous potassium carbonate and concentrated; 5.5 g. of a crystalline product, m.p. 134–135°, was obtained. This substance appears to be dimorphic. It crystallizes from chloroform-ethanol as cubes melting at 139–140° and from ether as needles melting at 149–150°. The two forms are interconvertible and mixtures melt over an intermediate range.

Anal. Calcd. for $C_{24}H_{31}NO$: C, 82.5; H, 8.9; N, 4.0. Found: 140° melting form: C, 82.2; H, 8.6; N, 4.2. Found: 150° melting form: C, 82.4; H, 8.5; N, 4.3.

The hydrochloride was obtained as a hemihydrate, m.p. 215° dec.

Anal. Calcd. for $C_{24}H_{31}NO \cdot HCl \cdot 1/2\ H_2O$: C, 73.0; H, 8.0. Found: C, 73.1; H, 7.7.

The anticipated diastereoisomeric form, if formed at all, must have been a very minor constituent of the reduction mixture.

1,1-Diphenyl-2-piperidinomethyl-3-cis-(1'-acetoxypropyl)-cyclopropane hydrochloride sesquihydrate. To 0.4 g. of the amino alcohol hydrochloride hemihydrate dissolved in 15 ml. of nitromethane, 1.2 ml. of acetyl chloride was added. On standing overnight near the edge of the steam bath in a pressure bottle, thick hard crystals were deposited. After recrystallization from methanol-ether, the m.p. was 120°.

Anal. Calcd. for $C_{26}H_{33}NO_2 \cdot HCl \cdot 3/2\ H_2O$: C, 68.6; H, 8.2. Found: C, 68.5; H, 8.3.

1,1-Diphenyl-2-piperidinomethyl-3-cis-propionylcyclopropane. In 20 ml. of glacial acetic acid was dissolved 0.875 g. (0.0025 mole) of the amino alkanol (higher melting form). To this was added gradually a solution of 0.5 g. of chromic anhydride in 50 ml. of water over a period of 20 min. at 60°. The reaction mixture was made basic by excess alkali, extracted with ether, and dried over solid sodium hydroxide. The ether was evaporated, the residue was dissolved in ethyl acetate, and pentane was added. One-half gram of crystalline product was obtained. Recrystallization from ethyl acetate–hexane gave material melting at 112°.

(28) N. B. Mehta and J. Zupicich, *Chemist Analyst*, **50**, [2], 55 (1961).

Anal. Calcd. for $C_{24}H_{29}NO$: C, 82.9; H, 8.4; N, 4.0. Found: C, 83.0; H, 8.0; N, 4.3.

The same base was obtained by similar oxidation of the lower-melting form of the amino alcohol. The hydrochloride was crystallized from acetone-ether, m.p. 212–213°.

Anal. Calcd. for $C_{24}H_{29}NO \cdot HCl \cdot 1/2\ H_2O$: C, 73.4; H, 7.9. Found: C, 73.3; H, 8.2.

1-Phenyl-1-cyclohexyl-2-piperidinomethyl-3-cis-hydroxymethylcyclopropane hydrochloride. One and two-tenths grams (3.3 mmoles) of 1,1-diphenyl-2-piperidinomethyl-3-*cis*-hydroxymethylcyclopropane hydrochloride (compound 51) was dissolved in 50 ml. of glacial acetic acid and shaken with Adams' catalyst under 2–3 atm. of hydrogen over pressure at 40° for 4 hr. Approximately 10 mmoles of hydrogen was absorbed at a moderate rate with no further absorption in the last hour of shaking. The solution was removed from the catalyst, and evaporated to dryness *in vacuo*. The residue was dissolved in acetone, filtered, and diluted with ether and ethereal hydrogen chloride solution was added to incipient turbidity. There was obtained 1.1 g. of a crystalline product, melting at 205–206°.

Anal. Calcd. for $C_{22}H_{33}NO \cdot HCl$: C, 72.6; H, 9.4. Found: C, 72.6; H, 9.6.

1-Phenyl-1-cyclohexyl-2-morpholinomethyl-3-cis-hydroxymethylcyclopropane hydrochloride. The hydrogenation of 1,1-diphenyl - 2 - morpholinomethyl - 3 - *cis* - hydroxymethylcyclopropane hydrochloride monohydrate (compound 54) (2.5 g., 0.0065 mole) was carried out by the same procedure as that above. On crystallization from acetone-ether, 2.2 g. of the product, m.p. 219°, was obtained.

Anal. Calcd. for $C_{21}H_{31}NO_2 \cdot HCl \cdot 1/2\ H_2O$: C, 67.3; H, 8.8. Found: C, 67.2; H, 8.9.

2,2-Diphenylcyclopropane carboxylic acid pyrrolidide. Four grams of 2,2-diphenylcyclopropane carboxylic acid,[29,30] m.p. 172°, obtained by the hydrolysis of the reaction product of the diphenyldiazomethane and methyl acrylate, was refluxed in 25 ml. of thionyl chloride for 2 hr. After removal of excess thionyl chloride, 2.4 g. of pyrrolidine in 10 ml. of benzene was added dropwise. The reaction mixture was left overnight on the steam bath. The benzene layer was washed with dilute hydrochloric acid, with saturated sodium carbonate solution and finally with water. On evaporation of the solvent an oily residue was obtained. It crystallized from benzene-pentane mixture. Four grams of colorless prisms, m.p. 129–130°, was obtained.

Anal. Calcd. for $C_{20}H_{21}NO$: C, 82.4; H, 7.1. Found: C, 82.5; H, 7.2.

1,1-Diphenyl-2-pyrrolidinomethylcyclopropane hydrochloride. The above amide (2.9 g.) was reduced with 0.8 g. of lithium aluminum hydride in 150 ml.of anhydrous ether. The ether extract was acidified with alcoholic hydrochloric acid and the solid product was recrystallized from methanol-ether as fine needles, m.p. 220°.

Anal. Calcd. for $C_{20}H_{24}N \cdot HCl$: C, 76.6; H, 7.7. Found: C, 76.4; H, 7.8.

1,1-Diphenyl-2-methylcyclopropane-2-carboxylic acid pyrrolidide. The method of Walborsky and Hornyak[30] afforded 1,1-diphenyl-2-methylcyclopropane-2-carboxylic acid which was converted to its methyl ester, m.p. 95°, by diazomethane. This ester survived for 10 hr. of refluxing with pyrrolidine substantially unchanged. Accordingly the acid was converted to the acid chloride (with thionyl chloride in hexane) and the latter was warmed with pyrrolidine in benzene. The amide melted at 101° after recrystallization from ether-pentane mixture.

Anal. Calcd. for $C_{21}H_{23}NO$: C, 82.6; H, 7.5. Found: C, 82.7; H, 7.7.

1,1-Diphenyl-2-methyl-2-pyrrolidinomethylcyclopropane hydrochloride. The above amide (3.1 g.) was reduced with 0.8 g. of lithium aluminum hydride. The ethereal solution of the base was acidified with methanolic hydrogen chloride solution and the resultant hydrochloride was recrystallized from methanol-ether mixture. There was obtained 1.5 g. of colorless prisms melting at 203°.

Anal. Calcd. for $C_{21}H_{25}N \cdot HCl$: C, 77.1; H, 8.0. Found: C, 77.0; H, 8.3.

TUCKAHOE, N. Y.

(29) H. Wieland and O. Probst, *Ann.*, **530**, 274 (1937).

(30) H. M. Walborsky and F. M. Hornyak, *J. Am. Chem. Soc.*, **77**, 6026 (1955).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, BAYLOR UNIVERSITY]

Hydrogenolysis by Metal Hydrides. III. Hydrogenolysis of Alkylallylarylamines by Lithium Aluminum Hydride[1]

VIRGIL L. TWEEDIE AND JOHN C. ALLABASHI[2]

Received August 18, 1960

Certain alkylallylarylamines readily undergo hydrogenolysis with lithium aluminum hydride in the presence of nickel(II) chloride to yield alkylarylamines and a mixture of propene and propane. The extent of hydrogenolysis showed a marked dependence on the solvent, the reaction temperature, the amount of nickel chloride, the mole ratio of lithium aluminum hydride to amine, and the structure of the tertiary amine. *N*-Allyl-*N*-methylaniline was 75% hydrogenolyzed after thirty hours in refluxing tetrahydrofuran with two moles of lithium aluminum hydride and 0.003 mole of nickel chloride. Hydrogenolysis was decreased by *o*-, *m*-, or *p*-methyl and *o*-chloro ring substituents but was increased by *m*- and *p*-chloro groups. A mechanism is proposed.

Among the numerous applications of lithium aluminum hydride there are relatively few reports of hydrogenolysis of the C—O or C—N single bond of the simple ether or amine functional groups. The alkyl-oxygen bond of allyl aryl ethers has been hydrogenolyzed by lithium aluminum hydride catalyzed with nickel or cobalt salts.[3,4] Under similar conditions aryl vinyl ethers have been

(1) Presented at the 135th Meeting of the American Chemical Society, Boston, Mass., April 1959, Abstracts of Papers, p. 102-0.

(2) Taken from the Ph.D. dissertation of J.C.A., Baylor University, 1959. Present address: Hercules Powder Co., Cumberland, Md.

(3) P. Karrer and O. Ruttner, *Helv. Chim. Acta*, **33**, 812 (1950).

(4) V. L. Tweedie and M. Cuscurida, *J. Am. Chem. Soc.*, **79**, 5463 (1957). (Paper I in this series.)